

**UK ABWR**

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## **UK ABWR Generic Design Assessment**

### **Generic PCSR Sub-chapter 5.7 : Monitoring, Inspections and Testing**



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### 5.7.1 Introduction

This sub-chapter describes the examination, maintenance, inspection and testing (EMIT) to be carried out to ensure that the required safety and reliability will be achieved throughout Facility Lifecycle of UK ABWR.

### 5.7.2 Purpose and Scope

The EMIT are carried out as the measures to verify that performance of Structures, Systems and Components (SSCs) satisfy the safety features intended in the design. EMIT verify if the performance requirements for the safety features prescribed with respect to claims and arguments in PCSR are duly satisfied. Also each SSCs is examined for its conformance with the requirements of codes and standards prescribed according to the relevant safety classification and quality classification. Details of such EMIT will be specified in the Design Specification and in the Quality Plan of each component.

- EMIT are prescribed according to relevant safety class and quality class of each SSCs. Especially, prescription of EMIT items for the SSCs classified as the safety class 1 and 2 are decided based on the required code and standard defined in the relevant quality class.
- Details of the EMIT items of the SSCs are prescribed in the Quality Plan with the specified EMIT items and implementation period.
- The Test and Inspection plan clarifies the Test and Inspection implementation method, acceptance/rejection criteria, required record and the hold point by client and independent third party inspection agency.
- The test, inspection and monitoring are ensured to be completed before receiving, application and in-service of products.
- Test and Inspection is basically carried out at the final stage, that is, the completed status of products, however is allowed to be done so at an adequate timing according to necessity.
- Instrumentation equipment used for test, inspection and monitoring specifies its appropriate measurement scope, model, accuracy and precision.
- Control measures are specified to ensure no process would be made by skipping the required Test and Inspection at the previous process.
- Test and Inspection is carried out at the presence of a third party inspection agency according to necessity. Considering the objectiveness of test and inspection as well as transparency and accountability required in the procedures, judgment by an independent third party inspection agency should be conducted for the Test and Inspection of the SSCs of high safety class.
- The type method, scope and test result evaluation criteria and schedule for maintenance Test and Inspection after start of in-service of products are to be clarified.

## 5.7.3 Examination, Maintenance, Inspection and Testing

### 5.7.3.1 Manufacture and Work Test (Factory Acceptance Tests)

Required tests and inspections together with the performance verifications are carried out at shop before the shipment of the SSCs in accordance with the design, code and standard.

Representative items of test and inspection at shop are specified as below but not limited to them.

Specific selection of the test items, implementation period and test guidance defined according to the quality class of relevant SCCs will be prescribed during the GDA step 2 and the step 3.

#### (1) Mechanical SSCs

- (a) Material Test
- (b) Dimensional Inspection
- (c) Visual Inspection
- (d) Hydrostatic Test and Leakage Test
- (e) Non Destructive Examination
- (f) Welding Process Monitoring and Inspection
- (g) Pre-Service Inspection
- (h) Performance Test
- (i) Lining Inspection
- (j) Painting or Coating Inspection
- (k) Cleaning and Preservation Inspection

#### (2) Electrical, Control and Instrumentation SSCs

- (a) Structure Inspection
- (b) Wiring Inspection
- (c) Piping Inspection
- (d) Sequence Test
- (e) Instrument and Relay Operation Test
- (f) Storage Equipment Operation Check
- (g) Performance and Characteristic Test
- (h) Temperature Test
- (i) Noise Measurement
- (j) Vibration Measurement
- (k) Insulation Resistance Measurement
- (l) Withstand Voltage Test
- (m) Pressure Test and Leakage Test
- (n) Earthquake Resistance Test
- (o) Combination Operation Test
- (p) Mounting Bolts Inspection
- (q) Material Test

### 5.7.3.2 On Site Plant Installation, Facility Acceptance Test and Commissioning (Site Acceptance Tests)

#### (1) Mechanical, Electrical, Control and Instrumentation SSCs at Plant Installation Phase

Test and Inspection on site verifies the Test and Inspection items that are yet to be confirmed at shop and the construction work implemented at construction on site.

Specific selection of the test items, implementation period and test guidance defined according to the quality class of relevant SCCs will be prescribed during the GDA step 2 and the step 3.

