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UK ABWR Generic Design Assessment

Generic PCSR Chapter 4 : Safety Management throughout Plant Lifecycle

Hitachi-GE Nuclear Energy, Ltd.

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Executive Summary

This chapter describes the generic safety management arrangements put in place by Hitachi-GE Nuclear Energy, Ltd. (Hitachi-GE). to ensure that the required levels of nuclear safety, environmental protection and security will be delivered throughout the Plant Lifecycle (i.e. design, construction, commissioning, operations and decommissioning) of the United Kingdom Advanced Boiling Water Reactor (UK ABWR).

Responsibility for safety of a future licensed site and for safe operation and management of the UK ABWR will rest with the future licensee and specific UK requirements go beyond what needs to be considered within Generic Design Assessment (GDA). However, certain elements of the nuclear regulatory regime are relevant to GDA and should be considered and applied as appropriate. Therefore Hitachi-GE has identified the safety management arrangements that have been applied, in GDA to ensure that the generic design of the UK ABWR is of appropriate quality. This chapter also describes Hitachi-GE's proposals for management arrangements to ensure nuclear safety can be maintained throughout the lifetime of the UK ABWR.

The safety and quality policy for UK ABWR is described together with the management system and supporting procedures that are required to implement safety policy throughout the Plant Lifecycle. Hitachi-GE's arrangements for cultivating and developing a strong nuclear safety culture are also described.

This chapter includes a summary of Hitachi-GE's construction experience and safety record and describes the organisation's history in nuclear power plant construction. This gives an overview of the progress in conventional and radiological safety that has been included in the development of the UK ABWR design. The relationship between the Pre-Construction Safety Report (PCSR) and Generic Environmental Permit – Radioactive Substances Regulations (GEP-RSR) is described. This identifies those PCSR chapters that are closely related to the GEP-RSR, and describes the arrangements in place to ensure consistency between the GEP-RSR and PCSR submissions.

It is explained how Hitachi-GE's safety management framework will support the future licensee to implement effective safety management over the entire Plant Lifecycle of the UK ABWR. This includes arrangements to transfer knowledge and information about the GDA safety case to the future licensee. It also covers arrangements for: support to the future licensee's Design Authority; documents and records; purchasing control; and management of non-conformances and corrective actions.

The management arrangements for identifying the Assumptions, Limits and Conditions for Operation from the GDA safety case, and the process for transfer of these to the future licensee are described.

In summary, this chapter describes, at an appropriate level of detail for a GDA PCSR, how Hitachi-GE's management arrangements contribute to reducing risks so far as is reasonably practicable during each of the stages of the UK ABWR Plant Lifecycle. It is acknowledged that further work will be required post GDA to fully incorporate site specific aspects, including setting up of corresponding management arrangements. This work will be the responsibility of any future licensee.

4.1 Introduction

The objective of the chapter is to describe Hitachi-GE's generic safety management arrangements which will ensure that the required levels of safety, environmental protection and security will be delivered throughout the lifetime of the UK ABWR. Hitachi-GE will share knowledge and information with the future licensee, to provide a safe and high quality nuclear power plant.

4.1.1 Background

The GDA process involves regulatory assessment of the safety, environmental and security safety case for the UK ABWR. Primarily this is an assessment of the deterministic and probabilistic safety analysis plus consideration of hazards, etc. Nevertheless, another important aspect is the safety management arrangements to ensure that the UK ABWR is appropriately designed and then operated and maintained in accordance with this safety case, and also that this safety case is maintained and updated through Plant Lifecycle.

Responsibility for safety on a future licensed site and for safe operation and management of the UK ABWR in accordance with the safety case will rest with the future licensee. In the UK regulatory system the future licensee needs to comply with the Energy Act 2013, Nuclear Installations Act and Site Licence and its 36 Licence Conditions through appropriate arrangements. An additional fundamental legal requirement in the UK is compliance with the Health and Safety at Work Act 1974 and there are many other UK and international requirements that should also be considered. A list of specific legal requirements is included in Appendix B. The future licensee will need appropriate arrangements to comply with all of these requirements, but these go beyond what needs to be considered within GDA.

Therefore, at the GDA PCSR stage, it is not possible or appropriate to describe all of the arrangements that will need to be in place to manage safety on the future nuclear licensed site. However, certain elements of the nuclear regulatory regime described above are relevant for GDA and should be considered and applied as appropriate. Therefore, in GDA, Hitachi-GE has identified the safety management arrangements that have been applied to ensure that the UK ABWR design is of appropriate quality and that nuclear safety, occupational health and conventional safety, environmental protection and security will be maintained throughout the lifetime of the UK ABWR.

The GDA arrangements also include a strategy to transfer knowledge and information from the GDA safety case to a future licensee to support the future licensee's activities to ensure it has an appropriate capability before an application is made for a nuclear site licence. As part of contractual arrangements, the future licensee will define the specific knowledge and information that it would require from GDA.

It is the objective of this PCSR chapter to provide an overview of these GDA safety management arrangements.

4.1.2 Document Structure

The following sections of PCSR Chapter 4 outline the safety management strategy implemented for GDA of the UK ABWR.

Section 4.2 Purpose and Scope: This section sets out the purpose and scope identifying the aspects included within the safety management arrangements for GDA. It also identifies what is not included and provides links to other relevant PCSR chapters.

Section 4.3 Hitachi-GE Safety and Quality Philosophy: This section describes the safety and quality policy that provides a basis for the safety and quality management system for ensuring that nuclear safety is maintained at all phases of the Plant Lifecycle. Its describes Hitachi-GE's integrated management system and supporting procedures which implement the safety policy at each phase of design, procurement, manufacturing, installation, testing, inspection, commissioning and maintenance. It also describes how introducing this policy contributes to developing and cultivating the nuclear safety culture.

Section 4.4 Hitachi-GE Construction Experience and Safety Record (including radiological safety): This section describes Hitachi-GE's history of project management and construction and the conventional safety record that has been achieved over time. It also describes the improvement in radiological safety performance throughout the development of the ABWR and compares radiation exposure to personnel after commencement of operation between ABWR and other Boiling Water Reactor (BWR) / Pressurized Water Reactor (PWR).

Section 4.5 Relationship between PCSR and GEP-RSR: This section identifies and lists PCSR chapters that have a deep relationship with the GEP-RSR in order to show the relationship between Hitachi-GE's PCSR and the GEP-RSR. Additionally, it describes the management arrangement established in order to prevent inconsistency that could be caused by the difference in publication periods of the PCSR and the GEP-RSR.

Section 4.6 Safety Management Framework: This section describes how Hitachi-GE will establish the organisation and system to support the future licensee and to implement effective safety, environment and security management over the entire Plant Lifecycle of UK ABWR, in order to achieve a high level of safety. This includes arrangements for knowledge transfer to the future licensee including the process to

identify and transfer the Assumptions, Limits and Conditions for Operation from the GDA safety case to the site specific phase. It also covers arrangements for Design Authority support, documents and records, purchasing control, management of non-conformances, corrective actions, and control of general safety.

Section 4.7 Safety in the Design Phase: This describes the Hitachi-GE management arrangements for the UK ABWR design process that ensures a quality design is achieved in GDA that eliminates, reduces or mitigates exposure to health and safety hazards during all phases of Plant Lifecycle and to ensure that the design reduces risks As Low As Reasonably Practicable (ALARP). This includes the processes of design review, design verification and design validation and also covers the arrangements for control of design change.

Section 4.8 Safety in the Construction Phase: This section describes Hitachi-GE's role in the construction phase as designer and manufacturer and supplier of some plant items and how this will be interfaced with the future licensee to ensure that safety functional and design requirements are fulfilled. Hitachi-GE's understanding of related duties under the Construction (Design and Management) Regulations 2015 (CDM Regulations 2015) is also described. Outline information is also provided on the quality assurance plan for construction, the construction control and verification processes, modular construction and the construction schedule.

Section 4.9 Safety in the Commissioning Phase: This section describes Hitachi-GE's role in the safe management of commissioning and how this will interface with the future licensee. This includes developing the commissioning schedule, appropriate arrangements for managing the hazards present during commissioning and the handing over of plant from the commissioning organisation to the operating organisation.

Section 4.10 Safety in the Operational Phase: This section describes Hitachi-GE's role in the safe management of the UK ABWR operation and how this will interface with the future licensee. It describes that this will include ensuring that all information (manning levels, Technical Specifications, maintenance requirements, outage schedules, etc.) related to plant safety that was established during GDA and during construction and commissioning is transferred from Hitachi-GE to the future licensee prior to plant handover.

Section 4.11 Safety in the Decommissioning Phase: This section describes Hitachi-GE's role in the safe management of the UK ABWR decommissioning and how this will interface with the future licensee. It describes how the risks during decommissioning have been analysed and minimised / mitigated in GDA,

especially from the point of view of minimising radiation exposure to the personnel engaged in the decommissioning. This section also describes how the decommissioning plan was developed in GDA.

Section 4.12 Assumptions, Limits and Conditions for Operation: This section provides a definition of Assumptions, Limits and Conditions identified within the GDA safety case.

Section 4.13 Conclusions: This section provides a summary of the main aspects of this chapter.

Section 4.14 References: This section lists documents referenced within this chapter.

Other relevant information is captured in Appendices as follows:
Appendix A - Document Map
Appendix B - List of Specific Legal Requirements

This chapter is supported by a set of reference documents, primarily quality assurance manuals and procedures, which describe where further information is presented. A list of supporting document for this chapter is provided within the document map in Appendix A.

The main links of this chapter with other Generic PCSR chapters are as follows:

- For generic links to GEP-RSR, and Conceptual Security Arrangements (CSA) documentation, please refer to Generic PCSR Chapter 1: Introduction. For GEP-RSR, where specific references are required, e.g. in Radioactive Waste Management, Radiation Protection, Decommissioning, these will be included in the specific sections within the relevant chapter.
- Applied Code and Standards and general definitions of Categorisation and Classification of Systems, Structures and Components (SSCs) as described in PCSR Chapter 5: General Design Aspects. Compliance with the Nuclear Safety and Environmental Design Principles (NSEDPs) [Ref-1] is demonstrated in PCSR Chapter 5: General Design Aspects, Section 5.3.
- Basic design and technical characteristics as detailed in PCSR Chapter 9: General Description of the Unit (Facility).
- The fault schedule for the UK ABWR identified in PCSR Chapter 24: Design Basis Analysis.
- General requirements for commissioning, operation and decommissioning of the systems, structures and components within this chapter scope are described in PCSR Chapter 29: Commissioning, PCSR Chapter 30: Operation and PCSR Chapter 31: Decommissioning.

4.2 Purpose and Scope

4.2.1 Purpose

This chapter identifies the generic management arrangements established by Hitachi-GE for the UK ABWR. These arrangements define the safety requirements that need to be in place throughout the Plant Lifecycle of the UK ABWR. This chapter also demonstrates that these arrangements will provide the appropriate standards of safety and quality at each phase of construction, commissioning, operation, and decommissioning as far as is practicable at the GDA stage. In addition, these arrangements ensure that the plant can be properly operated and maintained within safety and environment limits and conditions.
Specific objectives of the chapter are to:

- Describe the Hitachi-GE safety policy and safety management arrangements that are applied to the UK ABWR design, construction, commissioning, operation, and decommissioning.
- Describe the arrangements for identifying the Assumptions, Limits and Conditions for Operation from the GDA safety case, from all the relevant PCSR chapters.
- Describe or provide reference to the safety management arrangements related to the radiation dose for construction, commissioning, and operation.
- Describe where additional detailed supporting information can be found.
- Identify the plans for handover and knowledge transfer to future licensee.
- Provide information that can be used to demonstrate compliance of the UK ABWR generic design with relevant sections of Hitachi-GE's NSEDPs [Ref-1], and to justify any non-compliances (if any).
- Identify links to the relevant content of other GDA PCSR chapters, to ensure consistency across the whole safety case, and to ensure the overall safety case presented is complete.

4.2.2 Scope

The chapter identifies, at an appropriate level of detail for a GDA PCSR, the Hitachi-GE management arrangements that are required to be in place to support all phases of the Plant Lifecycle (design, manufacturing, construction, commissioning and into operation and eventual decommissioning).
This chapter covers the generic arrangements for:

- Quality management of the design and safety case production.
- Support to future licensees to put in place a Design Authority, including transfer of knowledge to the future licensee and record keeping.
- Ensuring safety during all phases of the Plant Lifecycle (design, manufacturing, construction,

commissioning and into operation and eventual decommissioning).

- Moving the safety case to an operating regime; i.e. the arrangements to ensure that the requirements of, and assumptions in, the safety case have been clearly identified and can readily be captured in operating documentation by the future licensee, including:
  - Technical specifications;
  - Maintenance schedule;
  - Procedures (normal operation, emergency, accident management);
  - Training programmes;
  - Emergency preparedness;
  - Operating limits;
  - Radiation protection arrangements for operators;
  - Lifetime records;
  - Commissioning requirements, etc.

This chapter provides reference to where non-nuclear/conventional safety is addressed (including compliance with the CDM regulations).

The chapter will not cover arrangements for safety management of a future site in accordance with the nuclear site licence.

This chapter makes it clear that responsibility for safety will rest with the future licensee. At the GDA PCSR stage it is not possible or appropriate to describe all of the arrangements that will need to be in place to manage safety on the future nuclear licensed site. However, this PCSR chapter provides the future licensee with a broad understanding of the safety management arrangements required to ensure nuclear safety throughout the lifetime of the UK ABWR.

