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UK ABWR

Document ID	:	GA91-9101-0101-04000
Document Number	:	QGI-GD-0008
Revision Number	:	A

UK ABWR Generic Design Assessment

Generic PCSR Chapter 4 : Safety Management throughout Plant Lifecycle

Hitachi-GE Nuclear Energy, Ltd.

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4.1 Introduction

This document indicates the safety management arrangements in order to ensure that safety and environmental protection will be achieved throughout the Plant Lifecycle of UK ABWR. With Hitachi-GE's motto of "Giving priority to health and safety in all activities", plant safety is achieved through design based on Hitachi-GE's safety and quality policy. It results in high standards of safety and quality at each phase of construction, commissioning, operation, and decommissioning; in addition, it ensures that the plant is properly operated and maintained within safety limits. Hitachi-GE will share knowledge and information with the Licensee, to provide a safe and high quality nuclear power plant.

In the UK regulatory system, the Licensee shall conform to the Nuclear Site License and the 36 Attached Site Licence Conditions through appropriate arrangements. A fundamental legal requirement in the UK is the Health and Safety at Work etc. Act 1974. Specific legal requirements for radiation protection are included in The Ionising Radiations Regulations 1999. Other equivalent laws and regulations are as follows:

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 2007

The requirements of above regulations and their relevant statutory provisions shall be complied with.

For safety management of nuclear facilities, it is required to address in a good practice stated in the following publications by the International Atomic Energy Agency (IAEA) and UK regulatory agencies:

- The Management Systems for Facilities and Activities (GS-R-3)[Ref-1]
- HSE Safety Assessment Principles (SAPs)[Ref-2]

4.2 Hitachi-GE's Safety and Quality Philosophy

4.2.1 Hitachi-GE's Safety and Quality Policy

Hitachi-GE has established the safety and quality policy as an objective for the organisation and employees to achieve nuclear safety at all phases of the Plant Lifecycle, which is the basis of quality management. The safety and quality policy is established as an absolute commitment in the organisation to continue raising awareness of safety. Accordingly, it is aimed that introducing its policy to the entire organisation contributes to cultivating the nuclear safety culture.

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

1. We recognize that achievement of nuclear safety is an integral part of our corporate social responsibility. With this acknowledgment, we ensure compliance with regulations, strive to keep cultivating our nuclear safety culture and always act in a way that places the highest priority on ensuring nuclear safety.
2. It is our principle that Safety always comes first followed by Quality, Schedule/Delivery and finally Cost/Budget. We always act in full compliance with this code of conduct.
3. We understand that it is of the upmost importance that our work processes are identified/clarified; that the processes and results are monitored; and the records are maintained/reviewed. We are committed to, by so doing, ensuring full transparency of our work and implementing continual improvement in our work processes.
4. We recognize that colleagues are also our "internal customers" in that they are involved in the work process and wait for the work to be completed. With this realization and by observing the requirement of the Quality Management System (QMS), we ensure that required processes are properly executed and our work is accurately completed as specified. We are committed to, by so doing, implementing our work processes to ensure that all products and services conform to the requirements.

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

4.2.2 Cultivation of a Safety Culture

The cultivation of a safety culture is being promoted according to "The Management Systems for Facilities and Activities (GS-R-3) [Ref-1]". In promoting the cultivation of a safety culture, consideration is given to the 14 items from a) to n) below in order to prevent deterioration of the safety culture and the organisational culture, as well as to keep achieving and maintaining good safety and quality.

a) Commitment to top management
b) Clear-cut principles and implementation by top management
c) Policy of avoiding erroneous decision-making
d) The attitude of always asking questions
e) A culture of reporting
f) Good communication
g) Accountability and transparency
h) Compliance
i) A learning organization
j) An organization working to prevent accidents, breakdowns, and other incidents
k) Self-evaluation or third-party evaluation
l) Work control
m) Change control
n) Attitude and motivation

The Nuclear Systems Quality Assurance Management Department Manager is responsible for performing activities for cultivation of the safety culture. The main activities conducted to achieve nuclear safety as the foundation of quality management are described in Table 4.2-1 Activities for Cultivation of a Safety Culture, but are not the only activities conducted. This activity status will be part of the input information for management review by senior management.

Table 4.2-1 : Activities for Cultivation of a 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 (once a term)
2	Meetings to promote thorough implementation of 'the basics and the right way'.	To raise awareness about compliance and penetrate the company with engineering ethics.	Every month (13^{th} day)
3	Learning about preventive ethics.	To give training on good judgment.	Once a year
4	Safety awareness questionnaire.	To monitor how well the safety culture has been achieved and identify any signs of safety culture deterioration.	Once a year
5	Compliance activities.	To cultivate programs and an atmosphere for addressing compliance issues.	As appropriate

4.2.3 Hitachi-GE's Management System

Hitachi-GE has established a Quality Management System based on ISO9001 and IAEA GS-R-3, an Environment Management System based on ISO14001, and a Quality Management System based on ASME Code Section III.

The specific content of Hitachi-GE's philosophy is detailed in the Quality Manual for Nuclear Power Equipment (HI-ISO-21)[Ref-3], Environment Manual (HI-ISO-02)[Ref-4], ASME Manual (HQA-0002) [Ref-5] and these supporting procedures in order to implement its philosophy at each phase of design, procurement, manufacturing, installation, testing, inspection, commissioning and maintenance. In addition, all activities for the UK ABWR project performed by Hitachi-GE are conducted centring on the Quality Manual for Nuclear Power Equipment (HI-ISO-21) [Ref-3] 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 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 [Ref-3] and illustrated below:

