

Revision	Approved by	Number of Pages
002		26
Approval Date	24/12/2021	
 General Nuclear System Ltd.		
UK HPR1000 GDA Project		
Document Reference:	HPR/GDA/PCSR/0030	
Title: Pre-Construction Safety Report Chapter 30 Commissioning		
<p>This document has been prepared on behalf of General Nuclear System Limited with the support of China General Nuclear Power Corporation (CGN) and Électricité de France S.A. (EDF).</p> <p>Although due care has been taken in compiling the content of this document, neither General Nuclear System Limited, CGN, EDF nor any of their respective affiliates accept any liability in respect to any errors, omissions or inaccuracies contained or referred to in it.</p>		

DISTRIBUTION LIST

Recipients	Cross Box
GNSL Executive	<input type="checkbox"/>
GNSL all staff	<input type="checkbox"/>
GNSL and BRB all staff	<input checked="" type="checkbox"/>
CGN	<input checked="" type="checkbox"/>
EDF	<input checked="" type="checkbox"/>
Regulators	<input checked="" type="checkbox"/>
Public	<input checked="" type="checkbox"/>

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 1 / 24

TABLE OF CONTENTS

TABLE OF CONTENTS

30.1 List of Abbreviations and Acronyms	3
30.2 Introduction	4
30.2.1 Chapter Route Map	4
30.2.2 Chapter Structure	6
30.2.3 Interfaces with Other Chapters	7
30.3 Applicable Codes and Standards	8
30.4 Site Licensee Commissioning Arrangements.....	9
30.4.1 Organisational Requirements.....	9
30.4.2 Programme Documentation	10
30.4.3 Design Substantiation	12
30.4.4 Classification of Commissioning Activities.....	13
30.4.5 Activity Schedule.....	13
30.5 Overall Plant Commissioning Programme Scope.....	14
30.5.1 Programme Phases.....	14
30.5.2 Commissioning Phased Approach	15
30.5.3 Content of Commissioning Phases	16
30.5.4 First Plant Only Test	18
30.5.5 OTS and Procedures	18

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 2 / 24

30.5.6 Operational Experience Feedback/Lessons Learned System..... 19

30.6 ALARP Assessment.....19

30.6.1 Scope of Relevant Good Practice 19

30.6.2 Consistency Review against RGP..... 19

30.6.3 Conclusions of ALARP Review 22

30.7 Concluding Remarks22

30.8 References22

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 3 / 24

30.1 List of Abbreviations and Acronyms

ACPR1000	Advanced Chinese Pressurised Reactor
ALARP	As Low As Reasonably Practicable
CFT	Cold Functional Test
CFTRVO	Cold Functional Test with Reactor Vessel Open
CGN	China General Nuclear Power Corporation
CI	Conventional Island
CPR1000	Chinese Pressurised Reactor
EOP	Emergency Operating Procedure
FAT	Factory Acceptance Test
FCG3	Fangchenggang Nuclear Power Plant Unit 3
GDA	Generic Design Assessment
HFT	Hot Functional Test
HPR1000 (FCG3)	Hua-long Pressurised Reactor under construction at Fangchenggang nuclear power plant unit 3
IAEA	International Atomic Energy Agency
NOP	Normal Operating Procedure
NPP	Nuclear Power Plant
NSSS	Nuclear Steam Supply System
ONR	Office for Nuclear Regulation (UK)
OTS	Operating Technical Specification
PCSR	Pre-Construction Safety Report
RGP	Relevant Good Practice
SCP	System Commissioning Programme
SSC	Structures, Systems and Components
STP	Stage Test Procedure
TP	Test Procedure
UK HPR1000	UK version of the Hua-long Pressurised Reactor

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 4 / 24

30.2 Introduction

‘Commissioning’ means the process during which plant components and systems, having been constructed or modified, are made operational and verified to be in accordance with design assumptions and to have met the appropriate safety criteria.

The role of commissioning is to collect evidence, and the evidence will be produced during the setup of the commissioning team and the performance of the commissioning activities - not during the Generic Design Assessment (GDA) process. This chapter only provides the requirements and arrangements for commissioning. The objective of this chapter is to present an overview of the arrangements that will be set up to commission the UK version of the Hua-long Pressurised Reactor (UK HPR1000) Nuclear Power Plant (NPP). These commissioning arrangements are used to support the fundamental objective of the Pre-Construction Safety Report (PCSR) and relevant PCSR claims.

To support the chapter claim, the commissioning work follows the strategy listed below:

- a) Identifying Relevant Good Practice (RGP) based on UK context, deriving special requirements for commissioning, comparing these with RGPs and identifying gaps;
- b) Fully deriving the requirements for commissioning, including site licensee commissioning arrangements and commissioning programme scope;
- c) Planning and performing commissioning tests to validate the function of Structures, Systems and Components (SSC); and
- d) Identifying and resolving any commissioning non-conformances.