4.3 Hitachi-GE Safety and Quality Philosophy

4.3.1 Hitachi-GE Safety and Quality Policy

Hitachi-GE has established its safety and quality policy to provide a basis for the quality management system and objectives for the organisation and employees to maintain nuclear safety at all phases of the Plant Lifecycle. The safety and quality policy is established as an absolute commitment in the organisation to continue raising awareness of safety. Accordingly, the introduction of the policy to the entire organisation is a key contributor to cultivating a positive nuclear safety culture.

The Hitachi-GE's Safety and Quality Policy states that:

- Hitachi-GE recognises that achievement of nuclear safety is an integral part of corporate social responsibility. With this acknowledgment, Hitachi-GE ensures compliance with regulations, strives to keep cultivating nuclear safety culture and always acts in a way that places the highest priority to ensuring nuclear safety.
- The key principle of the policy is that safety always comes first, and is considered with Environmental Protection, Security and Quality, followed by Schedule/Delivery and finally Cost/Budget. Hitachi-GE always acts in full compliance with this code of conduct.
- Hitachi-GE understands that it is of the upmost importance that work processes are identified/clarified; that the processes and results are monitored; and the records are maintained/reviewed. Hitachi-GE is committed to doing this, ensuring full transparency of the work and implementing continual improvement in work processes.
- Hitachi-GE recognises that colleagues are "internal customers" in that they are involved in the work process and depend on work to be appropriately completed. With this realisation and by observing the requirement of the Quality Management System (QMS), Hitachi-GE ensures that required processes are properly executed and work is accurately completed as specified. Hitachi-GE is committed, by so doing, to implement the work processes to ensure that all products and services conform to safety and all other requirements.

Hitachi-GE is committed to conduct all corporate activities in accordance with its safety and quality policy.

4.3.2 Development of a Nuclear Safety Culture

The development of a nuclear safety culture is in accordance with "Leadership and Management for Safety (GSR Part 2) [Ref-2]". In promoting the development of a nuclear safety culture, Hitachi-GE's consideration includes the 15 items from a) to o) below for the continual improvement of safety and organisational culture, as well as achieving and maintaining in practice, good design and quality.

- Commitment by top management
- Clear-cut principles and implementation by top management
- Policy of avoiding erroneous decision-making
- The attitude of always asking questions
- A culture of reporting
- Good communication
- Accountability and transparency
- Compliance
- A learning organisation
- An organisation working to prevent accidents, breakdowns, and other incidents
- Self-evaluation and third-party evaluation
- Work control
- Change control
- Attitude and motivation
- A willingness to accept challenge

Hitachi-GE promotes the development of a safety culture that involves all employees which is driven by a commitment from top management and by strong leadership. The main activities conducted to achieve nuclear safety in the foundation of quality and safety management are described in Table 4.3-1 Activities for Development of a Nuclear Safety Culture. The status of the activities will be part of the input information for Management Review undertaken by senior management.

Hitachi-GE, in its responsibility as nuclear equipment supplier, ensures the development of a nuclear safety culture extends down through its supply chain.

Table 4.3-1: Activities for Development of a Nuclear Safety Culture

No.	Activities	Purpose of the Activities	Implementation Frequency
1	Transmission of Presidential messages.	To penetrate the organisation with the principles of quality.	As appropriate
2	Meeting to promote cultivation activities for nuclear safety culture	To share information of cultivation activities for safety culture including activities at related works of Hitachi groups and Hitachi-GE.	Once a year
3	Meetings to promote thorough implementation of 'the basics and the right way'.	To raise awareness of compliance and to penetrate the company with its engineering ethics.	Every month
4	Learning about preventive ethics.	To provide training on making good business judgments.	Once a year
5	Safety awareness questionnaire.	To monitor how well the safety culture has been achieved and identify any signs of safety culture deterioration.	Once a year
6	Compliance activities.	To cultivate programmes and an atmosphere for addressing compliance issues.	As appropriate
7	Management Review	To assess implementation status of each activity for cultivating safety culture, review, and plan for the next fiscal year.	Once a year

4.3.3 Hitachi-GE Management System

Hitachi-GE has established a Management System, in which the elements of safety, health, environment, security, quality and economy are integrated. The Management System is based on ISO (International Organization for Standardization) 9001 [Ref-3], IAEA (International Atomic Energy Agency) GSR Part 2 [Ref-2] and ASME (American Society of Mechanical Engineers) Code Section III [Ref-4] for quality, ISO14001 for Environment [Ref-5] and OHSAS (Occupational Health and Safety Management System) 18001 for Occupational Health and Safety [Ref-6]. In order to ensure the adequate consideration of safety in all activities of the organisation, Hitachi-GE implements and assesses activities in accordance with these established management systems and conducts continuous improvements to enable appropriate provision for safety, environment and security throughout the Plant Lifecycle.

The specific content of Hitachi-GE's philosophy is detailed in the Quality Manual for Nuclear Power Equipment (HI-ISO-21 version 2)[Ref-7], Environmental Manual (D-EMS:2015)[Ref-8], Occupational Health and Safety Manual (HI-ISO-03)[Ref-9], ASME Manual (HQA-0002) [Ref-10]. Supporting procedures implement the philosophy at each phase of design, procurement, manufacturing, installation, testing, inspection, commissioning and maintenance. The essential purpose of these management system requirements is to ensure safety by considering expected effects of all actions related to safety, not as an individual management system but as an entire management system by positioning Hitachi-GE's Safety and Quality Policy at the top. All activities which may significantly affect nuclear safety of the UK ABWR project are conducted in accordance with the Quality Manual for Nuclear Power Equipment (HI-ISO-21 version 2) [Ref-7] which is positioned as the top level of the management system in Hitachi-GE.

In order to ensure safety and quality, it is important to prepare documentation detailing processes and activities, and to systematically organise those documents. Hitachi-GE has an organised and structured process for managing its documentation to ensure safety and quality at every level of the organisation as described in HI-ISO-21 version 2[Ref-7] and illustrated below:

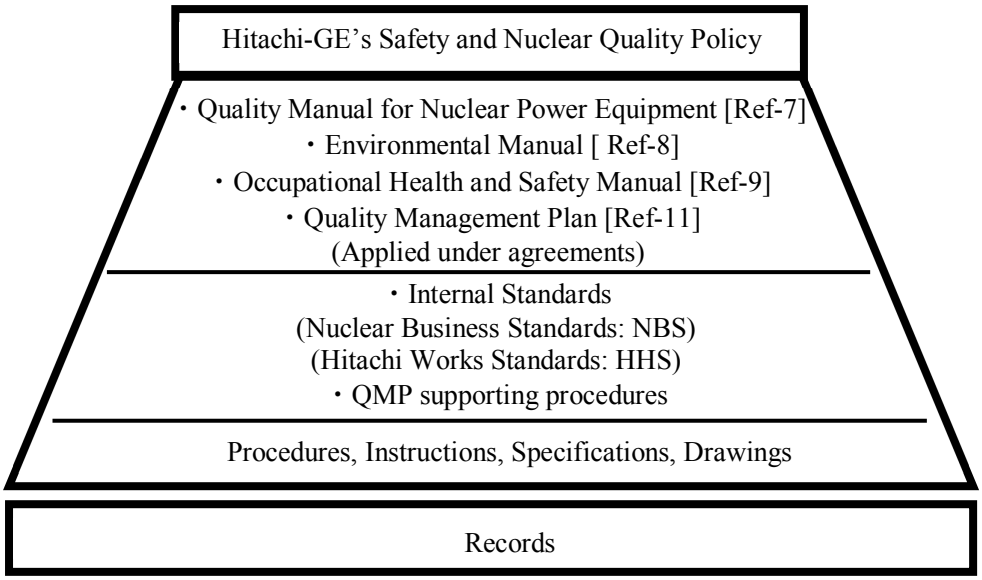


Figure 4.3-1: Hitachi-GE Management System

The quality assurance and management system arrangements for GDA were established at an early stage by the production of the Quality Management Plan (QMP) for UK ABWR GDA Project [Ref-11] and Communication, Reporting Lines and Distribution of Information in the GDA Organisation [Ref-12]. The QMP includes the arrangements for addressing;

- Safety culture
- Graded approach
- Management responsibility
- Resource management
- Process implementation including design and document control
- Measurement, assessment and improvement

A number of supporting procedures to the QMP have been established including Generic Design Development Control [Ref-13], which describes how the production of important safety case documents like this PCSR are controlled, reviewed, independently verified and approved. SQEP Requirements for Hitachi-GE and Supplier Personnel [Ref-14] specify the production of role profiles and competency evaluations to ensure that Suitably Qualified and Experienced Personnel (SQEP) are responsible for the delivery of the GDA project. The QA arrangements for GDA and the production of the PCSR will enable the UK ABWR to be built as designed. These documents and records for GDA are controlled in accordance with Control of General Documents and Records [Ref-15].

Hitachi-GE has prepared a compliance plan to demonstrate compliance with the GDA guidance document. The QMP and its supporting procedures have been reviewed and updated as appropriate throughout GDA. The effectiveness of the Quality Management System for GDA has been confirmed periodically in accordance with the requirements of Assessment of GDA Arrangements (Internal Audits, Self-Assessment) [Ref-16]. For site specific activities, the GDA management systems will allow a future licensee to develop its own appropriate quality assurance management systems appropriate to the site specific phase.

Hitachi-GE has developed the Safety Case Development Plan [Ref-17] and the Safety Case Development Manual [Ref-18] to control UK ABWR safety case. These documents support the establishment of important safety case documents like the PCSR. Furthermore, Hitachi-GE has developed the UK ABWR Principles (NSEDPs) [Ref-1]. The primary purpose of the NSEDPs [Ref-1] is to act as the foundation for all design aspects of the UK ABWR such that, when applied by Hitachi-GE in the design of the plant and in the production of the accompanying safety and environmental documentation, there is high confidence that the UK ABWR will demonstrate compliance with UK regulatory expectations and legal requirements. Compliance with the NSEDPs [Ref-1] is demonstrated in PCSR Chapter 5: General Design Aspects, Section 5.3.

4.4 Hitachi-GE Construction Experience and Safety Record (including radiological safety)

4.4.1 Hitachi-GE Construction Experience and Safety Record

Hitachi-GE obtained certification to ISO 9001 in 1999, and has been engaged in many nuclear power projects while continuously improving its management system. The scope of the Hitachi-GE ISO 9001 certification is "design, development, engineering, project management, manufacture, repair / refurbishment, installation, commissioning, and maintenance of heat exchangers, pressure vessels and their auxiliary equipment for nuclear power plants, nuclear fuel cycle plants, radioactive waste treatment plant, nuclear fusion equipment". Hitachi-GE has over 40 years' experience in the design, construction and maintenance of nuclear power plants in Japan and has participated in the construction of 20 of Japan's 55 light water reactors. Hitachi-GE has been and is currently involved in the construction of 6 ABWR units in Japan. A summary of Hitachi-GE's experience in the Japanese Advanced Boiling Water Reactor (J-ABWR) program is shown below:

Table 4.4-1: Hitachi-GE Construction Experience

ABWR	Nuclear Island Supplier	Turbine Island Supplier
Kashiwazaki-Kariwa 6	Other	Hitachi (Hitachi-GE)
Kashiwazaki-Kariwa 7	Hitachi (Hitachi-GE)	Other
Hamaoka 5	Other	Hitachi (Hitachi-GE)
Shika 2	Hitachi (Hitachi-GE)	Hitachi (Hitachi-GE)
Shimane 3 (Under Construction)	Hitachi-GE	Hitachi-GE
Ohma 1 (Under Construction)	Hitachi-GE	Other

Throughout the 40 year period of construction of boiling water reactors, Hitachi-GE has pioneered the use of computer aided design and engineering packages and the increased use of modularisation to reduce on-site work and increase safety and quality on the construction site. Shimane 3 in western Japan is Hitachi-GE's most recently completed ABWR. The personnel safety record for Shimane 3 is shown in Table 4.4-2.

Table 4.4-2 : Summary of Occupational Accidents at Shimane Unit 3 Site

Fiscal Year	Case without lost workdays		Lost Workdays Case			Fatal Accident		LWH Cases + Fatal Accident Incident Rate for general construction in Japan	Work Hours (h) at Hitachi-GE
	W/O LWH Cases	Incidence Rate	LWH Cases	Incidence Rate	Incident Rate for general construction in Japan	FA	Fatal Rate		
2007	0	0.00	0	0.00	1.89	0	0.00	1.95	331,856
2008	2	1.54	0	0.00	1.82	0	0.00	1.89	1,298,587
2009	3	0.98	0	0.00	1.07	0	0.00	1.09	3,069,498
2010	5	1.73	0	0.00	1.44	1	0.35	1.56	2,890,372
2011	0	0.00	0	0.00	0.81	0	0.00	0.85	472,132

Note 1: Fiscal year starts from April and runs through to next March.
Note 2: Rate and Work Hours are accumulated by Hitachi-GE only.
Note 3: Incidence/Fatal rate =LWH (Lost Work Hours) Case or Fatal accidents / Work Hour* 1,000,000.
Note 4: The cases exclude Heat Stroke.
Note 5: Incident Rate for general construction in Japan is cited from Ministry of Health, Labour and Welfare. (Reference information as of 8th August, 2017: http://www.mhlw.go.jp)
Note 6: Incident Rate for general construction in Japan is based on data from January to December.
Note 7: Construction works were suspended after Fukushima Daiichi Accident.

4.4.2 ABWR Radiological Safety

The ABWR design has been developed over decades by Hitachi-GE (Hitachi), allowing continuous improvement in radiological safety. This has been achieved by reducing the dose to personnel and reducing the radioactive waste, as described below.

