Office for Nuclear Regulation

Civil Nuclear Reactor Build - Generic Design Assessment

Step 2 Assessment of the Internal Hazards of Hitachi GE's UK Advanced Boiling Water Reactor (UK ABWR)

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EXECUTIVE SUMMARY

This report presents the results of my assessment of the safety case claims for internal hazards of Hitachi General Electric Nuclear Energy Ltd (Hitachi-GE) UK Advanced Boiling Water Reactor (UK ABWR) 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 getting increasingly detailed 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 review of key nuclear safety, nuclear security and environmental safety claims, with the aim of identifying any fundamental safety or security shortfalls that could prevent the proposed design from being licensed in Great Britain. Therefore during GDA Step 2 my work has focused on the assessment of the key claims in the area of internal hazards to judge whether they are complete and reasonable in the light of our current understanding of reactor technology.

For internal hazards, safety claims are interpreted as being specific statements about the design features, which prevent, limit the severity, and limit the consequences of the internal hazards on Structures, Systems and Components (SSCs) important in the delivery of the fundamental safety functions; which when implemented will demonstrate that the threats from internal hazards are either removed, withstood or minimised.

The standards I have used to judge the adequacy of the claims in the area of internal hazards have been primarily ONR's Safety Assessment Principles (SAPs) and ONR's Technical Assessment Guides (TAGs).

The treatment of internal Hazards in line with the UK's regulatory regime is a new area for the RP. To assist the RP, I have provided presentations on ONR's expectations in this area. My GDA Step 2 assessment work has also involved continuous engagement with the RP in the form of technical exchange workshops and progress meetings.

My assessment has benefited from visits to Ohma ABWR under construction, Shimane Unit 3 ABWR, and Hitachi Rinkai Works reactor internals components workshop.

My assessment has been based on the RP's Preliminary Safety Report (PSR) and supporting documents relevant to internal hazards claims. The RP's PSR claims on internal hazards, as presented in those documents, can be summarised as follows:

- Internal hazards do not compromise the control of core reactivity or the removal of heat from the core and spent fuel, and will not result in uncontrolled dispersion of radioactivity or the uncontrolled exposure of plant personnel or the public to radiation from any source;
- As the UK ABWR has three divisions of safety systems many of the hazards are mitigated by divisional segregation of safety components provided that barriers between divisions are not breached; and
- Barriers which support the above claim have been identified for the Reactor Building and Control Building.

During my Step 2 assessment I have concluded that the claim on passive safety barrier is reasonable and is in line with my expectations. However, this single claim may not be suitable

for those areas of the UK ABWR design where exceptions to the principle of segregation of SSCs exist (such as inside Primary Containment and the Main Steam tunnel). Additionally, they are insufficient to demonstrate that the risks from internal hazards have been reduced to As Low As Reasonably Practicable (ALARP). An appropriate level of defence in depth has not been demonstrated. However, with the appropriate level of Suitably Qualified and Experienced Person (SQEP) in place, I am confident that the RP will be able to articulate appropriate claims in the Pre-construction Safety Report (PCSR) and underpin them with sufficient arguments and robust evidence.

During my GDA Step 2 assessment of the UK ABWR aspects of the safety case related to internal hazards, I have identified the following areas of strength:

- The RP has adopted a reasonable approach for the internal hazards analysis which comprises identification of internal hazards, identification of SSCs which are required to deliver the safety functions, and analysis of how these SSCs are protected against the internal hazards;
- The RP has developed and adopted an approach to identify internal hazards and safety barriers claims; and
- The RP has demonstrated a high level of commitment in delivering complex studies involving different engineering disciplines within a short period of time to support the claims on safety barriers made within the PSR.

During my GDA Step 2 assessment of the UK ABWR aspects of the safety case related to internal hazards, I have identified the following areas that require follow-up:

- Suitable and sufficient development of claims for all applicable internal hazards, including coincident, combined and consequential events to demonstrate that the risks from internal hazards have been reduced to ALARP. This should cover all relevant buildings and areas where exceptions to segregation of SSCs by safety barriers exist, and for all plant conditions. An appropriate level of defence in depth should be demonstrated;
- The structure and contents of the PCSR including the route-map of the various supporting documents, demonstrating that the PCSR is accurate, objective and demonstrably complete for its intended purpose;
- The plant layout provisions in pace including redundancy, diversity and segregation of SSCs against internal hazards;
- The justification of the design provisions and the case being made against internal hazards for the following areas:

    - Emergency Diesel Generators (EDGs) and associated day tanks in the Reactor Building;
    - Single doors on Class 1 safety barriers separating safety divisions; and
    - The Main Steam tunnel.

- The analysis methodologies for all internal hazards; and
- The RP's capability and competency in internal hazards to enable the delivery of fit for purpose PCSR.

My interactions with the RP's Subject Matter Experts (SME) in internal hazards have been generally positive. Some of the work undertaken at Step 2 will form the basis for developing the arguments and evidence for Steps 3 and 4 of the GDA. The RP has indicated a commitment to bring additional SQEP resources that are also familiar with the UK regulatory regime to assist the RP in developing the PCSR during Step 3.

Overall, I see no reason, on internal hazards grounds, why the UK ABWR should not proceed to Step 3 of the GDA process.

LIST OF ABBREVIATIONS

ABWR	Advanced Boiling Water Reactor
ALARP	As Low As Reasonably Practicable
BMS	Business Management System
C/B	Control Building
EA	Environment Agency
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generators
FMCRD	Fine Motion Control Rod Drive Units
GDA	Generic Design Assessment
HAZOP	Hazard and Operability Study
Hitachi-GE	Hitachi General Electric Nuclear Energy Ltd
HPCF	High Pressure Core Flooder System
IAEA	International Atomic Energy Agency
MSIV	Main Steam Isolation Valve
ONR	Office for Nuclear Regulation
PCSR	Pre-construction Safety Report
PSR	Preliminary Safety Report
R/B	Reactor Building
RP	Requesting Party
RQ	Regulatory Query
Rw/B	Radwaste Building
SAP(s)	Safety Assessment Principle(s)
SSC	Structures, Systems and Components
SQEP	Suitably Qualified and Experienced Person
SME	Subject Matter Expert
TAG	Technical Assessment Guide(s)
T/B	Turbine Building

LIST OF ABBREVIATIONS

TSC	Technical Support Contractor
WENRA	Western European Nuclear Regulators' Association

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1 INTRODUCTION

1.1 Background

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 getting increasingly detailed as the project progresses. Hitachi General Electric Nuclear Energy Ltd's (Hitachi-GE) is the RP for the GDA of the UK Advanced Boiling Water Reactor (UK ABWR).

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 its ABWR design. Also, during Step 1 Hitachi-GE prepared submissions to be evaluated by ONR and the Environment Agency (EA) during Step 2.

3. Step 2 of GDA is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including review of key nuclear safety, nuclear security and environmental safety claims with the aim of identifying any fundamental safety or security shortfalls that could prevent the proposed design from being licensed in Great Britain.

4. This report presents the results of my assessment of the safety case claims for Internal Hazards of Hitachi-GE's UK ABWR as presented in the UK ABWR Preliminary Safety Report (PSR) and its supporting documentation.

