Office for Nuclear Regulation

Civil Nuclear Reactor Build - Generic Design Assessment

Step 2 Assessment of the Electrical Systems 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 electrical systems of Hitachi – GE 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 electrical systems to judge whether they are complete and reasonable in the light of our current understanding of reactor technology.

For electrical systems safety claims are interpreted as being a hierarchical structure of claims which demonstrate that the electrical systems system supports the functional safety systems of the plant by having the capability through defence in depth to withstand a wide range of internal and external events throughout its operational life.

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

I have based my judgment of the adequacy of the claims primarily on the following SAPs:

- EDR 2 – Redundancy, diversity and segregation
- EDR 3 – Common Cause Failure
- EDR 4 – Single Failure Criterion
- EKP 3 – Defence in Depth
- EKP 5 – Safety Measures
- ESS 2 – Determination of safety system requirements
- ESS 8 – Automatic initiation

I have applied the following TAG to support my judgment of the adequacy of the claims:

- NS-TAST-GD-019 – Essential Services

My GDA Step 2 assessment work has involved continuous engagement with the RP in the form of technical exchange workshops and progress meetings. In addition, my understanding of the ABWR technology, and, therefore, my assessment, has significantly benefited from visits to Kashiwazaki Kariwa ABWR site and Hitachi's Rinkai, Omika and Kokubu works.

My assessment has been based on the RP's Preliminary Safety Report (PSR) and its references relevant to electrical systems. The RP's preliminary safety case aspects related to electrical systems, as presented in those documents, can be summarised as follows:

- The electrical systems are designed so that the safety of reactor facilities can be assured by ensuring continuity of electrical power supplies regardless of transient disturbances and faults during operation.
- The electrical systems are designed so that in the event of loss of all off site alternating current (AC) power the reactor can be shut down and cooled safely.

- The safety class 1 on site power sources have redundancy, are physically separated and are independent from each other.

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

- The RP has presented a hierarchical structure of claims for the electrical systems based on a series of key claims. These key claims provide confidence that this can be developed through a set of sub claims within this structure to provide a comprehensive and logical set of safety claims to form the basis of the claims, arguments and evidence structure within the safety case.
- The structure of the AC distribution network providing separation by division fed from normal and standby grid supplies meets ONR's expectations for separation of supplies.

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

- Regulatory Observations covering common cause failure, loss of offsite power and analysis of failures of essential services will be followed up in conjunction with fault studies assessment.
- The measures proposed by the RP to achieve diversity between the electrical systems in the back up building and the reactor building.
- The nuclear safety classification of the electrical equipment.

In relation to my interactions with the RP's Subject Matter Experts (SME) in the electrical systems area, I have found them to be responsive and open in their approach to understanding and meeting ONR expectations for demonstration of the adequacy of the safety case. I am satisfied that adequate resources are in place to develop the UK ABWR safety case and to support interactions with ONR. The expertise of the RP's resources applied to electrical systems is appropriate to the development of the safety case and considerable effort is being devoted to the task by the RP's SMEs.

Overall, I see no reason, on electrical systems 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
B/B	Back Up Building
BMS	Business Management System
BSC	Basis of Safety Case
C&I	Control and Instrumentation
CCF	Common Cause Failure
DAC	Design Acceptance Confirmation
EA	Environment Agency
EDG	Emergency Diesel Generator
Hitachi-GE	Hitachi - GE Nuclear Energy Ltd
HVAC	Heating Ventilation and Air Conditioning
IAEA	International Atomic Energy Agency
JPO	(Regulators') Joint Programme Office
LOOP	Loss of Offsite Power
MSIV	Main Steam Isolation Valve
NPP	Nuclear Power Plant
ONR	Office for Nuclear Regulation
PCSR	Pre-construction Safety Report
PSA	Probabilistic Safety Assessment
PSR	Preliminary Safety Report
RHWG	Reactor Harmonization Working Group (of WENRA)
RO	Regulatory Observation
ROA	Regulatory Observation Action
RP	Requesting Party
RQ	Regulatory Query
RRP	Resource Review Panel

LIST OF ABBREVIATIONS

SAP(s)	Safety Assessment Principle(s)
SFAIRP	So far as is reasonably practicable
SME	Subject Matter Expert
SSC	System, Structure and Component
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

1.1 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 – GE 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 the RP 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 electrical systems of the Hitachi-GE's UK ABWR as presented in the UK ABWR Preliminary Safety Report (PSR) (Ref. 1) and Basis of Safety Case (BSC) (Ref. 2).