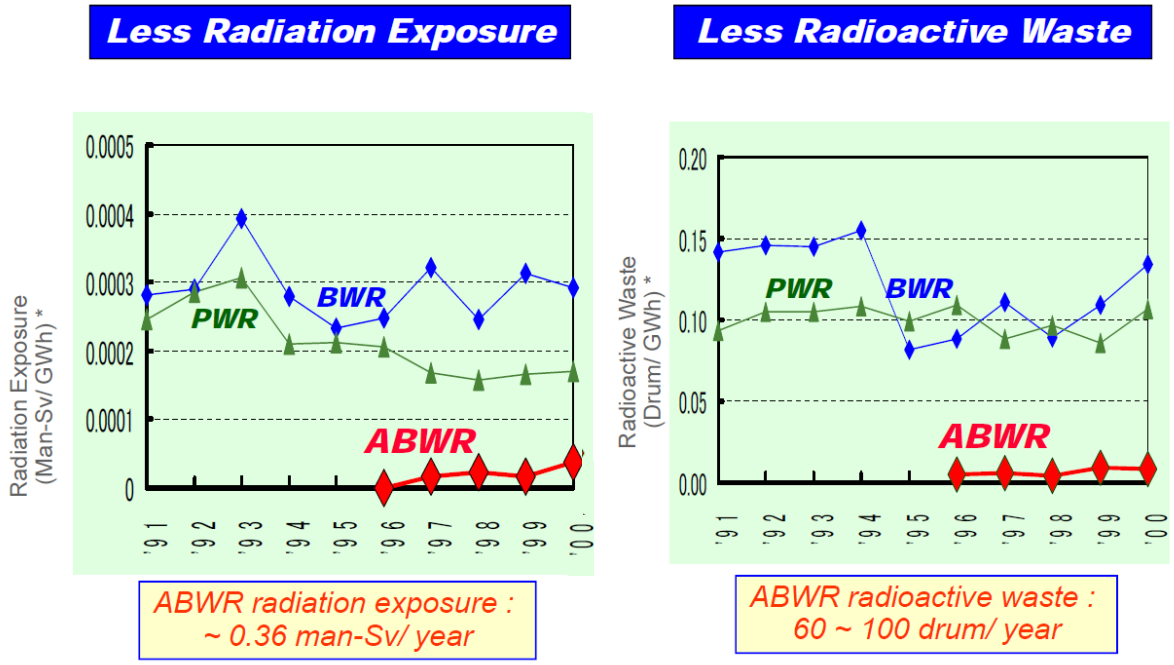
From the radiation protection perspective, the ABWR combines advanced design features and administrative controls designed to keep the occupational radiation exposure to personnel, and contamination, As Low As Reasonably Achievable (ALARA).

Reduction in the plant personnel exposure is achieved by (1) minimising exposure time in radiation and/or contamination areas, and (2) minimising radiation and contamination levels in routinely occupied areas. These minimisations are based on design improvement relative to the current operating BWRs such as; the elimination of external recirculation loops by adopting reactor internal pump system which results the reduction of active pipework and maintenance. Reduction of pipework maintenance and the associated reduction of weld lines, benefits the shortening of work times by removing the need for periodical inspections. Remote, automated inspection methods are designed for non-destructive examination in order to further reduce radiation exposure dose to personnel. Additionally, working spaces are designed to maximise efficiency for carrying out work.

Adopting these designs with appropriate controls provide the additional benefit of reducing radioactive waste. The ABWR has incorporated a number of design changes and innovations to structures and materials and has achieved a reduction in the amount of waste generated.

Further information on the improvements from BWRs is addressed in [Ref-19].

The ABWR has a superior radiological safety performance when compared to other reactor technologies. Figure 4.4-3 compares radiation exposure dose and radioactive waste production between the ABWR, BWR, and PWR. The ABWR is lowest for both the average radiation exposure at 0.36man-Sv/year, and for the average radioactive waste at 60 to 100 drums/year. Furthermore, the radiation exposure dose and radioactive waste amount per GWh is significantly lower compared to BWR and PWR.



Reference: JNES Reports;Average value of Japanese PWRs & BWRs

Figure 4.4-3: Comparison of radiation exposure and waste for ABWR, BWR and PWR

4.5 Relationship between PCSR and GEP-RSR

4.5.1 Link with PCSR and GEP-RSR

The complete GDA submission made to the ONR and the Environment Agency represents the full technical description of the generic design and Hitachi-GE activities. There are several important sources of GEP-RSR supporting information within the suite of safety-related documents being prepared as part of the UK ABWR GDA submission. The specific chapters of the PCSR containing sources of GEP-RSR supporting information are listed below, with the key references used to support the GEP-RSR submission highlighted in bold:

- **Chapter 2: Generic Site Envelope**
- Chapter 9: General Description of the Unit (Facility)
- Chapter 16: Auxiliary Systems
- **Chapter 18: Radioactive Waste Management**
- Chapter 19: Fuel Storage and Handling
- **Chapter 20: Radiation Protection**
- Chapter 23: Reactor Chemistry
- Chapter 27: Human Factors
- Chapter 28: ALARP Evaluation
- Chapter 29: Commissioning
- Chapter 30: Operation
- **Chapter 31: Decommissioning**
- Chapter 32: Spent Fuel Interim Storage

4.5.2 Consistency between PCSR and GEP-RSR

Hitachi-GE's GEP-RSR submission consists of core GEP-RSR documents and partly of PCSR related documents. However, the document submission period is different for the PCSR and the GEP-RSR, therefore providing a risk to consistency for common information. On this account, Hitachi-GE has developed the management system to ensure consistency, taking into account the parallel process and need for design control between the PCSR and the GEP-RSR [Ref-20]. Appropriate implementation of this process and configuration management of documents makes it possible to ensure consistency. Furthermore, the UK ABWR design considers ALARP and Best Available Technique (BAT) for safety and environmental aspects respectively and is therefore optimised. In cases where a design change is necessary, the established design review process is implemented such that the validity of the design change is verified for both ALARP and BAT.

4.6 Safety Management Framework

4.6.1 Responsibilities in Safety Management for Hitachi-GE and the Licensee

Responsibility for safety of a future licensed site and for safe operation and management of the UK ABWR will rest with the future licensee. Hitachi-GE has identified the safety management arrangements that have been applied, in GDA to ensure that the generic design of the UK ABWR is of appropriate quality. This chapter also describes Hitachi-GE's proposals for management arrangements to ensure nuclear safety can be maintained throughout the lifetime of the UK ABWR Safety arrangements for the future licensee will be defined as part of its compliance with the Nuclear Site Licence Conditions and other regulations and as part of an integrated management system. Compliance arrangements for these will detail how the future licensee intends to achieve safety through areas such as training, quality assurance and management and organisational systems.

Hitachi-GE is the technology provider and so has a key responsibility as Vendor, Constructor, and Contractor. The potential requirement for an enduring role as responsible designer is understood by Hitachi-GE and it has the necessary capability to satisfy such contractual requirements for this. Safety in each phase of the Plant Lifecycle and the responsibility for activities affecting the environment will be clarified in the coordinated management arrangements for both Hitachi-GE and the future licensee. Early in the site specific stage the coordination of the management system of Hitachi-GE and that of future licensee may be required with regard to procurement engineering activities related to Long Lead Items such as reactor pressure vessel and reactor containment vessel.

4.6.2 Delivery of Hitachi-GE's Responsibilities in Safety Management

Hitachi-GE has been and will continue to establish its organisation and systems to support future licensee and to implement effective safety, environment and security management over the entire Plant Lifecycle of UK ABWR, in order to achieve a high level of safety while maintaining configuration control and structural integrity of the plant design.

The most important aspect of safety management from a Hitachi-GE perspective is to harmonise the management arrangements between Hitachi-GE and the future licensee in an effective way so that the future licensee is able to fulfil its responsibility for safety in the nuclear power station.

Hitachi-GE will support future licensee in providing practical technical information required for preparing a site specific PCSR and environmental report. Hitachi-GE will continue, as necessary, to assist the future licensee with advice and support during the Plant Lifecycle, including during plant operation, to ensure that

the future licensee is able to satisfy requirements for safety and the environment. Hitachi-GE has been and will continue to share operational experience and knowledge as well as knowledge gained from the electrical power industry experience within and outside of Japan, other designers / operators and for non BWRs, in order to help ensure lessons learned are taken account of in this and future projects.
Hitachi-GE will work with future licensee to ensure that the appropriate knowledge is transferred from design and construction of the plant, ensuring that the future licensee can fully discharge its responsibilities under the Nuclear Site Licence and other regulations and legislation.

4.6.3 Knowledge and Information Transfer to the Licensee and Operating Organisation

Hitachi-GE will cooperate with the future licensee and ensure that design knowledge and information influencing safety and environment are communicated to the future licensee in a proper way, and its transfer is implemented in an acceptable manner. Hitachi-GE will have robust processes for transferring knowledge and the future licensee should have robust processes for managing it. The processes should be compatible and demonstrably effective. These assurances are demonstrated, for example, by the establishment of appropriate process, and the education and training of personnel.

Hitachi-GE has made suitable arrangements for communication of design information and knowledge transfer both during and post GDA, including as described by the procedure "Technology Transfer to Licensee and Operating Regime" [Ref-21]. This procedure defines the process to identify clearly the Assumptions, and Limits and Conditions for Operation from the safety case and the definition of Assumptions, and Limits and Conditions are discussed further in Section 4.12 of this chapter.

During GDA, Hitachi-GE designers identified Assumptions, Limits and Conditions for Operation (see also section 4.12) in the PCSR, Basis of Safety Case and Topic Reports. Then, operating documents that will be used in the operating phase were also identified so that the Assumptions, Limits and Conditions for Operation can readily be captured by the future licensee. (In terms of operating documents, please see the bullet point in section 4.2.2). Each Assumption, Limit and Condition for Operation in the safety case was registered and a unique identification number has been provided in a database system called 'AIRIS-Plus'. A comprehensive list of Assumptions, Limits and Conditions will be an available output from the database system. At the end of GDA, the contents of the database will be frozen to reflect the final GDA submission and will be identified in the master submissions list.

The Assumptions, Limits and Conditions for operation identified in GDA should therefore be captured in the subsequent site specific PCSR, and should be integrated into the future licensee's Operating Technical

Specification.

Further to this, the communication methods employed during GDA include a relationship with the future licensee as a part of the preparation and review process of documents related to safety and the environment. Moreover, it is considered beneficial that the future licensee is appropriately involved in the selection process of the design.

Hitachi-GE has been and will continue to assist the future licensee in making decisions based on valid information as an intelligent customer. The future licensee will have responsibility for the development of the site specific PCSR from the PCSR developed in GDA. Hitachi-GE will provide appropriate support and information to prepare technical explanations and justification with appropriate knowledge. These should be included in management arrangements of both Hitachi-GE and the future licensee.

Hitachi-GE is able to provide the future licensee with its knowledge gained from past experience and relevant good practice from around the world. Hitachi-GE has extensive experience on actual performance in design, construction, operation, maintenance, and decommissioning of BWR plants in Japan. This includes knowledge on plant resilience gained from the lessons learned from the accident at Fukushima Daiichi Power Plant due to the Great East Japan Earthquake. In order for the future licensee to benefit from this knowledge effectively, the management arrangements of Hitachi-GE enable a collaborative approach and exchange of information with the future licensee.

Hitachi-GE can support the future licensee to establish a credible Design Authority by means of a reliable transfer of knowledge and information including; design information, comprehensive capability training, and education programmes.

4.6.4 Design Authority

The future licensee is expected to have a Design Authority as is UK practice. The Design Authority normally holds the intelligent customer role whose purpose is to understand the design intent of the plant such that during future lifecycle stages it can understand the effects of proposed maintenance and modifications on the plant and its associated safety case. Hitachi-GE will work closely with the future licensee to ensure that knowledge is transferred to the future licensee's Design Authority at an early stage to allow the future licensee to discharge such obligations. Hitachi-GE, when appointed in the enduring role as responsible designer, will work through and with Design Authority. Hitachi-GE will support the future licensee in its duty to put in place a Design Authority and to supply the future licensee with necessary

design information. Hitachi-GE will also support the future licensee to manage any site specific changes against the generic design, within an agreed change control process. Knowledge Transfer is described in more detail in 4.6.3.

4.6.5 Documents and Records Control

The safety and quality for the UK ABWR will be assured and maintained by use of suitable documents and records throughout the Plant Lifecycle. Hitachi-GE will establish the control procedure to ensure that the set of plant documentation and records is complete and correct, and is delivered on time to the future licensee. These control procedures need to be accepted by the future licensee and to interface with the future licensee's management system.

4.6.6 Purchasing Control

Procurement of products and services are a highly important process in constructing a nuclear power plant. Hitachi-GE will be a Tier 1 supplier to the future licensee. The future licensee will have appropriate oversight of Hitachi-GE's purchasing control and acts as an intelligent customer.
Hitachi-GE will develop the site specific management system arrangements relating to the procurement of the products or services based on the GDA management system document Purchasing Control [Ref-22] established in consideration of nuclear safety, environment and security. Procurement that fully satisfies design requirement specifications will be attained by ensuring the control of suppliers in accordance with procurement processes such as; supplier evaluation and assessment, preparation of procurement specifications, witness inspection, receiving inspection, and verification. Hitachi-GE will instruct suppliers through procurement specifications to foster appropriate nuclear safety culture and will evaluate the effectiveness through audit activity.

4.6.7 Control of Non-conformance, Corrective and Preventive Action

Hitachi-GE establishes its quality management systems such that various measures including corrective actions can be implemented against non-conformances occurring in the design, manufacturing, construction and commissioning phases. The Control of Non-conformance, Corrective and Preventive Action for GDA [Ref-23] describes the process from identifying non-conformance, through the analyses, evaluation and necessary corrective and preventive actions. Design improvement and lessons learnt to eliminate the cause of potential non-conformance from other data sources will be taken into account through the preventive

action process.