1.2 Methodology

5. My assessment has been undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) procedure PI/FWD (Ref. 1). The ONR Safety Assessment Principles (SAPs) (Ref. 2), together with supporting Technical Assessment Guides (TAG) (Ref. 3) have been used as the basis for this assessment.

6. My assessment has followed my GDA Step 2 Assessment Plan for internal hazards prepared in December 2013 and shared with the RP to maximise openness and transparency (Ref. 6). All the key assessment tasks and interactions identified in Reference 6 have been undertaken, although the timing of some of the interactions with the RP has not always been in accordance with the dates originally envisaged in the plan.

2 ASSESSMENT STRATEGY

7. This section presents my strategy for the GDA Step 2 assessment of the internal hazards of the UK ABWR (Ref. 6). It also includes the scope of the assessment and the standards and criteria that I have applied.

2.1 Scope of the Step 2 Internal Hazards Assessment

8. The objective of my GDA Step 2 internal hazards assessment for the UK ABWR was to review and judge whether the claims made by the RP related to internal hazards that underpin the safety, security and environmental aspects of the UK ABWR are complete and reasonable in the light of our current understanding of reactor technology.

9. For internal hazards "safety claim" is interpreted as being:

- Specific statements about the design features which prevent, limit the severity, and limit the consequences of the internal hazards on SSCs important to the delivery of the fundamental safety functions; which when implemented will demonstrate that the threats from internal hazards are either removed, withstood or minimised.

10. During GDA Step 2 I have also evaluated whether the safety claims related to internal hazards are supported by a body of technical documentation sufficient to allow me to proceed with GDA work beyond Step 2.

11. Finally, during Step 2 I have undertaken the following preparatory work for my Step 3 assessment:

- Preliminary review of Chapter 5.6 (Internal Hazards) of the PCSR;
- Discussions with the RP to develop its PCSR document structure, including the route map of various supporting documents, and documentation delivery schedule; and
- Preliminary planning of Step 3 assessment activities.

2.2 Standards and Criteria

12. The goal of the GDA Step 2 assessment is to reach an independent and informed judgment on the adequacy of nuclear safety, security and environmental fundamental claims related to internal hazards. For this purpose, within ONR, assessment is undertaken in line with the requirements of the How2 Business Management System (BMS) document PI/FWD (Ref. 1). Appendix 1 of Ref. 1 sets down the process of assessment within ONR; Appendix 2 explains the process associated with sampling of safety case documentation.

13. In addition, the SAPs (Ref. 2) constitute the regulatory principles against which duty holders' safety cases are judged, and are the basis for ONR's nuclear safety assessment, and therefore have been used for GDA Step 2 assessment of the UK ABWR. The SAPs 2006 Edition (Revision 1 January 2008) were benchmarked against the IAEA standards (as they existed in 2004). They are currently being reviewed.

14. Furthermore, ONR is a member of the Western European Nuclear Regulators 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 Safety Assessment Principles

15. The key SAPs (Ref. 2) applied within the internal hazards assessment at Step 2 are.

- Safety cases SAP SC.4;
- Key Principles SAPs EKP.1, EKP.3, EKP.5;
- Design for reliability SAPs EDR.2 and EDR.4;
- Safety systems SAP ESS.18;
- Layout SAP ELO.4; and
- External and internal hazards SAPs EHA.1, EHA.6, EHA.13, EHA.14, EHA.15 EHA.16, and EHA.17.

16. Table 1 provides further details.

2.2.2 Technical Assessment Guides

17. The following TAG has been used as part of this assessment (Ref. 3):

- Nuclear Safety Technical Assessment Guide. Internal Hazards. NS-TAST-GD-014, Revision 3. April 2013.

2.2.3 National and International Standards and Guidance

18. The following national and international standards and guidance have also been used as part of this assessment:

- Relevant IAEA standards (Ref. 4):
  - Safety of Nuclear Power Plants: Design. Specific Safety Requirements. International Atomic Energy Agency (IAEA). Safety Standards Series No. SSR-2/1. IAEA. Vienna. 2012;
  - Protection Against Internal Fires and Explosions in the Design of Nuclear Power Plants. Safety Guide. International Atomic Energy Agency (IAEA) Safety Standards Series No. NS-G-1.7. IAEA. Vienna. 2004; and
  - Protection against Internal Hazards other than Fires and Explosions in the Design of Nuclear Power Plants. Safety Guide. International Atomic Energy Agency (IAEA) Safety Standards Series No. NS-G-1.11. IAEA, Vienna 2004.
- WENRA references (Ref. 5):
  - Western European Nuclear Regulators' Association, Reactor Safety Reference Levels (January 2008);
  - WENRA Statement on Safety Objectives for New Nuclear Power Plants (November 2010); and
  - WENRA Report Safety of New NPP Designs (March 2013).

19. The relevant SAPs, IAEA standards and WENRA reference levels are broadly captured in the Technical Assessment Guide (TAG) on internal hazards (Ref. 3). This guide provides the principal means for assessing the internal hazards aspects in practice

2.3 Use of Technical Support Contractors

20. During Step 2 I haven't engaged TSCs to support my assessment.

2.4 Integration with Other Assessment Topics

21. Early in GDA I recognised that during the project there would be a need to consult with other assessors (including Environment Agency's assessors) as part of the internal hazards assessment process. Similarly, other assessors will seek input from my assessment of the internal hazards for the UK ABWR. I consider these interactions very important to ensure the prevention of assessment gaps and duplications, and, therefore, are key to the success of the project. Thus, from the start of the project, I made every effort to identify as many potential interactions as possible between the internal hazards and other technical areas, with the understanding that this position would evolve throughout the UK ABWR GDA.

22. Also, it should be noted that the interactions between the internal hazards and some technical areas need to be formalised since aspects of the assessment in those areas constitute formal inputs to the internal hazards assessment, and vice versa. These are:

- Civil Engineering and External Hazards: provides input to the analyses and claims aspects of the internal hazards assessment. This formal interaction has commenced during GDA Step 2 work. This work will be led by me in coordination with the Civil Engineering and External Hazards Inspector;
- Reactor Chemistry: provides input to the analyses aspect of the internal hazards assessment. This formal interaction has commenced during GDA Step 2 work. This work will be led by me in coordination with the Reactor Chemistry Inspector;
- Control and Instrumentation: provides input to the claims aspect of the internal hazards assessment. This formal interaction has commenced during GDA Step 2 work. This work will be led by me in coordination with the Control and Instrumentation Inspector;
- Electrical Engineering: provides input to the claims aspect of the internal hazards assessment. This formal interaction has commenced during GDA Step 2 work. This work will be led by me in coordination with the Electrical Engineering Inspector;
- Fault Studies: provides input to the analyses and claims aspects of the internal hazards assessment. This formal interaction has commenced during GDA Step 2 work. This work will be led by me in coordination with the Fault Studies Inspector;
- Human Factors: provides input to the analyses and claims aspects of the internal hazards assessment. This formal interaction has not commenced during GDA Step 2 work, as yet. This work will be led by me in coordination with the Human Factors Inspector;
- Mechanical Engineering: provides input to the claims aspect of the internal hazards assessment. This formal interaction has commenced during GDA Step 2 work. This work will be led by me in coordination with the Mechanical Engineering Inspector;
- Management of Safety and Quality Assurance: provides input to the management of Safety and Quality Assurance submissions on the internal hazards assessment. This formal interaction has not commenced during GDA Step 2 work. This work will be led by the Management of Safety and Quality Assurance Inspector;
- Probabilistic Safety Analysis and Severe Accident Analysis: provides input to the analyses and claims aspects of the internal hazards assessment. This formal interaction has commenced during GDA Step 2 work. This work will be led by me in coordination with the Probabilistic Safety Analysis and Severe Accident Analysis Inspector;
- Radwaste and Decommissioning: provides input to the analyses and claims aspects of the internal hazards assessment. This formal interaction has commenced during GDA Step 2 work. This work will be led by me in coordination with the Radioactive Waste and Decommissioning Inspector; and
- Structural Integrity: provides input to the analyses and claims aspects of the internal hazards assessment. This formal interaction has commenced during GDA Step 2 work. This work will be led by me in coordination with the Structural Integrity Inspector.