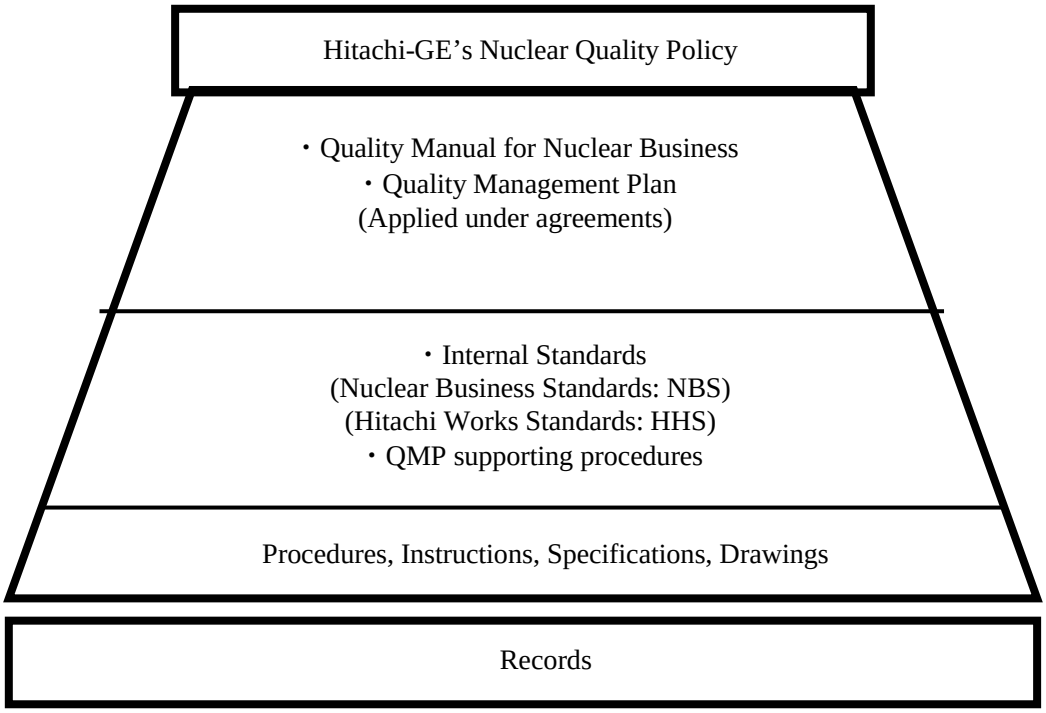


Figure 4.2-1 : Hitachi-GE's Management System

The Quality Assurance and management system arrangements for GDA have been established at the end of step 1 in the Quality Management Plan (QMP) for UK ABWR GDA Project [Ref-6]. 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-7], which describes how the production of important safety case documents like this PCSR are controlled; review, independent verification and approval. Role profiles and competency evaluations ensure that Suitably Qualified and Experienced Persons are responsible for the delivery of the GDA project. The QA arrangements for GDA and the production of the PCSR will ensure that the UK ABWR will be built as designed.

Hitachi-GE has prepared a matrix document to demonstrate compliance with the GDA guidance requirements during GDA step 3 and step 4. The QMP and its supporting procedure will be reviewed and updated accordingly during GDA step 3 and step 4.

4.3 Hitachi-GE Construction Experience and Safety Record

Hitachi-GE obtained the certification of ISO 9001 in 1999, and has been engaged in many nuclear power projects while continuously improving the management system. Hitachi-GE has over 40 years' worth of experience in the 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's involvement in the Japanese ABWR program is shown below:

Table 4.3-1 : Hitachi-GE Construction Experience

ABWR	Nuclear Island Supplier	Turbine Island Supplier
Kashiwazaki-Kariwa 6	Other	Hitachi
Kashiwazaki-Kariwa 7	Hitachi	Other
Hamaoka 5	Other	Hitachi
Shika 2	Hitachi	Hitachi
Shimane 3	Hitachi	Hitachi
Ohma 1	Hitachi	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 onsite work and increase safety and quality on the jobsite. Shimane 3 in western Japan is Hitachi-GE's latest completed ABWR. The personnel safety record for Shimane-3 is shown below:

Table 4.3-2 : Summary of Occupational Accidents at Unit 3 of Nuclear Shimane Site

Fiscal Year Note 1	Case without lost workdays		Lost Workdays Case		Fatal Accident		Work Hours (hr) at Hitachi-GE
	W/O LWH Cases	Incidence Rate Note 2	LWH Cases	Incidence Rate Note 2	FA	Fatal Rate Note 2	
2007	0	0.00	0	0.00	0	0.00	331,856
2008	2	1.54	0	0.00	0	0.00	1,298,587
2009	3	0.98	0	0.00	0	0.00	3,069,498
2010	5	1.73	0	0.00	1	0.35	2,890,372
2011	0	0.00	0	0.00	0	0.00	472,132
2012	0	0.00	0	0.00	0	0.00	561,557
2013 Note 4	0	0.00	0	0.00	0	0.00	99,006
SUM Average	10	1.15	0	0.00	1	0.11	-

Note 1: Fiscal year start from April to next March
Note 2: Rate and Work Hours are accumulated by Hitachi-GE only
Note 3: Fatal rate = Fatal accidents / Work Hour* 1,000,000
Note 4: In FY 2013, Counted April to June Only.
Note 5: The cases exclude Heat Stroke

4.4 Safety Management Framework

4.4.1 Responsibility for Hitachi-GE's Safety Management

Hitachi-GE establishes the organisation and the system to implement effective safety 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. However, responsibility for safety management during plant operation and final decommissioning lies with the Licensee. The most important aspect of safety management is to harmonise the management arrangements between Hitachi-GE and the Licensee in an effective way so that the Licensee is able to fulfil the responsibility for safety in the nuclear power station. Safety in each phase of the Plant Lifecycle or the responsibility for activities affecting the environment are clarified in the coordinated management arrangements for both Hitachi-GE and the Licensee.

Hitachi-GE assumes responsibility for providing practical technical information required for preparing a site specific PCSR and environmental report. Hitachi-GE will continue to assist the Licensee during the Plant Lifecycle, as required, to ensure that the Licensee is able to satisfy requirements for safety and the environment. In addition, Hitachi-GE can advise and support the Licensee during plant operation. Hitachi-GE is active in sharing operational experience and knowledge as well as knowledge gained from the electrical power industry in Japan to help ensure lessons learned are taken account of in future projects.

4.4.2 Responsibility for Licensee's Safety Management

Safety arrangements for the Licensee will be defined as part of their compliance with the Nuclear Site Licence Conditions and other regulations. Compliance arrangements for these from the Licensee will detail how the Licensee intends to achieve safety through areas such as training, quality assurance and management and organisational systems. Hitachi-GE has similar arrangements and Hitachi-GE will work with the Licensee to ensure that the appropriate knowledge is transferred to the Licensee prior to operation of the plant, ensuring that the Licensee can fully discharge their responsibilities under the Nuclear Site Licence and other regulations and legislation.

