

UK ABWR

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UK ABWR Generic Design Assessment
Codes and Standards Report



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Abbreviations and Acronyms

Abbreviations and Acronyms	Description
ABWR	Advanced Boiling Water Reactor
ACI	American Concrete Institute
AIJ	Architectural Institute of Japan
ALARP	As Low As Reasonably Practicable
ANSI	American National Standards Institute
ANSI/AISC	American National Standards Institute / American Institute of Steel Construction
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
BOP	Balance Of Plant
BS	British Standard
EUR	European Utility Requirements for LWR Nuclear Power Plants
IAEA	The International Atomic Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ISO9001	International Organization for Standardization 9001
JEAC	Japan Electric Association Code
JEAC4111	Code for Quality Assurance of Nuclear Power Plants
JEAC4601	Technical Code for seismic design of nuclear power plants
JEM	The Japan Electrical Manufactures' Association
JIS	Japanese Industrial Standards
JSME	Japan Society of Mechanical Engineers
JSME S NC-1	Codes for Nuclear Power Generation Facilities - Rules on Design and Construction for Nuclear Power Plants
JSME S NE-1	Codes for Nuclear Power Generation Facilities - Rules on Concrete Containment Vessels for Nuclear Power Plants
MCR	Main Control Room
NSSS	Nuclear Steam Supply System
RCCV	Reinforced Concrete Containment Vessel
RG	Regulatory Guide (US-NRC)
SSC	Systems, Structures and Components

1. Introduction

This report describes the codes and standards to be applied to UK ABWR that will be designed and constructed by Hitachi-GE Nuclear Energy, Ltd. in United Kingdom. The previous codes and standards that have been applied to the ABWR design and construction have been mainly Japanese codes and standards these include: the Japan Society of Mechanical Engineers (JSME), Japan Electrical Manufacturers' Association (JEM), Japan Industrial Standards (JIS), Japan Electric Association Code (JEAC) and Architectural Institute of Japan (AIJ). However, Hitachi-GE will take into account the UK regulatory expectations, practices and applicability when adopting codes and standard for the UK ABWR. The UK nuclear safety regulation is based on a non-prescriptive regime and consequently it does not prescribe the technical codes and standards that must be used for nuclear new build. However, the codes and standards must represent good practice and be consistent with the requirements of ALARP. Hitachi-GE identifies the appropriate international and national codes and standards and particularly those that are nuclear-specific and applies them to the design and construction of the UK ABWR.

The codes and standards identified in this report are following categorization of technical area.

- a) Structural Integrity
- b) Mechanical
- c) Control and Instrumentation
- d) Electric
- e) Civil Engineering
- f) Hazard , Seismic Design and Fire Protection
- g) Quality Assurance

For the purpose of GDA a separate report defines the Categorisation of the safety functions and the Classification of Structures Systems and Components (SSC) of the UK ABWR (Ref [RD1]). This report is currently limited to a discussion of international and national codes and standards to be adopted for class 1 and 2 SSC for the UK ABWR. The codes and standards related to manufacturing such as material selection and welding, special process for example heat treatment, and Non Destructive Examination will be provided in GDA Step-3.

2. Technical Approach

The codes and standards used are selected in accordance with the safety categorisation of the function and safety classification of the SSC. Appropriate codes and standards for the category and class are evaluated for their applicability, adequacy and sufficiency in this report. Hitachi-GE considers that the applicability of the codes and standard should also be based on their practical experience in the design and construction of the ABWR. Table 2-1 provides a summary and comparison of the principal codes and standard to be adopted for the UK ABWR. These codes and standards are specific to nuclear applications.

Table 2-1 Principal Codes and Standard to be adopted for the UK ABWR

Technical Area	UK ABWR	Reference ABWR in Japan
Structural Integrity	ASME BPVC Sec. III Div.1 ASME BPVC Sec. VIII	JSME S NC-1 JIS
Mechanical	BS, ISO Manufacturer's standards	JIS Manufacturer's standards
C&I	IEC Nuclear Power Plant	JEM, JIS, JEAC and JEAG
Electrical	IEC Nuclear Power Plant	JEM and JIS
Civil	ASME BPVC Sec. III Div.2 ACI 349 ANSI/AISC N690	JSME S NE-1 AIJ standards
Seismic	ASCE 4 ASCE 43	JEAC4601
Quality Assurance	GS-R-3, ISO9001 ASME NQA-1	JEAC4111, ISO9001

To summarise:

- The codes and for design discussed here are limited to the Class 1 and 2 SSCs. The approach will be extended to class 3 SSCs and non-safety standards during GDA.
- The equivalence of codes and standards used historically for the ABWR and those to be used for the UK ABWR is illustrated below:
 - The JSME code is highly compatible with the ASME code as it has its origin in the ASME code dating back to the 1980s.