30.2.1 Chapter Route Map

The ***Fundamental Objective*** of the UK HPR1000 is that: *The Generic UK HPR1000 could be constructed, operated, and decommissioned in the UK on a site bounded by the generic site envelope in a way that is safe, secure and that protects people and the environment.*

To underpin this objective, five high level claims (Level 1 claims) and a number of Level 2 claims are developed and presented in Chapter 1. This chapter supports the ***Claim 3.3.14*** derived from the high level ***Claim 3***.

Claim 3: *The design and intended construction and operation of the UK HPR1000 will protect the workers and the public by providing multiple levels of defence to fulfil the fundamental safety functions, reducing the nuclear safety risks to a level that is as low as reasonably practicable.*

Claim 3.3: *The design of the processes and systems has been substantiated and the*

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 5 / 24

safety aspects of operation and management have been substantiated.

Claim 3.3.14: *An overall plant commissioning programme will be established to ensure that the plant will be substantiated in a safe, efficient and informative manner.*

To support the Claim 3.3.14, this chapter developed three Sub-claims and a number of relevant arguments:

- a) **Sub-claim 3.3.14.SC30.1:** *The overall plant commissioning programme, will contribute to the demonstration that the UK HPR1000, as built, will be capable of safe and reliable commercial operation throughout its life cycle, in accordance with the design intent, as claimed in the plant overall safety case.*

The UK HPR1000 overall plant commissioning programme will be designed to:

- 1) **Argument 3.3.14.SC30.1-A1:** *Demonstrate that adequate organisational arrangements are in place which support the change in risk associated with the change from inactive commissioning (non-nuclear testing, before first core loading) to active commissioning (nuclear testing, after first core loading), described in Sub-chapter 30.4.1;*
 - 2) **Argument 3.3.14.SC30.1-A2:** *Verify, where possible, that the plant meets the design intent (in accordance with the design specification, as claimed in the plant overall safety case), described in Sub-chapter 30.4.3;*
 - 3) **Argument 3.3.14.SC30.1-A3:** *Confirm the main design parameters, including compliance with applicable codes, standards and the UK HPR1000 quality assurance programme, described in Sub-chapter 30.4.3 and Sub-chapter 30.4.4.*
- b) **Sub-Claim 3.3.14.SC30.2:** *The overall plant commissioning programme, will contribute to the demonstration that the UK HPR1000, as built, will be in compliance with the requirements of Reference [1].*

The UK HPR1000 overall plant commissioning programme will be designed to:

- 1) **Argument 3.3.14.SC30.2-A1:** *Provide substantiation that the commissioning team are suitably qualified and experienced, described in Sub-chapter 30.4.1;*
- 2) **Argument 3.3.14.SC30.2-A2:** *Develop a comprehensive portfolio of plant baseline data to support the progression between commissioning activities and for comparison with future Examination, Maintenance, Inspection and Testing, described in Sub-chapter 30.4.2;*
- 3) **Argument 3.3.14.SC30.2-A3:** *Provide an opportunity to train/familiarise plant operating and technical personnel with plant SSC, Reference [2], described in Sub-chapter 30.4.1 and Sub-chapter 30.5.3;*

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 6 / 24

- 4) **Argument 3.3.14.SC30.2-A4:** Demonstrate, where commissioning provides a representative approach, the use of Operating Technical Specification (OTS), and so far as reasonably practicable procedures (including Normal Operating Procedure (NOP) and Emergency Operating Procedure (EOP), according to Chapter 31, and Emergency Preparedness, according to Chapter 32), described in Sub-chapter 30.5.5.
- c) **Sub-claim 3.3.14.SC30.3:** The overall plant commissioning programme, will contribute to the demonstration that the UK HPR1000, as built, will present inactive/active commissioning risks that are As Low As Reasonably Practicable (ALARP).

The UK HPR1000 overall plant commissioning programme will be designed to:

- 1) **Argument 3.3.14.SC30.3-A1:** Consider any remediation required where design, programme or test changes are necessary, or where unexpected results (anomalies) are obtained, or adverse events occur, ensuring that systems are in place to manage the implications (for example, establish the reasons and devise resolutions where possible), described in Sub-chapter 30.4.3;
- 2) **Argument 3.3.14.SC30.3-A2:** Demonstrate the safety functional and operational requirements of the plant, through a structured, systematic and progressive programme of activities (testing and inspection of plant SSC), described in Sub-chapter 30.4.5 and Sub-chapter 30.5;
- 3) **Argument 3.3.14.SC30.3-A3:** Demonstrate that, so far as reasonably practicable, commissioning does not introduce additional hazards (for example, conventional and nuclear safety related), described in Sub-chapter 30.4.3;
- 4) **Argument 3.3.14.SC30.3-A4:** Demonstrate that commissioning risks arising are ALARP and justified, taking into account relevant good practice, described in Sub-chapter 30.6.