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. 3). The ONR Safety Assessment Principles (SAPs) (Ref. 4), together with supporting Technical Assessment Guides (TAG) (Ref. 5) have been used as the basis for this assessment.

6. My assessment has followed my GDA Step 2 Assessment Plan for electrical systems (Ref. 8) prepared in December 2013 and shared with the RP to maximise openness and transparency. All the activities identified in the plan have been completed although there have been changes to timescales to align with the RP's document submission dates.

2 ASSESSMENT STRATEGY

7. This section presents my strategy for the GDA Step 2 assessment of the electrical systems of the UK ABWR (Ref 8). It also includes the scope of the assessment and the standards and criteria that I have applied.

2.1 Scope of the Step 2 Electrical Systems Assessment

8. The objective of my GDA Step 2 electrical systems assessment for the UK ABWR was to review and judge whether the claims made by the RP related to electrical systems 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 the electrical systems a "safety claim" is interpreted in the RP's Basis of Safety Case as:

- The electrical power supply system is designed in accordance with its safety functional requirements defined from the safety analysis.
- The electrical system architecture supports the SSC's providing Category A safety functions required for frequent faults. This requires 2 independent and diverse provisions. The first line provision is implemented by a Class 1 system, the second line provision is implemented by a Class 1, 2 or 3 system as required by the reliability and risk reduction assessment.
- Where functions are claimed to be independent in the safety analysis they will be assigned to independent systems in the electrical power supply system.
- The divisions of the safety Class 1 and Back up Building (B/B) Class 2 power supply systems are designed to be physically and electrically separated from each other thus ensuring independence among the divisions as much as possible.
- The safety Class 1 power supply systems and B/B Class 2 power supply systems are designed to be both independent of and diverse from each other as much as practically possible.
- Classification, independence, redundancy and diversity requirements placed on Structures Systems and Components (SSC) is applied in principle to the design of to the electrical power supply system and associated support systems including C&I, HVAC and cooling systems.
- Provision will be made in the design to protect against the common cause failure (CCF) of the safety Class 1 power supply system and the B/B Class 2 power supply system.
- The electrical equipment is designed to be robust to a wide range of electrical transients assumed during plant operation and to the assumed environmental conditions.
- The electrical system is designed to be robust to internal hazards. Electrical faults will be contained and cleared so as not to affect other equipment.
- The electrical system is designed to be robust to external hazards.
- The electrical power supply system has several levels of provision to supply electrical power in order to secure the safety of the power station during both normal operation and accidents without losing all of the on-site power.
- Safety measures to deliver the safety functions will be automatically initiated.

10. During GDA Step 2 I have also evaluated whether the safety claims related to electrical systems 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:

- preparation of my GDA Step 3 Assessment Plan;
- agreement with the RP on the programme of work for Step 3;
- agreement with the RP on design information required to support TSC work; and
- agreement with the RP on submissions for Step 3 assessment.

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 a nuclear safety, security and environmental case. For this purpose, within ONR, assessment is undertaken in line with the requirements of the How2 Business Management System (BMS) document PI/FWD (Ref. 3). 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 Safety Assessment Principles (SAPs) (Ref. 4) constitute the regulatory principles against which duty holders' safety cases are judged, and, therefore, they 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) was benchmarked against the IAEA standards (as they existed in 2004). They are currently being reviewed.

14. Furthermore, ONR is a member of the Western Regulators Nuclear Association (WENRA). WENRA has developed Reference Levels, which represent good practices for existing nuclear power plants, and Safety Objectives for new reactors.

15. The relevant SAPs, IAEA standards and WENRA reference levels are embodied and enlarged on in the Technical Assessment Guide on Essential Services (Ref. 5). This guide provides the principal means for assessing the electrical systems aspects in practice.

2.2.1 Safety Assessment Principles

16. The key SAPs (Ref. 4) applied within the assessment are SAPs, EDR2, EDR3, EDR4, EKP3, EKP5, ESS2 and ESS8 (see also Table 1 for further details).