4.4.3 Knowledge and Information Transfer to the Licensee and Operating Organisation

Hitachi-GE will cooperate with the Licensee and ensure that design knowledge and information influencing

safety and environment are communicated in a proper way, and its processes are implemented in an acceptable manner. These assurances are demonstrated, for example, by proper process establishment and education and training to personnel.

Communication of design information and knowledge during the GDA process is implemented systematically, including preparation of procedures. One of the communication methods during the GDA is to have a relationship with the Licensee as a part of the preparation of documents related to safety and the environment and as a part of the review process. Moreover, it is considered beneficial that the Licensee is involved in the selection process of design.

Hitachi-GE assists the Licensee to make decisions based on valid information as an intelligent customer, and supports the operating organisation to gain the relevant permits. In addition, if the Licensee explains to the regulators regarding changes, Hitachi-GE provides any support and information to prepare theoretical explanation and reason with appropriate knowledge. These are included in management arrangements of both Hitachi-GE and the Licensee.

Hitachi-GE is able to provide the Licensee with their knowledge gained from past experiences and recent evidence from around the world. Their knowledge was gained from the lessons from the accident at Fukushima Daiichi Power Plant due to the Great East Japan Earthquake, and from a wealth of experiences based on actual performance in design, construction, and operation of BWR plants in Japan. In order for the Licensee to take advantage of knowledge effectively, the management arrangements of Hitachi-GE are enabled to raise attention for content related to safety or the environment by exchanging information with the Licensee. Moreover, the management arrangements of Hitachi-GE include the requirements that permits the Licensee's participation in discussion or forums and permits access to Hitachi-GE's knowledge.

Hitachi-GE supports the 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.

4.4.4 Design Authority

The Licensee will have a Design Authority whose purpose is to understand the design intent of the plant such that during future lifecycle stages of the plant, the Design Authority retains the knowledge to understand the effects of proposed maintenance and modifications on the plant and its associated safety case. Hitachi-GE will work closely with the Licensee to ensure that knowledge is transferred to the Licensee's Design Authority at an early stage to allow the Licensee to discharge such obligations. Knowledge Transfer is described in more detail in 4.4.3.

4.4.5 Control of Non-conformance, Corrective, and Preventive Action

Hitachi-GE establishes the quality management system such that various measures including corrective action can be implemented against non-conformances occurring in the design, manufacturing, commissioning and later phases. Control of Non-conformance, Corrective Action, and Preventive Action [Ref-8] describe the process from identifying non-conformance through analyses, evaluation and necessary corrective and preventive action. Design improvement and lessons learnt to eliminate the cause of potential non-conformance from other data sources will be taken into account through preventive action process.

4.5 Safety in the Design Phase

4.5.1 UK ABWR Features for Design

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 development, ABWR designs have improved on safety and economics. The design genesis of UK ABWR is described in [Ref-9].UK ABWR features have come about from the primary design objectives for 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.

4.5.2 General

Hitachi-GE has designed UK ABWR to minimise risk during all phases of operation and to ensure that the design is ALARP with respect to the UK regulatory framework. Also as for plant operation management, Hitachi-GE provides any supports to establish necessary arrangements related to Security and Safeguards in order to protect the health and safety of the public and employees through the design.

For UK ABWR, UK regulations, British standards, ISO, ASME, and IEC Codes and Standards in are applied in accordance with Categorisation and Classification of Systems, Structures and Components (SCC) for ensuring safety of the design and the validity of quality. Applied Code and Standards and general definitions of Categorisation and Classification of SCC are described in PCSR Ch.5.

Hitachi-GE has a well established design review process [Ref-7, 10]. The Designer conducts a design activity that is consistent with the process for assuring design quality. Checking, approval and if necessary, verification are carried out in the process of design activity. If the design process sequence and interaction, and technical and/or organisational design interfaces are needed, they are clarified properly in the design activity plan and the design Process Quality Control (PQC).

Hitachi-GE's ABWR plant design is suitably graded in all process of preparing, checking, approving and verifying relevant documents, and implemented by suitably qualified and experienced persons (SQEP) [Ref-11]. The Designer has been trained properly, and their professional competence is evaluated through an appropriate process.

Various review meetings and check sheets such as PQC are implemented in order to avoid design mistakes resulting from lack of human awareness. In the safety culture cultivation activity, it aims to reduce design mistakes by means of measures such as questioning attitude and STAR activity.

4.5.3 Design Review

Hitachi-GE considers that it is important to establish all safety requirements related to manufacturing, construction, operation and maintenance during earlier phases of designing equipment or facilities. Design review is one of the major processes to achieve establishment of safety. When a different material or a new technology not employed in the reference design or in reference standards is to be considered, the design department shall adequately study the purpose and implications of the proposed specification, both technically and for impacts on nuclear safety to ensure they are fully understood, prior to the application of a design change. The design department shall evaluate that the design satisfies such requirements at the appropriate design phase. There shall be two methods of conducting design reviews; (i) Line examination and (ii) Design review meetings. Line examination shall be 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 of the Design department. In design review, the following items are considered:

- Validity of design input selection
- Adequacy and rationality of the assumptions of the design
- Adequacy of the design technique and applicable laws, and the compliance to code and standards such as the specified quality standard.
- 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.
- How BAT will be utilized throughout the lifecycle of the plant (design, construction, commissioning, operation and decommissioning) to minimise the production and impact of radioactive wastes.

4.5.4 Design Change

Hitachi-GE controls design changes properly that might have impacts on safety and the environment, and evaluates their impact. Verification and checking of the validity of design changes are 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.

For the generic safety case, impact assessment is carried out on the design reference which is agreed between Hitachi-GE and the regulators as frozen. The frozen point of design reference is denoted as the Design Reference Point (DRP). The starting point of change control is from DRP. Hitachi-GE is responsible for controlling all subsequent changes necessary during the GDA process by means of Hitachi-GE's design change control process. The same process is required for controlling changes related to the safety case. The figure of the next page shows the overview of the design change control process.