30.2.2 Chapter Structure

The general structure of this chapter is presented as below:

- a) Sub-chapter 30.1 List of Abbreviations and Acronyms:

This section lists the abbreviations, acronyms that are used in the PCSR Chapter 30.

- b) Sub-chapter 30.2 Introduction:

This section gives a brief introduction of PCSR Chapter 30.

- c) Sub-chapter 30.3 Applicable Codes and Standards:

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 7 / 24

This section describes the applicable codes and standards.

d) Sub-chapter 30.4 Site Licensee Commissioning Arrangements:

This section describes the site licensee commissioning arrangements.

e) Sub-chapter 30.5 Overall Plant Commissioning Programme Scope:

This section describes the scope of overall plant commissioning programme.

f) Sub-chapter 30.6 ALARP Assessment:

This section presents the ALARP Assessment of this chapter.

g) Sub-chapter 30.7 Concluding Remarks:

This section provides the concluding remarks.

h) Sub-chapter 30.8 References:

This section lists the supporting references of this chapter.

30.2.3 Interfaces with Other Chapters

The interfaces with other chapters are listed in the following table.

T-30.2-1 Interfaces between Chapter 30 and Other Chapters

PCSR Chapter	Interface
Chapter 1 Introduction	Chapter 1 provides the Fundamental Objective, Level 1 Claims and Level 2 Claims. Chapter 30 provides chapter claims, and arguments to support relevant high level claims that are addressed in Chapter 1.
Chapter 4 General Safety and Design Principles	Chapter 4 provides the safety classification principles and selection principles of codes and standards. The design of commissioning tests considers these design principles.
Chapter 5 Reactor Core	The arrangements and requirements for commissioning align with SSC design requirements.
Chapter 6 Reactor Coolant System	
Chapter 7 Safety Systems	
Chapter 8 Instrumentation and Control	
Chapter 9 Electric Power	
Chapter 10 Auxiliary	

PCSR Chapter	Interface
Systems	
Chapter 11 Steam and Power Conversion System	
Chapter 16 Civil Works & Structures	
Chapter 23 Radioactive Waste Management	
Chapter 28 Fuel Route and Storage	
Chapter 21 Reactor Chemistry	Chapter 21 provides the objectives for commissioning from the chemistry and material aspects. Chapter 30 provides the arrangements and requirements for commissioning according to these objectives.
Chapter 25 Conventional Safety and Fire Safety	Chapter 25 provides the requirements for conventional safety and fire safety. Chapter 30 considers these requirements.
Chapter 31 Operational Management	Chapter 31 provides the methodology of OTS, NOP and EOP. The commissioning tests design considers these documents.
Chapter 32 Emergency Preparedness	Chapter 32 provides the requirements of emergency preparedness. Chapter 30 considers these requirements of emergency preparedness.
Chapter 33 ALARP Evaluation	Chapter 33 provides the overall ALARP demonstration of ALARP. Chapter 30 demonstrates that the safety risks are reduced to the level that is ALARP by in the consideration of commissioning.

30.3 Applicable Codes and Standards

The selection of codes and standards for the design of the overall plant commissioning programme of the UK HPR1000 follows the selection principles and selection process presented in Chapter 4 (Sub-chapter 4.4.7) and *General Principles for Application of Laws, Regulations, Codes and Standards*, Reference [3]. The selection of codes and standards for this chapter complies with the RGP of international organisations or other countries acknowledged by the UK regulators.

The factors provided below have been considered sufficiently when exploring the selection principles.

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 9 / 24

- a) Design characteristics;
- b) Regulatory expectations;
- c) Requirements of the guidance issued by authority organisations; and
- d) Other considerations (e.g. relevant good practice and other experience).

Safety requirements, safety guides and standards of international organisations (e.g. International Atomic Energy Agency (IAEA)) used in the UK HPR1000 are the same series as Fangchenggang Nuclear Power Plant Unit 3 (FCG3). Therefore, applying these standards does not affect the design of the UK HPR1000.

The Safety Standards from IAEA are identified as RGP for commissioning and the design of the overall plant commissioning programme has been undertaken in accordance with:

- a) IAEA, Safety of Nuclear Power Plants: Commissioning and Operation, IAEA Safety Standards Series No.SSR-2/2, Rev.1, 2016, Reference [4].
- b) IAEA, Commissioning for Nuclear Power Plants, IAEA Safety Standards Series No.SSG-28, 2014, Reference [5].