The future licensee as intelligent customer will oversee the control of significant non-conformances, and the implementation of corrective and preventive actions. Site specific processes and procedures will be developed in collaboration with the future licensee and its management system.

4.6.8 Control for General Health and Safety

Hitachi-GE implements risk analysis in each design phase considering the whole Plant Lifecycle of the UK ABWR in order to meet requirements for safety, security and environmental protection. Safety in this context includes nuclear safety, conventional health and safety and fire safety.

Within GDA, Hitachi-GE has systematically carried out its risk analysis process to identify hazards, to control and mitigate the risks associated with those hazards with the aim of reducing the risks so far as is reasonably practicable. The risk assessments consider legislation and statutory requirements, regulatory expectations, UK practice, J-ABWR experience, international good practice and Operational Experience (OPEX).

Hitachi-GE has fulfilled its responsibilities as designer under the CDM Regulations 2015 within the scope of GDA. These arrangements are defined in the CDM Regulations 2015 Compliance Plan for Generic Design Activities [Ref-24]. The Compliance Plan is specifically written giving consideration to the provision of information for ongoing site specific design and construction planning. Design options are not foreclosed, but information is provided, allowing site specific designers and contractors to develop them further. A series of reports looking at specific areas of risk have been submitted during GDA to demonstrate understanding and implementation of the Compliance Plan, as described in the Topic Report of CDM2015 Compliance [Ref-25]. This information includes designers' hazard logs which record residual risks to be considered by the future licensee.

Beyond GDA, conventional health and safety and fire safety assessments will be progressed to the next level of detail as required in the site specific design stage. This will include further reviews of designs for identification of constructability, operability, maintainability and decommissioning hazards, risk assessments, option evaluation, application of principles of prevention and providing design information in accordance with the future licensee's project arrangements. Evaluation of options and risk assessments should confirm that the design has adequately addressed all the criteria for nuclear safety, conventional health and safety and fire safety, security and environmental protection and justified that the design

satisfies the ALARP principle.

It is normal practice in the UK for all parties to include the following related risk mitigation activities in their own company arrangements:

- Safety training, competence and induction
- Safety themes to raise awareness
- Safety briefings and toolbox talks
- Work Planning
- Risk Assessments, Method Statements and Safe Systems of Work established prior to work and operation activities
- Accident, near-miss and condition reporting and investigation
- Records keeping
- Workers health control, including; control of substances hazardous to health (COSHH), oxygen depletion, heat stress, display screen equipment (DSE), etc.)

4.7 Safety in the Design Phase

4.7.1 UK ABWR Features for Design

The UK ABWR is an advanced evolutionary reactor. The ABWR design was developed from a consortium of plant designers and utilities, which incorporated design improvements and modifications into the latest plant evolution. At each stage of the development, the ABWR design has been improved on grounds of safety. The design genesis of the UK ABWR is described in Safety Case Development Plan [Ref-17]. The features of the UK ABWR have been the result of the primary design objectives for the ABWR, which were:

- Improved safety with diversity,
- Improved operation and maintenance,
- Use of advanced technology,
- Reduction in construction time,
- Reduction in power generation cost,
- Minimisation of environmental impact,
- Reduction in worker radiological dose,
- Planned for safer decommissioning.

4.7.2 General

Hitachi-GE has suitable management systems for the design process which are certified to ISO 9001. The UK laws and standards such as the Energy Act 2013， Nuclear Installations Act 1965 (as amended) and the Licence Conditions must be considered in the design phase. Hitachi-GE has established a design process that controls design inputs and outputs in order to achieve appropriate; conventional safety, fire safety, nuclear safety, environmental protection and security throughout Plant Lifecycle . In the design of the UK ABWR, Hitachi-GE has sought to eliminate, reduce or mitigate exposure to harm from health and safety hazards during all phases of Plant Lifecycle and to ensure that the design is ALARP with respect to the UK regulatory expectations. Design decisions will be taken with the application of ALARP principles. Also, through the design, Hitachi-GE provides any necessary support to establish arrangements related to Security and Safeguards in order to protect the health and safety of the public and employees. Hitachi-GE configuration management arrangements make sure that the requirements are captured, such that the documentation and the physical plant are aligned at all times.

For the UK ABWR, UK regulations, British Standards, ISO, ASME, and IEC (International Electrotechnical Commission) Codes and Standards are applied in accordance with Categorisation and Classification of Systems, Structures and Components for ensuring safety of the design and the validity of quality. Applied Codes and Standards for Structural Integrity, Mechanical, Control and Instrumentation, Electrical Supplies, Civil Engineering, Resilience to Hazards including Seismic Design and Fire Protection and Quality Assurance are described in PCSR Chapter 5.8. General definitions of Categorisation and Classification of SCCs are described in PCSR Chapter 5.6.

Hitachi-GE has a well-established design review process [Ref-13, 26]. The designer performs design activities in a way that is consistent with the process for assuring design quality. Checking, approval and as appropriate verification and validation are carried out in the design process. The design process sequence and interaction, and technical and/or organisational design interfaces are clarified in a design activity plan and a design Process Quality Control (PQC). The process by which requirements are captured, documented and fed into the design phase is managed in the design PQC. The design review, design verification and design validation are implemented and recorded to confirm that the design meets the requirement. As technology provider, Hitachi-GE will be responsible for the detailed design that might not be finalised within GDA. The review and acceptance for this less mature design will be carried out through design verification and design validation. Hitachi-GE is also responsible for conducting the tests, the test results and any changes to be made to the design.

Hitachi-GE's ABWR plant design is appropriately assessed in the processes of preparing, checking, approving and verifying relevant documents, and is implemented by SQEP [Ref-14]. The designer has been appropriately educated and trained, and their professional competence is evaluated through this process.

Various review meetings and check sheets such as that in the PQC are utilised in order to avoid design mistakes resulting from human error or lack of awareness. The cultivation of a safety culture aims to reduce design mistakes by measures such as developing a questioning attitude and implementing STAR (Stop Think Act Review) activity.

4.7.3 Design Review

Hitachi-GE considers that it is important to establish all safety requirements related to manufacturing, construction, operation, maintenance and decommissioning during early phases of designing equipment or facilities. Design review is one of the major processes in establishing a safe and appropriate design. During

GDA, when a different material or a new technology not employed in the reference design or in the applied reference standards was considered, design departments adequately studied the purpose and implications of the proposed specification, both technically and for impacts on nuclear safety, health and safety, environment and security. This is to ensure the implications are fully understood, prior to the application of a design change. Design departments evaluated that the design satisfies such requirements at the appropriate design phase. There are two methods of conducting design reviews; (i) Line examination and (ii) Design review meetings. Line examination is conducted by a responsible engineer independent of the original designer, prior to the issue of the design documents as part of examining those documents. The responsibility for design review meetings lies with the General Manager or Senior Technical Staff Engineer of the design department. The design review method is selected based on the safety, environmental and security significance of the design. In design review, the following items are considered:

- Validity of design input selection.
- What are the potential hazards that workers may be exposed to and their risk severity.
- Adequacy and rationality of the assumptions of the design.
- Adequacy of the design technique and applicable laws, and the compliance to codes and standards such as the specified quality standard and consideration of how these can be applied in the UK with need for guidance, adaptation documents, etc.
- Impact on nuclear safety.
- The design input properly corresponding to the design document, and the appropriateness of its content.
- The compliance to the design procedure such as design PQC.
- Confirmation of design interfaces with the design interface organisation.
  (Other designers, constructors, operators and maintainers)
- How BAT will be utilised throughout the lifecycle of the plant (design, construction, commissioning, operation and decommissioning) to minimise the production and impact of radioactive wastes.
- Consideration of ALARP in the UK ABWR design in terms of Nuclear Safety.
- How the design has mitigated the workers' exposure to hazards to ensure the risk is ALARP.

4.7.4 Design Verification

Hitachi-GE implements design verification to prove that the design output duly satisfies the input requirements through the following methods in addition to the application of design review. A graded approach is applied for implementing design verification based on the significance of the SSCs.

- Implementation and evaluation of the verification test
- Evaluation of the results of calculations by comparison using a different formula
- Evaluation by comparison with a similar design with a proven record
- Evaluation in comparison with design input and the design review records
- Evaluation by comparison with the lessons learned from past experience of non-conformance or defects

4.7.5 Design Validation

Hitachi-GE implements design validation to ensure that the products duly fulfil the requirements complying with the designated or intended uses through the following methods.

- Inspection and test at Hitachi-GE's factory or at the supplier's facility
- Inspection, testing or commissioning at the site installation
- Model certification test for mass-produced products
- Document inspection (mainly if the documents account for the major part such as in laboratories)
- Computer simulation
- Periodical inspection

4.7.6 Design Change

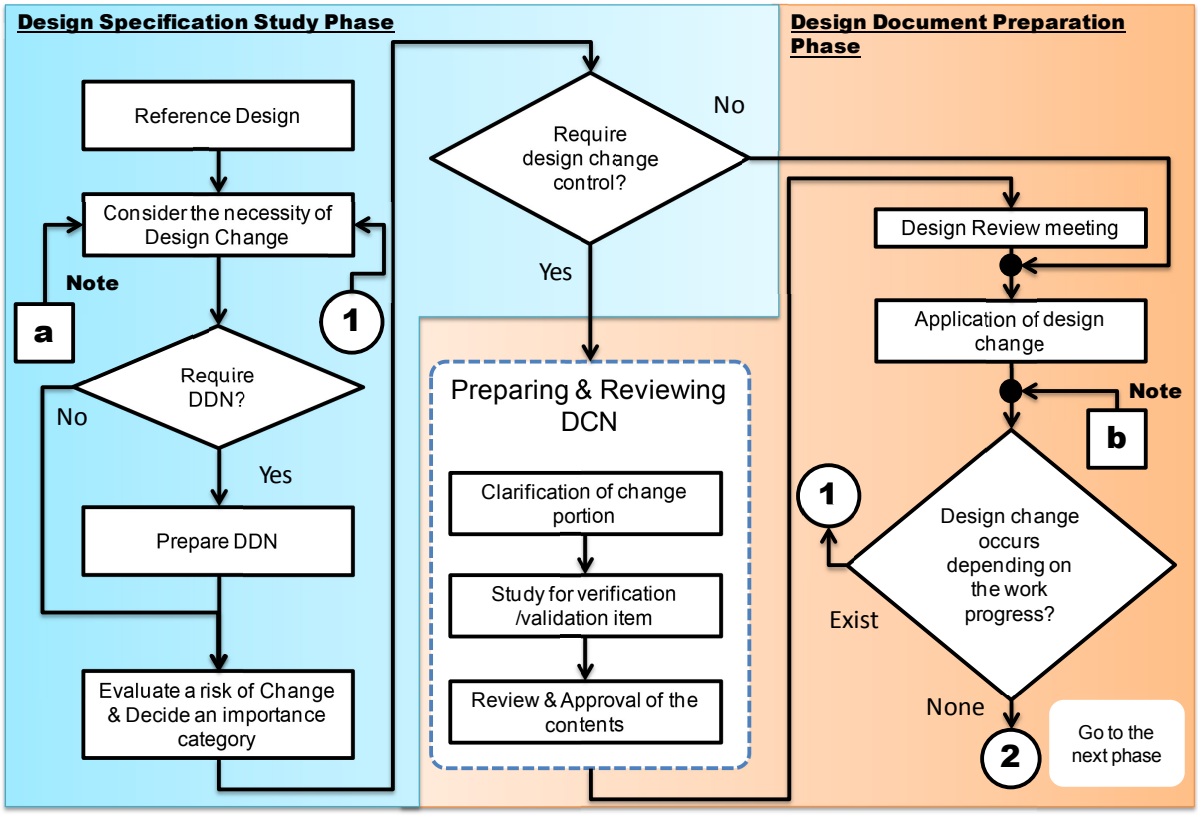
Hitachi-GE appropriately controls and evaluates the impact of any design changes that might have impacts on safety, the environment or security. Verification and checking of the validity of design changes is carried out by personnel independent from the individual responsible for the original design. Design changes are documented and communicated according to a defined systematic process [Ref-26]. The figure 4.7-1 shows an overview of the design change control process.

For the generic safety case, impact assessment was carried out on the design reference which is agreed between Hitachi-GE and the regulators as frozen. The point at which the design reference is frozen is denoted as the Design Reference Point (DRP). Hitachi-GE is responsible for controlling all subsequent design changes necessary during the GDA process by means of Hitachi-GE's design change control process [Ref-26]. In addition to this change control, interface between regulators is controlled by a six step process shown in the Figure 4.7-2. The starting point for use of the six step process is from DRP. The application of the six step process takes into consideration the safety, environment and security significance of the design change. It is anticipated that there will be similar processes required for controlling changes related to the

site specific safety case. Hitachi-GE is responsible for controlling design change during GDA, however, Hitachi-GE will enable the future licensee's Design Authority to have access to available information and to engage in the process, in support of their role as an Intelligent Customer. Hitachi-GE will make the arrangements to transfer to the future licensee, design changes accepted in GDA. The future licensee will be fully responsible for incorporating design changes into the site specific safety case.

The future licensee will require a configuration management process to control any changes to the baseline design. Hitachi-GE will work closely with the future licensee to ensure that the design is closely controlled and handed over to the future licensee in a controlled manner.

Although the ABWR was not originally designed with UK regulation in mind, it has been designed with appropriate regard to safety. During the GDA process, Hitachi-GE has worked closely with the future licensees and the regulators to demonstrate that sufficient consideration to health and safety aspects has been given during the design phase.



