

UK ABWR

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UK ABWR Generic Design Assessment

Generic PCSR Chapter 29 : Commissioning



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29.1 Commissioning Programme 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, their safety requirements and reliability requirements as claimed in the safety case. The commissioning programme is formed around international guidance of [Ref-1], [Ref-2], [Ref-3], and [Ref-4].

29.2 Commissioning Programme 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 tests will be grouped into commissioning phases in a logical sequence from non-nuclear testing phases to nuclear testing phases, and from testing for individual components and systems to overall testing for integrated systems, with overall testing for the plant at the end of commissioning. 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. Where appropriate there will be a progressive sequence of tests so that the plant is exposed to less onerous test conditions before it is exposed to more onerous conditions.

29.3 Commissioning Programme Objectives

The objectives of the commissioning programme are to:

- 1) Ensure that the structures, systems and components have been constructed, manufactured and installed correctly and that they are functioning as anticipated by the design specification.
- 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 instructions 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.
- 8) Familiarise the Licensee's staff (including Operators) with the operation of the facility.

29.4 Commissioning Programme Organization

An organization 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.

Organizational arrangement is taken into account that construction work, commissioning, and operation, are conducted and overlapped for the duration of commissioning. Also, the arrangements clarify the role and responsibility. As described in the IAEA NS-G-2.9 [Ref-5], there are many ways in which the construction, commissioning, and operating groups could be formed by different organizations. This may depend on the industrial practice and contractual arrangements. However, in general, plant operation during Start-up testing phase is arranged, performed, and managed by the licensee based on the licence conditions of the site license. Hence, the details of the organizational arrangement will be provided after 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 programme is conducted in accordance with arrangements set forth by the Licensee. The arrangements will include the Hitachi-GE administrative methodology and requirements that govern the activities of the commissioning group and their interfaces with other organizations. These administrative methodologies are based on extensive BWR & ABWR commissioning experience, which have been used for commissioning of many BWR and ABWR stations and will be the subject of knowledge transfer to the licensee, and will be summarised as the administrative procedures for site commissioning to underpin the commissioning programme. 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 programme 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. C&I 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

Arrangements will be established to develop, check, and approve test procedures.

Majority of 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

Arrangements 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 pre-operational and start-up test phases. Additionally, reactor operating and testing experience of similar nuclear power plants obtained from other industry sources will be utilised to the extent practicable in developing and carrying out the commissioning programme.

29.5.5 Validation of Operating Instructions

Arrangements will be established to ensure test procedures, to the extent practicable, use existing operating instructions, emergency, and abnormal instructions in performance of tests. These instructions will be developed by the Licensee with HGNE input. The use of these operating, emergency, and abnormal instructions is intended to do the following:

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

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

29.5.6 Turnover Principles

Turnover of a system which is planned implementation of Pre-Operational Testing will occur in phases from Construction Testing/Work to Pre-Operational Testing and Pre-Operational Testing to Licensee. 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 Testing/Work to Pre-Operational Testing is that a system will be ready for Pre-Operational 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 Testing/Work to Pre-operational Testing 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 Pre-Operational Testing to Licensee 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 Pre-Operational Testing to Licensee 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 Programme Schedule

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

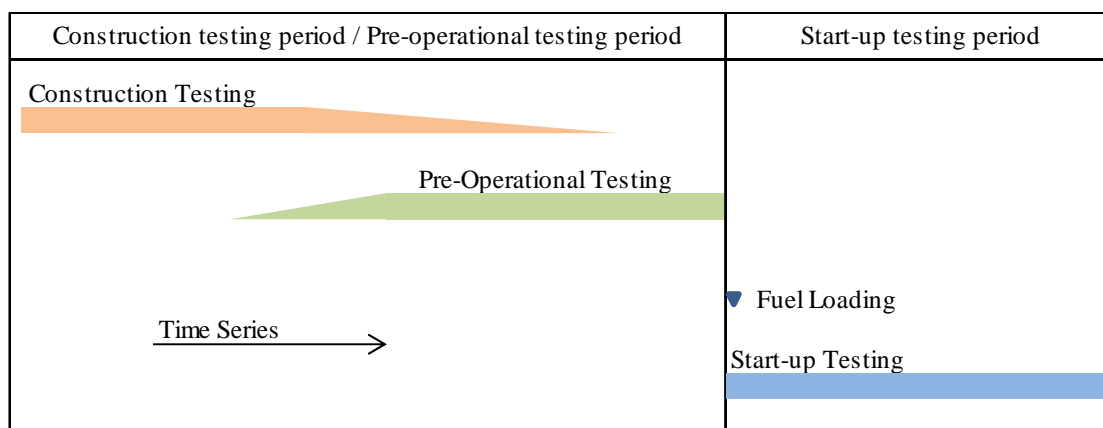


Figure 29.6-1 Commissioning Schedule Overview

Construction testing determines correct installation and functionality of equipment. Pre-Operational 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 Testing 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, wiring continuity and separation checks, hydrostatic pressure tests, electric power distribution facilities test 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 programme. 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 Pre-Operational Testing phase, testing should be performed as system turnover from construction testing/work allows. Further, the system turnover from the construction testing/work is conducted one after another. Therefore, not only Pre-operational tests but also construction tests/inspections/works are carried out in various places during this period in general. However, the interdependence of systems will be considered so that common support systems, such as service and instrument air, 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 and performed such as interlock test, pump/fan/blower test, and system operation/function test; however a few more integrated pre-operational tests and integrated construction inspections/tests will be performed during this phase with operating each related system. For example, the RPV Hydrostatic Test, RCCV Structural Integrity and Integrated Leak Rate Tests, Condenser vacuum up test, and integrated interlock test (including 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 programme. This part begins after all systems have been turned over from Pre-operational Testing to the Licensee. 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 whilst 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. Technical Specifications will be applied in this period and contributes safety operation at start-up test.

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 (including pump trips); and (5) major plant transients (including plant 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 Testing/Work to Pre-Operational Testing and Pre-Operational Testing to Licensee and prior to each Start-Up testing plateau to review adequacy of testing in the previous plateau.

29.7 Commissioning Programme Test Summaries

29.7.1 Pre-Operational Tests

The pre-operational 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 stages of the licensing process, after GDA.

All pre-operational tests are normally completed before the initial core is loaded. 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 stages of the licensing process, after GDA.

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.

29.8 References

- [Ref-1] International Atomic Energy Agency, 'Commissioning for Nuclear Power Plants', IAEA Safety Standards Series No. SSG-28, Vienna, May 2014
- [Ref-2] International Atomic Energy Agency, 'Safety of Nuclear Power Plants: Commissioning and Operation', IAEA Safety Standards Series No. SSR-2/2, Vienna, July 2011
- [Ref-3] UK Office for Nuclear Regulation, 'Safety Assessment Principles for Nuclear Facilities: 2014 Edition', Rev. 0, November 2014
- [Ref-4] US Nuclear Regulatory Commission, 'Initial Test Programs For Water-Cooled Nuclear Power Plants', Regulatory Guide 1.68, Rev. 3, March 2007
- [Ref-5] International Atomic Energy Agency, 'Commissioning for Nuclear Power Plants', IAEA Safety Guide Series No. NS-G-2.9, Vienna, June 2003