30.4 Site Licensee Commissioning Arrangements

The responsibility for ensuring fulfilment of the safety functional requirements (see sub-claims), during the overall plant commissioning programme will rest with the site licensee, and will be supported as required by the responsible designer. Hence, the site licensee commissioning arrangements given in this section are illustrative and will be developed as part of the overall plant commissioning programme during the site specific nuclear site licensing phase by the site licensee.

Commissioning of the UK HPR1000 is performed following handover from the construction phase and verifies that the design, manufacture, installation or construction, and operation of the plant behave according to their design intent, as claimed in the overall safety case.

30.4.1 Organisational Requirements

A suitable commissioning organisation will be developed, with appropriate arrangements, capabilities and experience to undertake commissioning (including inactive commissioning and active commissioning).

The programme will include:

- a) Commissioning terms of reference;
- b) Review/approval of test procedures;
- c) Review/approval of test results (whether or not safety requirements, design intent

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 10 / 24

and performance levels are met);

- d) Identification and resolution of any commissioning non-conformances;
- e) Quality management;
- f) Familiarisation and training of operating and technical personnel;
- g) Nuclear regulatory compliance activities;
- h) Resources; and
- i) Operational experience feedback database/lessons learned system.

30.4.2 Programme Documentation

The commissioning organisation documentation forms a significant part of the design substantiation process and will include:

- a) Commissioning activity continuity, including activity (milestone/hold point) stage reviews;
- b) Evidence that the design intent, as claimed in the plant overall safety case, has been met. Or if any non-conformances have been identified, these have been satisfactorily addressed;
- c) Confirmation that commissioning can proceed safely;
- d) Input to the plant lifetime records data system; and
- e) An opportunity for regulatory assessment.

The provisions of commissioning documents are shown in *Structure and Compilation Principles of Documentation for Commissioning*, Reference [6]. There are three types of important commissioning execution documents:

- a) System Commissioning Programmes

System Commissioning Programmes (SCPs) are related to a system or to a group of systems, or to a particular scope of commissioning, and specify, in detail, all tests and their sequences that are applicable to a particular system or function.

Based on *Methodology of Design for System Commissioning Programme*, Reference [7], SCPs generally consist of three parts:

- 1) Test description including the objectives, contents, principle, and acceptance criteria for all the tests;
- 2) Test sequence describing the list of tests, the commissioning stages during which the tests are implemented and their logical sequence; and
- 3) Relevant information including system functions, safety requirements and

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 11 / 24

operating documents.

b) Test Procedures and Test Reports

Test procedures (TPs) are based on SCPs. They describe objectives, prerequisites, precautions, initial status and step by step instructions of the tests. The TPs also include proper checklists and signature blocks to control the test implementation and sequence.

The TPs are generally divided into three categories:

- 1) Preliminary tests;
- 2) System functional tests in cold conditions; and
- 3) System functional tests in normal operating conditions.

All tests will be performed in accordance with the approved TPs. The test reports will be written at the end of the test and will include the following content:

- 1) Summary of test objectives;
- 2) Conduct of the test, including initial and final state of plant, the actual limitations experienced, problems encountered and the actions taken to overcome them, including modifications to the plant or the procedures arising therefrom;
- 3) A concise description of any special test equipment used;
- 4) A summary of data collected and analyses of the data;
- 5) An evaluation of the results; and
- 6) Conclusions.

c) Stage Test Procedures and Phased Commissioning Reports

Stage Test Procedures (STPs) are related to a single commissioning stage (or sub-stage) of commissioning. STP of each commissioning stage or sub-stage will include:

- 1) The prior conditions for starting the stage and the conditions of each test during the stage;
- 2) The chronology of all the tests and activities to be performed during the stage; and
- 3) The list of TPs and relevant documents for the stage.

After one commissioning phase is completed, a phased commissioning report will be written to summarise all commissioning activities in this phase, in order to determine whether the next phase can be entered. The report will contain essential results of the

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 12 / 24

commissioning phase concerned. The commissioning phases/stages are given in Sub-chapter 30.5.2.

30.4.3 Design Substantiation

According to *Safety Assessment Principles for Nuclear Facilities*, Reference [8], the overall plant commissioning programme will incorporate design substantiation for all SSC tests that are necessary to demonstrate that the plant meets the design intent, as claimed in the overall safety case. The design of the commissioning tests will be facilitated for the purpose of maintaining the capability of SSCs important to safety, so as to satisfy the reliability requirement. The design of the SSC is made to ensure that they are testable according to *General Safety Requirements*, Reference [9].