23. In addition to the above, during GDA Step 2 there have been interactions between internal hazards and the rest of the technical areas, ie, Security and Environment Agency etc. Although these interactions, which are expected to continue thorough GDA, are mostly of an informal nature, they are essential to ensure consistency across the technical assessment areas.

3 REQUESTING PARTY'S SAFETY CASE

24. This section presents a summary of the RP's preliminary safety case claims in the area of internal hazards. It also identifies the documents submitted by the RP which have formed the basis of my assessment of the UK ABWR internal hazards during GDA Step 2.

3.1 Summary of the RP's Preliminary Safety Report (PSR) in the Area of Internal Hazards

25. The aspects covered by the UK ABWR preliminary safety case submissions in the area of internal hazards can be broadly grouped under three headings which can be summarised as follows:

- Internal Hazards preliminary safety report;
- Example internal hazards claims for the Reactor Building and Control Building based on previous ABWR; and
- Internal Hazards assessment methodologies.

3.1.1 Internal Hazards Preliminary Safety Report

26. As part of its Step 2 submission the RP has issued a PSR for internal hazards (Ref. 7). This sets out the strategy for its GDA safety case from an Internal Hazards perspective. The PSR (Rev. C) was based on the Topic Report (Rev. A).

27. The PSR describes general principles, including the identification process of internal hazards relevant to the generic UK ABWR design, and outlines the assessment methodology.

28. The RP identified the following Internal Hazards for the generic UK ABWR:

- Internal fire;
- Internal flooding (also includes steam release and water spray);
- Pipe whip / jet impact (which also bounds vibration);
- Dropped load (also includes collapsing and falling loads);
- Internal missiles; and
- Internal explosions.

29. The RP stated in the PSR that the vehicular transport impact on SSCs has been screened out of the assessment, whereas damage to fuel assemblies during transport will be considered within the dropped load analysis. In addition, electromagnetic interference will be discussed within Electrical supply and Instrumentation and Control.

30. The RP made the following key claim in the PSR:

31. The generic UK ABWR has been designed so that identified internal hazards will not compromise the control of core reactivity, or the removal of heat from the core and spent fuel, and will not result in uncontrolled dispersion of radioactivity or the uncontrolled exposure of plant personnel or the public to radiation. This claim will be demonstrated during GDA. It will also be demonstrated that risks from Internal Hazards are reduced to a level which is ALARP. The list of SSC's required to deliver the safety functions and the justification of how they are protected against the Internal Hazards will be defined during subsequent GDA steps.

32. The RP focused in the PSR only on the mitigation of Internal Hazards only, and claimed that, as the generic UK ABWR has three divisions of safety systems, many of

the hazards are mitigated by divisional segregation of safety components provided that barriers between divisions are not breached.

33. The RP stated in the PSR that claims for internal hazards for all relevant UK ABWR buildings (Reactor Building (R/B), Control Building (C/B), Turbine Building (T/B) and Radwaste Building (Rw/B) will be discussed in separate documents and the outcome will be reflected in the PCSR.

34. Combined consequential internal hazards have also been presented, and this area will be further developed, which will also give consideration to external hazards combinations including external hazards causing consequential internal hazards.

3.1.2 Example Internal Hazards Claims for the Reactor Building (R/B) and Control Building (C/B) Based on Previous ABWR

35. The RP explained that the purpose of these documents was to demonstrate the process of identification of internal hazards and the claims on barriers in the R/B and the C/B, based on previous ABWR design (Refs 8 and 9). The documents aim to support the claims made in the PSR on safety barriers. The documents will be updated and re-issued during the next Steps of the GDA. Therefore, arguments and evidence will be provided at Step 3 and 4 of the GDA.

36. The RP focused on a number of representative rooms containing safety related components and the identification of internal hazards and safety barriers.

37. The RP explained that the studies focused on the mitigation aspect against internal hazards. Preventative claims against internal hazards will be demonstrated in the PCSR.

3.1.3 Internal Hazards Assessment Methodologies

38. The RP submitted the following Internal Hazard Assessment Methodologies (Ref. 10):

- Fire hazard analysis;
- Local fire effects on fire barriers;
- Internal explosion;
- Internal flooding;
- Pipe whip/ jet impact;
- Internal missile; and
- Dropped load.

39. The RP indicated that these documents will be developed further as part of the PCSR submission.

3.2 Basis of Assessment: RP's Documentation

40. The RP's documentation that have formed the basis for my GDA Step 2 assessment of the safety claims related to the internal hazards for the UK ABWR are:

- UK ABWR GDA (Generic Design Assessment) Internal hazards (Ref. 7);
- UK ABWR "Example of Internal Hazards Claims for R/B based on previous ABWR", and supporting documents (Ref. 8);
- UK ABWR "Example of Internal Hazards Claims for C/B based on previous ABWR", and supporting documents (Ref. 9);
- Internal Hazards Assessment Methodologies (Ref. 10);
- Regulatory Queries and Responses (Refs. 11 to 14);

- Preliminary Internal Hazards Assessment in Main Steam Tunnel Room (Ref. 15). This document presents the preliminary results of the internal hazards consequences analysis focusing on internal flooding and the adequacy of the mitigation measures in place; and
- UK ABWR GDA tracking sheet (Ref. 16).

41. My Step 2 assessment has been limited to the extent of the issued submissions. A number of the submissions were only issued during my assessment report completion stage, which did not allow me sufficient time to undertake a detailed assessment. However, I have acknowledged and undertaken a high level assessment of the submissions given above.

42. I also acknowledge that a number of submissions are at an early stage of development, and are the subject of controlled updates as Hitachi-GE develops its UK ABWR safety case and to take account ONR regulatory expectations.

43. In addition, in May 2014 Hitachi-GE has submitted to ONR for information an advance copy of the UK ABWR PCSR. Chapter 5.6 (Ref. 17) addresses internal hazards. Although I have not covered this report in my GDA Step 2 formal assessment, seeing it has been useful to start planning and preparing my GDA Step 3 work and provided a degree of confidence and clarity.

4 ONR ASSESSMENT

44. My assessment has been carried out in accordance with ONR How2 BMS document PI/FWD, “Purpose and Scope of Permissioning” (Ref. 1).