- (a) Dimensional Inspection
- (b) Visual Inspection
- (c) Hydrostatic Test and Leakage Test
- (d) Non Destructive Examination
- (e) Welding Process Monitoring and Inspection
- (f) Pre-Service Inspection
- (g) Performance Test
- (h) Lining Inspection
- (i) Painting or Coating Inspection
- (j) Cleaning and Preservation Inspection
- (k) Overall Containment Pressure Test, Leakage Test and Diaphragm Floor Leak Rate Test
- (l) Integrated Leak Rate Test for Reinforced Concrete Containment Vessel
- (m) Panel Test
- (n) Sequence Test
- (o) Performance and Characteristic Test
- (p) Instruments Actuation Test
- (q) Unit Test of Motor and Pump
- (r) Valve Actuation Test
- (s) Heater Unit Test
- (t) Performance and Characteristic Test of Power System
- (u) In-core and Radiation Monitor Actuation Test

#### (2) Test and Inspection of Building and Structure at Plant Installation Phase

Inspection and testing that commensurate with the safety class and quality class are carried out for the reactor building of UK ABWR in the construction period and in-service period as follows. Specific selection of the test items, implementation period and test guidance defined according to the level of importance of relevant SCCs will be basically prescribed during the GDA step 2 and the step 3.

##### (a) Bedrock Inspection

This inspection is carried out before commencement of the building construction in order to prove that basic infrastructure where the reactor building is directly built would not cause the public exposure by damages caused by an earthquake.

- Rock Testing (Physical Test, Compression Test, Tensile Test)
- Bedrock Deformation Test

- Rebound Measurement of Schmidt Rock Hammer
- Check the Construction Status of Drainage Facility
- Check the Height of the Basic Infrastructure
- Check the Surface Cleaning of the Basic Infrastructure

(b) Inspection in the construction period

Following inspections are carried out in order to ensure that the reactor building in the construction period satisfies the requirements of material, structure, and function which are specified by the design.

- Material Inspection  
This inspection ensures that each type of material including cement used for the reactor building is commensurate with the determination value specified in the design and Code and Standard.
  - Cement
  - Characteristics of Aggregate, Water, and Admixture
  - Characteristics of Fresh Concrete
  - Compressive Strength of Concrete
  - Alkali Silica Reaction of Concrete
  - Radiation Shielding Concrete, Mortar
  - Product Accuracy of Reinforcing Bar, Steel Material, and Steel, High Strength Bolt, Steel Plate
  - Painting
- Structure Integrity Inspection  
This inspection ensures that the structure of reactor building is commensurate with tolerance specified in the design and Code and Standard.
  - Assembling Accuracy of Mould
  - Assembling Accuracy of Reinforcing Bars
  - Accuracy of Concrete Placing
  - Erection Accuracy of Steel Frame
  - Dimensional Accuracy of Shielding Door
  - Dimensional Accuracy of Lead Glass
  - Dimensional Accuracy, Appearance, Installation of Reactor Shielding
  - Dimensional Accuracy, Appearance, Installation of Prevention Dam for Leakage Expansion, and Prevention Dam of Leakage outside of the Facility

(c) Leakage Testing of the Reactor Building (Function Test)

Function Test of the reactor building ensures that the leak tightness of openings and penetrations in the building structure and the auxiliary structure of the reactor building satisfies the designed air resistance.

At the phase of the reactor building completion before fuel loading, the air leak rate is calculated based on the amount of exhaust air when keeping the inside of the reactor building at negative pressure.

**(3) Commissioning**

The adequacy of construction and installation of SSCs are verified during construction and installation commissioning. The commissioning consists of two processes, pre-operational (inactive commissioning) and start-up tests (active commissioning). Detail programme of the commissioning is described in PCSR Chapter 29.

Representative items of the inactive/active commissioning are described in Sub-Chapter 5.7.4.3 but not limited to them.

**(a) Pre-Operational Test (inactive commissioning)**

Following construction and installation testing, inactive commissioning is performed to demonstrate that equipment and systems perform in accordance with their design specification so that initial fuel loading, initial criticality and subsequent power operation can be safely undertaken.

**(b) Start-Up Test (active commissioning)**

The active commissioning confirms that a plant can run for safety and stability at a start-up, a shutdown and normal operating. Also, the active commissioning confirms that get a plant event under control for safety and stability at an unanticipated transient and postulated failures at the operating.

