

UK ABWR

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UK ABWR Generic Design Assessment

Generic PCSR Chapter 29 : Commissioning



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29.1 Commissioning Program Basis

The commissioning programme will demonstrate, to the extent practicable, that the plant components and systems, as constructed/erected or installed are capable of safe and reliable operation in accordance with their design specifications, their performance objectives and their safety requirements as claimed in the safety case.

29.2 Commissioning Program Requirements

A comprehensive commissioning programme, which includes Construction Testing, Pre-Operational Testing, and Start-up Testing, will be prepared by the licensee for implementation on site.

This programme will be structured to include hold points at key milestones, at which the acceptability of the commissioning tests results will be verified (with particular focus on demonstrating that the plant will meet the appropriate design safety requirements) before entering into the next phase of commissioning.

This programme will consider all plant configurations assumed to be feasible - (at least, those described in the safety case) - and identify the performances expected from the safety-classified systems and equipment for each configuration. The sequence of tests will be such that plant safety is never dependent on the performances or availability of structures, systems or equipment that have not yet been tested.

29.3 Commissioning Program Objectives

The objectives of the commissioning program are to:

- 1) Ensure that the construction is complete and acceptable
- 2) Demonstrate the systems, structures, and components operate in accordance with design bases, specifically with regard to safety requirements. This demonstration primarily implies verifying:
 - That the unit operates correctly under steady state and transient conditions,
 - That plant performance complies with safety criteria,
 - That hypotheses postulated for safety analysis are suitably conservative,
 - That operating rules are suitably adapted to the plant.
- 3) Effect fuel loading in a safe manner
- 4) Demonstrate, where practical, that the plant is capable of withstanding anticipated transients and postulated accidents
- 5) Evaluate and demonstrate, to the extent possible, that the plant operating procedures reflect the installed equipment and contain the correct information to ensure that the plant can be operated in a safe manner.
- 6) Provide measured data for use as a reference in subsequent plant operation and testing during plant-life.
- 7) Bring the plant to rated capacity and sustained power operation and confirm that the plant is capable of generating the power required under the specified operating conditions.

29.4 Commissioning Program Organization

An organisation for implementing the commissioning programme will be defined and consists of Hitachi-GE, Licensee, architect engineer, and other vendor personnel. The Licensee will be involved in the preparation, performance and analysis of the tests, as well as in the application of improvements to plant operations which may result from any lessons learned during commissioning tests. Additional details of the organizational arrangement will be provided in the PCSR during later stages of GDA.

Qualification of commissioning personnel will be consistent with international standards and best practices, following Hitachi-GE and Licensee procedures.

29.5 Conduct of Commissioning

29.5.1 Overview

The commissioning program is conducted in accordance with arrangements set forth by the Licensee. The arrangements will include the Hitachi-GE administrative procedures and requirements that govern the activities of the commissioning group and their interfaces with other organizations. These administrative procedures are based on extensive BWR & ABWR commissioning experience and Hitachi-GE's administrative methodology, which have been used for commissioning of many BWR and ABWR stations and will be the subject of knowledge transfer to the licensee. These administrative procedures address, development and control of test procedures, review and approval of test results, resolution of failures to meet acceptance criteria, test records, requirements for progressing from one testing hold point to the next, conduct of maintenance, and system turnover processes. The administrative procedures are intended to supplement normal plant administrative procedures by addressing those concerns that are unique to the commissioning program or that are best approached in a different manner.

Commissioning tests serve as a progressive transition between the erection, installation and the start of normal operation of the various plant systems. These tests may take place in-factory, on specific test facilities or on-site. The choice depends on the type of equipment, on the level of a system's integration that can be simulated off-site (e.g. I&C systems), and on the ability to obtain specific conditions on-site (e.g. for qualification tests or accident transients).

29.5.2 Test Procedure Development

An administrative procedure will be established to develop, check, and approve test procedures.

Commissioning testing is conducted using step-by-step procedures to control the conduct of each test. Such test procedures typically specify testing prerequisites, describe desired initial conditions, include appropriate methods to direct and control test performance (including the sequencing of testing), specify acceptance criteria by which the test is to be evaluated, and provide for or specify the format by which data or observations are to be recorded. The Licensee procedures will be developed and reviewed by personnel with appropriate technical backgrounds and experience. This includes the participation of principal design organizations in the establishment of test performance requirements and acceptance criteria.

