GE Hitachi Nuclear Energy

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Revision A

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BWRX-300 UK Preliminary Safety Report (PSR) Chapter 14 – Plant Construction and Commissioning

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NEDO-34177 Revision A

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EXECUTIVE SUMMARY

The BWRX-300 Generic Design Assessment (GDA) Preliminary Safety Report Chapter 14 presents at a high-level how the BWRX-300 construction and commissioning documentation can enable a future duty holder/licensee to implement the processes to ensure the suitability of the documentation, training, and organisational structure/arrangement for the implementation of the construction and commissioning program, together with plant and system interfaces.

Detail of the duty holder/licensee arrangements are currently unknown and are not specific. Therefore, at this stage the scope of this chapter is limited to a summary of the operational philosophies developed for the BWRX-300 design. For example, the conduct of construction and commissioning will attempt to define the approach to program schedule and resource requirements, which may be currently out of scope.

Claims and arguments relevant to GDA step 2 objectives and scope are summarised in Appendix A, along with an As Low as Reasonably Practicable (ALARP) position. Appendix B provides a Forward Action Plan.

ACRONYMS AND ABBREVIATIONS

Acronym	Explanation
ALARP	As Low As Reasonably Practicable
BAT	Best Available Technique
CAE	Claims, Arguments and Evidence
CDM 2015	Construction (Design Management) Regulation 2015
EPS	Electrical Power System
FAT	Factory Acceptance Test
GDA	Generic Design Assessment
GEH	GE Hitachi Nuclear Energy
IAEA	International Atomic Energy Agency
LfE	Learning from Experience
MSQA	Management for Safety and Quality Arrangements
OPEX	Operating Experience
ONR	Office for Nuclear Regulation
QA	Quality Assurance
RB	Reactor Building
RGP	Relevant Good Practice
RWB	Radwaste Building
SMR	Small Modular Reactor
SSCs	Structures, Systems, and Components
UK	United Kingdom

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REVISION SUMMARY

Revision #	Section Modified	Revision Summary
A	All	Initial Issuance

14. PLANT CONSTRUCTION AND COMMISSIONING

This chapter presents how the construction and commissioning workstreams will provide assurance that the BWRX-300 Small Modular Reactor (SMR) plant can meet the requirements for service with respect to construction and commissioning for plant sited within the United Kingdom (UK) boundary and ensure that safety and reliability remain key within the project.

The following chapters will support PSR Ch. 14 – Plant Construction and Commissioning:

- PSR Ch. 3 – NEDC-34165P, “PSR Ch. 3 – Safety Objectives and Design Rules for SSCs,” (Reference 14-1) - describes the approach to delivering the safety objectives and design rules. The safety objectives and design rules provide the basis by which the commissioning requirements are derived.
- PSR Ch. 4 – NEDC-34166P, “PSR Ch. 4 – Reactor,” (Reference 14-2) provides a high-level description of the design of the GNF2 fuel assembly, the core loading pattern, and the associated reactor core systems to be adopted for the BWRX-300.
- PSR Ch. 5 – NEDC-34167P, “PSR Ch. 5 – Reactor Coolant System,” (Reference 14-3) describes the BWRX-300 Nuclear Boiler System, which generates and delivers steam to the turbine for power generation.
- PSR Ch. 6 – NEDC-34168P, “PSR Ch. 6 – Engineered Safety Features,” (Reference 14-4) describes the BWRX-300 Engineered Safety Features which mitigate the consequences of Anticipated Operational Occurrences or postulated Design Basis Accidents without any core damage, including systems such as Isolation Condenser System, Containment and Associated Systems and Control Room Habitability.
- PSR Ch. 7 – NEDC-34169P, “PSR Ch. 7 – Instrumentation and Control,” (Reference 14-5) describes the systems required to support the plant safety strategy described in PSR Ch. 3, and how these systems will comply with their design and safety requirements.
- PSR Ch. 8 – NEDC-34170P, “PSR Ch. 8 - Electrical Engineering,” (Reference 14-6) describes the Electrical Power System (EPS) that is relied upon to support the plant safety strategy described in PSR Ch. 3, covering the EPS and associated systems, including the Electrical Distribution System.
- PSR Ch. 9A – NEDC-34171P, “PSR Ch. 9A – Auxiliary Systems,” (Reference 14-7) describes the BWRX-300 Auxiliary Systems including:
  - Fuel Storage and Handling Systems
  - Water Systems
  - Process Auxiliary Systems
  - Air and Gas System
  - Heating, Ventilation and Air Conditioning Systems
  - Fire Protection Systems
  - Supporting Systems for Diesel Generators
  - Overhead Lifting Equipment
  - Miscellaneous Auxiliary Systems