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- The Japanese Industrial Standards (JIS) are compatible with international standards for example those from the International Electrotechnical Commission.
- ASME BPVC Sec III is a notable nuclear specific standard for structural integrity and has been applied in UK nuclear reactor design and it will be adopted for the UK ABWR.
- The detailed justification of the approach to the selection and application of the codes and standards to the SSCs will be provided in latter steps of the GDA.
- The adoption of European Union and British standards for civil design and construction may be required but the selection and justification of their applicability and adequacy will be provided in GDA step 3.
- The selection of codes and standards will be prioritized for example for electrical engineering IEC standards will have priority but in the absence of a suitable standard JIS or IEEE standards will be used particularly when they have been shown to be practical and proven by application for the Reference ABWR in Japan.
- The combination and mixing of standards from different sources will be avoided to ensure that the standards used are complete and consistent
- The version of the standard applied will be the latest editions with their addenda; the actual versions will be identified during GDA as part of the Design Reference point. However, where designs have been completed or procurement / engineering practice requires historic versions to be used a gap analysis will be undertaken to demonstrate equivalence. If gaps are found remedial measures will be identified and applied; this will be done on a case by case basis.

3. Design Codes and Standards

3.1. Structural Integrity

Major structural components whose integrity is important to safety are designed in accordance with the ASME Boiler & Pressure Vessel Codes Section III (ASME Sec. III) which is most familiar to nuclear specific and recognized as international practical codes and standard.

Table 3.1-1 Structural Integrity Codes and Standards identifies the major codes and standards to be applied for Class 1 components of UK ABWR.

Class 2 components for the NSSS will be designed in accordance with ASME Boiler & Pressure Vessel Codes Section III, Division 1, specifically subsection ND. For BOP items, the current proposal is to use ASME Boiler & Pressure Vessel Codes Section VIII, although this may be amended following the completion of the classification process for BOP SSCs.

Class 3 components will be designed in accordance with ASME Boiler & Pressure Vessel Codes Section VIII with ISO, European and BS standards also used on some components, and explicitly stated where applied. Piping and valves will be designed in accordance with ANSI/ASME B31.1 and B16.34 to maintain consistency with ASME Sec. III piping. Japanese Codes and Standards which are proven in reference plant may apply to Class 3 components due to availability and practical reason.

Table 3.1-2 Structural Integrity Codes and Standards identifies the codes and standards to be applied to Class 2 or Class 3 components.

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Table 3.1-1 Structural Integrity Codes and Standards for Class 1

SSCs Type	Applicable Codes and Standards
Pressure Vessel	ASME BPVC Section III, Division 1 ASME BPVC Section II, ASME BPVC Section V, ASME BPVC Section IX, ASME BPVC Section XI
Heat Exchanger	
Storage Tank	
Valves	
Piping	
Pump	
Support	
Reactor Internal	
Reinforced Concrete Containment Vessel	ASME BPVC Section III, Division 1 ASME BPVC Section III, Division 2
Lining Pools	ASME BPVC Section II, ASME BPVC Section V, ASME BPVC Section IX,

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Table 3.1-2 Structural Integrity Codes and Standards for Class 2 and Class 3

SSCs Type	Applicable Codes and Standards
Pressure vessels	ASME BPVC Section VIII, Division 1 and 2
Heat Exchanger	ASME BPVC Section VIII, Division 1 and 2
Piping	ASME BPVC Section VIII, Division 1 and 2 ANSI/ASME B31.1 BS EN 13480
Pumps	BS EN ISO 13709 Hydraulic Institute Standards BS Pump Manufacturers Association API 610
Valves	ANSI/ASME B31.1 ANSI/ASME B16.34
Storage Tanks	BS EN 14015 API 650 ANSI/ASME B96.1 API standard 2000

3.2. Mechanical

Mechanical equipment is designed in accordance with ISO, BS and European standards in principle. Pumps, diesel engine, crane etc are designed to ISO standards basically. However, nuclear specific equipment such as the Fine Motion Control Rod Drives, Hydraulic Control Units and Reactor Internal Pumps are designed to the manufacturer’s standards; the design and drawings are required to be justified prior to construction. Table 3.2-1 shows the list of major mechanical codes and standards; further details will be provided in the PCSR in step-2.