DDN: Design Difference Notice
DCN: Design Change Notice

Note

a: Design condition
- -Customer requirements
- -Environmental condition
- -Limitation of manufacturing/purchasing

etc.

b: Change of design condition
- -Requirements from regarding design section (Design Change Notification)
- -Supplier change request
- -Customer requirements

etc.

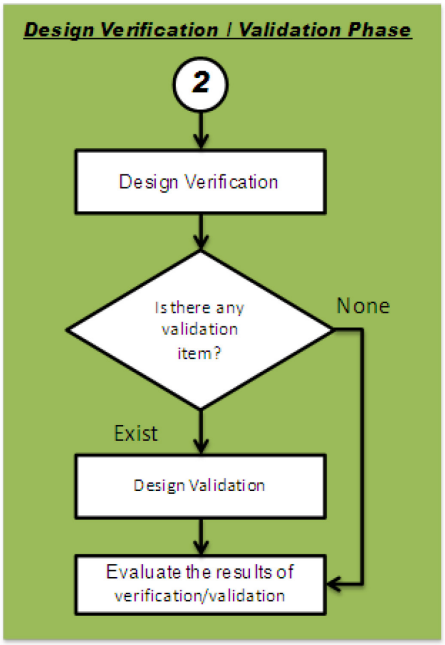


Figure 4.7-1: Design Change Control Process

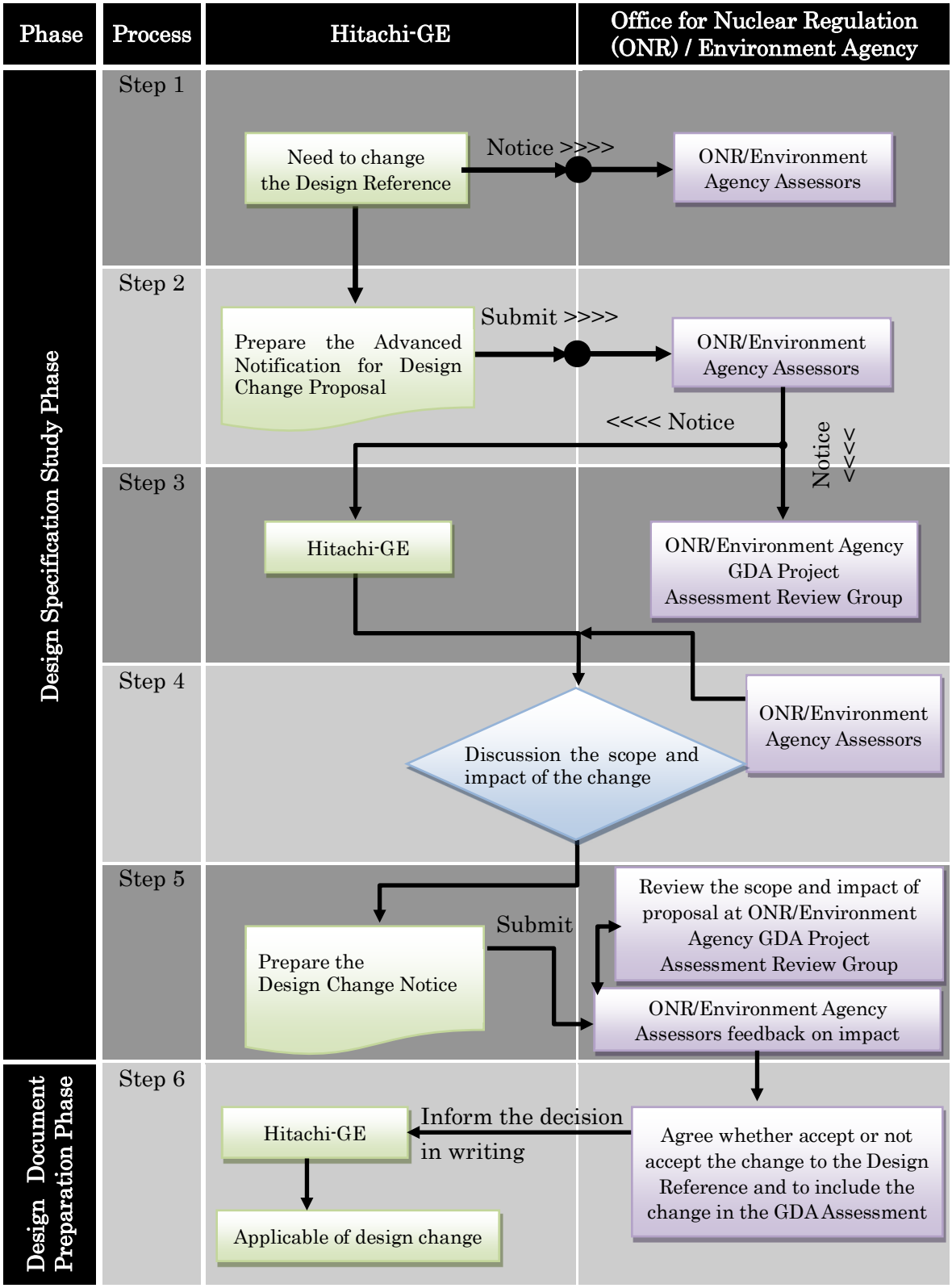


Figure 4.7-2: Workflow of the Six Step Process used after DRP during GDA

4.8 Safety in the Construction Phase

4.8.1 General

The construction of the UK ABWR is likely to be carried out by a consortium of companies appointed by the future licensee, and managed under a principal contractor. Hitachi-GE, as technology provider, expects to be appointed as a designer, manufacturer and supplier of some plant items. Therefore, for clarity within this document it has been assumed that Hitachi-GE will fulfil the role of responsible designer, within the scope of activities assigned by the future licensee. The future licensee should have arrangements to specify which contractors will be used for construction activities and have oversight of the selection process used by any Tier 1 contractor. Hitachi-GE will use suppliers which are certificated to ISO9001 and/or have been evaluated by Hitachi-GE and the future licensee to have a suitable quality management system. All suppliers will be assessed to confirm that they are suitably qualified to undertake the work and that they have adequate skills and knowledge to address health and safety, environmental and security requirements, attitude, training and UK experience, in order to be part of project team capable of successfully delivering a UK ABWR.

The responsibility for safeguarding safety, environment and security during construction lies with the future licensee but it will be supported by contractors, including Hitachi-GE. Licence condition arrangements should ensure that construction methods do not adversely affect the nuclear safety functional or design requirements of the finished works. Hitachi-GE will also support the establishment of suitable arrangements in order to protect the health and safety of the public and construction workers, and to protect the environment during construction using risk assessment and development of safe systems of work. Arrangements between Hitachi-GE, the future licensee and the principal contractor, and arrangements under the CDM Regulations will be described in detail in the Site Construction Phase Safety and Health Management Plan and Site Construction Quality Assurance Plan.

For the radiation protection of personnel during the construction period, the appropriate control processes for radiographic testing using radioisotopes and X-ray generators will be stipulated in the Site Construction Phase Safety and Health Management Plan. The control process includes the responsibility and authority for the radiographic testing and radiation protection advisors, organisation, designation of radiation control areas, radiation measurement, training and indoctrination, and records.

The construction of the UK ABWR should achieve the appropriate safety, environmental performance, security and quality by applying applicable codes and standards in accordance with the Categorisation and Classification of SSCs. This will apply to all processes of manufacturing, installation, testing and inspection. Each activity is implemented by competent persons in accordance with the specified procedures.

Hitachi-GE is able to support efficient plant construction in terms of safety and quality by using an Information Technology system which centrally manages and supports each activity during construction for; safety, construction schedule, work activities, testing and inspection. Hitachi-GE, the future licensee and the principal contractor will consider the site layout at different stages to ensure nuclear safety and worker safety are optimised during construction and later phases. Modular construction techniques are one of the options considered during GDA for the construction method. Modular construction techniques which include assembly and testing in a factory, can contribute to safety by shortening the construction time and reducing construction steps on the site. Hitachi-GE is able to cooperate closely with the future licensee during the construction phase in order to provide technical information to help prepare and develop the documents related to the safety case. This includes control of design changes, in accordance with the future licensee's arrangements for the modification to plant under construction.

4.8.2 Site Construction Phase Safety and Health Management Plan

The future licensee is expected, by having suitable construction project management arrangements in place, to define and evaluate the skills, knowledge, attitude, training and experience and organisational capability required for Hitachi-GE and other contractors involved in construction. During the construction phase the duties of a principal designer include providing pre-construction information to all contractors, and liaising and sharing information with the principal contractor. The principal designer is responsible for preparation of the health and safety file under the CDM Regulations. Hitachi-GE, other designers and contractors will provide sufficient information about the design, construction or maintenance of the structure, to adequately assist the principal designer, other designers and contractors in accordance with the future licensee's requirements. Hitachi-GE will coordinate the collection of information for the health and safety file from its own sub-designers and sub-contractors in accordance with arrangements specified by the future licensee.

The selected construction principal contractor will, with the support of the principal designer, prepare a construction phase plan describing how health and safety management arrangements will be implemented. The construction phase plan should include health and safety arrangements, site rules, and work specific control measures. The Site Construction Phase Safety and Health Management Plan should address project health and safety arrangements including;, arrangements for cooperation and coordination between project teams, arrangements for involving workers in planning, site induction, provision of welfare facilities and fire and emergency procedures.The selected principal contractor should provide training to all contractors on the construction site on the Site Construction Phase Safety and Health Management Plan.
The future licensee is responsible for the arrangements for the control and oversight of all activities on the

licensed site. It is for the future licensee to approve safe systems of work and to monitor health and safety performance, and for the contractors to develop and own their specific safe systems of work.

4.8.3 Quality Assurance Plan for Construction

The construction principal contractor should prepare the site construction quality assurance plan, which will reflect the overall quality assurance requirements of the UK ABWR site construction work to ensure that the requirements of the design are fulfilled. The site construction quality assurance plan describes the control procedures, for example; quality management system at site construction, management responsibility, operation and management of resources, product realisation (communication with the future licensee, provision of manufacturing or service, control of monitoring equipment and measuring equipment), measurements, analysis and improvement (monitoring and measurement, non-conformance control, corrective action etc.). The future licensee is responsible for reviewing and accepting the site construction quality plan before site construction starts.

4.8.4 Construction Verification Process

The construction of the plant must be controlled and completed such that the finished works fulfil the nuclear safety case. Planning and implementation of appropriate testing and inspection in the manufacturing and installation demonstrates or verifies that the plant meets the design intent and specification.

The required testing and inspection activities for items are defined in Quality Plans in accordance with the Categorisation and Classification of the SSCs and the relevant Codes and Standards. Internal hold points are set out as required for monitoring, in-process inspection and final inspection including acceptance testing of manufacturing and installation process. These internal hold point inspections assist in preventing any deterioration in quality from being carried forward to the next process and to ensure that no process steps have been missed.

The need for, and frequency of, additional witness testing and inspection by third party inspection agencies, the future licensee or regulators are agreed and included following consultation with the relevant parties.

Each process of manufacturing, installation, testing and inspection is carried out in accordance with the appropriate predefined procedures. The construction verification process, confirms how SSCs comply with the construction plan, and are manufactured and installed correctly in accordance with laws and regulations,

applicable codes and standards, and designer's instructions. This verification process is performed by competent persons, from a point of view of independence, such that testing and inspections are verified by individuals that are not directly involved in the manufacturing and installation itself. Verification records are documented and maintained for the specified appropriate period of time. The records should be transferred to the future licensee in accordance with future licensee's configuration management system requirements.

4.8.5 Control of Construction Works and Environment

In fabrication and installation phases of the UK ABWR, the principal contractor, supported by Hitachi-GE will control construction works and the environment to enable continuous, safe operation after the commissioning phase. Important working and environmental conditions to be controlled, which are assumptions in establishing safety, are given below. Specific controlling values, control procedures, maintenance procedures, frequency of application, etc. for such conditions will be determined and appropriately controlled in the construction phase in order to prevent product degradation and to preserve required operation safety functions.

- Prevention of contamination of equipment and piping (mixed foreign materials exclusion)
- Water quality for pipe cleaning, pressure testing, etc.
- Preservation of products (salt erosion prevention, temperature and humidity, dust and dirt)
- Correct storage and handling of all materials, including stainless steel, steel fabricated items, concrete mixes, reinforcing bar, waterproofing and coating finishes
- On site storage facilities for SSCs

4.8.6 Site Layout

The GDA site layout is based on a single unit of ABWR. Basic design and technical characteristics are detailed in PCSR Chapter 9: General Description of the Unit (Facility) Section 9.4 Facility Layout. Safety during construction has been considered during GDA, and Hitachi-GE has fulfilled its designers' responsibilities under the CDM Regulations.

Designers' risk assessments have been carried out in order to ensure that design of the UK ABWR has an appropriate plant layout so that safety and health of the public and workers, as well as the environment are protected during construction and later phases of commissioning, operation and decommissioning. Where practicable these risks have been resolved by the GDA design, and residual risks have been recorded to transfer to the future licensee.

During the site specific stage, Hitachi-GE is assumed to supporting the future licensee in optioneering of the final site layout to achieve the future licensee's operating regime. Other considerations in site layout design development are large crane locations, laydown areas, equipment movement routes for Abnormal Indivisible Loads, segregation of worker (pedestrian) and vehicle traffic, welfare facilities and fire-fighting provision. Hitachi-GE will use its construction experience from the J-ABWRs to support the future licensee.