2.2.2 Technical Assessment Guides

17. The following Technical Assessment Guides have been used as part of this assessment (Ref. 5):

18. NS-TAST-GD-019 – Essential Services

2.2.3 National and International Standards and Guidance

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

- Relevant IAEA standards (Ref. 6):
  - NS G 1.8: Design of Emergency Power Systems for Nuclear Power Plants Safety Guide
- WENRA references (Ref. 7):
  - Reactor Safety Reference Levels (January 2008)
  - Safety Objectives for New Power Reactors (December 2009) and Statement on Safety Objectives for New Nuclear Power Plants (November 2010)
  - Waste and Spent Fuel Storage Safety Reference Levels (February 2011)
  - Decommissioning Safety Reference Levels (March 2012)
  - Statement on Safety Objectives for New Nuclear Power Plants (March 2013) and Safety of New NPP Designs (March 2013)

2.3 Use of Technical Support Contractors

20. Technical Support Contractors were not used during the Step 2 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 electrical systems assessment process. Similarly, other assessors will seek input from my assessment of the electrical systems 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 electrical systems 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 electrical systems and some technical areas need to be formalised since aspects of the assessment in those areas constitute formal inputs to the electrical systems assessment, and vice versa. These are:

- The Fault Schedule provides input to the system architecture aspects of the electrical systems assessment. This formal interaction has commenced during GDA Step 2. This work is being led by the Fault Studies Inspector.
- The PSA provides input to the system architecture aspects of the electrical systems assessment. This formal interaction has commenced during GDA Step 2. This work is being led by the PSA Inspector.
- C&I due to the use of embedded C&I in much of the electrical network protection and control system.

23. In addition to the above, during GDA Step 2 there have been interactions between electrical systems and the rest of the technical areas, ie, security, mechanical engineering, civil engineering, MSQA, internal hazards, human factors 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 in the area of electrical systems. It also identifies the documents submitted by the RP which have formed the basis of my assessment of the UK ABWR electrical systems during GDA Step 2.

3.1 Summary of the RP's Preliminary Safety Case in the Area of Electrical systems

25. The aspects covered by the UK ABWR preliminary safety case in the area of electrical systems can be broadly grouped under five headings which can be summarised as follows:

- AC Power System Architecture: The AC power system is designed so that the safety of the reactor facilities can be assured by ensuring continuity of electrical power supplies, regardless of transient disturbances and faults during operation.
- Direct current (DC) Power System Architecture: The DC power system is designed so that the safety of the reactor facilities can be assured by ensuring continuity of electrical power supplies, regardless of transient disturbances and faults during operation.
- Classification and Categorisation of Systems, Structures and Components: The classification and categorisation of the electrical system is designed to be consistent with the requirements and configuration of the plant systems, structures and components to which the electrical power is applied.
- Basis of Safety Case (BSC): The BSC contains the detailed safety case of a system or group of systems and links the related PCSR chapters, which are a summary of the safety case presented in BSC, with the evidence contained in the support documents.
- Lighting and Communications: The lighting system is designed to give necessary illumination during plant operation, maintenance, test conditions and emergency conditions. The communication systems are designed to communicate within the plant and to external organisations during normal operations and emergency conditions.

3.2 Basis of Assessment: RP's Documentation

26. The RP's documentation that has formed the basis for my GDA Step 2 assessment of the safety claims related to the electrical systems for the UK ABWR is:

- UK ABWR PSR chapter on electrical engineering (Ref. 1). This document describes the electrical power supplies on the UK ABWR for connection of the main generator to the grid and to provide power for station supplies. It also describes the standby generator and battery systems for providing electrical power supplies to support reactor safety systems.
- UK ABWR Basis of Safety Case on Electrical System (Ref. 2). This document is a living document for safety assessment of the GDA process. The Basis of Safety Case (BSC) contains the detailed safety case of a system or a group of systems and links the related PCSR chapters.
- UK ABWR DC Power Supply System Design Description (Ref.11). This document describes the DC power systems on the UK ABWR reactor.
- UK ABWR GDA tracking sheet (Ref. 9).

- Responses to Regulatory Queries RQ-ABWR-0023, RQ-ABWR-0050, RQ-ABWR-0054, RQ-ABWR-0056, RQ-ABWR-0086, RQ-ABWR-0135, RQ-ABWR-0136 and RQ-ABWR-0137 (Ref. 12).

27. In addition, in May 2014 the RP has submitted to ONR for information an advance copy of the UK ABWR Pre-Construction Safety Report (PCSR). Chapter 12 (Ref. 10) addresses electrical systems. Although I have not covered this report in my GDA Step 2 formal assessment, it provides a basis on which to plan and prepare my GDA Step 3 work.

4 ONR ASSESSMENT

28. My assessment has been carried out in accordance with ONR How2 BMS document PI/FWD, “Purpose and Scope of Permissioning” (Ref. 3).