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

Although the ABWR was not designed with British regulation in mind, it has been designed with safety in mind. During the GDA process, Hitachi-GE will work closely with the Licensees and the regulators to demonstrate that sufficient consideration has been given during the design phase to safety. Examples of this include the consideration of and mapping to the Construction, Design and Management Regulations 2007, the Confined Spaces Regulations, 1997 and the Control Of Substances Hazardous to Health regulations 2002.

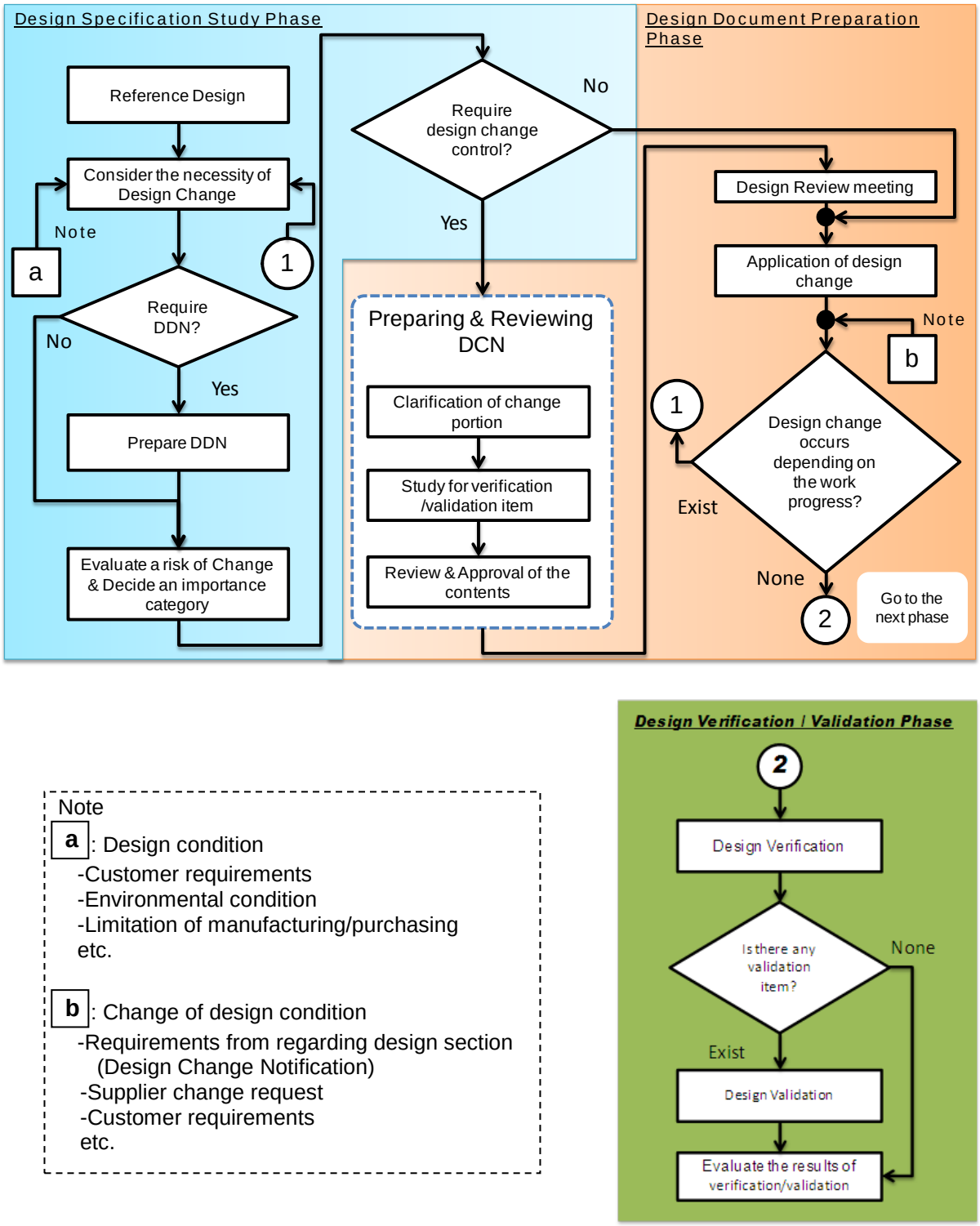


Figure 4.5-1 : Design Change Control Process

4.6 Safety in the Construction Phase

4.6.1 General

Construction of UK ABWR will be performed by a consortium involving Hitachi-GE. Hitachi-GE will use suppliers which are certificated to ISO9001 and/or which have been evaluated by Hitachi-GE as suitably qualified and experienced contractors with UK experience to help successfully deliver UK ABWR.
The responsibility for protecting safety and the environment during construction lies with Hitachi-GE under the supervision of the Licensee. The highest standards of nuclear safety quality management principles and systems will be used to ensure that safety functional and design requirements are fulfilled during the construction phase. Hitachi-GE establishes proper arrangements in order to protect the health and safety of the public, subcontractor employees, and Hitachi-GE's employees, as well as to protect the environment during construction. Arrangements between Hitachi-GE and the Licensee are described in detail in the Basic Plan of Site Construction Safety and Health Management and Site Construction Quality Assurance Plan. In addition to this, Hitachi-GE assures that this arrangement fully conforms to the Construction Design and Management Regulations 2007.

The construction of UK ABWR secures safety and quality by applying codes and standards in accordance with the Categorisation and Classification of Systems, Structures and Components in each activity process of manufacturing, installation, testing and inspection. Each activity is implemented by SQEP in accordance with suitably specified procedures.

Hitachi-GE is able to implement efficient plant construction in terms of safety and quality by using an Information Technology system which centrally manages and supports each activity during construction regarding safety, construction schedule, work, testing and inspection. Hitachi-GE and the Licensee have optimised the plant layout and the method of construction that enables the ability to secure worker safety and nuclear safety during construction and later phases. Modular construction techniques which enable assembly and testing in a factory as much as possible are applied. This approach contributes to safety by shortening the construction process and reducing construction steps on the site.

Hitachi-GE cooperates closely with the Licensee during the construction phase in order to provide technical information to help prepare and develop the documents related to the safety case. In accordance with the Licensee's arrangements for the modification to plant under construction, Hitachi-GE properly controls design changes during the construction in the same manner as applied to that at the design phase.