The active commissioning commences on an initial fuel loading after the inactive commissioning has been successfully completed.

**5.7.3.3 Operations (Data Acquisition During Operation)**

The EMIT activities in routine operation monitor the condition of the SSCs related to plant operation parameter tracing and vibration level measurement and record the collected data. The emergency facilities in standby carry out the surveillance test according to the Operating Technical Requirements. The soundness and reliability of the facilities will be confirmed by the test records.

**5.7.3.4 Outages**

A nuclear reactor and the auxiliary facilities cease operation in a planned periodicity, and carry out maintenance and inspection in order to confirm the soundness of the SSCs that are important to safety, to prevent occurrence or spreading of an accident or a failure, and to continue safe and stable operation of a power station.

The content to be carried out is as follows;

- (a) Confirmation of the functions such as the operational performance and parameter of main SSCs.
- (b) Confirmation of the soundness of the SSCs by an overhaul and a leakage test.
- (c) Periodical exchange of consumable supplies
- (d) Measures for the aging
- (e) Early detection of abnormality and its measures
- (f) Inspection and measures for the SSCs similar to those which experienced accidents and troubles at other power stations



In outage the EMIT carry out the following inspection, examinations and maintenance, but the details will be described during the GDA step 2 and the step 3.

(a) Overhaul and care

An overhaul and the checking is carried out by periodically disassembling and thoroughly inspecting each part visually in order to grasp the soundness in terms of aging of the SSCs, together with a care for the sliding surfaces, and replacement of the consumable supplies such as gaskets and O-rings.

The consumable supplies are replaced according to the maintenance plan.

(b) In-Service Inspection (ISI)

An in-service inspection is planned systematically to confirm the soundness mainly in terms of the aging of welded parts of equipments and piping , carrying out relevant non destructive inspection.

Scope, method, evaluation criteria, examiners' qualification, record and report of the ISI of the UK ABWR components (including vessels, piping, pumps, valves, bolts and their supporting structures) are provided in accordance with ASME Code Section XI.

Detailed procedures of the scope for inspection and testing, inspection and testing schedule, and its frequency will be specified during the GDA step 2 and the step 3.

(c) Calibration and Characteristic Test

Output calibration and a characteristic test are carried out on the electrical, control and instrumentation in order to be confirmed of the soundness, as well as the adjustment of their drift. Functional Test

In the stage of basic design and detailed design of the plant, the functional test are carried out to confirm that the required function and the performance for the system or the components are ensured in commercial operation as well.

## 5.7.4 Inspection Requirements

### 5.7.4.1 General Terms

Test and inspection carried out in the UK ABWR conforms to the requirements prescribed in accordance with the Design Specification and Quality Plan.

The requirements for test and inspection of SSCs are prescribed and carried out in order to verify the safety function, soundness and reliability of the nuclear power generation facility

### 5.7.4.2 Requirements for Test and Inspection

Evaluation and judgment of the result of the test and inspection is required to comply with the requirements defined in the laws, regulations, spec and standard and Design Description etc.

Examples of the relevant laws, regulations, spec and standard are indicated as below. Specific specs and standards applied to each SSCs is prescribed during the GDA step 2 and the step 3.

(1) Laws and Regulations

- Safety Assessment principle

(2) Spec and Standard

- ASME Section III (Material, Design, Fabrication, Examination, Testing)

- ASME Section V (Non Destructive Examination)
  - ASME Section IX (Welding)
  - ASME Section XI (Inservice Inspection)
  - IEC 60964 (Control Panel)
  - IEC 62271-SER (Switchgear)
  - IEC 60034-SER (Motor, Generator)
  - IEC 60076-SER (Transformer)
  - IEC 60896 -11 (Battery)
  - etc.
- (3) Design Description
  - (4) Agreement
  - (5) Procurement Specification
  - (6) Others

### **5.7.4.3 Test and Inspection Items Required for SSCs**

Representative components extracted from important SSCs and their test and inspection items are indicated as below. Specific test items required for each SSC are prescribed in accordance with Quality Plan in the next stage of the GDA.