- PSR Ch. 9B – NEDC-34172P, “PSR Ch. 9B – Civil Structures,” (Reference 14-8) covers the following Civil Engineering structures:
  - The Integrated Reactor Building (RB). Reference to the integrated RB is inclusive of the RB, containment, and containment internals Reactor Pressure Vessel support pedestal, Bio Shield, and internal structural steelwork, including the Containment Equipment and Piping Support Structure and the support floors, whereas RB is used to refer to the reactor building structure outside of containment.
  - Pools within the RB
  - Radwaste Building (RWB)
  - Tanks within the RWB
  - Turbine Building
  - Service Building
  - Control Building
  - Reactor Auxiliary Structures
  - Fire Water Storage Tank and Pump Enclosure
- PSR Ch. 10 – NEDC-34173P, “PSR Ch. 10 – Steam and Power Conversion Systems,” (Reference 14-9) describes the components of the BWRX-300 steam and power conversion system, how these are designed to produce electrical power utilising the steam generated by the reactor. The Main Turbine Equipment consists of the systems below:
  - High Pressure and Low Pressure Turbines, casings, Main Steam stop and control valves, non-return valves, reheat steam stop (intermediate stop) and intercept valves, and turning gear
  - Turbine Gland Seal Subsystem
  - Turbine Lube Oil System
  - Extraction Steam System
  - Electro-Hydraulic Controls Subsystem
  - Feedwater Systems
  - Main Condenser and Auxiliaries
  - Moisture Separator Reheater System
  - Circulating Water System
- PSR Ch. 23 – NEDC-34195P, “PSR Ch. 23 – Chemistry,” (Reference 14-10) provides a functional description of the reactor chemistry management and control approach to be implemented for the BWRX-300.

Claims and arguments relevant to GDA step 2 objectives and scope are summarised in Appendix A, along with an ALARP position. Appendix B provides a Forward Action Plan, which includes future work commitments and recommendations for future work where ‘gaps’ to GDA expectations have been identified. Appendix C summarises key regulatory requirements in the UK and presents considerations with regards to addressing these.

14.1 Construction

14.1.1 Management System

The primary responsibility for safety and security is assigned to the future licensee or the constructor (depending on the project phase and model adopted). This responsibility includes the supervision of activities of all other related groups, such as design, supply, manufacture, and construction, employers, and contractors, as well as the operating organization itself.

Construction, commissioning, and related activities are developed and implemented under a management system that meets the minimum general requirements, which may include:

- A clear requirement that the arrangements control construction or installation of new plant which may affect safety.
- The requirement to submit to the regulator for approval such part or parts of the arrangements as the regulator may specify.
- The requirement that once approved by the regulators arrangements cannot be altered or amended without the approval of the regulator.
- The requirement, where appropriate, that the construction or installation shall be divided into stages.
- The requirement that where the regulator so specifies, the licensee shall not commence nor thereafter proceed from one stage to the next without the consent of the regulator thereby providing regulatory control by requiring hold points in the implementation process.
- The requirement for the provision of adequate safety documentation to justify the safety of the construction or installation and where appropriate provide for the submission of this documentation to the regulator.
- The requirement to halt the construction or installation if so, directed by the regulator and not to recommence without the consent of the regulator.

The Licensees responsibilities cover all aspects related to the construction and commissioning of the facility. These responsibilities include the oversight of contracted activities as well as activities that are specifically performed by the licensee to include:

- Ownership of the safety case (including information provided by design authority, constructors, and contractors)
- Confirmation that the facility is built in accordance with the design basis, regulatory requirements, and applicable codes and standards
- Preparation and updating (management) of construction plan documents
- Performance of inspections, tests, and verification of safety class Structures, Systems, and Components (SSC)
- Evaluation of safety-significant inspection findings and associated reports to the regulator
- Identification of jurisdictional boundaries and responsibilities where more than one regulatory body governs

Preparation, construction and operation phases, uses a graded approach, as applicable to the phase to support the following:

- Developing and maintaining Operating Experience (OPEX), Risk Management and Significant OPEX Report programs

- Work Protection
- Operations Scoping and Assessment
- Design Package Review and Approval
- Work Plan Review and Approval
- Support for commissioning and turnover of plant systems
- Document Reviews and Governance Development and Revisions
- Strategic Plans and Schedules Development and Reviews

The processes that comprise the management system and maintain objective evidence to demonstrate effective implementation of the management system are defined, documented, controlled, and maintained.