4.6.2 Basic Plan of Site Construction Safety and Health Management

Hitachi-GE issues the Basic Plan of Site Construction Safety and Health Management to protect health and safety of the public, employees of contracting companies and Hitachi-GE employees during construction and trial operation. In this plan, it specifies control procedures such as the safety and health management system, work plan and training for workers, risk assessment, disaster countermeasures (falling/crushing, deficiency of oxygen, electrical hazards and fires/explosion), identification of hazardous work, prevention of radiation hazard, and accident report and analysis.

4.6.3 Quality Assurance Plan for Construction

Hitachi-GE prepares the site construction quality assurance plan, which is related to the overall quality assurance of UK ABWR site construction work to ensure that the requirements of the design are fulfilled. This 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 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.).

4.6.4 Construction Verification Process

The required plant safety is built in the construction phase. Planning and implementation of appropriate testing and inspection at manufacturing and installation phase enables to achieve its safety establishment.

Testing and inspection plan and items are clarified in the Quality Plan in accordance with Categorisation and Classification of Systems, Structures and Components and Codes and Standards Report. Moreover, the frequency of witness testing and inspection by the regulators, the Licensee, or third party are considered and categorised after making adjustment with them.

Each process of manufacturing, installation, testing and inspection is carried out in accordance with appropriately predefined procedures. Therefore, in the Construction Verification Process, it describes how plant structures, systems and components (SSC) 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 SQEP. In addition to that, from the point of view of independence; testing and inspections are verified by the person in the department who is not

directly related to manufacturing and installation. These records are documented and maintained for an appropriate period of time.

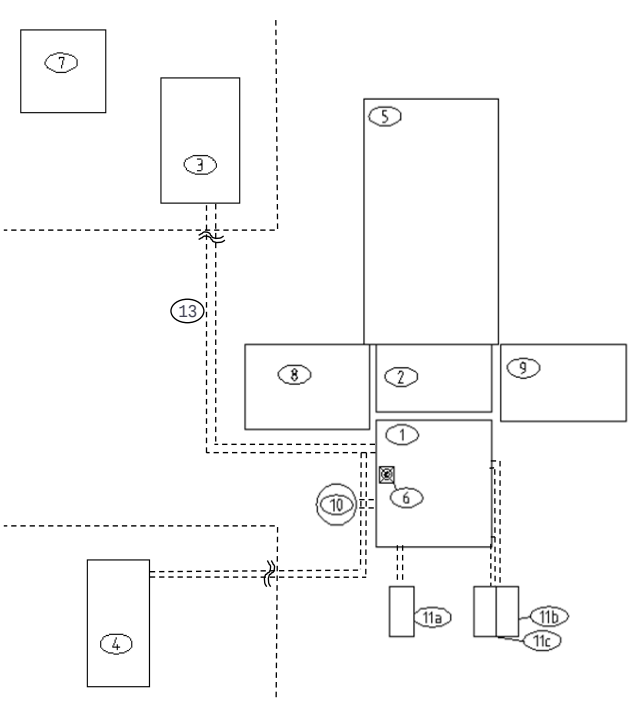
In the Construction Verification Process, an internal hold point is set out as required for monitoring, in-process inspection and final inspection including acceptance testing of manufacturing and installation process. These internal hold point inspections make it possible to prevent any deterioration in quality from being carried forward to the next process and to monitor if any important process step is missing or has been skipped.

4.6.5 Site Layout

UK ABWR applies an appropriate plant layout so that safety and health of public and workers, as well as the environment are protected during construction and later during each phase. Basic design and technical characteristics are detailed in Chapter 9 of the PCSR; but on the assumption of a risk factor in each building, it is basically designed in consideration of the following items:

- To ensure enough evacuation routes in the event of a disaster.
- To secure an easy access to the route for rescue in the event of a disaster.
- To secure layout or space so that installed equipment is readily and safely operated, inspected, and maintained.
- To secure enough space and delivery routes for removal and replacement of equipment.
- To secure sufficient lay-down area for equipment.

The diagram below shows a generic layout for an ABWR unit. It should be noted that this is an indicative layout and licensing and site specific requirements may change the layout from that shown below.



This drawing illustrates conceptual site plan and not intended to show final exact location of the structures.
Structures NOT included in the GDA scope

No.	FACILITY
1	REACTOR BUILDING
2	CONTROL BUILDING
3	HEAT EXCHANGER BUILDING
4	BACKUP BUILDING
5	TURBINE BUILDING
6	MAIN STACK
7#	CIRCULATING WATER STRUCTURE
8	RADWASTE BUILDING
9#	SERVICE BUILDING
10	CONDENSATE STORAGE TANK (CST)
11	LIGHT OIL STORAGE VAULT
12#	SPENT FUEL STORAGE FACILITY
13	RCW TUNNEL

Figure 4.6-1 : Site Layout

4.6.6 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. Hitachi-GE prepares and controls 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.

The typical construction sequence 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 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. 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.