Specifically, Hitachi-GE will provide the licensee with scoping documents (i.e., pre-operational and start-up test specifications) containing testing objectives and acceptance criteria applicable to its scope of design responsibility.

29.5.3 Evaluation, Review and Approval of Test Results

An administrative procedure will be established to evaluate, review and approve test results. Individual test results are evaluated and reviewed by suitably qualified and experienced personnel of the commissioning group. Test exceptions or acceptance criteria violations are communicated to the affected and responsible organizations that will help resolve the issues by suggesting corrective actions, design modifications, and retests. Test results, including final resolutions, are then reviewed and approved by Hitachi-GE and Licensee personnel who will also have responsibility for final review and approval of overall test phase results and for selected milestones or hold-points within the testing phases.

29.5.4 Use of Operating Experience

The Advanced Boiling Water Reactor design is an evolutionary development of the previous BWR plants. The ABWR plants have the benefits of experience acquired with the successful and safe start-up of more than 30 previous BWR/1–6 and ABWR plants. The operational experience and knowledge gained from these plants and other reactor types has been factored into the design and test specifications of the Hitachi-GE supplied systems and equipment that will be demonstrated during the preoperational and start-up test phases. Additionally, reactor operating and testing experience of similar nuclear power plants obtained from other industry sources will be utilized to the extent practicable in developing and carrying out the commissioning programme.

29.5.5 Validation of Operating Procedures

Administrative procedures will be established to ensure test procedures, to the extent practicable, use existing operating procedures, emergency, and abnormal procedures in performance of tests. The use of these operating, emergency, and abnormal procedures is intended to do the following:

- 1) Prove the specific procedure or illustrate changes which may be required
- 2) Supplement training of plant personnel in the use of these procedures
- 3) Increase the level of knowledge of plant personnel on the systems being tested

Procedures will be in place to ensure that the lessons learned during use of the operating procedures are captured and the procedures updated as applicable.

29.5.6 Turnover Principles

Turnover will occur in phases from Construction to Commissioning and Commissioning to Licensee Operations. The turnovers will be used to clearly defined responsibility for plant equipment. Turnovers will be performed on systems and structures (areas).

The expectation at turnover from Construction to Commissioning is that a system will be ready for preoperational testing. In addition, it is expected that controlling processes are in place and suitably qualified and experienced personnel are in place ready to accept the turnover. The Construction to Commissioning turnover of a system shall typically involve the following: Clearly defined scope of the system being turned over, review and acceptance of system deficiencies or open items, review and acceptance of completed test results and records performed by construction, and review and acceptance of completed maintenance and calibration records performed by construction.

The expectation at turnover from Commissioning to Operations is that a system will be ready to operate and support Unit start-up. In addition, it is expected that controlling processes and procedures are in place and suitably qualified and experienced personnel are available to operate and maintain the system. The Commissioning to Licensee Operations turnover of a system shall typically involve the following: Clearly defined scope of the system being turned over, review and acceptance of system deficiencies or open items, review and acceptance of baseline testing data collected for future use and comparison, review and acceptance of records showing validation of operating and surveillance test procedures with associated changes if not already submitted.

29.6 Commissioning Program Schedule

The following description gives a preliminary overview of the plant commissioning program schedule. Only the main test phases are listed. The detailed and comprehensive programme schedule will be developed during later program stages.

The project commissioning phase starts during the later parts of the construction phase and ends at the start of the commercial operation phase. The commissioning phase is broken into three parts:

- Construction Testing,
- Pre-operational Testing, and
- Start-up Testing.

Construction testing determines correct installation and functionality of equipment. Preoperational tests are those tests normally conducted prior to fuel loading to demonstrate the capability of plant systems to meet performance requirements. Start-up tests begin with fuel loading and demonstrate the capability of the integrated plant to meet performance requirements.