45. My GDA Step 2 internal hazards assessment has followed the strategy described in Section 2 of this report.

46. My Step 2 assessment work has involved continual engagement with the RP’s internal hazards SME, ie, 2 Technical Exchange Workshops in Japan and 4 progress meetings (mostly video conferences) have been held. I have also visited:

- Hitachi Rinkai Works where reactor internal components and Fine Motion Control Rod Drive Units (FMCRD) are manufactured and tested, where I gained an overview of their manufacturing capability for the FMCRD units. In addition, it clarified my understanding of how the component functions;
- Ohma ABWR, which was approximately 35% built and where I got an appreciation of the construction site, in particular the drywell floor construction module; and
- Shimane Unit 3 ABWR where I toured all main buildings.

47. During my GDA Step 2 assessment, I have identified some shortfalls in the case presented, which have generally led to the issue of Regulatory Queries (RQs). Overall I have raised 8 RQs.

48. Details of my GDA Step 2 assessment of the UK ABWR preliminary safety case in the area of Internal Hazards fundamental claims are presented in the following sub-sections. My conclusions are presented, as well as areas of strength and items that require follow-up.

4.1 Assessment of UK ABWR GDA Internal Hazards Topic Report

4.1.1 Assessment

49. The RP has formally issued 3 revisions of the internal hazards document (Ref. 7 Rev. A, B and C). Revision C is the formal PSR document on internal hazards, issued to ensure consistency with the PSR version published on the World Wide Web. Revision C has been developed and based on Revision A which was issued at the end of Step 1. There are no significant change between Revision B and C.

50. Initially, and in order to provide feedback to the RP on ONR’s expectations, I undertook a detailed review of Revision A focusing on the following areas:

- The scope and contents of the submission;
- Internal hazards identified;
- Internal hazards management strategy;
- Fundamental claims made; and
- Hazard analysis methodologies.

51. The clarity and contents of the submission were not in line with my expectations and I sought clarity by raising RQ- 0072 to 0075 on the above areas (Ref. 11). These RQs were aimed to provide assistance to the RP in developing their PSR submission in line with my expectations.

52. The RP submitted responses to my RQs indicating that the majority of my comments will be addressed within the draft PCSR. A draft submission of the PCSR provided

confidence that these RQs will be addressed (Ref. 17). This area will be further assessed during my Step 3 assessment.

53. I have also assessed Revision C of the PSR focusing on the areas raised in my RQs above. This submission broadly captured a number of my comments and in particular on the clarity and scope of the document. The document also included high level generic statements on defence in depth for each internal hazard and provided information on combined consequential internal hazards.

54. I am broadly satisfied with the overall approach adopted for the internal hazards analysis, which comprises the following: identification of internal hazards, identification of SSCs which are required to deliver the safety functions, and analysis of how these SSCs are protected against the internal hazards to ensure delivery of the safety functions.

55. During Step 2 the PSR focused on the identification of a generic list of internal hazards applicable to UK ABWR design. The list of SSCs to be protected and the justification of how they are protected will be defined during the next GDA steps.

56. I am broadly satisfied with the literature review undertaken to identify internal hazards applicable to UK ABWR. In addition the RP has undertaken a Hazard and Operability (HAZOP) study for the High Pressure Core Flooder System (HPCF) which forms part of the Emergency Core Cooling System (ECCS) to confirm the list of applicable internal hazards identified by the literature review. This work resulted in a confirmed list of internal hazards applicable to UK ABWR design. The RP intents to apply the confirmed list of internal hazards to specific rooms within the various buildings on the UK ABWR to identify room specific internal hazards and safety barriers (see also Section 4.2.1 below). This area will be further assessed during Step 3 including the justification of those internal hazards which have been screened out (e.g. vehicle transport), and those internal hazards which have been grouped or bounded by other internal hazards.

57. The PSR makes the following explicit claim on internal hazards "*As generic UK ABWR has three divisions of safety systems, many of the hazards are mitigated by divisional segregation of safety components. If it is assumed that an internal hazard affects everything in a division, even with the assumption of a single failure in another division, all of the safety functions can still be delivered by the redundant SSC's to be protected in the third division provided the barriers between divisions are not breached. This leads to a series of safety claims on the barriers-walls and doors etc. – between divisions."*

58. This claim appears to be in line with ONR's SAP ESS.18 which states that "*No fault, internal or external hazard should disable a safety system*". It also states that "*Safety systems should be physically separate, independent, isolated from other systems, including safety-related systems, and share no equipment or services.*" The provisions of passive safety measures such as safety barriers that do not rely on control systems, active safety systems or human intervention is also on the top of the hierarchy of safety measures given in ONR's SAP EKP.5 - Safety Measures.

59. To test the suitability and sufficiency of the claim made on safety barriers, I sampled a number of areas of the UK ABWR design and I have identified areas where the segregation principle of SSCs by safety barriers does not apply and where claims other than safety barriers or additional to the safety barriers are required to demonstrate that the risk from internal hazards is reduced ALARP . Such areas include the Primary Containment, the Main Steam Tunnel and the Turbine Building. My understanding is that other engineering features are in place for the primary

containment such as the inert nitrogen gas system to prevent fire, the containment spray system against overpressure, and pipe whip restraints. In the Main Steam Tunnel a blowout panel is also in place to vent the overpressure generated by steam release, in addition to the safety barriers. The PSR did not identify any areas where exceptions to protection by segregation exist and therefore no claims other than on the safety barriers have been identified. During my interactions with the RP I discussed this aspect and an early draft of the PCSR highlighted areas where exceptions to the segregation principle exist (Ref. 17).

60. Steam release and water spray including their environmental effects of temperature, pressure and humidity have not been explicitly considered in the PSR and therefore claims other than safety barriers, or additional to safety barriers, may be required, such as the blowout panel in the Main Steam Tunnel. Similarly, the dropped loads case presented is focused on dropped loads on SSCs and a claim on safety barriers segregating SSCs has been made. However, claims other than safety barriers may be required against potential dropped loads on civil structures, containment, spent fuel pool, reactor internal and other areas of the UK ABWR design.

61. From the above, the suitability and sufficiency of the claims presented at Step 2 appear to be incomplete (see also Section 4.2.1 below). ONRs SAP EKP.5 – Safety Measures states that "*Safety measures should be identified to deliver the required safety function(s)*", whereas SAP EKP.3 – Defence in depth states that "*A nuclear facility should be so designed and operated that defence in depth against potentially significant faults or failures is achieved by the provision of several levels of protection*."

62. The adequacy of the claims presented in Step 2 was the focus of my discussions with the RP in a number of meetings. I explained that appropriate "multi-legged" claims should be provided to demonstrate that the risk of internal hazards has been reduced to ALARP. The RP acknowledged my concern and explained that preventative claims dealing with inherent features, equipment and procedures will be stated in the draft PCSR. The draft PCSR provided some confidence. This area will be monitored and further assessed during the next step of GDA.

63. I have also considered the structure of the PSR and in particular the "route-map" of the various documents being produced at Step 2. During the development of the PSR, the RP undertook parallel work on the identification of internal hazards and barrier claims on a compartment by compartment basis for the R/B and C/B (Refs. 8 and 9). Similarly, a number of hazard analysis methodologies have been produced (Ref. 10). Although all these documents provide much needed confidence for the case being made, and on the capability of the RP, these documents have not been discussed or referenced in the PSR.