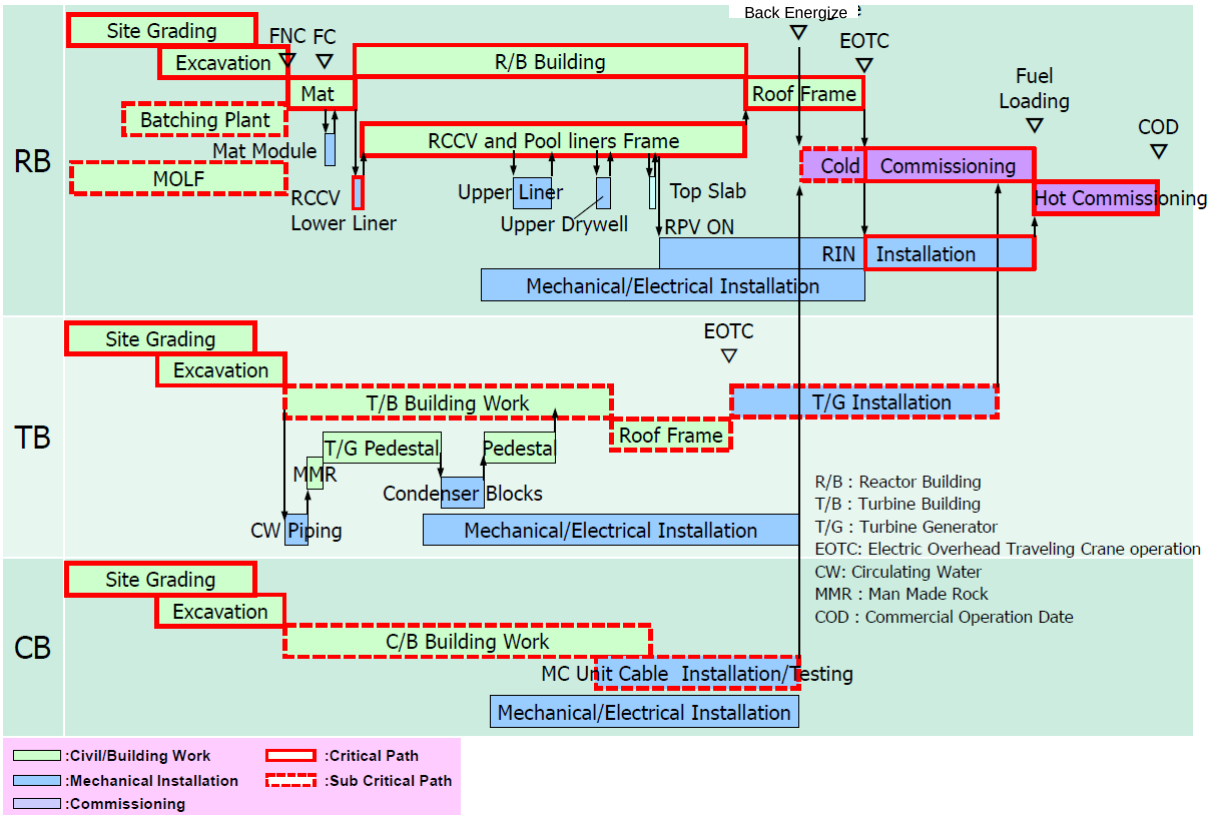


Figure 4.6-2 : Construction Schedule

4.6.7 Modular Construction

Modular Design maximises the standardisation of work by using standardised components. In the design process, it is considered for installation, maintenance, operation including removal of equipment and parts or accessibility for replacement work. The advantage of applying modular construction to 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, for example, less occupational radiation exposure and the enhancement of plant safety.

4.7 Safety in the Commissioning Phase

4.7.1 General

When entering into the phase when the plant is able to receive power from an external source to the station boards while plant construction work progresses, each system of the plant is handed over to the commissioning organisation in a prescribed manner. Responsibility for safety and environmental protection during the commissioning of UK ABWR lies with the Licensee. Appropriate arrangements are needed to reduce the risk of electrical issues and radiation hazards, especially during the commissioning phase. Commissioning will be carried out in accordance with the Licensee's commissioning arrangements and Hitachi-GE's commissioning procedures. In this phase, Hitachi-GE's arrangements will be aligned with the Licensee's. Furthermore, each activity is performed according to the Site Construction Safety and Health Management and Site Construction Quality Assurance Plan as it is implemented during the construction phase. Hitachi-GE ensures that this arrangement conforms with the related requirements of the Construction Design and Management Regulations 2007 including the appropriate condition of handing over the plant from the commissioning organisation to the operating organisation.

Only when the function of many systems, equipment and facilities of the nuclear power plant are available, can its performance be demonstrated, and the safety of the nuclear power plant demonstrated. In the commissioning phase, Electrical Instrumentation 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 by SQEP 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, operation control of testing (including safety management, chemical/radiation control). Each test during the commissioning phase prior to fuel load is performed by Hitachi-GE according to the instructions from the Licensee according to the start-up test plan defined and agreed between Hitachi-GE and the Licensee. 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 Design Authority.

Hitachi-GE considers that it is significant to formulate and perform an appropriate testing schedule in the commissioning phase in order to enhance safety and quality. In this phase, by means of the Information Technology system that enables central management of each operational process, Hitachi-GE reduces the occurrence of unexpected work, omission of testing, and backtracking work, and this also supports both safety and quality.

4.7.2 Electric Test and Control & Instrumentation Test

Electrical Instrumentation Testing is carried out in order to demonstrate that the sequence of the electric tests on each piece of electrical machinery and apparatus and the calibration of test equipment comply with laws and regulations, applicable codes and standards, and designer's instructions. The Electrical Instrumentation Test is firstly classified as electric test or control and instrumentation test, and then performed in accordance with the Electric Instrumentation Test Plan.

4.7.3 Pre-operational Test

Pre-operational Test is carried out in order to demonstrate that the overall function of each system or equipment per unit satisfies the required performance in accordance with laws and regulations, applicable codes and standards, and designer's instructions.

4.7.4 Start-up Test

Start-up testing is carried out in order to demonstrate and achieve safe and stable plant operation. Start-up testing is also used to collect operating data for testing and monitoring purposes for future operation and maintenance. Start-up testing is divided into start-up tests and plant performance tests. The Licensee's safety arrangements and permit for work systems are applied to perform testing. Operators of the Licensee are assigned for start-up testing; they manage overall plant safely during start-up. All tests are carried out with the Licensee as holder of the Nuclear Site Licence ultimately responsible.

4.7.5 Commissioning Schedule

Establishing a suitable test schedule and having a basic plan such as personnel distribution before starting commissioning is important for enhancing safety and quality. Based on the construction work schedule (Master and Sub master schedule) stated in Section 6.6, Hitachi-GE is responsible for proper management of commissioning by taking advantage of supporting tools such as the Information Technology systems for achieving efficient and safe test operations.

Safety in the commissioning phase is discussed more in detail in Chapter 29.

4.8 Safety in the Operational Phase

4.8.1 General

All information related to plant safety established in the phases of design, construction and commissioning is handed over from Hitachi-GE to the Licensee prior to plant handover. Safety management of UK ABWR during operation will be the responsibility of the operator under the 36 conditions of the Licence granted under the Nuclear Installations Act 1965 (as amended) and other applicable legislation and regulation. The Licensee is responsible for protecting the public, operators and the environment from the hazards arising from ionising radiation and other potential hazards in UK ABWR. In addition to the Licence, the Licensee will be responsible for complying with all other applicable laws and regulation in the UK.

The Licensee ensures that the operating organisation is able to readily access proper information to maintain the continuity of engineering skill and knowledge necessary for operation obtained from the GDA process and other operating experience.