Optimization of the construction and commissioning approach to the BWRX-300 design will continue beyond the Pre-Construction Safety Report into the Pre-Commissioning Safety Report, where optimization of the test sequencing can be identified and progressed to ensure that the potential risks of failures or errors relating to the Structures, Systems, and Components (SSCs) during construction and commissioning are minimized.

14.1.2 Construction Organization

The Construction Program Management Plan will provide guidance and identify activities necessary for the planning, construction and commissioning of the BWRX-300 plant.

A typical organization will consist of directors, management team, supervisors and support staff, quality officer, entry level workers together with functional departments for each area (Project site manager, technical services lead, trade disciplined superintendents, quality lead, Health and Safety lead).

The construction organization will install and erect plant equipment, perform construction and installation tests i.e. visual inspections, test procedures until testing is completed where plant systems are prepared for pre-operational / pre-start up testing by the licensee's operating / commissioning organization.

The exact construction organization is dependent on the future licensee's construction, commissioning and operation model. The BWRX-300 design and construction does not preclude any construction organization models.

14.1.3 Plant Construction

The Construction Strategy Report, 006N8706, "BWRX-300 Construcion Strategy Report," (Reference 14-11) documents a viable construction execution approach that can be used to build an advanced BWRX-300 SMR on a generic site. For the contracting approach, it is anticipated that GEH will work with an Engineering, Procurement, and Construction contractor or a constructor to deliver the project in a consortium or similar arrangement. However, this does not preclude other delivery models but intends to demonstrate that a common approach is viable.

Operating and testing experience is utilized in the development and implementation of the BWRX-300 construction and commissioning program. Lessons learned from previous plant designs, construction, testing and operation are incorporated into the plant construction program as well as commissioning test specifications for use with test procedures. This will ensure that arrangements will be in place to capture and respond to OPEX feedback thus sharing learning within the GEH program.

14.1.4 Modularisation

The BWRX-300 employs modularization construction techniques, which reduce the onsite construction time, lower onsite craft peaks, etc. with a goal of reducing the overall project schedule risk. These improved construction techniques are also employed to improve quality, reduce field personnel hours, reduce weather-related delays and improve schedule duration and margin. The Modularization Strategy Report, 006N8670, "BWRX-300 Modularization Strategy Report," (Reference 14-12) provides a background on nuclear modularization and how GEH utilizes modularization techniques to deliver the BWRX-300 plant design to support accelerated construction.

14.1.5 Construction Readiness Review

Prior to the beginning of construction, the readiness of contractors to proceed is ensured by a construction readiness review. The construction readiness review verifies:

- Management systems are in place
- Adequate planning has been conducted
- Procedures and training are completed as necessary
- Construction hazards have been adequately evaluated with control measures identified
- Environmental controls are in place consistent with assessed risks and potential or planned impacts

The construction readiness review assesses the following areas:

- Regulatory requirements
  - Satisfaction of all applicable regulatory requirements and all required permits obtained.
- Management system
  - Key construction positions are established with related organizational roles and responsibilities known with the project sufficiently staffed to oversee construction.
  - Management systems are in place to monitor performance against the project baseline.
- Design completion
  - Design is sufficiently complete to allow the construction readiness review verification steps listed above to be undertaken. Incomplete areas are identified, and schedules established for completion.
- Information technology
  - Alignment and interoperability of hardware, software, information communications and the information technology environment for communications with contractors.
- Construction procedures
  - Contractor and subcontractor procedures used for completion of the facility construction in accordance with applicable regulations, design, and contract requirements.