4.8.7 Construction Schedule

It is important for the enhancement of safety and quality to establish an appropriate construction schedule before starting construction work, as well as to have a basic plan of installation such as an equipment delivery route plan. It is intended that Hitachi-GE will support the principal contractor to prepare and hence control the construction work schedule (master and sub master schedule) that shows the basic process of the construction work, and also establishes the construction techniques for major equipment. Testing and inspections which give a significant impact on plant safety and quality are identified and included in the construction process. These arrangements will be agreed with the future licensee. In addition, the final schedule and the proposed method of construction will be subject to acceptance of the Health and Safety Executive. It is assumed that Hitachi-GE will discharge duties of designers under the CDM Regulations, during development of the construction schedule.

The typical construction schedule for an ABWR is shown below. On average, civil works lasts approximately 30 months, construction 50 months and start-up phase, 12 months. Following an extensive series of commissioning tests and inspections, the plant is declared available for commercial operation. Hitachi-GE has incorporated lessons learned from over 25 years of construction experience of the ABWR to enable swifter, safer construction of plant. The use of modularisation and computer aided engineering has improved the efficiency of construction and has been proven on construction sites in Japan and Taiwan.

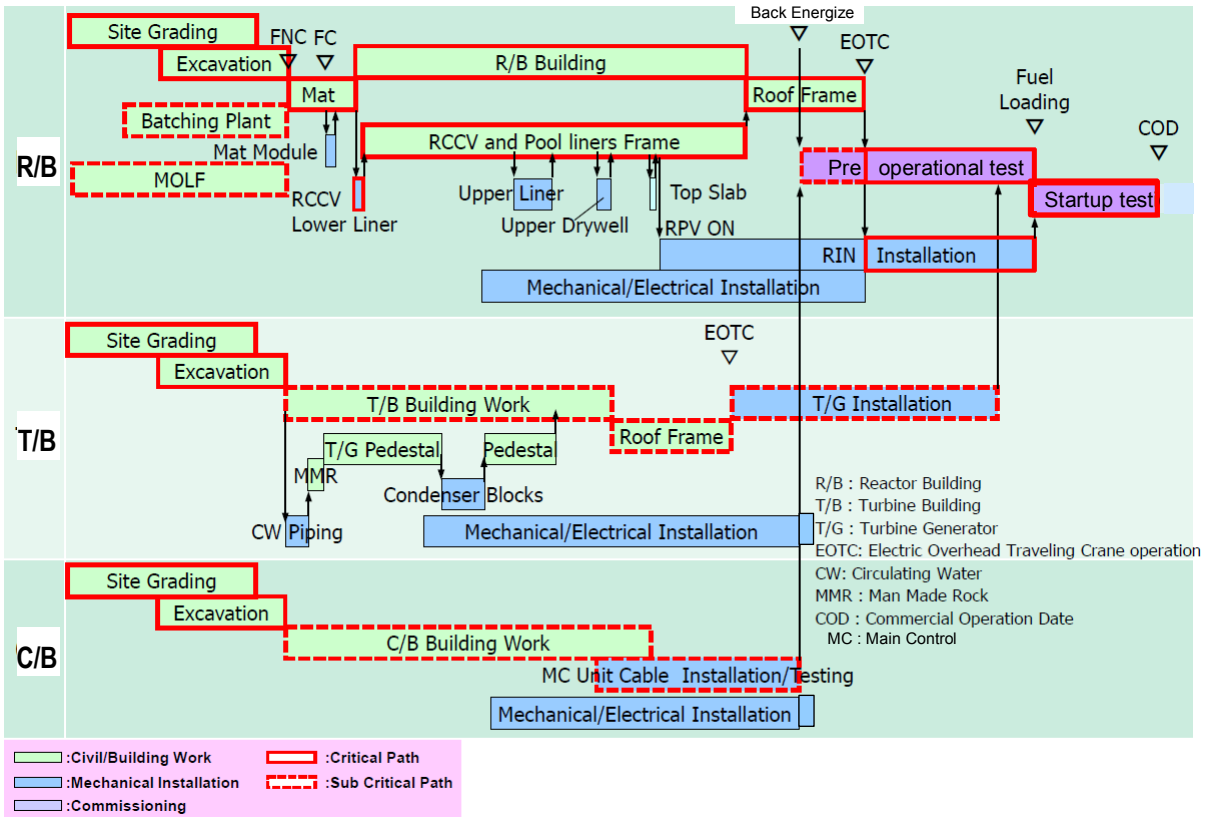


Figure 4.8-1: Construction Schedule

4.8.8 Modular Construction

The increasing use of modularisation ensures that components can be tested and inspected in module component factories rather than on-site, providing a more thorough means of inspection and testing. Adoption of appropriate construction methods such as modular construction has been evaluated for GDA considering UK laws and regulations in addition to evidence from past construction performance and experiences. This evaluation has demonstrated that modular construction has safety benefits and residual risks have been appropriately identified within GDA [Ref-27].

Modular design maximises the standardisation of work by using standardised components. In the design process, consideration is given for installation, maintenance and operation, including removal of equipment and parts or accessibility for replacement work. For the application of modular construction, a comprehensive management competence related to plant construction engineering, such as appropriate transportation controls, construction method using large cranes and just-on-time delivery, etc., is required. Hitachi-GE has considerable experience and knowledge in successful modular construction from previous construction project of nuclear power plants in Japan. During GDA design, Hitachi-GE has employed UK consultants to provide specialist advice in UK specific laws and regulations e.g. Lifting Operations Lifting

Equipment Regulations 1998 (LOLER), Hitachi-GE plans to continue using UK supplier frameworks to develop and deliver arrangements for the site specific design.

The advantage of applying modular construction to the UK ABWR is to maximise safety, quality, and work efficiency and minimise construction process and cost. A plant construction site is a less desirable working environment in comparison with a factory, and is likely to be affected by the weather. Construction work at the factory, where it is kept clean and equipped with bright lighting, reduces the potential for non-conformances related to safety and quality in comparison with normal construction work that does not apply modular construction. Moreover, modularisation facilitates minimisation of maintenance requirements during plant operation, and it is expected to result in good influences on both safety and quality.

Modularisation or pre-fabrication of plant and structures, also benefits conventional safety since it reduces the time spent by workers outside and can avoid risks such as working at height.
Regarding modular products manufacturing, installation and inspection, certain plans and specific procedures for each modular product would be established and implemented by SQEP in both Hitachi-GE and principal contractor organisations.

4.9 Safety in the Commissioning Phase

4.9.1 General

Arrangements for the commissioning of the UK ABWR have been addressed within GDA in PCSR Chapter 29: Commissioning. This section summarises the management of safety during commissioning which Hitachi-GE has considered within the GDA design.

Commissioning is the phase when the plant is able to receive power from an external source in order to carry out pre-operational tests and start-up tests on the plant. Construction work may still be progressing on the site when commissioning is undertaken.

Hitachi-GE has a suitable management system certified according to ISO 9001 for the commissioning, however, the responsibility for safety, environmental protection and security during commissioning of the UK ABWR lies with the future licensee. Appropriate arrangements are needed to reduce the risk of electrical issues, radiation hazards, fire hazards, conventional safety issues (for example, falls from height, and work in confined spaces, etc.), especially during the commissioning phase. Commissioning will be carried out in accordance with the future licensee's, Hitachi-GE's, and/or their partner's commissioning arrangements and procedures, which will be aligned for consistency. Furthermore, each activity will be performed according to the Site Construction Phase Safety and Health Management Plan and Site Construction Quality Assurance Plan as it is implemented during the construction phase. These arrangements will need to conform with the related requirements of the CDM Regulations including the appropriate handing over of the plant and supporting information to the operating organisation.

The future licensee will need to put in place a suitable safety case and a Pre-Commissioning Safety Report (or the relevant documentation) which justify that commissioning can be carried out safely. Furthermore, the future licensee should be in control of the site and have in place all arrangements to satisfy the 36 Licence Conditions prior to fuel arrival on site. Radiation protection after fuel loading should comply with the radiation control procedures established by the future licensee. These may be additional to the radiation control established during the construction period in the Site Construction Phase Safety and Health Management Plan, to further address matters such as; access control into controlled areas, waste disposition methods within those areas, and emergency measures.

During the Start-up Tests period, validation of plant design will include measuring; dose equivalent rate related to external radiation within the plant, surface concentration of contamination and concentration of

radioactive materials in the air.

Only when the function of many systems, equipment and facilities of the nuclear power plant are available, can its performance and safety functions be demonstrated. In the commissioning phase, Construction Tests, Pre-operational Tests, and Start-up Tests are carried out in order to ensure function, performance, structural integrity and safety of all equipment, facilities and systems. Each test is performed in accordance with the relevant test plan and supporting procedures. Each test plan describes procedures in detail for the proper testing system, implementation of testing and the administrative control of testing. Data and results of testing are documented and kept for an appropriate period of time to ensure safety and quality of the plant during operation and maintenance. Moreover, changes made to the design at this time are properly controlled and managed by the future licensee.

An appropriate testing schedule is required in the commissioning phase in order to enhance safety and quality. This schedule should be controlled by a quality management process to minimise the occurrence of unexpected work, omission of tests, or abortive works and tests and ensure that appropriate standards of safety and quality will be achieved.

4.9.2 Pre-operational and Start-up Test

Pre-operational testing will be conducted using Hitachi-GE's and its partner's management arrangements. The next stage of commissioning is start-up testing and this begins after all SSCs have been handed over to the future licensee. The handover will be carried out by either the future licensee's witness or record review. At this point the future licensee's safety arrangements and permit to work systems are applied. The future licensee's operators are responsible for the direction, control and management of the receipt of nuclear fuel and the subsequent start-up testing.

4.9.3 Commissioning Schedule

Commissioning is normally controlled by establishing a suitable test schedule and a control plan, such as personnel distribution before starting commissioning work. Based on the construction work schedule (Master and Sub-master schedule) as stated in Section 4.6.7, Hitachi-GE will support the future licensee, in proper management to achieve efficient and safe test operations in commissioning.

4.10 Safety in the Operational Phase

4.10.1 General

The operating phase is discussed in more detail in PCSR Chapter 30: Operation. This section summarises the management of safety in the operational phase which Hitachi-GE has considered within GDA.

The arrangements included in the GDA design for the safe operation of the UK ABWR are adequate and appropriate to be taken forward by the future licensee. Information related to plant safety established during site specific phases of design, construction and commissioning will need to be incorporated into the future licensee's start-up operational arrangements. Hitachi-GE, in the role of responsible designer, is assumed to supporting the future licensee by ensuring that these arrangements are suitable and acceptable by the UK regulators.

Safety management of the UK ABWR during operation will be the responsibility of the future licensee, in accordance with the 36 Licence Conditions, the Nuclear Installations Act 1965 (as amended) and other applicable legislation and regulation. The future licensee is responsible for protecting the public, operators and the environment from the hazards arising from ionising radiation and other potential hazards arising from the UK ABWR. In addition to being a nuclear site future licence holder, the future licensee will be responsible for complying with all other applicable laws and regulations in the UK.

For radiation protection and radioactive waste control during the operational period, the future licensee will establish appropriate processes and apply them in accordance with the documented procedures. This will include controls for conservation areas and environment surveillance areas surrounding the sites. The technical information produced and assessed for radiation protection and radioactive waste control during GDA will be transferred to the future licensee and for incorporation its safety management system.

In the operational phase, appropriate arrangements are established by the future licensee for management of plant operation, shutdown, and maintenance, as well as emergency preparedness. These arrangements are expected to be in the integrated management system including Operating and Maintenance Instructions based on risk assessment, and Work Authorisations. The management of hazards should consider the maintenance (requirements, strategy and plans, etc.), operation (rules and instructions), safety operation envelope and training. The future licensee maintains necessary control procedures including items to be implemented in the operation of nuclear power plant, implementation policy of training to employees, as well as the safety regulations that describe the fundamental items required for safety of the nuclear power plant.

The design basis for the UK ABWR manning levels and training requirements is provided in Human Factors Evaluation. It is the responsibility of the future licensee to ensure that these requirements are met or to justify otherwise under the terms of the future licence. All of the staff that perform or supervise operations critical to safety should be suitably qualified and experienced. The future licensee will be responsible for the training programmes for operational staff, with assistance from Hitachi-GE where appropriate. Procurement of simulators and other training products is the responsibility of the future licensee.

The list of bounding design basis faults for UK ABWR is provided in the GDA faults schedule (See PCSR Chapter 24: Section 24.4). Hitachi-GE is assumed to providing the operating organisation with necessary information for safety and stable plant operation in accordance with the requirements of the site license. This will be achieved through use of the Operating Technical Specifications, maintenance manual, and emergency manual, etc. Operational documents will need to consider requirements from the safety case for all faults/ hazards and normal operations.

4.10.2 Operating Envelope of the Plant

The UK ABWR has been designed to operate within an operating envelope, an example of which, related to pressure, is shown diagrammatically below in Figure 4.10-1. Operation within the envelope ensures safety through multiple barriers, providing defence in depth during normal operations. These barriers constitute layers of protection, all of which must be breached in order to constitute the potential for a breach of one of the multiple fission barriers.