The Construction Inspection and Test part occurs during the later portions of the construction phase. The Construction Inspection and Testing part ensures system construction is sufficiently complete to support safe performance of pre-operational testing. Construction inspections and tests consist of activities such as initial instrument calibration, flushing, cleaning, wiring continuity and separation checks, hydrostatic pressure tests, functional tests of components (e.g., valve testing), factory acceptance tests of digital equipment and initial energization and operation of components and systems. In some cases, it may also include final calibration of digital interfaces.

Pre-operational Testing is the second part of the commissioning program. The Pre-Operational Testing part ensures that plant systems are capable of operating in a safe and efficient manner compatible with the system design bases and safety case. Completion of Pre-Operational Testing will demonstrate that systems and safety equipment are operational and that it is possible to proceed to fuel loading and Start-up Testing.

During the preoperational phase, testing should be performed as system turnover from construction allows. However, the interdependence of systems will be considered so that common support systems, such as electrical power distribution, service and instrument air, and the various makeup water and cooling water systems, are tested as early as possible. The majority of pre-operational testing will be performed on an individual system bases; however a few more integrated tests will be performed during this phase. For example, the RPV Hydrostatic Test, RCCV Structural Integrity and Integrated Leak Rate tests, and ECCS LOOP/LOCA test will involve multiple systems.

The tests are organised by sequences so that the satisfactory completion of one test ensures the safe performance of subsequent tests. Steps could therefore necessitate the simulation of some operating situations that cannot otherwise be achieved at this stage. The above corresponding tests are repeated as soon as required plant conditions can be obtained.

Start-Up Testing is the third part of the commissioning program. This part begins after all systems have been turned over from commissioning to the Licensee's operating organization. This part ends with completion of the Warranty Run. The tests conducted during the start-up phase consist of major and minor plant transients, steady-state tests, and process control system tests all of which are directed towards demonstrating correct performance of the nuclear boiler and the various plant systems while at power. The testing in this part is performed in various test plateaus (For example, Open Vessel, Nuclear Heat-up, Low Power, Mid Power and High Power) which are defined by plant operational conditions.

Although the order of testing within a given plateau is somewhat flexible, the normal recommended sequence of tests would be: (1) core performance analysis; (2) steady state tests; (3) control system tuning; (4) system transient tests; and (5) major plant transients (including trips). Also, for a given testing plateau, testing at lower power and flow levels should generally be performed prior to higher power and flow levels.

Tentatively the commissioning organization will have hold points before systems are turned over from Construction to Commissioning and Commissioning to Licensee and prior to each Start-Up testing plateau to review adequacy of testing in the previous plateau.

29.7 Commissioning Program Test Summaries

29.7.1 Pre-Operational Tests

The preoperational tests anticipated for the UK ABWR will be listed and described in this section. These test descriptions will include purpose, prerequisites, general test methods and acceptance criteria. The list and details of these pre-operational tests will be defined during later program stages.

All pre-operational tests are normally completed before the initial core is loaded. This is not the case for tests performed on equipment or functional assemblies that can only be operated after core loading. An example is the case of the control rod system tests. Complete hot and cold tests are performed on this equipment after core loading and before actual reactor start-up.

Moreover, when a pre-operational test cannot normally be completed before initial core loading, due to unavailability of associated equipment and/or systems or when its results are deemed unsatisfactory, then the test with rare exception may be carried out or repeated after fuel loading has taken place. However, neither test performance nor lack of test results may in any way conflict with the safety requirements.

29.7.2 Start-up Test

The start-up tests anticipated for the UK ABWR will be listed and described in this section. These general test descriptions will provide a test purpose, test prerequisites, test description and test acceptance criteria, where applicable. The list and details of these Start-up tests will be defined during later program stages.

Start-up tests types are defined as:

- *Standard start-up tests*, which are designed to verify the proper operation of the installation and its compliance with the associated performance objectives;
- *Tests, which are repeated at different power levels* during power escalation (core physics and control systems tests) for the purpose of confirming, for each power level, the validity of the hypotheses used in the plant operation and safety analyses and during the design of protection systems;
- *“First-of-a-kind” tests* are performed in order to verify an innovative concept, which has not yet been validated. Such tests may require specific instrumentation capable of confirming theoretical data.