- Materials management
  - Process for construction activities, including the acquisition of materials, delivery, inspection, packaging, storage requirements and waste management from materials receipt.
- Health, safety and environmental assurance
  - Capability of the constructor to manage a safe project that includes safety management system key requirements, specific plans and procedures related to industrial health and safety, industrial hygiene, and environmental controls. Verification that contractors have a completed project safety and health plan and environmental management plan.
- Project control
  - Adequacy of project controls that ensure adherence to the performance baseline and the systems or processes relied on for monitoring and controlling the project.
- Construction execution plan
  - Specific construction activities and the qualified personnel and procedures in place to accomplish the work; to include general construction topics such as site preparedness and work sequencing.
- Training and qualification
  - Training and qualification of personnel responsible for construction activities to encompass the general training required for site access and specific training necessary to perform planned work activities.
- Work planning
  - Work processes are controlled by approved instructions, procedures, design documents, technical standards, or hazard controls appropriate for the task performed.
  - The organization of work and whether systems are in place and sufficiently mature to support the development of work packages or processes.
- Constructability
  - Design specifications, drawings, site conditions and construction schedule are reviewed by the construction organization and deemed practicable and efficient.
- Field engineering
  - Readiness explicit to construction of specific facility systems in accordance with the approved design, taking into account field observation feedback that may impact design.
  - Field staff in place to support construction with technical guidance and oversight and ensure adherence to the design requirements.
- Infrastructure
  - Support systems including required electricity, gas and water supply, fire protection, temporary offices and sanitation facilities, protection of SSC after installation (including environmental requirements).

- Quality Assurance (QA)
  - Verification of an approved QA plan to address construction and procurement activities.
- Labour management
  - Labour management necessary to successfully execute the project and ensure the adequacy of the local labour force to support the project.
- Construction tools and equipment
  - Availability and operability of tools and equipment necessary to support construction activities and ensuring the equipment meets jurisdictional requirements.

Construction of SSC is established and controlled using generally accepted construction and project management practices in accordance with the design documents. Construction activities are controlled in accordance with design drawings, specifications, and procedures that include:

- Prerequisites
- Precautions to be observed
- Installation requirements
- Sequential actions to be followed, including coordinating construction and verification activities
- Inspection and test plans
- Special equipment and procedures required for installation
- Specific document reference
- Data report forms and records
- Reviews and approvals
- Housekeeping requirements
- Foreign material exclusion requirements

14.1.6 Program Schedule

A Construction Program establishes the planning, scheduling and construction sequencing. Hold and witness points are identified with provisions for interested parties such as engineers, architects and inspectors. Right of access to facilities and records for witness points or audit is assured.

Items with long lead times, on-site manufacturing, modular assembly, and testing are identified with provisions to ensure construction sequencing is not adversely affected. Any differences between purchasing requirements, the licence to construct design basis and as-built items are evaluated, reconciled, and reported to the authorized inspection agencies. Long lead items for the BWRX-300 construction include, but are not limited to:

- Reactor Pressure Vessel
- Hydraulic Control Units
- Fine Motion Control Rod Drives
- Steam Turbine Generator Set

- Reactor Pressure Vessel Internals – Large
- Main Output Transformer
- Diaprhagm Plate Steel Composite Structure

Measures addressed in the Construction Program will be in place that define management and oversight responsibilities. Contractors maintain a defined management system that is compliant with the current standards. The licensee ensures that the required quality, health, safety, and security of the public and workers, and protection of the environment are maintained.

The Maintenance Program will describe the processes for planning, monitoring, scheduling, and executing maintenance work activities performed during the construction and commissioning phases. During construction and commissioning (prior to fuel load) the maintenance, surveillance and in-service testing of components and systems will be managed by the design authority.

A chemistry control program, specifications, or procedures, established by the constructor, is expected to be in place to cover the requirements/aspects for the construction and commissioning phases of the project. The Chemistry Control Program establishes processes used to control contaminants to maintain system integrity during construction and commissioning. Chemistry control during construction and commissioning is discussed in PSR Ch. 23 (Reference 14-10).

14.2 Commissioning

Commissioning is the responsibility of the future licensee. The commissioning organization plans, organizes, coordinates, and maintains the status of deliverables associated with the turnover of the new facility. The commissioning organization is a multi-disciplinary team with individuals from the various organizations including construction contractor(s), GEH, equipment vendors, licensee, and others.

14.2.1 Commissioning Program

The Commissioning Program covers the range of activities from completion of installation work to reactor power ascension to 100%. SSC are tested to provide assurance that the facility has been properly designed and constructed and is ready for safe operation.