64. ONR's SAP SC.4 states that "*A safety case should be accurate, objective and demonstrably complete for its intended purpose". In particular it states that "a safety case should a) link the information necessary to show that the facility is adequately safe, and what will be needed for it to remain so over the period for which the safety case is valid; b) support arguments with appropriate evidence, and with experiment and/or analysis that validates performance assumptions".*

65. During my interactions with the RP, I discussed this aspect and the RP provided some clarity, which will be reflected in the draft PCSR (Ref. 17). The draft PCSR is now available and I have checked that it provides this clarity. This area will be monitored during the next step of GDA.

4.1.2 Strengths

66. The RP outlined a reasonable approach for the internal hazards analysis, have undertaken confirmatory work on the list of internal hazards applicable to UK ABWR design and expressed commitment to undertake a compartment-by-compartment deterministic analysis to identify internal hazards and the hazard barriers between compartments that protect SSCs.

67. The draft PCSR appears to have captured my RQ comments in this area (Ref. 17).

4.1.3 Items that Require Follow-up

68. During my GDA Step 2 assessment of internal hazards I have identified the following shortcomings that I will follow-up during Step 3.

- Suitable and sufficient development of claims for all applicable internal hazards, including coincident, combined and consequential events to demonstrate that the risks from internal hazards have been reduced to ALARP. This should cover all relevant buildings and areas where exceptions to segregation of SSCs by safety barriers exist, and for all plant conditions. An appropriate level of defence in depth should be demonstrated; and
- The structure and content of the PCSR including the “route-map” of the various supporting documents, demonstrating that the PCSR is accurate, objective and demonstrably complete for its intended purpose.

4.1.4 Conclusions

69. Based on the outcome of my assessment of internal hazards PSR, I have concluded that although the claim on passive safety barriers is in line with my expectations this single claim may not be suitable for those areas of the UK ABWR design where exception to segregation of SSCs principle exist and is not sufficient in demonstrating that the risks from internal hazards have been reduced to ALARP.

70. Therefore, the scope and contents of the submissions including the internal hazard management strategies need further development.

4.2 Assessment of Example of Internal Hazards Claims for the Reactor Building (R/B) and Control Building (C/B) Based on Previous ABWR

4.2.1 Assessment

71. The PSR made explicit claims on safety barriers against internal hazards (Ref. 7).

72. To support the above claims, the RP has undertaken studies on a compartment-by-compartment or room-by-room basis for the R/B and C/B containing safety related components (Refs. 8 and 9). The RP applied the generic list of internal hazards identified in Reference 7 and focused on “example” rooms of a previous ABWR design. The RP has evaluated that the rooms considered in these studies present redundant SSCs delivering the same function and have identical internal hazards consequences to those in other divisions of the UK ABWR design (i.e. SSC and internal hazards consequences are “mirrored” in other divisions).

73. The RP explained that these documents focus, initially, on the identification of internal hazards and safety barriers. These will be updated during Step 3 and 4 of the GDA process to also include arguments and evidence (analysis and substantiation) to support the safety barriers claimed.

74. I initially undertook an assessment of Revision 0 of References 8 and 9 focusing on the following areas:

- The rationale for selection of example rooms in the R/B;
- The list of internal hazards identified for each example room and the safety barrier justification required;
- The rationale for assigning different classification to barriers which appear to be for the same division/ compartment;
- Identification, as appropriate, multi-legged claims, in addition to the safety barriers, especially in the areas where exception to segregation of SSCs exist;
- The location of redundant SSCs delivering safety functions; and
- Plant layouts.

75. The initial submissions were not in line with my expectations and I sought clarity by raising RQ-0087 for the C/B and RQ-0088 for the R/B on the above areas (Ref. 11). These RQs also aimed to provide assistance to the RP in developing their submissions in line with my expectations. These RQs have also been the subject of discussions in a number of meetings with the RP.

76. The RP responded to the various points raised in my RQs and have recently re-submitted all relevant documents (Refs 8 and 9 Revision 1 and supporting documents).

77. Thus far, I have only undertaken a high level assessment of the revised documents focusing on the areas given in my RQs above.

78. The revised submissions provided more comprehensive information on the criteria used in the selection of the rooms, and for each room identified potential internal hazards, the safety barriers, the justification of the safety barriers required, the SSCs present in the rooms, and information on adjacent rooms.

79. The work undertaken, so far, appears to broadly satisfy the internal hazards identification aspect as stipulated in SAPs EHA.1 and EHA.14:

- EHA.1- Identification, which state "*External and internal hazards that could affect the safety of the facility should be identified and treated as events that can give rise to possible initiating faults*"; and
- EHA.14 - Fire, explosion, missiles, toxic gases etc – sources of harm which state "*Sources that could give rise to fire, explosion, missiles, toxic gas release, collapsing or falling loads, pipe failure effects, or internal and external flooding should be identified, specified quantitatively and their potential as a source of harm to the nuclear facility assessed.*"

80. A number of internal hazards SAPs, however, have yet to be fully considered by the RP, but as these submissions will be further developed during the next Steps of GDA, I expect the RP to consider the following:

- EHA.6 – Analysis which state "*Analyses should take into account simultaneous effects, common cause failure, defence in depth and consequential effects";*
- EHA.13 - Fire, explosion, missiles, toxic gases etc – use and storage of hazardous materials which state **"***The on-site use, storage or generation of hazardous materials should be minimised, and controlled and located so that any accident to, or release of, the materials will not jeopardise the establishing of safe conditions on the facility";*

- EHA.15 - Fire, explosion, missiles, toxic gases etc – effect of water which state "*The design of the facility should prevent water from adversely affecting structures, systems and components important to safety*";
- EHA.16 - Fire, explosion, missiles, toxic gases etc – fire detection and fighting which state **"***Fire detection and fire-fighting systems of a capacity and capability commensurate with the credible worst-case scenarios should be provided*"; and
- EHA.17 - Fire, explosion, missiles, toxic gases etc – use of materials which state **"***Non-combustible or fire-retardant and heat-resistant materials should be used throughout the facility*".

81. In addition, there is a need to articulate the consolidated safety measures / claims to prevent, limit the severity and limit the consequences, as appropriate, against the internal hazards presented in each room. The RP has already indicated that claims on prevention will be presented in the draft PCSR (Ref. 17). The draft PCSR provided such information, but this should be also captured in the specific room assessment presented here.

82. The information presented on the location of redundant SSCs in the other Divisions within the R/B, provided much needed confidence on the claim made on Divisional segregation of SSCs delivering the safety functions (Ref. 12). At high level this appears to satisfy ONR's SAP EDR.2 - Redundancy, diversity and segregation which states that **"***Redundancy, diversity and segregation should be incorporated as appropriate within the designs of structures, systems and components important to safety*." However, as stated in Section 4.1.1 there are areas of the UK ABWR design where exceptions to segregation exist. In addition there are areas of the design where cables, ducts and components of a number of safety divisions are in the same location (e.g. Rooms 103, 113 in the R/B, Rooms 113, 211, 313, 403, 404 in the C/B), which do not fully satisfy SAP EDR.2.