Table 3.2-1 Mechanical Codes and Standards

SSCs Type	Applicable Codes and Standards
Fine Motion Control Rod Drive	Manufacturer’s Standards
Hydraulic Control Unit	Manufacturer’s Standards
Reactor Internal Pump	Manufacturer’s Standards
Fuel Handling Machine	Manufacturer’s Standards
Pumps	BS EN ISO 13709 Hydraulic Institute Standards BS Pump Manufacturers Association API 610
Valves	ASME BPVC Sec. III Div. 1 ASME QME-1
Diesel Engine	ISO 8528 (series) Reciprocating internal combustion engine driven alternating current generating sets
MCR Emergency Ventilation (HVAC)	NVF/DG001 Issue 1 An Aid to the Design of Ventilation of Radioactive Area

3.3. Control and Instrumentation

Control and Instrument equipment is, in principle, designed in accordance with standards produced by International Electrotechnical Commission (IEC) TC45/ SC 45A Nuclear Power Plant standards. These are recognized international nuclear codes and standards and they are applied to new civil nuclear projects in European countries. Table 3.3-1 C&I Codes and Standards, shows a list of high level C&I codes and standards to be applied in the design of the UK ABWR; further details will be provided in the PCSR in step-2.

Table 3.3-1 C&I Codes and Standards

IEC Standard	Title
IEC 61513	Nuclear power plants - Instrumentation and control important to safety - General requirements for systems
IEC 61226	Nuclear power plants - Instrumentation and control important to safety - Classification of instrumentation and control functions
IEC 60880	Nuclear power plants – Instrumentation and control systems important safety – Software aspects for computer – based systems performing category A functions
IEC 62138	Nuclear power plants – Instrumentation and control systems important safety Software aspects for computer – based systems performing category B or C functions
IEC 60987	Nuclear power plants – Instrumentation and control important to safety – Hardware design requirements for computer-based systems

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3.4. Electrical Code

Electrical equipment is designed and constructed in accordance with IEC standards that are recognized as international codes and standards appropriate for nuclear application in European countries. IEC codes and standards are given priority over the other codes and standards and are available for specific equipment; in the absence of an IEC standard, a BS or European standard will be used. Special equipments may apply existing codes and standard with justification. Table 3.4-1 Electrical Codes and Standards show the list of major electrical equipments such as control panel, switchgear, motor, generator, transformer, power bus and batteries. Detail will be listed in the PCSR in step 2. Codes and standards for manufacturing, testing and maintenance of the electrical equipment will be discussed in step 3 and 4.

Table 3.4-1 Electrical Codes and Standards

Main Equipment	Sub Equipment	Applicable Codes and Standards
Control Panel	Main Control Panel Local Control Panel	IEC 60964 IEC 61227 IEC 61839 IEC 61772
Switchgear	Metal-clad Switchgear Power Center Motor Control Center	IEC 62271-SER IEC 60947-SER IEC/TR 62271-300 IEC 60038
Motor	High Voltage Induction Motor Low Voltage Induction Motor Direct Current Motor Stepping Motor	IEC 60034-SER
Generator	Main Generator Diesel Engine Generator	IEC 60034-SER
Transformer	Exciter Transformer Service Transformer	IEC 60076-SER IEC 60044-SER IEC 60137
Power Bus	Isolated Phase BUS (IPB) Non-segregated phase Bus	IEC 298
Battery	Battery Battery Rack	IEC 60896-11 IEC 60896-22 IEC 61056

3.5. Civil Engineering

UK ABWR civil engineering is designed in accordance with ASME BPVC Sec. III and Division 2 for Reinforced Concrete Containment Vessel and to ACI 349 and ANSI/AISC N690 for other major buildings. These are recognized international codes and standards for civil engineering. Table 3.5-1 Civil Engineering Codes and Standards identifies the applicable codes and standards for civil engineering of the UK ABWR. ACI 349 is applied to civil engineering because ACI is consistent with the use of ASME BPVC Sec. III Div. 2 that is design codes used for the RCCV. The applicable codes and standards will be allocated to each building commensurate with their safety classification. European or British codes and standards may be applied to the buildings that are not related with off-site large scale release of radiation; their use will be identified from safety categorizations and classification of the buildings.

The codes and standards related to construction, test and qualification of civil engineering may use European and BS standards in line with their applicability at a construction site. International ISO, EN or BS materials codes and standards will be justified along with US design codes. This will be provided in later steps of GDA and the difference between ISO and US codes and standards will be discussed in step 3 and 4.

Table 3.5-1 Civil Engineering Codes and Standards

Codes and Standards	Title
ASME BPVC Sec. III Division 2	Rules for Construction of Nuclear Facility Components, Division 2: Code for Concrete Containments
ACI 349	Code Requirements for Nuclear Safety- Related Concrete Structures
ANSI /AISC N690	Specification for Safety-Related Steel Structures for Nuclear Facilities
NUREG-800	USNRC Standard Review Plan for Review of Safety Analysis Report for Nuclear Power Plants- LWR Edition 3.8.1 Concrete Containments 3.8.4 Other Seismic Category I Structure 3.8.5 Foundation
RG 1.136	Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments

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Codes and Standards	Title
RG 1.142	Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)
ACI 318	Building Code Requirements for Structural Concrete and Commentary
ANSI/AISC 360	Specification for Structural Steel Buildings

4. Hazard Codes and Standards

This section describes hazard codes and standards related to UK ABWR. The codes and standards for seismic design and fire protection are described in following subsections, and the codes and standards against other hazard will be discussed in later steps.