The Commissioning Program:

- Defines clear responsibilities for commissioning activities and oversight.
- Is structured such that objectives and methods of testing are understood to allow management control and coordination.
- Outlines testing performed to ensure that SSC are built as designed and meets the safety analysis requirements.
- Verifies safety analysis assumptions, satisfaction of design requirements and the presence of adequate safety and operating margins.
- Ensures tests are only conducted if the reactor facility remains within the range of assumptions made in the safety analysis and the licensing basis remains valid.
- Includes the provision of temporary equipment and utilities that may be controlled by temporary modifications.
- Identifies security systems to be commissioned before nuclear fuel or material is brought on-site.
- Documents test results and identifies any impact on or changes made to the facility design.
- Validates operating and emergency procedures to the extent practical.
- Ensures integrated system validation of control rooms and control areas.
- Ensures a schedule including milestones and regulatory hold points, and test results to be submitted for review are identified and communicated to the regulator.

The Commissioning Program has three distinct test phases:

- Construction Testing: Confirms components are correctly installed and confirms components fitness for use in preoperational testing. The specifics of construction testing are defined in installation specifications or in documentation provided by equipment suppliers.
- Preoperational Testing: Verifies that SSCs are capable of operating in a safe and efficient manner compatible with the system design bases. After preoperational testing is complete, systems turnover to the owner is performed. The testing requirements for preoperational testing are found in the preoperational test specifications.
- Startup Testing: Testing conducted during (in preparation for) fuel loading and at incrementally ascending power levels to demonstrate performance of the nuclear boiler and various unit systems while at power.

The process for commissioning SSC is established and controlled to confirm that the design and safety analysis requirements are met prior to placing them in service. During commissioning of SSC, they are operated and maintained within the safe operating envelope and in accordance with documentation consistent with the design. A system of permits, tags, or equivalent controls are in place to support safe operation to include the marking of the boundary of commissioning, construction, and operational activities.

SSC are commissioned in accordance with written specifications and work procedures that clearly identify the test objectives, required performance data, acceptance criteria and prerequisites for commissioning.

Commissioning documentation is verified for design conformity and commissioning results are reviewed and confirmed to be acceptable. Commissioning results are incorporated into operating documentation as appropriate. Commissioning work procedures describe the specific commissioning activities and contain:

- Precautions relative to the activities to be performed.
- Back-out provisions to place the nuclear power plant in a safe condition for all anticipated risks to plant and workers.
- Identification of characteristics to be inspected or tested and the conditions to be controlled.
- Sequential actions to be followed, including coordinating construction, commissioning, operations.
- Verification activities, and hold points to be used.
- Acceptance criteria to be used.
- Special equipment requirements to be used.
- Data to be collected.

Additionally, the program allows for:

- Withstanding allowable transients and postulated accidents.
- Indicating that the plant operating instructions can be verified and validated with respect to the SSCs to ensure the plant can be operated safely.
- Providing baseline data for testing during plant life.
- Confirming to the licensee that staff / operators are fully familiar with plant operation.

The commissioning program is also to be established using qualified personnel at all levels that will be involved in the commissioning process, develop and approve test procedures, conduct performance tests and verify and validate the results.

Commissioning of system/plant equipment will be performed in a systematic sequence; tests are arranged to be progressive for the systems to submit to more onerous conditions in a gradual process through to the start of normal operation. There will be a secure, robust and reliable process for the differing aspects of the commissioning cycle, developing from component testing through to integrated system testing.

A commissioning team structure involves a multi-disciplinary team including contractors, equipment suppliers, licensee organization, etc. It plans and co-ordinates the activities associated with initial energization of systems and handover of the facility.

The team will be required to have a representative from quality control, mechanical systems, electrical systems, testing team, operators and the design contractor. A witness from the relevant team will also be required if the testing is to be conducted by contracted staff.

Each team member is to have a defined set of responsibilities and the authority to co-ordinate the commissioning process.

The full commissioning program should be in line with the sequencing outlined in the NP-T-2.10, “Commissioning Guidelines for Nuclear Power Plants,” (Reference 14-13). This will take into account the necessary health, safety and security of the workers and public, as well as ensuring that protection of the environment is maintained.

The program, relative to the initial fuel load date, for conducting each major phase of commissioning is described and is dynamic in nature. The commissioning program is still under development; dependent on the time periods for pre-operational testing and start-up testing being used, a justification is to be provided. To allow for regulatory inspection, test procedure preparation is scheduled such that applicable approved procedures are available prior to their intended use.

The overall objectives of the program are to:

- Demonstrate that construction is complete and acceptable, including required testing.
- Ensure the capability of SSCs to meet design performance requirements.
- Provide additional assurance that the facility has been adequately designed.
- Achieve fuel loading in a safe manner.
- Bring the unit to rated capacity and sustained power operation.