The design of the UK HPR1000 shall ensure that foreseeable conventional health and safety risks to the workers and the public are identified. A risk assessment of conventional health and safety shall be undertaken in the design of the UK HPR1000 and design mitigations shall be developed to eliminate, reduce and control the risks so far as is reasonably practicable.

The conventional health and safety risks relating to commissioning are analysed. The information of these risks is recorded in the conventional health and safety design risk registers, which are regarded as live documents and will be continually developed throughout the lifetime of the plant.

The design substantiation approach and documentation will contain sufficient information about the design, function and expected performance of the safety significant SSC which support safe and reliable commercial operation. This will provide a clear, coherent and auditable reference to the commissioning related safety functional requirements, in combination with the associated plant configuration under which the safety case claims need to be demonstrated. This evidential design substantiation (sometimes referred to as the ‘golden thread’) will include demonstration that:

- a) Sufficient analysis and engineering substantiation has been performed to ensure that the operational plant SSC will be demonstrably safe and secure (e.g. demonstration through pre-commissioning and commissioning activities, including calculations, material certification, inspections, Factory Acceptance Test (FAT), handover tests of installation, flushing records, commissioning tests and qualified procedures);
- b) According to *Training and Assuring Personnel Competence*, Reference [2], personnel are suitably qualified and experienced (e.g. proof of qualification of designers, welder qualification records and suitably qualified and experienced person records for test team personnel);
- c) Remediation and records for the identification and disposition of necessary

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 13 / 24

changes and anomalous behaviour of the plant will form part of the commissioning test reports; and

- d) Test results have been confirmed and the objectives have been achieved with no unexpected outcomes arising. The substantiation should ensure, so far as is reasonably practicable, that all necessary data has been obtained and analysed, and that a technical evaluation has been completed. The evaluation of the test results must include a comparison with the acceptance criteria.

30.4.4 Classification of Commissioning Activities

Commissioning activities will be classified commensurate with their safety or nuclear safety significance, *Commissioning for Nuclear Power Plants*, Reference [5], as reflected in the safety classification of the associated SSC, according to PCSR Chapter 4.

The quality assurance arrangements for commissioning activities will be established. There will be higher levels of quality assurance arrangements for the safety functions than for non-classified SSCs.

The classification methodology for commissioning activities will ensure that the SSCs are systematically tested and operated commensurate with the related safety functional requirements that they perform. Records of their identification and agreed resolution will form part of the commissioning substantiation.

30.4.5 Activity Schedule

A commissioning activity schedule approach will be established, to meet the expectations of their permission regime and satisfy the site licensee's due process requirements, *Safety of Nuclear Power Plants: Commissioning and Operation*, Reference [4].

The overall plant commissioning programme will be designed by the site licensee, to provide appropriate activity based milestone/hold points, incorporating a structured, systematic and progressive phased approach for the management of the overall plant commissioning programme. It is anticipated that this will include:

- a) Key milestones and hold points, as justified in or assumed by the overall safety case;
- b) Satisfactory completion (verification through demonstration and acceptance) of the acceptability of earlier test results, before releasing the key milestone/hold point to enter the next phase/stage of commissioning;
- c) Tracking the demonstration and acceptance of commissioning related safety functional requirements; and
- d) Support to the site licensee by providing substantiation for moving from one

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 14 / 24

milestone/hold point to the next.

30.5 Overall Plant Commissioning Programme Scope

The responsibility for the overall plant commissioning programme scope will rest with the site licensee, supported as required by the responsible designer. Hence, the overall plant commissioning programme scope arrangements given below are illustrative and will be developed as part of the overall plant commissioning programme during the site specific nuclear site licensing phase by the licensee.

The overall plant commissioning programme scope will incorporate a structured, systematic and progressive test programme, that facilitates the transition from construction to operation of the plant. This includes all the activities required for confirmation and demonstration of the plant SSC operational and commissioning related safety functional performance requirements.

30.5.1 Programme Phases

The overall plant commissioning programme will group commissioning into phases/stages with a logical sequence from inactive to active nuclear tests. Based on *Division and Utilization of Commissioning Phases*, Reference [10], the overall plant commissioning programme is split into two phases (inactive and active), given in T-30.5-1 below:

- a) Pre-operational Tests Phase (inactive commissioning);
- b) Initial Startup Tests Phase (active commissioning).

The objective of inactive tests (phase 1) includes:

- a) Description and justification of the pre-operational test activities to demonstrate, so far as reasonably practicable that the safety claims, assumptions, procedures and design intent, as claimed in the overall safety case have been achieved;
- b) Identification of gaps in demonstration of commissioning related safety functional requirements and anomalies which result from and could not be justified during design, manufacture, installation or construction; and
- c) Systematic validation of SSCs.