In the operational phase, appropriate arrangement is established by the Licensee for management of plant operation, shutdown, and maintenance, as well as emergency preparedness. The 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 UK ABWR manning levels and training requirements is provided in chapter 27 of the PCSR, Human Factors Evaluation. It is the responsibility of the Licensee to ensure that these requirements are met or to justify otherwise under the terms of the Licence. All of the staff that perform or supervise operations critical to safety shall be suitably qualified and experienced. The Licensee will be responsible for the training programs for operational staff, with assistance from Hitachi-GE where appropriate. Procurement of simulators and other training products is the responsibility of the Licensee.

Through use of the Operating Technical Requirements, Hitachi-GE provides the operating organisation with the necessary information for safe and stable plant operation in accordance with the requirements of the Site License. In addition to this, the fault schedule for UK ABWR (see PCSR chapter 24) will identify and list a series of bounding design basis faults for UK ABWR.

4.8.2 Operating Envelope of the Plant

UK ABWR has been designed to operate within an operating envelope, an example of which, related to pressure, is shown diagrammatically below. 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 three fission product barriers.

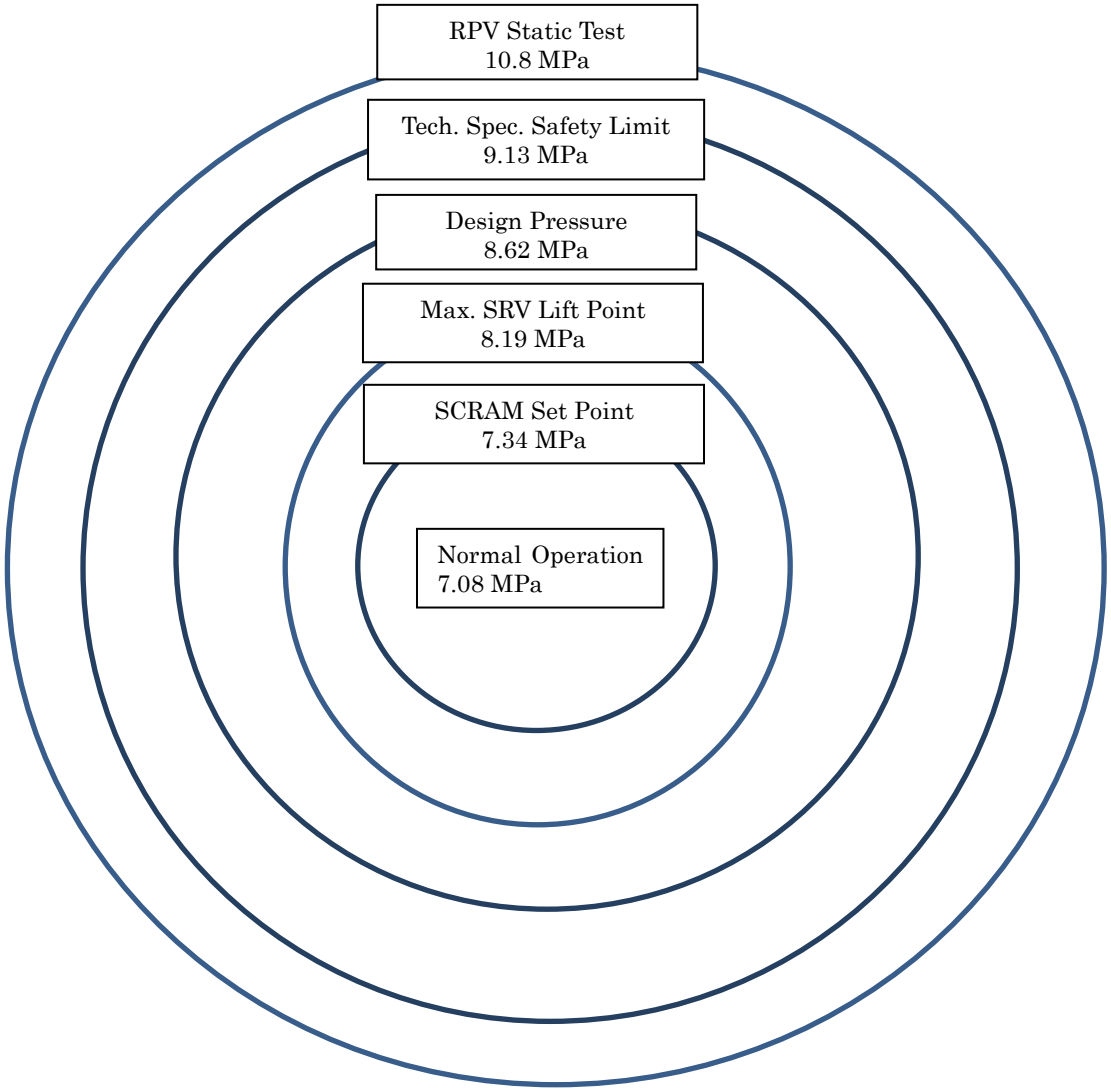


Figure 4.8-1 : Operating Envelope of the Plant

In the example highlighted above, operators and the control system maintain the Reactor Pressure Vessel (RPV) at or around its normal operating pressure of 7.08 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 set point of 7.34 MPa, the plant 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.

4.8.3 Use of Operating Technical Requirements and Procedures, Verification and Validation

UK ABWR is designed for use with Operating Technical Requirements which are used in the majority of Boiling Water Reactor (BWR) units worldwide. The Operating Technical Requirements encompass the equipment condition, limits, operating rules and requirements from the design basis accidents postulated within the safety case fault schedule. The Operating Technical Requirements ensure that the assumptions and requirements in the safety case are maintained at all times during all modes 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 Requirements.

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

Hitachi-GE will provide the basis of procedures to the Licensee for operating UK ABWR and the procedures themselves will be completed by the Licensee. These may also be modified by the 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 BWR preventive maintenance technology centre. BWR preventive maintenance technology

centre is the facility owned by Hitachi-GE equipped with simulated model of actual plant equipment; it enables to carry out the maintenance of reactor pressure vessel and reactor internals, repair, development of replacement technology, handling checking of various equipment, and training for workers.