83. Therefore, SAP EDR.2 along with SAP ESS.18 (stated in Section 4.1.1), and ELO.4 - on the minimisation of the effects of incidents, will be further considered during my Step 3 assessment. This will also take into account the detailed plant layouts, potential internal hazard consequences and test the assumption that the rooms considered in these documents are "mirrored" in other divisions of the UK ABWR.

84. To gain confidence on the robustness of the proposed UK ABWR design, I also sampled the following areas:

- The Emergency Diesel Generators (EDGs) in R/B and associated day tanks (Rooms, 408, 421 and 611);
- The Presence of single doors of Class 1 safety barriers; and
- The Main Steam Tunnel (Room 406).

85. I have raised RQ-0089 relevant to the presence of EDGs and associated day tanks and pipework within the R/B, and RQ-0090 on the use of single doors on Class 1 safety barriers (Ref. 11).

86. The presence of EDG and day tanks in the R/B appears not to satisfy ONR's SAP EHA.13, and EKP.1 - Inherent safety which *state* "*The underpinning safety aim for any nuclear facility should be an inherently safe design, consistent with the operational purposes of the facility".*

87. The RP has provided a response to my RQ (Ref. 13) indicating that the rooms will be equipped with a fire detection system and an active fire protection system. The RP also indicated that a fire modelling analysis will be undertaken to justify the adequacy of the 3 hours resistance of the safety barriers claimed.

88. I undertook a high level assessment of the RP's response and noted that the fire detection system and the active fire protection system will satisfy SAP EHA.16 and should be explicitly stated in Ref. 8. I also noted that the RP intends to justify the adequacy of the safety barriers provided (of 3 hours of fire resistance) based on only 8 hours EDGs operation. ONR's expectation is that the RP should demonstrate sufficient diesel stocks for a period of autonomous operation in line with safety case requirements. Furthermore, the role of HVAC system and/ or the need to suppress the overpressure generated by the fire have not been stated.

89. The proposed EDG design and associated day tanks is not consistent with the relevant good practice established in the UK, whereas the current justification presented is not robust. This area of the UK ABWR design will be further considered during my Step 3 assessment of GDA.

90. The presence of single doors on Class 1 safety barriers does not satisfy ONR's SAP EDR.4 – Single Failure Criterion which states "*During any normally permissible state of plant availability no single random failure, assumed to occur anywhere within the systems provided to secure a safety function, should prevent the performance of that safety function*." RP's response to my RQ (Ref. 14) indicated that in order to satisfy the single failure criterion consideration will be given to install a local alarm for an operator to close the door. No formal claim will be made on the local alarm.

91. The case presented in the RQ response is not in line with my expectations as a robust justification of the local alarm and operator action claim has not been presented; neither has an ALARP justification. My expectation is to: a) minimise the number of single doors on Class 1 safety barriers, b) provide a second door by adopting a lobby approach, where reasonably practicable, and c) for the remaining single doors engineer local and remote alarms and provide a robust justification in line with the relevant good practice established in the UK. This area of the design will be considered during my Step 3 assessment of GDA.

92. During the interactions with the RP, I also had discussions on the adequacy of the safety claim made in Main Steam Tunnel (Room 406). This room contains 4 Main Steam lines and 2 feed water lines, outboard Main Steam Isolation Valves (MSIVs) that provide containment of radioactive substance, and various other SSC's including valves and instrumentation. In response the RP presented a preliminary internal hazards assessment (Ref. 15) covering a number of internal hazards but mainly focusing on the flooding case.

93. The preliminary analysis is not in line with my expectations, as it did not present the worst case scenario - it focused on flooding from individual pipelines. A pipe whip event could potentially damage a number of lines resulting in much higher water volumes in the area. Furthermore, steam release and water jet including the environmental effects have not been mentioned. As stated previously there is a blowout panel in the area to vent the overpressure generated. This area of the design will be considered during Step 3 of GDA.

4.2.2 Strengths

94. The RP have developed and adopted a reasonable approach to identify internal hazards and safety barriers claims, however further work is needed on application of the approach at Step 3. The RP has demonstrated a reasonable level of understanding in delivering complex studies within short period of time. RP's work in this area provided a basis and a commitment to build the internal hazards case during the next steps of GDA.

4.2.3 Items that Require Follow-up

95. During my GDA Step 2 assessment of "Examples of Internal Hazards Claims for R/B and C/B based on previous ABWR" I have identified the following areas that I will follow-up during Step 3.

- The plant layout provisions in place including redundancy, diversity and segregation of SSCs against internal hazards;
- The justification of the design provisions and the case being made against internal hazards for:
  - The EDGs and associated day tanks in the R/B;
  - The single doors on Class 1 safety barriers; and
  - The Main Steam Tunnel.
- Assessment of RQs responses.

4.2.4 Conclusions

96. Based on the outcome of my assessment of Examples of Internal Hazards Claims for R/B and C/B based on previous ABWR, I have concluded that these documents provide a basis to develop the claims, arguments and evidence during GDA. These documents identify internal hazards and safety barriers to support the PSR claim on safety barriers. However, there is a need to identify and list all relevant claims especially those where segregation does not apply. In addition the submission needs to present the consolidated case to include prevention, protection and mitigation claims specific to the internal hazards consequences presented in the rooms considered.

4.3 Internal Hazards Assessment Methodologies

97. During Step 2 the RP has submitted the following internal hazards methodologies (Ref. 10):

- Fire hazard analysis;
- Local fire effects on fire barriers;
- Internal explosion;
- Internal flooding;
- Pipe whip/ jet impact;
- Internal missile; and
- Dropped Load.

98. The RP has indicated that the above methodologies are currently being revised to include further information and will be re-issued as part of the PCSR submission.

99. During Step 2 I undertook a high level assessment of the fire hazard analysis, local fire effects on fire barriers, internal explosion and internal flooding. I also had discussions with the RP and provided feedback on the suitability and sufficiency of its methodologies. My current position can be summarised as follows:

- I am broadly satisfied with the fire hazard analysis methodology and the local fire effects on fire barriers;
- The explosion analysis methodology should be further developed to include the scope of the consequences analysis to be undertaken and to reflect UK applicable regulations;
- ONR issued a letter on the pipe whip analysis stating ONR's position in this area (Ref. 18) The RP provided a draft response which takes into account

ONR's position. This will be reflected in a revised pipe whip analysis methodology submitted as part of the PCSR; and

- ONR challenged the RP's flooding analysis methodology in particular on the failure mode for medium energy nuclear classified pipework which should take into account other much larger leak areas, generally full bore ruptures. The RP responded positively and this has been reflected in the flooding analysis methodology. The flooding analysis methodology, however still needs further development to include steam release and water spray.

100. Internal missiles and dropped loads will be assessed during Step 3 of the GDA.

4.3.1 Strengths

101. The RP has begun its work on internal hazards analysis methodologies. The RP demonstrated reasonable awareness of international guidance, standards and relevant good practice. The RP responded positively to my comments and has also demonstrated commitment to develop these methodologies further as part of the PCSR.

4.3.2 Items that Require Follow-up

102. During my GDA Step 2 assessment of the internal hazards analysis methodologies I have identified the following areas that I will follow-up during Step 3.

- Assessment of all internal hazards analysis methodologies.

4.3.3 Conclusions

103. The RP has delivered a number of internal hazards analysis methodologies demonstrating in some areas a good level of understanding. The RP is currently updating the internal hazards analysis methodologies to also capture ONR's comments. These will be re-submitted as part of the PCSR.