The objective of active tests (phase 2) includes:

- a) Addressing potential shortfalls identified during inactive commissioning;
- b) Use of test data 'evidence' from the inactive commissioning;
- c) Description and justification of active commissioning to demonstrate that the tests can be carried out safely;
- d) Justification that active commissioning tests will demonstrate, so far as

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 15 / 24

reasonably practicable, the safety claims, assumptions, procedures, design intent, as claimed in the overall safety case, have been achieved; and

- e) Demonstration of completeness following active commissioning.

The test results of the previous phase/stage shall be reviewed before continuing to the next phase/stage, *Safety of Nuclear Power Plants: Commissioning and Operation*, Reference [4] and *Division and Utilization of Commissioning Phases*, Reference [10]. This is required to ensure that:

- a) SSC configuration/condition is defined, controlled and protected such that testing does not put the plant at an unacceptable risk;
- b) It is acceptable to enter the next phase/stage; and
- c) The status and implications for the commissioning plan of the next phase/stage are clearly understood and modified in accordance with the conclusions of the previous test results or in recognition that some tests are not performed or finished.

The different phases/stages will include activities to progressively substantiate the design, gradually introducing more onerous steps, including:

- a) Plant static and dynamic tests which contribute to the demonstration that the SSCs' design, manufacture, installation or construction are acceptable; and
- b) Whole system/plant commissioning tests, which identify and confirm the SSC and whole plant operational characteristics and which are required to meet the design intent substantiation, demonstrating functionality, safety documentation commitments and acceptance criteria are as claimed in the plant overall safety case.

30.5.2 Commissioning Phased Approach

According to *Division and Utilization of Commissioning Phases*, Reference [10], two overall commissioning phases are sub-divided into three test stages, with further sub-stages, as given in T-30.5-1 below.

T-30.5-1 UK HPR1000 Overall Plant Commissioning Programme Phases

Phase	Stage	Sub-stage
Pre-operational Tests Phase (inactive)	Stage I : Preliminary Tests Period	Initial Test of Structures, Systems and Components
	Stage II : Functional Tests	Sub-stage II .1: Cold Functional Test (CFT)
		Sub-stage II .2: Preparation for Hot Functional Test (HFT)

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 16 / 24

Phase	Stage	Sub-stage
Initial Startup Tests Phase (active)	Period	Sub-stage II .3: Hot Functional Test (HFT)
		Sub-stage II .4: Preparation for First Core Loading
	Stage III: Initial Startup Tests Period	Sub-stage III.1: First Core Loading
		Sub-stage III.2: Pre-Critical Test
		Sub-stage III.3: Initial Criticality Test and Initial Power Ascension Period
		Sub-stage III.4: Final Power Ascension Period

In support of the overall plant commissioning programme, initial tests before the equipment delivery to site, will be performed to support the demonstration of SSC performance. For example, FAT contributes to the SSC commissioning design substantiation.

30.5.3 Content of Commissioning Phases

The commissioning test terms are considered during the design process of SSC. The strategies of commissioning for the main technical areas are presented in *Strategy of Electrical Power System Commissioning and Test*, Reference [11], *Topic Report on Commissioning Chemistry*, Reference [12], *Topic Report on the Commissioning Requirements of Radioactive Waste Management Systems*, Reference [13] and *Commissioning Strategy for I&C Systems*, Reference [14].

This section provides a list of representative tests to be considered in the development of the UK HPR1000 overall plant commissioning programme in accordance with the structure given in T-30.5-1.

The familiarisation and training of operating and technical personnel will be conducted during each phase/stage of commissioning.

Stage I : Preliminary Tests Period

This stage consists of component tests (e.g. motor test, valve test and pump test), first startup of single systems, instrumentation and control channel test, *Control and Instrumentation Aspects of Nuclear Plant Commissioning*, Reference [15], flushing of fluid system (e.g. reactor coolant system, chemical and volume control system, nuclear circuit cleaning (clean the reactor coolant system piping and main nuclear auxiliary systems by flushing water through safety injection lines and charging line into the reactor vessel), and a Cold Functional Test with Reactor Vessel Open (CFTRVO).

Stage II : Functional Tests Period

Sub-stage II .1: Cold Functional Test

The CFT includes the initial startup of fluid systems, associated support systems and the primary circuit hydrostatic test. The objective of this stage is to obtain initial

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 17 / 24

operational data of equipment, ensure compatibility of operation with interfacing systems and verify the functional performance of these systems.