Operating organization functions are demonstrated as part of the Commissioning Program. The demonstrated functions include:

- Management
- Personnel Training
- Radiation Protection Program
- Waste Management
- Records Management
- Fire Safety
- Physical Protection
- Emergency Plan

A detailed testing / commissioning program is to be developed and made available for regulatory awareness. The schedule within the program may be updated and continually optimised to reflect actual progress and any potential revised projections. Milestones for the commissioning program, along with plans for training plant personnel and the development of plant operating and emergency procedures are provided in PSR Ch. 13.

In addition to GEH experience related to the commissioning and startup of new nuclear power plants, the plant OPEX from organisations such as the World Association of Nuclear Operators, Institute of Nuclear Power Operations, and Electric Power Research Institute is reviewed and applied to the development of the initial Commissioning Program of the BWRX-300.

14.2.2 Commissioning Procedures

All procedures and documentation relating to the construction and commissioning phases of the project are to be authored in line with the appropriate Management for Safety and Quality Arrangements (MSQA) documentation. This includes classification, control, storage, updating, revising and deleting documents to remain extant with respect to the QA arrangements. All

reports that are relevant to the construction and commissioning of the plant are to be developed in relation to the testing and operation of the facility.

Commissioning procedures are developed as part of the initial test program and are authored, reviewed and approved by a suitably qualified person relative to the complexity of the system under test. They are also to take into consideration the additional documentation relating to the equipment being commissioned, i.e. operating manuals, Factory Acceptance Testing (FAT) records and manufacturers manuals.

FAT is designed to ensure that there is no manufacturing or performance issues with the approved system components or equipment and is based on:

- Manufacturer drawings
- Data sheets
- Design specifications
- Testing Method Statement

FAT is part of the plant design substantiation that leads to the Pre-commissioning and Commissioning activities of the testing process. It includes inspections together with static and/or dynamic testing of all components to support integrated system testing and to qualify the standards, determine reliability and verify efficiencies, all documented by the supplier.

The FAT protocols will involve:

- Maintenance user manuals
- Work and maintenance procedures
- Certificates of compliance
- As built technical drawings
- Equipment data sheets and calibration certificates

The purpose of the Site Acceptance Testing (SAT) is to determine that the equipment performs as intended once it has been located (installed and configured) following FAT, within the plant construction/commissioning area. This will involve testing to full capacity with all components included, rather than the deterministic approach during FAT, allowing local adjustments and potential design modifications to be made that will respond to all of the on-site conditions. All operators and maintainers will be required to be conversant with the SAT procedures.

The SAT checks will include:

- Visual check
- Functional check
- Safety check
- Pressure and endurance check

The SAT procedure documentation is then reviewed and validated by the Test group, Owner and Licensee.

14.2.3 Program Hold Points

Commissioning and associated testing occurs in four basic phases with-hold points to ensure the prerequisites are complete and required approvals obtained prior to transitioning from one phase to another. Written confirmation for hold points is provided that identifies the following:

- Completion of project commitments tied to the hold point.

- Confirmation that all required system functions for safe operation beyond the hold point are available.
- Other information as appropriate.

Review of test results for each stage is completed before commissioning continues to the next stage.

Specific testing is addressed in commissioning testing procedures. The Commissioning Program establishes the tests necessary to demonstrate the as-built, as installed plant satisfies the approved design, meets the requirements of the safety analysis report, and the plant can be operated in accordance with the operational limits and conditions.

Testing is performed in three basic phases:

- Construction Testing
- Preoperational Testing
- Startup Testing

14.3 References

14-1 NEDC-34165P, “PSR Ch. 3 – Safety Objectives and Design Rules for SSCs,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-2 NEDC-34166P, “PSR Ch. 4 – Reactor,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-3 NEDC-34167P, “PSR Ch. 5 – Reactor Coolant System,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-4 NEDC-34168P, “PSR Ch. 6 – Engineered Safety Features,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-5 NEDC-34169P, “PSR Ch. 7 – Instrumentation and Control,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-6 NEDC-34170P, “PSR Ch. 8 - Electrical Engineering,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-7 NEDC-34171P, “PSR Ch. 9A – Auxiliary Systems,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-8 NEDC-34172P, “PSR Ch. 9B – Civil Structures,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-9 NEDC-34173P, “PSR Ch. 10 – Steam and Power Conversion Systems,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-10 NEDC-34195P, “PSR Ch. 23 – Chemistry,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-11 006N8706, “BWRX-300 Construcion Strategy Report,” Revision A, GE-Hitachi Nuclear Energy, Americas, LLC, November 2021.