4.1. Seismic Design

Seismic design of UK ABWR applies the IAEA safety standards in principle. Table 4.1-1 Codes and Standards for Seismic Design identifies the codes and standards for seismic design. Soil investigation and hazard assessment that provide the seismic design conditions are addressed in accordance with IAEA safety standard and recognized international standards. Seismic design is not provided in IAEA safety standards; ASCE nuclear specific standards are applied to detail seismic design. The methodology is to apply IAEA standards and ASCE that will be described in the initial safety case on Civil Engineering and External Hazard.

Table 4.1-1 Codes and Standards for Seismic Design

Items	Standard
Soil Investigation Seismic Hazard Assessment	IAEA SSG-9 Seismic Hazards in Site Evaluation for Nuclear Installations
	NS-G-3.6 IAEA, Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants
Seismic Design	ASCE 4 Seismic Analysis of Safety-Related Nuclear Structures and Commentary
	ASCE 43 Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities
	EUR Volume 2 General Nuclear Island Requirements, Chapter 4 Design Basis
Seismic Design Parameter Seismic Systems Analysis Seismic Subsystem Analysis	NUREG-0800 USNRC Standard Review Plan for Review of Safety Analysis Report for Nuclear Power Plants- LWR Edition 3.7.1 Seismic Design Parameter 3.7.2 Seismic System Analysis 3.7.3 Seismic Subsystem analysis

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Items	Standard
Damping Values	RG 1.61 Damping Values for Seismic Design of Nuclear Power Plants
Seismic Response Analysis	RG 1.92, Combining Modal Responses and Spatial Components in Seismic Response Analysis

4.2. Fire Protection

Fire protection for nuclear safety is designed in accordance with the principles of IAEA NS-G-1.7. The hard design, materials and equipments are constructed in accordance with BS standards to ensure the consistency with requirements for conventional safety and qualification. BS standards will be used in preference to other codes and standards; however, if no appropriate BS standards are available, other existing applicable codes and standards may be applied and their use accompanied with a justification.

Table 4.2-1 Codes and Standards for Fire Protection

Standards	Title
NS-G-1.7	Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants
BS 9990	Code of practice for non-automatic fire-fighting systems in buildings
BS 5306-1	Code of practice for fire extinguishing installations and equipment on premises. Hydrant systems, hose reels and foam inlets.
BS 5306-2	Fire extinguishing installations and equipment on premises. Specification for sprinklers systems
BS 5839-1	Fire detection and fire alarm systems for buildings
BS 476-10	Fire tests on building materials and structures.
BS EN 13501-1	Fire classification of construction products and building elements Classification using test data from reaction to fire tests

BS 9999, the code of practice for fire safety in the design, management and use of building is not applicable to nuclear licensed plant but will be considered as a source of good practice in the design and operation of UK ABWR.

5. Quality Assurance

Quality Management Systems are established and addressed in accordance with IAEA GS-R-3 and ISO 9001 quality standards. IAEA GS-R-3 is considered in respect of nuclear safety culture and is implemented in the management systems. A graded approach will be applied to design quality assurance that commensurate with the safety class. ASME NQA-1 Quality Assurance requirements will be added as appropriate for design and construction of ASME BPVC Sec. III. Table 5-1 identifies the codes and standards for quality management systems commensurate with the safety class.

Table 5-1 Codes and Standards for Quality Assurance

Safety Class	Codes and Standards
Class 1	IAEA GS-R-3 ISO9001 ASME NQA-1 for SSC adopt ASME BPVC Sec. III Div.1 & 2
Class 2	IAEA GS-R-3 ISO9001 ASME NQA-1 for SSC adopt ASME BPVC Sec. III Div.1 & 2
Class 3	IAEA GS-R-3 ISO9001

6. Conclusion

This document describes the codes and standards, recognized as international and nuclear specific, that are considered for application to the major design and engineering works of new nuclear build of the UK ABWR.

During the next GDA step, detail design codes and standards for each engineering area, and the codes and standards related with manufacturing, inspection, test and qualification will be described. An equivalency and maturity study (gap analysis) will be provided as required when Japanese, American or old edition of codes and standards are to be applied to UK ABWR.

7. Reference

- [RD1] Categorisation and Classification of Systems, Structures and Components
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