- (1) Reactor Pressure Vessel (RPV)
  - Hydrostatic Test at shop and site
  - Installation Inspection at site
  - Pre-service Inspection and In Service Inspection
- (2) Main Steam Safety Relief Valve (SRV)
  - Hydrostatic Test at shop
  - Installation Inspection at site
  - Function Test and Leak Test at shop
    - Functional test and valve seat leak test by nitrogen gas
    - Functional test and valve seat leak test by steam
  - Function Test and Leak Test at site
    - Functional test and valve seat leak test by nitrogen gas
  - System Functional Test
    - Automatic Depression System Test
    - Functional Test for Safety relief valve
- (3) Main Steam Isolation Valve (MSIV)
  - Hydrostatic Test at shop
  - Installation Inspection at site
  - Pre-service Inspection and In Service Inspection
  - Valve Seat Leak Test by air
  - System Functional Test
    - Automated isolation Test (Logic circuit test, Isolation valve close test)

- (4) Residual Heat Removal system (RHR)
  - Hydrostatic Test at shop and site
  - Installation Inspection at site
  - Pre-service Inspection and In Service Inspection
  - System Function Test
    - Low-pressure Coolant Injection System Automatic Start Test
    - PCV Spray Cooling System Manual Start-up Test (Drywell, Suppression Chamber)
  - System Performance Test
    - RHR Pump Performance Test
    - Equipment Running Performance Test
- (5) High-Pressure Core Flooder system (HPCF)
  - Hydrostatic Test at shop and site
  - Installation Inspection at site
  - Pre-service Inspection and In Service Inspection
  - System Functional Test
    - Automatic Start Test
    - Automatic Switching Inspection for suction valve of HPCF
  - System Performance Test
    - HPCF Pump Performance Test
    - (Low rated capacity operation, High rated capacity operation)
- (6) Reactor Core Isolation Cooling system (RCIC)
  - Hydrostatic Test at shop and site
  - Installation Inspection at site
  - Pre-service Inspection and In Service Inspection
  - System Functional Test
    - RCIC Pump Automatic Start Test
    - Reactor Injection Test
    - Automatic switching inspection for suction valve of RCIC
    - Reactor Water Level Set Value Inspection
  - System Performance Test
    - RCIC Pump Performance Test at 1.0MPa of steam
  - RCIC System Performance Test at Approximately 7.1 MPa
- (7) Control Rod Drive system (CRD)
  - Hydrostatic Test at shop and site
  - Installation Inspection at site
  - System Function Test
    - RC & IS Inspection (Manual Drive, Automatic Drive, Automated Control)
    - Scram Test
    - Rod Block Inspection
    - Loss of Power Inspection

- Selected Control Rod Run Inspection
  - System Performance Test
  - CRD Test at Atmospheric Pressure
  - CRD Test at Approximately 7.1 MPa
  - Single, Pair Rods Scram Test at Approximately 7.1 MPa
- (8) Reinforced Concrete Containment Vessel (RCCV)
  - Hydrostatic Test at shop (Personal Airlock, Piping Penetration)
  - Bubble Test-Vacuum Box
  - Installation Inspection at site
  - RCCV Integrate Pressure Test and Leakage Test including Structural Integrity Test(SIT)
  - RCCV Initial Leak Rate Test
- (9) Reactor Safety Protection System and Reactor Recirculation Flow Control System
  - System Functional Test
    - RPS Trip system logic test
    - PCV isolation valve automatically isolation test
    - RIP trip inspection by RPT signal
- (10) Fuel Servicing Equipment
  - System Functional Test
    - Loss of Power Source Test for Fuel Handling Machine
    - Loss of Power Source Test for Reactor Building Crane
  - System Performance Test
    - Capacity Inspection for Fuel Handling Machine
    - Capacity Inspection for Reactor Building Crane
- (11) Control Building HVAC System
  - System Functional Test
    - Switching Operation Test
  - System Performance Test (Charcoal Filter for Iodine Performance Test)
    - Removal Performance Test for Radioactive methyl iodine
    - Removal Performance Test for Radioactive iodine
    - Total Performance Test
- (12) Emergency Diesel Generator System
  - Visual Inspection
  - Dielectric Strength Test
  - System Functional Test
    - Alarm Inspection
    - Automatic Shutdown Test
    - Over speed Trip Test
    - Automatic Application of Load Test
  - System Performance Test

System performance Test for Diesel Generator

Smoke concentration measurement

(13) Electrical Power Distribution system

- Visual Inspection
- Dielectric Strength Test
- Alarm Test for Protection System
- Circuit Breaker Inspection