29. My GDA Step 2 electrical systems assessment has followed the strategy described in Section 2 of this report.

30. My Step 2 assessment work has involved continuous engagement with the RP’s electrical systems Subject Matter Experts (SME), ie, Technical Exchange Workshops (in Japan and the UK) and progress meetings (mostly video conferences) have been held. I have also visited:

- Kashiwazaki Kariwa Units 6&7 ABWRs where I could tour the majority of the facility including the upper drywell where the (internal) Main Steam Isolation Valves (MSIV) are located. I also viewed the control room from the visitors viewing area and the electrical power supplies in a number of plant areas.
- Omika Works where they manufacture and assemble control systems and I could see the manufacturing facility and the ABWR control room simulator.
- Hitachi Works (reactor internals workshop), where they manufacture reactor internal components and I could see the manufacturing facility and components which were destined for other ABWRs currently under construction.
- Kokubu works where they manufacture electrical power equipment and I could see the switchgear and transformer manufacturing and type testing facilities.

31. During my GDA Step 2 assessment, I have identified some shortfalls in documentation which have generally led to the issue of Regulatory Queries (RQ); overall I have raised eight RQs. Shortfalls in the safety case have generally led to the issue of Regulatory Observations (RO). I have not raised any specific electrical systems ROs during GDA Step 2 but have contributed to ROs raised by the fault studies topic assessors which relate to the UK ABWR electrical systems design.

32. Details of my GDA Step 2 assessment of the UK ABWR preliminary safety case in the area of electrical systems including the areas of strength that I have identified, as well as the items that require follow-up and the conclusions reached are presented in the following sub-sections.

4.1 AC Power System Architecture

4.1.1 Assessment

33. I assessed the architecture of the UK ABWR AC electrical power system based on the description of the system in the PSR (Ref.1) and on the overall electrical single line diagrams. Details of the design were discussed during a series of electrical topical meetings and video conferences with the RP.

34. The main considerations of the assessment were the following:

- provisions of off site power supplies;
- provisions of standby generation;
- divisional segregation of electrical system;
- protection from common cause failure;

- operating modes of system; and
- demands on the electrical system to provide power supplies to fulfil safety functions.

The following RQs (Ref. 12) were raised by ONR concerning the design details of the AC power system:

- RQ-ABWR-0050 – Back up building electrical supplies
- RQ-ABWR-0054 – Use of alternative diesel generator to back up emergency diesel generator
- RQ-ABWR-0136 – Emergency diesel generator starting

4.1.2 Strengths

35. I identified the following areas of strength in the AC power system:

- The preferred supply of offsite power is provided from a normal supply which connects to the main generator and grid system. There is an independent auxiliary supply from the grid to station AC power supply. Each grid input supply has independent connections to the three divisions of Class 1 power supplies.
- In normal operation at power the Class 1 divisions operate independently with no interconnections between divisions.
- Emergency diesel generators are installed in each of the three class 1 divisions each one of which can independently support the reactor safety functions. In addition there are two separate diesel generators in the back up building which can provide supplies to back up building loads which support safety functions. The back up building electrical system can operate independently of the main electrical distribution network to support independent back up building safety functions.

4.1.3 Items that Require Follow-up

36. During my GDA Step 2 assessment of the AC Power System I have identified the following shortcomings in conjunction with other assessors:

- Regulatory Observation RO-ABWR-0008 requires the RP to undertake a design basis analysis of a range of major common cause failures of key systems involved in the distribution of power within the UK ABWR site. This is a cross cutting Regulatory Observation led by fault studies but supported by electrical engineering and PSA.
- Regulatory Observation RO-ABWR-0009 requires the RP to review the resilience of the UK ABWR to Loss of Offsite Power (LOOP) events and to LOOP events coincident with common cause failures of onsite electrical systems. This is a cross cutting RO led by fault studies but supported by electrical engineering, human factors and PSA.
- Regulatory Observation RO-ABWR-0010 requires the RP to undertake a design basis analysis of failures of essential services and support systems. This is a cross cutting RO led by fault studies but supported by electrical engineering, mechanical engineering, C&I and PSA.

37. During my GDA Step 2 assessment of the AC power system I have identified the following additional shortcomings that I will follow-up during Step 3:

- I will expect the RP to provide complete diversity between the technology used in the reactor building and that used in the back up building. I will address this issue during Step 3 by seeking the RP to examine following areas:

  - The RP should propose a design modification for the back up building using diverse technology from that used for the emergency and normal power supplies.
  - If there is a deterministic or probabilistic requirement then consideration should be given to an additional power source to support the Emergency Diesel Generators (EDG).