Sub-stage II .2: Preparation for Hot Functional Test

This stage starts upon completion of the CFT and finishes at the beginning of HFT. The objective is to complete the outstanding activities, such as:

- a) Balance of the CFTRVO activities shall be performed;
- b) Single system tests or special commissioning activities related to the HFT;
- c) Containment structural integrity test and containment integrated leakage rate test;
- d) Conventional Island (CI) shall be prepared for first startup during this stage to get CI systems ready for the HFT; and
- e) Pre-service inspection.

Sub-stage II .3: Hot Functional Test

The objective of the HFT is to perform a series of integrated nuclear power plant commissioning tests of the plant and systems for all normal reactor temperature and pressure states from cold shut down conditions to hot shutdown conditions. A number of tests will be performed (such as the loss of offsite power tests and the first startup activities of CI) which, together with plant operating procedures enable the verification of Nuclear Steam Supply System (NSSS) and associated nuclear island auxiliaries up to hot shutdown conditions, prior to fuel loading.

Sub-stage II .4: Preparation for First Core Loading

This stage starts at the completion of the HFT and finishes at the beginning of first core loading. The objective is to set up the plant ready for first core loading, including activities such as final nuclear cleaning, establishing a radiologically controlled area, implementation of fuel handling and storage system tests, making up boron water and other related commissioning activities.

Stage III: Initial Startup Tests Period

Sub-stage III.1: First Core Loading

The objective of this sub-stage is to ensure that the fuel is loaded into the reactor safely in accordance with the loading pattern calculated in the design. First fuel loading shall be implemented under refuelling cold shutdown conditions. Precautions will be taken to avoid inadvertent boron dilution, fuel damage and misloading.

Sub-stage III.2: Pre-Critical Test

The objective of this sub-stage is to ensure that the reactor is in a suitable condition to be started up and that all prerequisites for permitting the reactor to go critical have

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 18 / 24

been met. With the core loaded and the reactor maintained in a subcritical condition, a series of performance tests will be carried out. These tests include checks on coolant flow rates, instrumentation, rod control mechanisms, automatic rod insertion and other important features of the primary circuit.

Sub-stage III.3: Initial Criticality Test and Initial Power Ascension Period

The main tasks of this stage include initial criticality tests, reactor physics tests at zero power, turbine generator run-up test, transient tests (e.g. ramp or step load change test, load shedding test and reactor or turbine trip tests), and performance tests on different power platform.

Sub-stage III.4: Final Power Ascension Period

Transient tests are carried out to demonstrate that the integrated response of the plant to significant transients is acceptable. The main tasks of this stage include core conformity tests, feedwater flow and level control test of steam generator, transient tests (e.g. ramp or step load change test, house load operation test, reactor or turbine trip test), performance tests (e.g. NSSS rated thermal output test, steam generator moisture carryover measurement test, steam generator design margin test, nominal power output test, auxiliary power rate measurement test and CI performance guarantees test).

30.5.4 First Plant Only Test

The Hua-long Pressurised Reactor under construction at Fangchenggang nuclear power plant unit 3 (HPR1000 (FCG3)) which is the reference NPP of the UK HPR1000 will perform the first plant only tests such as reactor internals flow induced vibration tests.

30.5.5 OTS and Procedures

Where plant commissioning activities (e.g. configurations/conditions) allow, operating rules, *LC23: Operating Rules*, Reference [16] and procedures will be observed from when core loading is started. Prior to this, OTS and, so far as reasonably practicable, NOP and EOP will be used when performing pre-operational tests (inactive commissioning) and initial start-up tests (active commissioning). Where this is not possible, for example, where commissioning activities do not provide representative activities, specific arrangements will be produced to support the demonstration of the design intent.

The relevant operational and technical personnel will be qualified and experienced, including regarding the use of OTS. The UK HPR1000 simulator will be in particular used to ensure the proper training and qualification of the personnel. This approach will contribute to:

- a) Familiarisation of operators with the OTS or the identification of changes that

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 19 / 24

may be required; and

- b) Improvements to the operators' knowledge of plant SSCs and valuable experience provided by engineering personnel, promoting the transfer and retention of knowledge and experience within the operational organisation.

30.5.6 Operational Experience Feedback/Lessons Learned System

China General Nuclear Power Corporation (CGN) has participated in the commissioning process of various nuclear power technologies which are mentioned below.

CGN has rich experience in the commissioning of nuclear power plants. CGN has successfully completed commissioning of 4 units of M310, 14 units of Chinese Pressurised Reactor (CPR1000), 2 units of Chinese Improved Pressurised Reactor, 3 units of Advanced Chinese Pressurised Reactor (ACPR1000), 2 units of European Pressurised Reactor, Taishan NPP in China and Flamanville 3 NPP in France. Concurrently, CGN is implementing the commissioning of HPR1000 (FCG3) and participating in the commissioning of Olkiluoto 3 NPP in Finland.