4.8.4 Maintenance and Outage Overview and Schedules

Under the Nuclear Site Licence and other health and safety related legislation are requirements for maintainability and inspect ability. Periodic inspection is carried out while stopping the reactor operation at fixed intervals in order to ensure the structural integrity of the reactor and its attached facilities and the turbine body and its attached facilities. This inspection is intended to prevent accidents and failures, minimize its damage, and also it aims the safe and stable operation of power plant to supply sustainable electricity. Hitachi-GE has considered such principles throughout the design stages of UK ABWR to ensure the easy maintenance, testing and inspection of plant and systems

Hitachi-GE has considered maintainability and inspect ability throughout the design stages of 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.

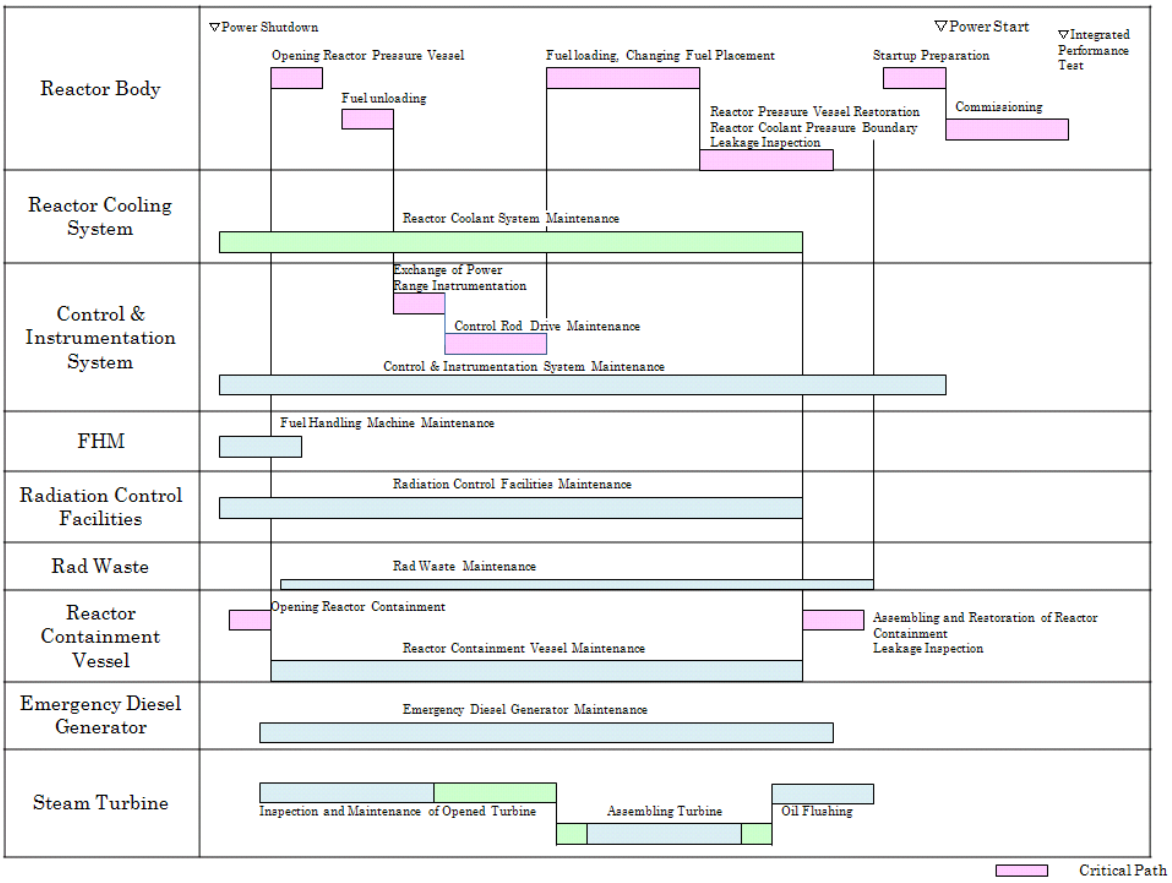


Figure 4.8-2 : Typical Flow of Periodic Inspection of ABWR

4.8.5 Permit to Work Systems

The Licensee establishes Permit to work systems which aim to reduce potential risks as far as possible and prevent major disaster from maintenance activities. The development and use of permit to work systems is the responsibility of the Licensee in order to ensure safety of maintenance and other workers from 'the system'. Hitachi-GE will work with the Licensee during the design stages to ensure that any physical requirements for such permit to work systems are taken account of in the plant design of components where possible.

Permit to work systems take into consideration the followings.

- Human factors
- Management of the work permit systems
- Poorly skilled work force
- Unconscious and conscious incompetence

- Objectives of the work permit system
- Types of work permits required
- Contents of the work permits

Safety in the operating phase is discussed more in detail in Chapter 30.

4.9 Safety in the Decommissioning Phase

The responsibility of safety management during plant decommissioning lies with the Licensee. The 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 addition, the Licensee is responsible for creating a decommissioning safety case and evaluating its impact on the environment. Safety in the decommissioning phase will be addressed in chapter 31.

4.10 References

[Ref-1] The Management System for Facilities and Activities, Safety Requirements No. GS-R-3, 2006.

[Ref-2] Safety Assessment Principles for Nuclear Facilities, 2006 Edition, Revision 1

[Ref-3] Quality Manual for Nuclear Power Equipment, HI-ISO-21 Rev.21

[Ref-4] Environmental Manual, HI-ISO-02 Rev.14

[Ref-5] Quality Assurance Manual for Nuclear Power Plant Construction, HQA-0002 Rev.38

[Ref-6] QUALITY MANAGEMENT PLAN (For UK ABWR GDA Project), GA70-1501-0007-00001 Rev.2

[Ref-7] Generic Design Development Control, GA70-1501-0002-00001 Rev.4

[Ref-8] Control of Non-conformance, Corrective Action, and Preventive Action, GA70-1501-0008-00001 Rev.1

[Ref-9] ABWR Design Genesis Report, GA91-9901-0034-00001 Rev. A

[Ref-10] Design Change Control and Documentation, GA70-1501-0003-00001 Rev.2

[Ref-11] SQEP Requirements for HITACHI-GE and Supplier Personnel, GA70-1501-0010-00001 Rev.1