4.4 RP's Competency and Availability of Suitably Qualified and Experienced Person (SQEP) Resources

104. During Step 1 and 2 I have given presentations to the RP on ONR's expectations including examples on claims, arguments and evidence from the previous GDA.

105. The documents submitted by the RP during Step 2, have not been in line with ONR's regulatory expectations. To gain the requisite clarity and to aid RP's understanding in this area I have raised a number of detailed RQs.

106. During my Step 2 interactions with the RP, the RP acknowledged that the internal hazards area in line with the UK regulatory regime is a new area. This, when coupled with the areas of work undertaken against tight timescales put the RP in a challenging position.

107. I questioned the RP's availability of adequate SQEP resources who are also experienced in the UK regulatory regime, in the topic area of internal hazards. The RP responded positively and confirmed that further SQEP resources from UK based TSCs will be in place prior to the commencement of Step 3.

108. Prior to the commencement of Step 3, the RP should demonstrate that it has a capable and competent internal hazards team in place to enable the delivery of fit for purpose safety case documentation in this area. This area will form part of ONR's readiness review and will be monitored during Step 3.

4.5 Out of Scope Items

109. There are no items out of the scope of my GDA Step 2 assessment of the UK ABWR internal hazards.

4.6 Comparison with Standards, Guidance and Relevant Good Practice

110. In Section 2.2 above I have listed the standards and criteria I have used during my GDA Step 2 assessment of the UK ABWR internal hazards to judge the adequacy of the preliminary safety case. My overall conclusions in this regard can be summarised as follows:

- SAPs: I have reviewed the PSR and supporting documents taking into account the relevant SAPs. I have concluded that the submission partially satisfies the expectations set out in each SAP. I expect, however, that as these documents will be further developed during Step 3, ONR's relevant SAPs to be fully satisfied. The draft PCSR appears to fulfil this to some extent; and
- TAGs: The TAG on internal hazards broadly reflects the SAPs and international guidance (IAEA standards and WENRA reference levels). I have concluded that the submission only partly satisfies the expectations set out in ONR's TAG. This has been reflected within my assessment. I have made a number of recommendations that the RP should address at Step 3 of the GDA.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

111. The treatment of internal hazard in line with the UK's regulatory regime is a new area for the RP.

112. Hitachi-GE has provided a PSR for the UK ABWR for assessment by ONR during Step 2 of GDA. The PSR together with its supporting documents only partially present the claims in the area of internal hazards that underpin the safety of the UK ABWR.

113. During Step 2 of GDA I have conducted an assessment of the parts of the PSR and its supporting documents that are relevant to the area of internal hazards against the expectations of the SAPs and TAG. From the UK ABWR assessment done so far I conclude the following:

- The RP has adopted a reasonable approach for the internal hazards analysis which comprises identification of internal hazards, identification of SSCs which are required to deliver the safety functions, and analysis of how these SSCs are protected against the internal hazards.
- The RP has developed and adopted an approach to identify internal hazards and safety barriers claims.
- The claims presented at Step 2 whilst reasonable are incomplete as the claim on safety barrier may not be suitable for those areas of the UK ABWR design where exceptions to the principle of segregation of SSCs exist. Additionally, they are insufficient to demonstrate that the risks from internal hazards have been reduced to ALARP. An appropriate level of defence in depth has not been demonstrated. However, I am confident that the RP will be able to articulate reasonable claims in the PCSR and underpin them with sufficient arguments and robust evidence;
- The RP has already provided a level of assurance that the PCSR will be able to set out the claims, arguments and evidence in this area to a level commensurate with ONR's expectations;
- The RP has been proactive in all engagements with ONR and has made available resources to support the development of the internal hazards safety case. The RP expressed commitment to bring additional SQEP resources that are also familiar with the UK regulatory regime to assist in the development of the PCSR; and
- I have identified a number of shortcomings during my assessment, which are identified in section 4 of this report. I will follow up these matters during the following steps of GDA.

114. Overall, I see no reason, on internal hazards grounds, why the UK ABWR should not proceed to Step 3 of the GDA process.

5.2 Recommendations

115. My recommendations are as follows.

- Recommendation 1: The UK ABWR should proceed to Step 3 of the GDA process; and
- Recommendation 2: All the items identified in Step 2 as important to be followed up should be included in ONR's GDA Step 3 Assessment Plan for the UK ABWR internal hazards.

6 REFERENCES

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2 *Safety Assessment Principles for Nuclear Facilities.* 2006 Edition Revision 1. HSE. January 2008.

www.onr.gov.uk/SAPS/index.htm.

3 *Technical Assessment Guides*

Nuclear Safety Technical Assessment Guide. Internal Hazards. NS-TAST-GD-014, Revision 3. April 2013.

www.onr.gov.uk/operational/tech_asst_guides/index.htm.

4 *IAEA Standards and Guidance*

1. *Safety of Nuclear Power Plants: Design. Specific Safety Requirements*. International Atomic Energy Agency (IAEA). Safety Standards Series No. SSR-2/1. IAEA. Vienna. 2012.
2. *Protection Against Internal Fires and Explosions in the Design of Nuclear Power Plants.* Safety Guide. International Atomic Energy Agency (IAEA) Safety Standards Series No. NS-G-1.7. IAEA. Vienna. 2004.
3. *Protection against Internal Hazards other than Fires and Explosions in the Design of Nuclear Power Plants.* Safety Guide. International Atomic Energy Agency (IAEA) Safety Standards Series No. NS-G-1.11. IAEA, Vienna 2004.

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5 *Western European Nuclear Regulators' Association*

1. *Reactor Safety Reference Levels (January 2008).*
2. *WENRA Statement on Safety Objectives for New Nuclear Power Plants (November 2010).*
3. *WENRA Report Safety of New NPP Designs (March 2013).*

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6 *Generic Design Assessment of HGNE's Advanced Boiling Water Reactor (ABWR) - Step 2 Assessment Plan for Internal Hazards* ONR-GDA-AP-13-007 Revision**.** ONR December 2013. TRIM Ref 2013/463878.

7 *Internal Hazards Report*

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8 *Example of Internal Hazards Claims for R/B Based on Previous ABWR and Supporting Documents.*

UK ABWR GDA (Generic Design Assessment) Example of Internal Hazards Claims for R/B Based on Previous ABWR, GA91-9201-0003-00022, SE-GD-0039, Revision 1, 16th May 2014.

UK ABWR GDA (Generic Design Assessment) Configuration of R/B Based on Previous ABWR, GA91-9201-0003-00023, SE-GD-0040, Revision 1, 16th May 2014.

UK ABWR GDA (Generic Design Assessment) Example of Internal Hazards Claims for R/B Based on Previous ABWR, SE-GD-0039, Revision 0, 14th February 2014.

UK ABWR GDA (Generic Design Assessment) Configuration of R/B Based on Previous ABWR, SE-GD-0040, Revision 0, 14th February 2014.

UK ABWR GDA (Generic Design Assessment) Criteria for Selecting Representative Rooms in R/B Implemented in SE-GD-0039, SE-GD-0065, 14th April 2014.