4.1.4 Conclusions

38. Based on the outcome of my assessment of AC power supply I have concluded that the fundamental divisional structure of the design is robust. However, I have significant concerns regarding the diversity between the back up building power system and the emergency and normal power systems. ONR have discussed this issue with the RP who are seeking to address this issue during Step 3.

4.2 DC Power System Architecture

4.2.1 Assessment

39. I assessed the DC power system based on the description in the PSR and the DC power supply system design description (Ref. 11).

40. The main considerations of the assessment were:

- overall system architecture of the DC systems;
- divisional segregation of the DC system;
- protection from common cause failure;
- battery capacity and operating times; and
- operating modes of the system including maintenance connections.

41. The following RQ (Ref. 12) was raised concerning the DC power system:

- RQ-ABWR-0056 – Battery backed power supplies

4.2.2 Strengths

42. There is a clear segregated divisional structure of battery backed power supplies to support the reactor safety functions. The battery systems independently support the safety systems for each division.

4.2.3 Items that Require Follow-up

43. During Step 3 I intend to follow up to establish design details of the DC systems by assessing operating and maintenance configurations, battery capacity calculations, system monitoring and claims made on the DC power system architecture.

4.2.4 Conclusions

44. I am content with the basic structure of the DC power system as presented in the PSR. During Step 3 I will carry out further assessment of the DC power system architecture based on the submission of further design details from the RP.

4.3 Categorisation and Classification of Systems, Structures and Components

4.3.1 Assessment

45. I assessed the categorisation and classification of systems structures and components based on the description of the system in the PSR (Ref.1) and the document Categorisation and Classification of Structures systems and Components (Ref. 13). Details of the design were discussed in electrical topical meetings between the RP and ONR.

46. The main consideration of the assessment was to assess that the electrical system classification and categorisations are consistent with those of the safety systems supplied by the electrical distribution system.

47. The following RQs (Ref. 12) were raised by ONR concerning the classification and categorisation of systems structures and components:

- RQ-ABWR-0086 – Switchboard classification
- RQ-ABWR-0135 – Further query on switchboard classification

4.3.2 Strengths

48. The electrical system classifications have been determined taking due consideration of the categorisation and classifications of the loads supported by the electrical system.

4.3.3 Items that Require Follow-up

49. During Step 3 I intend to follow up the categorisation and classification of electrical systems to verify any implications on the categorisation and classification of the electrical system resulting from the RP's responses to ROs and from the RP addressing the implications of claims on the electrical system from development of the safety case.

4.3.4 Conclusions

50. I am content with the current classifications of the electrical system based on the current safety claims on the system. These will require review and confirmation by the RP as the safety case is developed.

4.4 Basis of Safety Case

4.4.1 Assessment

51. I assessed the Basis of Safety Case (BSC) document (Ref. 2), particularly the proposed structure of safety claims for the electrical system which will be used as the basis for the claims, arguments evidence structure presented in the safety case.

52. The main consideration of the assessment was to assess that the approach to the presentation of the safety case was adequate for the development of an acceptable PCSR.

4.4.2 Strengths

53. I consider that the structure of high level claims presented in the BSC provides a good basis for developing the safety case for the electrical system in a claims arguments and evidence structure. Demonstration has been provided that the high level claims on the electrical system are related to overall reactor safety claims.

4.4.3 Items that Require Follow-up

54. There are shortcomings in the sub claims presented in the BSC as they do not form an acceptable basis for providing a fully comprehensive safety case in a claims, arguments and evidence structure. Some claims are repeated under more than one high level claim and there are omissions from the safety claims which should be addressed by the RP. Sub claims are made for individual electrical equipment items rather than for the electrical system. I intend to follow up on this topic during Step 3 to ensure that the structure and content of sub claims is developed from the high level safety claims. I expect this to provide the basis for a comprehensive safety case for the electrical system.

4.4.4 Conclusions

55. The high level structure of claims forms a good basis for development of the safety case.

56. The structure and content of the sub claims require revision by the RP in order to provide the basis for the development of a claims arguments and evidence structure for the safety case for the electrical power system.

4.5 Lighting and Communications

4.5.1 Assessment

57. I assessed the lighting and communications based on the description in the PSR.

58. The main consideration of the assessment was to determine the adequacy of the proposed design in these areas.

4.5.2 Strengths

59. The PSR provides details of classified systems which provide comprehensive communications and lighting for the reactor building.