14-12 006N8670, “BWRX-300 Modularization Strategy Report,” Revision A, GE-Hitachi Nuclear Energy, Americas, LLC, November 2021.

14-13 NP-T-2.10, “Commissioning Guidelines for Nuclear Power Plants,” IAEA.

14-14 “Safety Assessment Principles for Nuclear Facilities,” Revision 1, Office for Nuclear Regulation, 2014 Editions, January 2020.

14-15 NEDC-34140P, “BWRX-300 UK GDA Safety Case Development Strategy,” GE-Hitachi Nuclear Energy, Americas, LLC.

14-16 NEDC-34196P, “PSR Ch. 24 – Conventional Safety and Fire Safety,” GE-Hitachi Nuclear Energy, Americas, LLC.

APPENDIX A CLAIMS, ARGUMENTS AND EVIDENCE

The Office for Nuclear Regulation (ONR) "Safety Assessment Principles for Nuclear Facilities," (Reference 14-14) identify ONR's expectation that a safety case should clearly set out the trail from safety claims, through arguments to evidence. The Claims, Arguments and Evidence (CAE) approach can be explained as follows:

1. Claims (assertions) are statements that indicate why a facility is safe,
2. Arguments (reasoning) explain the approaches to satisfying the claims,
3. Evidence (facts) supports and forms the basis (justification) of the arguments.

The GDA CAE structure is defined within the Safety Case Development Strategy (SCDS), NEDC-34140P, "BWRX-300 UK GDA Safety Case Development Strategy," (Reference 14-15) and is a logical breakdown of an overall claim that:

> *"The BWRX-300 is capable of being constructed, operated and decommissioned in accordance with the standards of environmental, safety, security and safeguard protection required in the UK".*

This overall claim is broken down into Level 1 claims relating to environment, safety, security, and safeguards, which are then broken down again into Level 2 area related sub-claims and then finally into Level 3 (chapter level) sub-claims.

The Level 3 sub-claims that this chapter demonstrates compliance against are identified within the SCDS and are as follows:

> *2.2.1 Appropriate MSQA procedures controlling documentation production are in place.*
>
> *2.2.4 Future arrangements can be developed to support an operational facility including normal and emergency arrangements.*

In order to facilitate compliance, demonstration against the above Level 3 sub-claims, this Preliminary Safety Report (PSR) chapter has derived a suite of arguments that comprehensively explain how their applicable Level 3 sub-claims are met (see Table A-1 below).

Risk Reduction As Low As Reasonably Practicable

It is important to note that nuclear safety risks cannot be demonstrated to have been reduced ALARP within the scope of a 2-Step GDA. It is considered that the most that can be realistically achieved is to provide a reasoned justification that the BWRX-300 SMR design aspects will effectively contribute to the development of a future ALARP statement. In this respect, this chapter contributes to the overall future ALARP case by demonstrating that:

- The chapter-specific arguments derived may be supported by existing and future planned evidence sources covering the following topics:
  - Relevant Good Practice (RGP) has demonstrably been followed.
  - OPEX has been taken into account within the design process.
  - All reasonably practicable options to reduce risk have been incorporated within the design.
- It supports its applicable level 3 sub-claims, defined within the Safety Case Development Strategy.

Probabilistic safety aspects of the ALARP argument are addressed within PSR Ch. 15.

Table A-1: Conduct of Operations Claims and Arguments

Level 14 Chapter Claim	Chapter 14 Argument	Sections and/or Reports that Evidence the Arguments
2.1 The functions of systems and structures have been derived and substantiated taking into account RGP and OPEX, and processes are in place to maintain these through-life. (Engineering Analysis)		
2.1.2 The design of the system / structure has been substantiated to achieve the safety functions in all relevant operating modes	Procedures will be developed that will provide assurance that the safety functions within all aspects of the construction and commissioning cycles can be controlled, recorded and updated as required dependent on design modifications, commissioning requirements and test acceptance.	14.2.2 Commissioning Procedures
2.1.3 The system/structure design has been undertaken in accordance with relevant design codes and standards (RGP) and design safety principles and taking into account of Operating Experience to support reducing risks to ALARP	RGP and OPEX is demonstrated throughout both the construction and commissioning programs, drawing on expertise from Subject Matter Experts and qualified resource from similar projects to reduce the ALARP risks.	APPENDIX C UK/International Requirements
2.1.4 System/structure performance will be validated by suitable testing throughout manufacturing, construction and commissioning.	Factory Acceptance and Site Acceptance testing shows that SSCs will provide assurance of plant / system performance with respect to Commissioning. Construction testing will be performed in line with the document route map and CDM 2015 regulations.	14.2.2 Commissioning Procedures APPENDIX C UK/International Requirements