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UK ABWR GDA (Generic Design Assessment) Clarity on the Output of Internal Hazards for the Reactor Building (Response to RQ-ABWR-0088, GA91-9201-0003-00081, SE-GD-0079, Revision 0, 28th April 2014.

9 *Example of Internal Hazards Claims for C/B Based on Previous ABWR and Supporting Documents.*

UK ABWR GDA (Generic Design Assessment) Example of Internal Hazards Claims for C/B Based on Previous ABWR, GA91-9201-0003-00024, SE-GD-0061, Revision 1, 16th May 2014.

UK ABWR GDA (Generic Design Assessment) Configuration of C/B Based on Previous ABWR, GA91-9201-0003-00025, SE-GD-0062, Revision 1, 28th May 2014.

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10 *Internal Hazards Assessment Methodologies.*

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11 *Regulatory Queries*

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13 *UK ABWR GDA (Generic Design Assessment) Claims of Emergency Diesel Generator and Fuel Day Tank (Response to RQ-ABWR-0089),* GA91-9201-0003-00083, SE-GD-0074, Revision 0, 22nd May 2014.

14 *UK ABWR GDA (Generic Design Assessment) Philosophy for Doors in Safety Class 1 Barriers (Response to RQ-ABWR-0090),* GA91-9201-0003-00084, SE-GD-0082, Revision 0, 12th May 2014.

15 *UK ABWR GDA (Generic Design Assessment) Preliminary Internal Hazards Assessment in Main Steam Tunnel Room,* GA91-9201-0003-00085, SE-GD-0071, Revision 0, 12th May 2014.

16 *UK ABWR Document Tracking Sheets.* Updated versions submitted to the Joint Programme Office (JPO) throughout GDA Step 2. Tracking Sheet Number 52, 16th June 2014 ONR TRIM Ref. 2014/227609.

17 *UK ABWR GDA (Generic Design Assessment) Generic PCSR Sub-Chapter 5.6: Internal Hazards,* GA10-9101-0100-05006, SE-GD-0100, Revision DR1.

18 *ONR, ONR's Position on Pipe Whip Analysis for Internal Hazards,* ONR TRIM Ref. 2014/137270, REG-HGNE-0022N, 9th April 2014.

Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No and Title	Description	Interpretation	Comment
SC.4	The Regulatory Assessment of Safety Cases	SC.4 – Safety Case Characteristics A safety case should be accurate, objective and demonstrably complete for its intended purpose	See Section 4.1.1 The PSR did not satisfy this SAP, however the draft PCSR provided some evidence. This aspect will be further assessed during Step 3 of GDA.
EKP.1	Engineering Principle: Key principles	EKP.1 – Inherent safety The underpinning safety aim for any nuclear facility should be an inherently safe design, consistent with the operational purposes of the facility	See Section 4.2.1 This SAP has yet to be fully satisfied and will be further assessed during Step 3 of GDA.
EKP.3	Engineering Principle: Key principles	EKP.3 – Defence in depth A nuclear facility should be so designed and operated that defence in depth against potentially significant faults or failures is achieved by the provision of several levels of protection.	See Section 4.1.1 This SAP has yet to be fully satisfied and will be further assessed during Step 3 of GDA.
EKP.5	Engineering Principle: Key principles	EKP.5 – Safety measures Safety measures should be identified to deliver the required safety function(s).	See Section 4.1.1 This SAP has yet to be fully satisfied and will be further assessed during Step 3 of GDA.
EDR.2	Engineering Principle: Design for reliability	EDR. 2 - Redundancy, diversity and segregation Redundancy, diversity and segregation should	See Section 4.2.1 This SAP has yet to be fully satisfied and will

SAP No and Title	Description	Interpretation	Comment
		be incorporated as appropriate within the designs of structures, systems and components important to safety.	be further assessed during Step 3 of GDA especially those areas where exceptions to segregation by safety barriers exist.
EDR.4	Engineering Principle: Design for reliability	EDR. 4 – Single Failure Criterion During any normally permissible state of plant availability, no single random failure, assumed to occur anywhere within the systems provided to secure a safety function, should prevent the performance of that safety function.	See Section 4.2.1 This SAP has yet to be satisfied and will be considered during Step 3 of GDA.
ELO.4	Engineering principles: layout	ELO.4 - Minimisation of the effects of incidents The design and layout of the site and its facilities, the plant within a facility and support facilities and services should be such that the effects of incidents are minimised	See Section 4.2.1 This SAP has yet to be satisfied and will be considered during Step 3 of GDA.
EHA.1	Engineering principles: external and internal hazards	EHA.1 - Identification External and internal hazards that could affect the safety of the facility should be identified and treated as events that can give rise to possible initiating faults.	See Section 4.2.1 Based on the submissions so far, this SAP has been broadly satisfied but will be further assessed during Step 3 of GDA.
EHA.6	Engineering principles: external and internal hazards	EHA.6 - Analysis Analyses should take into account simultaneous effects, common cause failure, defence in depth and consequential effects	See Section 4.2.1 This SAP has yet to be satisfied and will be considered during Step 3 of GDA.
EHA.13	Engineering principles:	EHA.13 -	See Section 4.2.1

SAP No and Title	Description	Interpretation	Comment
	external and internal hazards	EHA.13 - Fire, explosion, missiles, toxic gases etc – use and storage of hazardous materials The on-site use, storage or generation of hazardous materials should be minimised, and controlled and located so that any accident to, or release of, the materials will not jeopardise the establishing of safe conditions on the facility	This SAP has yet to be fully satisfied and will be considered during Step 3 of GDA.
EHA.14	Engineering principles: external and internal hazards	EHA.14 - Fire, explosion, missiles, toxic gases etc – sources of harm Sources that could give rise to fire, explosion, missiles, toxic gas release, collapsing or falling loads, pipe failure effects, or internal and external flooding should be identified, specified quantitatively and their potential as a source of harm to the nuclear facility assessed	See Section 4.2.1 Based on the submissions so far, this SAP has been broadly satisfied but will be further assessed during Step 3 of GDA.
EHA.15	Engineering principles: external and internal hazards	EHA.15 - Fire, explosion, missiles, toxic gases etc – effect of water The design of the facility should prevent water from adversely affecting structures, systems and components important to safety.	See Section 4.2.1 This SAP has yet to be satisfied and will be considered during Step 3 of GDA.
EHA.16	Engineering principles: external and internal hazards	EHA.16 - Fire, explosion, missiles, toxic gases etc – fire detection and fighting Fire detection and fire-fighting systems of a capacity and capability commensurate with the credible worst-case scenarios should be	See Section 4.2.1 This SAP has yet to be satisfied and will be considered during Step 3 of GDA.

SAP No and Title	Description	Interpretation	Comment
		provided.	
EHA.17	Engineering principles: external and internal hazards	EHA.17 - Fire, explosion, missiles, toxic gases etc – use of materials Non-combustible or fire-retardant and heat-resistant materials should be used throughout the facility.	See Section 4.2.1 This SAP has yet to be satisfied and will be considered during Step 3 of GDA.
ESS.18	Engineering principles: safety systems	ESS.18 - Failure independence No fault, internal or external hazard should disable a safety system	See Section 4.1.1 This SAP has yet to be fully satisfied and will be further assessed during Step 3 of GDA especially those areas where exceptions to segregation by safety barriers exist.