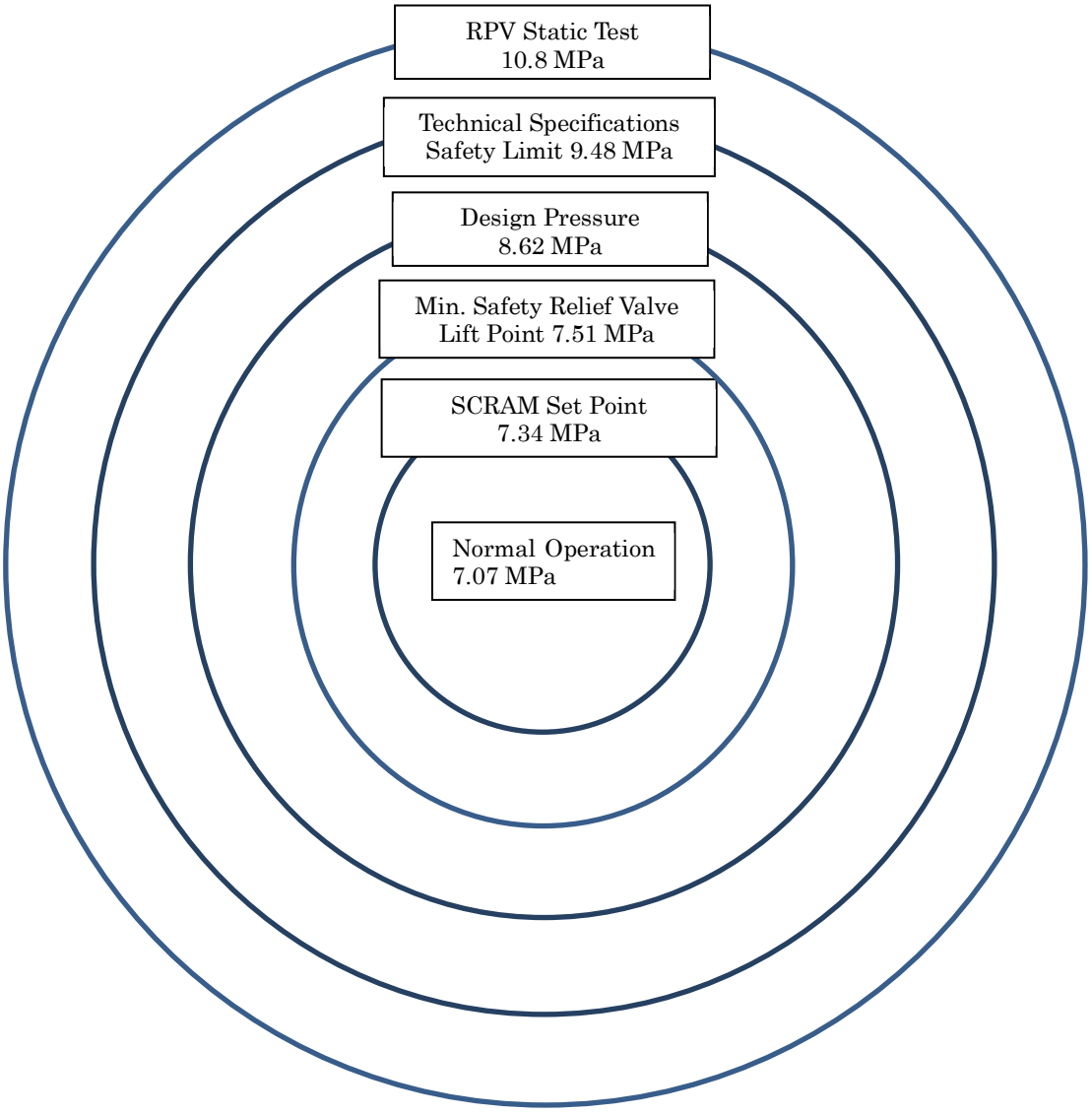


Figure 4.10-1: Operating Envelope of the Plant

In the example highlighted above, operators and the control system maintain the Reactor Pressure Vessel (RPV) at or around its normal operating pressure of 7.07 MPa. This is accomplished through the design of the plant (e.g. through the use of control systems) and operator procedures. Should the pressure increase above the SCRAM (Reactor Emergency Shutdown (Safety Control Rod Insertion)) set point of 7.34 MPa, the Safety System Logic Control System will SCRAM the reactor, shutting down the fission reaction and allowing operators to take action to address the cause. This SCRAM set point is well below the design pressure of 8.62 MPa which in turn is below the RPV hydrostatic test pressure (10.8 MPa). This defence in depth approach ensures that the plant operates within a safe envelope.

4.10.3 Use of Operating Technical Specifications and Procedures, Verification and Validation

The UK ABWR is designed for use with Operating Technical Specifications which are used in the majority of BWR units worldwide. In GDA, Hitachi-GE has produced a set of Generic Technical Specifications [Ref-28] and these should be used by the future licensee to develop its Operating Technical Specifications that encompass the equipment condition, limits, operating rules and requirements from the design basis accidents postulated within the safety case fault schedule. The Operating Technical Specifications should ensure that the assumptions and requirements in the safety case are maintained at all times during all mode of plant operation (such as refuelling, start-up, power operation and shutdown). Requirements for surveillance testing and inspection of plant during operation are also described in the Operating Technical Specifications. Further information on Assumptions, Limits and Conditions for Operation are given in section 12 of this chapter.

Operating Technical Specifications currently exist for both the J-ABWR and US-ABWR and these may be modified in consideration of Generic Technical Specifications following the GDA process for the UK ABWR. Training will be carried out for the future licensee in the Operating Technical Specifications and Operating Technical Specifications Bases as part of knowledge transfer from Hitachi-GE.

Hitachi-GE will provide the basis of procedures to the future licensee for operating the UK ABWR and the procedures themselves will be completed by the future licensee. These may also be modified by the future licensee to incorporate risk assessments for the required tasks and to ensure compliance with applicable UK health and safety legislation. Examples of such procedures are:

- Operation procedures
- Maintenance procedures

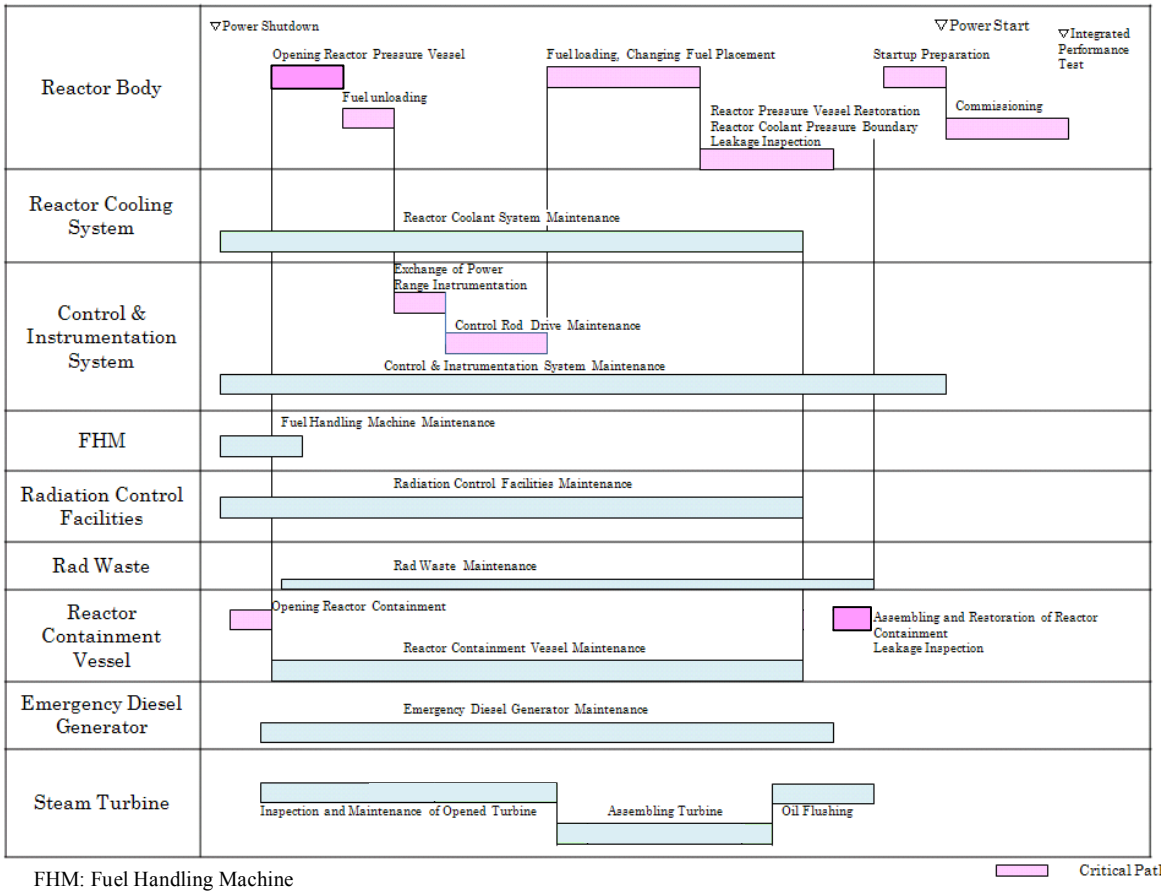
- Periodic inspections procedures
- Emergency operations procedures (symptom and event based)

The validity of these procedures is verified by existing ABWR plant operating experience, use of full scope simulators, and the BWR preventive maintenance technology centre. The BWR preventive maintenance technology centre is the facility owned by Hitachi-GE equipped with simulated models of actual plant equipment. Its capability enables the training of workers to carry out; maintenance of reactor pressure vessel and reactor internals, repairs, development of replacement technology, and the handling/checking of various equipment.

4.10.4 Maintenance and Outage Overview and Schedules

The nuclear site licence and other health and safety related legislation define requirements for maintainability and inspectability. Periodic inspection is carried out while stopping the reactor operation at fixed intervals (typically during refueling outages) in order to ensure the structural integrity of the reactor and its attached facilities and the turbine body and its attached facilities. The typical sequence of refueling outage for ABWR is shown in Figure 4.10-2. This inspection is intended to prevent accidents and failures, to minimise its degradation, and also aims for the safe and stable operation of the power plant to supply sustainable electricity. Hitachi-GE has considered such principles throughout the design stages of the UK ABWR to ensure the easy maintenance, testing and inspection of plant and systems.

Hitachi-GE has considered maintainability and inspectability throughout the design stages of the UK ABWR to ensure ease of maintenance, testing and inspection of plant and systems whilst reducing radiation exposure and thus improving plant safety and reliability. Hitachi-GE will provide the future licensee with the requirements of maintenance for systems and components by the production of maintenance manuals.



FHM: Fuel Handling Machine

Figure 4.10-2: Typical Sequence of Refueling Outage of ABWR

4.11 Safety in the Decommissioning Phase

4.11.1 General

Arrangements for the decommissioning of the UK ABWR have been addressed within GDA in PCSR Chapter 31: Decommissioning. This section summarises the management of safety during decommissioning which Hitachi-GE has considered within the GDA design. The future licensee is responsible for creating a decommissioning safety case and evaluating its impact on the environment.

The responsibility for safety, environment and security management during plant decommissioning lies with the future licensee. The future licensee's safety management arrangements specify control procedures for decommissioning in order to reduce to a safe and reasonable level the risk of radiation exposure to public. In the UK, future licensee is required to have a Funded Decommissioning Plan prior to start-up.

Designers and contractors involved in the plan and work for decommissioning of the UK ABWR would seek for continued improvement as an entire organisation by applying the management system for quality, safety, environment and security as defined in IAEA GSR Part 2 [Ref-2], ISO9001 [Ref-3], OHSAS18001 [Ref-6] and ISO14001 [Ref-5]. The risks for decommissioning will be analysed and minimised / mitigated especially from the point of view of preventing radiation exposure to the personnel engaged in the decommissioning.

The elements of the work, presented below, can be regarded as generic to decommissioning for the UK ABWR. Designers and contractors respectively involved in the plan and work for decommissioning would establish a decommissioning plan and implement appropriate safety management for these works.

- Post Operation Clean Out (POCO)
- Fuel Management
- Site Operation and Plant Preparation
- Management of Radioactive Wastes
- Plant and Reactor Decommissioning

Methods for the decommissioning would be planned by selecting the current technology that can minimise radioactive wastes and the impacts on the future environment within the range as low as reasonably practicable. Application of relevant technologies on material selection and chemical decontamination would be considered in order to reduce radiation doses to the personnel engaged in decommissioning. At this GDA phase, BAT and ALARP approaches, based on the current technology are considered for the purpose of minimising impacts on the environment and the amount of radioactive wastes. The BAT case

will be reviewed periodically until the time of actual decommissioning. Documents related to decommissioning technology would be reviewed and assessed by relevant qualified Radioactive Waste Adviser (RWA) and Radiation Protection Adviser (RPA), not only from the viewpoint of compliance with the regulatory expectations but also from that of BAT and ALARP.

4.11.2 Management before Fuel Transportation from the Reactor

Operational management relevant to the fuel facility is applied for the period that the fuel is transported from the reactor to the Spent Fuel Pool, where it is cooled and stored. In the case that the reactor is to be completely de-fuelled, application of operational management related to the reactor core such as Reactor Shutdown System, Emergency Core Cooling System, function of primary containment equipment, would not be necessary. Requirements related to operational management would be applied, mainly limited to Spent Fuel Pool cooling, Emergency Diesel Generator, and repair and maintenance. The future licensee would be responsible for analysing the risks at each stage of decommissioning activities, ensuring to maintain the security of facilities and workers. Until the reactor fuel is transported out of the plant facility, an equivalent level of management would be required for security and radiation control as is required during the operation. Also, the same management is applied to the temporary fuel pooling and on-site spent fuel movements.

4.11.3 Management after Fuel Transportation from the facility

After all the fuel has been transported out of the plant facility, management systems for demolition work within the controlled area would be applied, while radiation control would still be continued as appropriate. Disposal of radioactive wastes would be planned by monitoring radiation dosage so that impacts on the environment will be minimised as much as practicable.

4.11.4 Application of New Technology

Application of new technology to decommissioning would be considered at the time when such technology becomes practical by evaluating BAT and ALARP so that technology transfer will be executed to operators and decommissioning designers, ensuring minimisation of impacts on the environment.