Level 14 Chapter Claim	Chapter 14 Argument	Sections and/or Reports that Evidence the Arguments
2.1.6 The BWRX-300 will be designed so that it can be decommissioned safely, using current available technologies, and with minimal impact on the environment and people	Best Available Techniques and Relevant Good Practice will be part of each documented procedure and included within the structure of each defined area of the project, construction, commissioning, etc.	APPENDIX C UK/International Requirements
2.2 The BWRX-300 has been developed in accordance with approved procedures, with appropriate governance and assurance arrangements by a competent and clearly defined organization (Safety Case Area)		
2.2.3 Appropriate governance and assurance arrangements are in place to manage the design and substantiation of the BWRX-300	Legislation and current standards will be adhered to during the full lifecycle of the construction and commissioning phases of the project.	APPENDIX C UK/International Requirements
2.4 Safety risks have been reduced as low as reasonably practicable		
2.4.1 Relevant Good Practice (RGP) has been taken into account across all disciplines	RGP and Best Available Technique (BAT) will be considered through the project lifecycle and will include the disciplines necessary for all workstreams: mechanical, electrical, lifting, construction, etc.	APPENDIX C UK/International Requirements
2.4.2 Operating Experience (OPEX) and Learning from Experience (LfE) has been taken into account across all disciplines	Risks to ALARP will be reduced following the use of RGP and LfE.	APPENDIX C UK/International Requirements

APPENDIX B FORWARD ACTIONS

Table B-1: Construction and Commissioning Forward Actions

Finding	Forward Actions	Delivery Phase
Detail of the duty holder/licensee arrangements for Construction and Commissioning are currently unknown and are not specific. Therefore, at this stage the scope of this chapter is limited to a summary of the construction and commissioning philosophies developed for the BWRX-300 design.	Detail to be added for conduct of plant construction and commissioning once future duty holder/licensee arrangements are known.	Before Site License Application

APPENDIX C UK/INTERNATIONAL REQUIREMENTS

As Low As Reasonably Practicable (ALARP) aspects with respect to the construction and commissioning workstreams will be demonstrated by utilising safety techniques and LfE (with good practice and the potential for improvements) to minimise the risk to nuclear safety.

The Construction (Design and Management) Regulations 2015 (CDM 2015) place legal duties on those involved in construction work, commonly referred to as 'duty holders', which include clients, principal designers, designers, principal contractors, contractors and workers. An assessment has been undertaken and concludes that the construction and commissioning of BWRX-300 is possible within the requirements set out in CDM 2015. NEDC-34196P, "PSR Ch. 24 – Conventional Safety and Fire Safety," (Reference 14-16) provides further discussion on CDM 2015 and the review that has been undertaken.

The GEH program includes the Best Available Techniques (BAT) and up-to-date technologies for construction and commissioning (including future decommissioning) to reduce the impact on workers, the public and the environment.

The documents relating to the regulatory requirements for the BWRX-300 plant will include, but not be limited to:

- IAEA Nuclear Energy Series NP-T-2.10, "Commissioning Guidelines for Nuclear Power Plants," International Atomic Energy Agency.
- IAEA Safety Standards: SSG-28, "Commissioning for Nuclear Power Plants," International Atomic Energy Agency.
- IAEA Safety Standards: SSG-38, "Construction for Nuclear Power Plants," International Atomic Energy Agency.
- IAEA Nuclear Energy Series, Commissioning of Nuclear Power Plants: Training and Human Resource Considerations, NG-T-2.2, 2008
- US DOE Nuclear Facilities Commissioning, G 413.3-23, 8-30, 2019.
- ONR Technical Inspection Guide License Conditions, LC21 – Commissioning.
- ONR Commissioning of Security Systems and Infrastructure, CNS-TAST-GD-4.4.
- UK Nuclear Institute, Nuclear Commissioning Excellence Manual.
- IAEA Safety Standards: SSG-61, "Format and Content of the Safety Analysis Report for Nuclear Power Plants," International Atomic Energy Agency.