4.5.3 Items that Require Follow-up

60. The design of the lighting and communication systems will be followed up during Step 3. In conjunction with C&I, fault studies and human factors assessors I will assess whether the electrical system design meets the operational and safety requirements for the reactor in all operating conditions.

4.5.4 Conclusions

61. I will carry out further assessment during Step 3 based on the submission of more detailed information from the RP.

4.6 Out of Scope Items

62. No items have been left outside the scope of my GDA Step 2 assessment of the UK ABWR electrical systems.

4.7 Comparison with Standards, Guidance and Relevant Good Practice

63. 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 electrical systems 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 design of the electrical systems in line with the requirements of the relevant SAPs. I am satisfied that the fundamental design complies with the SAPs. Table 1 provides further details.
- TAGs: The design of the electrical systems generally complies with the requirements of the TAG on Essential Services.

4.8 Interactions with Other Regulators

64. There have been no interactions with other regulators during Step 2 assessment.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

65. The RP has provided a PSR for the UK ABWR for assessment by ONR during Step 2 of GDA. The PSR together with its supporting references present at a high level the claims in the area of electrical systems that underpin the safety of the UK ABWR.

66. During Step 2 of GDA I have conducted an assessment of the parts of the PSR and its references that are relevant to the area of electrical systems against the expectations of the SAPs and TAGs. From the UK ABWR assessment done so far I conclude the following:

- The RP has produced a well structured set of high level claims to form the basis of the PCSR. More development is required for the sub claims but I am confident that these can be developed by the RP to complete the safety case.
- There are shortcomings in the demonstration of diversity which I will address with the RP during Step 3.
- I have found the RP to be responsive and open in its approach to understanding and meeting ONR expectations. I am satisfied that adequate resources are in place to develop the UK ABWR safety case and to support interactions with ONR.

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

5.2 Recommendations

68. My recommendations are as follows:

- Recommendation 1: The UK ABWR should proceed to Step 3 of the GDA process.
- 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 electrical systems.

6 REFERENCES

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9 *UK ABWR Document Tracking Sheets. Updated versions submitted to the Joint Programme Office (JPO) throughout GDA Step 2. TRIM Ref. 5.1.3.9587*

10 *Generic Pre Construction Safety Report – Chapter 12 – Electrical System. GA10-9101-0100-12001 Rev. DR1. Hitachi – GE May 2014. TRIM Ref. 2014/209786*

11 *DC power Supply System Design Description. GR42-1001-0001-00001. Hitachi – GE May 2014. TRIM Ref. 2014/190375*

12 *Regulatory Queries raised during Step 2 assessment of Hitachi – GE ABWR. TRIM folder 5.1.3 9389*

13 *Categorisation and Classification of Structures, Systems and Components. GA91-9901-0007-00001. Hitachi – GE March 2014. TRIM Ref. 2014/109462*

Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No and Title	Description	Interpretation	Comment
EDR.2	**Engineering Principles: Redundancy, diversity and segregation**	Redundancy, diversity and segregation should be incorporated as appropriate within the designs of structures, systems and components important to safety	The top level claim TC6 in the BSC addresses the requirements of this SAP
EDR.3	**Engineering Principles: Common cause failure**	Common cause failure should be explicitly addressed where a structure, system or component important to safety employs redundant or diverse components, measurements or actions to provide high reliability	The top level claim TC7 in the BSC addresses the requirements of this SAP
EDR.4	**Engineering Principles: Single failure criteria**	During any normally permissible state of plant availability no random single failure, assumed to occur anywhere within the systems provided to secure a safety function, should prevent the performance of that safety function	The top level claims TC3, TC4, TC5 and TC8 in the BSC address the requirements of this SAP
EKP.3	**Engineering Principles: 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	The top level claims TC9, TC10 and TC11 in the BSC address the requirements of this SAP
EKP.5	**Engineering Principles Safety Measures**	Safety measures should be identified to deliver the required safety function	The top level claim TC1 in the BSC addresses the requirements of this SAP
ESS.2	**Determination of safety system requirements**	The extent of safety system provisions, their functions, levels of protection necessary to achieve defence in depth and required reliabilities should be determined	The top level claim TC2 in the BSC addresses the requirements of this SAP
ESS.8	**Automatic Initiation**	A safety system should be automatically initiated and normally no human intervention should be necessary following the start of a requirement for protective action	The top level claim TC12 in the BSC addresses the requirements of this SAP