4.11.5 Record Control for Decommissioning

The future licensee is required by the nuclear site licence to retain the relevant design and construction documents until the completion of the decommissioning. The future licensee should also ensure it retains the records of any reconstruction / modifications performed during the operating life of the plant and to consider and control them in an appropriate way not to adversely affect decommissioning work.
Hitachi-GE, as responsible designer, is assumed to support the future licensee in appropriate record control.

4.12 Assumptions, Limits and Conditions for Operation

4.12.1 Limits and Conditions for Operation

This section provides a definition of Assumptions, Limits and Conditions for Operation. The process of identification of Assumptions, Limits and Conditions for Operation and transferring them to future licensee is described in section 4.6.3 in this chapter.

The safety case presented in this PCSR demonstrates that the UK ABWR can be operated in a manner that meets the following objectives:

- relevant regulations are complied with
- dose-risk targets given in the NSEDPs are met
- risks to the public and workforce are ALARP

To ensure that these objectives are met not just in theory but also by the operating plant, the future licensee must operate the plant in a manner that is consistent with the safety case. To ensure this, Limits and Conditions for Operations (LCOs) are defined throughout the safety case in order to define the operating envelope in which the safety case remains valid. For GDA, it is assumed that the future licensee will operate the plant within this operating envelope (noting that the future licensee has the option of revising the safety case to justify a different operating envelope). LCOs are of a number of types, however all LCOs should be measureable:

- LCOs that define the initial conditions of faults analysed in Fault studies, Probabilistic Safety Analysis (PSA), Beyond Design Basis Analysis (BDBA) and Severe Accident Analysis (SAA)
- LCOs that guarantee the delivery of Safety Functions
- LCOs that maintain accident doses within limits

4.12.2 LCOs that define the initial conditions of faults analysed in Fault studies, PSA, BDBA and SAA

The fault analyses described in this PCSR presuppose starting conditions corresponding to normal operation. Normal operation is defined in terms of the operating mode and the corresponding values (or range of values) of important system parameters, and the fault analyses start from these values (or worst case values within the bounds of the definition of normal operation). These values are defined as LCOs.

Therefore, in commercial operation, these parameters need to be kept within the range defined by the LCOs

as, otherwise, the safety case would be invalidated. If any parameter goes outside the prescribed range then corrective action will need to be taken within a prescribed timescale to meet the LCO.

The exact parameters to be designated to have LCOs are outside the scope of this Chapter but are likely to include some or all of:

- Reactor power
- Neutron flux
- Primary pressure and temperature
- Reactor water level
- Core flow rate
- Radwaste inventories
- SFP water level and temperature

4.12.3 LCOs that guarantee the delivery of Safety Functions

The fault assessments presuppose the availability of a certain number of safety systems, usually a minimum of one division of each system. The analysis also presumes single failures, again usually of one division of each system. These presuppositions lead to the Safety Property Claims derived from the NSDEPs [Ref-1] that, for example standby on-demand Class 1 systems have N+2 redundancy and standby on-demand Class 2 systems have N+1 redundancy.

In operation, the maintenance of the required availability for safety systems will place constraints on, for example, which systems may undergo planned maintenance or testing during specific operational modes or what action must be taken in what timescale if a system is discovered to be in a failed or degraded state during testing. These factors will lead to LCOs being defined to ensure the required availability. Such LCOs may be of a simple form such as “System ABC must be operable in modes X and Y” or more operational such as “Only one division of system ABC must be tested or maintained at any one time regardless of mode of operation”.

LCOs that guarantee delivery of safety functions may also specify minimum performance requirements for the systems that deliver those functions, which must be confirmed by specified surveillance requirements to ensure that parameters that control the delivery of the safety function are within prescribed limits. Such LCOs may be of the form “testing of system ABC must ensure that flowrates are greater than x m^3/h” or “the temperature of the water in tank ABC must be greater than x °C and less than y °C”.

Again, if any of the corresponding systems fall outside the limits set by the LCO for any reason, the operators must restore the system to the defined operability within a prescribed timescale.

4.12.4 LCOs that maintain accident doses within limits

There are a small number of events that form part of the safety case, usually those where the initiating event involves the loss of a barrier to radioactive release, where correct delivery of safety functions cannot prevent some release of radioactivity. Examples are some loss of coolant events or spills in the Radwaste systems. For these events to meet dose-risk targets it may be necessary to impose additional LCOs to those guaranteeing the delivery of safety functions in order to limit releases. Such LCOs may be of a form limiting inventories of radioactive materials in the corresponding systems.

Again, if any of the corresponding parameters fall outside the limits set by the LCO for any reason, the operators must restore the system to within the defined limit within a prescribed timescale.

[Ref-29] gives the procedure for the identification of LCOs. Many LCOs are also identified as generic Technical Specifications in [Ref-28].

4.12.5 Assumptions

Almost every part of the safety case has assumptions, that is, design details, material data, operating conditions or other information that form part of the basis of the assessment but are taken for granted and often presented without justification or evidence, and which are vital to the understanding and justification of the assessment.

For example, it is assumed throughout the PCSR that the design is as in the design reference without any further justification; It is assumed that the reactor will be fuelled with a particular type of fuel that is defined in Chapter 11: but assumed elsewhere; in most of the analysis, it is assumed that the reactor is operating at 100 percent design power without any further justification.

Assumptions do not have the same force as LCOs in that they do not defined the operating envelope in which the safety case is valid, although an assumption in one chapter may be an LCO in another. Unlike an LCO, an assumption does not have to be measureable. For example, the design of the Emergency Core Cooling System (ECCS) is described in Chapter 13, where it is assumed that the design is as given in the design reference and that the system is maintained according to the maintenance schedule. However, the requirement that only one division of ECCS is under testing or maintenance at any one time is a LCO in Chapter 24: as there is a requirement that one division is available for each initiating event where it is claimed.

Anything that forms part of the Claim-Argument-Evidence (CAE) structure for a SSC is not an assumption. [Ref-29] gives the procedure for identifying assumptions.

4.13 Conclusions

It is important that management arrangements are in place to ensure safety and environmental protection through the nuclear power Plant Lifecycle. This chapter has described Hitachi-GE's generic safety management arrangements which are proposed to ensure that the required levels of nuclear safety, environmental protection and security will be delivered throughout the lifetime of the UK ABWR. This includes the safety management arrangements to ensure that the UK ABWR is appropriately designed and then operated and maintained in accordance with the safety case. Responsibility for safety on a future licensed site and for safe operation and management of the UK ABWR in accordance with the safety case will rest with the future licensee.

This chapter has identified the safety management arrangements that have been applied during GDA to ensure that the UK ABWR design is of appropriate quality and those arrangements required to ensure nuclear, environmental and security safety will be maintained throughout the lifetime of the UK ABWR. The future licensee can develop its arrangements in-line with the fundamental principles and philosophy that is set-out in this chapter and is embedded in the GDA design.

This chapter has described the management arrangements for the UK ABWR design process that have ensured an appropriate design has been achieved in GDA that eliminates, reduces or mitigates exposure to health and safety hazards during all phases of Plant Lifecycle and ensures that the design reduces risks so far as is reasonably practicable. This includes the processes of design review, design verification and design validation and also covers the arrangements for control of design change.

The safety and quality philosophy for the UK ABWR has been described together with the integrated management system and supporting procedures that will be required to implement the safety policy at each phase of design, procurement, manufacturing, installation, commissioning, operation, maintenance and decommissioning. It also describes how to introduce this policy contributes to developing and cultivating the nuclear safety culture.

Hitachi-GE's construction experience and safety record demonstrates the progress that has been made in conventional and radiological safety and how learning has been included in the development of the UK ABWR design. Hitachi-GE's role in the construction phase as responsible designer and manufacturer, supplier of plant items and understanding of duties under the CDM regulations has also been described. The arrangements for the safe management of commissioning, operation and decommissioning have also been described.

The relationship between the PCSR and GEP-RSR has been described. PCSR chapters that are closely related to the GEP-RSR have been identified, and the arrangements in place to ensure consistency between the GEP-RSR and PCSR submissions have been described.

Appropriate arrangements to support the future licensee have been identified including the strategy to transfer knowledge and information from the GDA safety case to a future licensee. This includes arrangements for identifying the Assumptions, Limits and Conditions for operation from the GDA safety case, together with the arrangements for: support to the future licensee's Design Authority; control of documents and records; purchasing control; and management of non-conformances and corrective actions.

In summary, this chapter has shown, at an appropriate level of detail for a GDA PCSR, how the identified management arrangements will contribute to reducing risks so far as is reasonably practicable during each of the stages of the UK ABWR lifecycle (i.e. design, construction, commissioning, operations and decommissioning). Further work will of course be required post GDA phase to fully develop site specific management arrangements. This work will be the responsibility of any future licensee.

4.14 References

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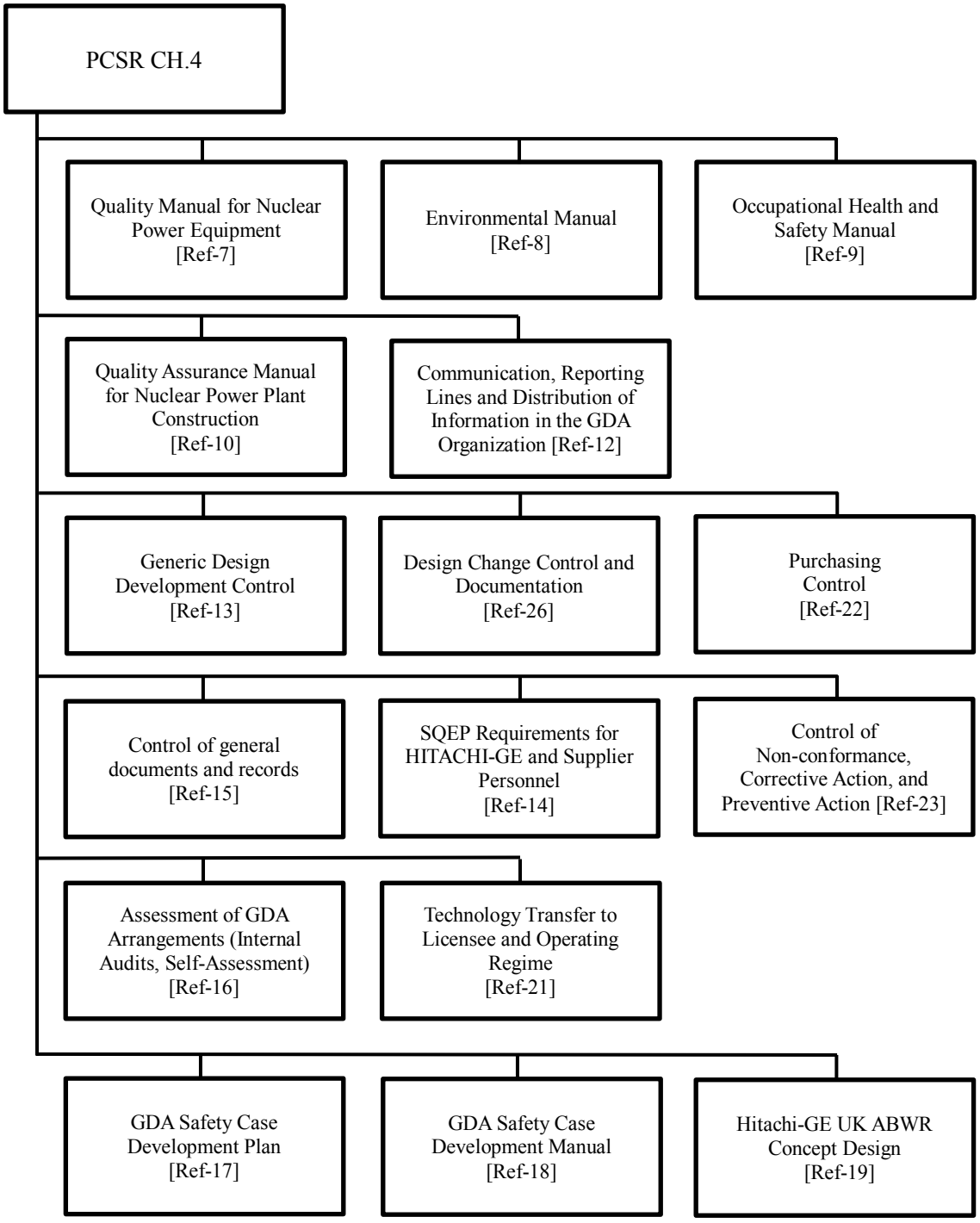
[Ref-31] ONR, "Technical Assessment Guides"

Appendix A: Document Map



Appendix B: List of Specific Legal Requirements

In the UK regulatory system, the future licensee is required to comply with the nuclear site licence and the attached 36 Licence Conditions through appropriate arrangements. A fundamental legal requirement in the UK is the Health and Safety at Work Act 1974. Specific legal requirements for radiation protection are included in The Ionising Radiations Regulations 1999. Other appropriate laws and regulations include but not limited to:

- The Management of Health and Safety at Work Regulations 1999
- The Control of Major Accident Hazards Regulations 1999 (COMAH)
- Nuclear Installations Act 1965
- The Construction (Design and Management) Regulations 2015
- The Energy Act 2013
- Environmental Permitting (England and Wales) Regulations 2010
- Environmental permitting (England and Wales) (Amendment) Regulations 2011
- Anti-terrorism, Crime and Security Act 2001
- Nuclear Industries Security Regulations 2003

It is a legal requirement that applicable legislation is complied with.

For safety management of nuclear facilities, the future licensee is expected to address the good practices stated in the following publications by IAEA and UK regulatory agencies:

- The Management Systems for Facilities and Activities (GSR Part2)[Ref-2]
- ONR Safety Assessment Principles (SAPs)[Ref-30]
- ONR Technical Assessment Guides (TAGs)[Ref-31]