CGN has continuously fed the commissioning and operating experiences into the experience feedback/lesson learned system. With commissioning work developing, CGN will also input experience of the HPR1000 (FCG3) and experience from the Hinkley Point C NPP into the experience feedback/lesson learned system.

All the experience, considering RGPs, will be used as a reference in the development of the UK HPR1000 overall plant commissioning programme's operational experience feedback/lesson learned system. This will be continuously updated with the latest experience during commissioning of the UK HPR1000.

30.6 ALARP Assessment

30.6.1 Scope of Relevant Good Practice

The standards and guides *Safety of Nuclear Power Plants: Commissioning and Operation*, References [4], *Commissioning for Nuclear Power Plants*, References [5], *LC23: Operating Rules*, Reference [16], *LC21: Commissioning*, References [17] and *LC24: Operating Instructions*, Reference [18] are deemed RGPs for commissioning.

30.6.2 Consistency Review against RGP

T-30.6-1 Holistic ALARP Review against the UK HPR1000

No.	RGP	The UK HPR1000 design
	IAEA Safety Standard Series No.SSR-2/2 (Rev.1), Reference [4]	

No.	RGP	The UK HPR1000 design
1.	The operating organisation shall ensure that a commissioning programme for the plant is established and implemented.	The UK HPR1000 complies with No.SSR-2/2 (Rev.1). The commissioning programme will be established and implemented during the site-specific nuclear site licensing phase, as described in Sub-chapter 30.4 and Sub-chapter 30.5.
IAEA Safety Standard Series No.SSG-28, Reference [5]		
2.	Organisational arrangements should be put in place to achieve the safety objectives of commissioning in accordance with the commissioning programme.	The UK HPR1000 complies with this requirement, as described in Sub-chapter 30.4.1.
3.	The documentation for commissioning should consist of the organisation and management documents for commissioning, the commissioning procedures and the reporting documentation for commissioning.	The UK HPR1000 complies with this requirement, as described in Sub-chapter 30.4.2.
4.	The commissioning programme should cover all the activities to be performed on structures, systems and components to make them operable in accordance with the design intent.	The UK HPR1000 complies with this requirement, as described in Sub-chapter 30.4.3.
5.	Structures, systems and components are classified in the design stage on the basis of their importance to safety. The classification provides an input in determining commissioning requirements, and requirements for methods, testing, inspections, reviews, qualification of personnel and records.	The UK HPR1000 complies with this requirement, as described in Sub-chapter 30.4.4.
6.	The commissioning programme should be implemented in stages and sub-stages in accordance with the text on the stages of commissioning (see paras 2.17–2.22) and on testing stages and sequences (see paras 4.28–4.60).	The UK HPR1000 complies with this requirement, as described in Sub-chapter 30.4.5–30.5.3.

No.	RGP	The UK HPR1000 design
7.	During commissioning, normal operating procedures, including those for operational periodic tests, should be widely used to validate the applicability of the procedures. The emergency operating procedures should also be validated in the commissioning programme, to the extent possible.	The UK HPR1000 complies with this requirement, described in 30.5.5.
8.	<p>The responsibilities of the commissioning group should include, but are not limited to, the following:</p> <p>a) To record all the feedback of experience from commissioning;</p> <p>b) To establish a procedure to compile the lessons learned from commissioning activities, to draw conclusions and to determine the necessary corrective actions.</p>	The UK HPR1000 complies with this requirement, as described in Sub-chapter 30.5.6.
ONR Nuclear Safety Technical Inspection Guide NS-INSP-GD-021, Reference [17]		
9.	LC21 provides guidance on arrangements for commissioning.	The UK HPR1000 complies with these arrangements, as described in Sub-chapter 30.4 and Sub-chapter 30.5.
ONR Nuclear Safety Technical Inspection Guide NS-INSP-GD-023, Reference [16]		
10.	LC23 provides guidance on arrangements for operating rules.	The UK HPR1000 complies with these arrangements, as described in Sub-chapter 30.5.5. The operating rules will be observed as far as possible during commissioning process.
ONR Nuclear Safety Technical Inspection Guide NS-INSP-GD-024, Reference [18]		

No.	RGP	The UK HPR1000 design
11.	LC24 provides guidance on arrangements for operating instructions.	The UK HPR1000 complies with these arrangements, described in 30.5.5. During the commissioning process, the test will be carried out as far as possible with reference to the operating instructions to verify the operating instructions as much as possible.

30.6.3 Conclusions of ALARP Review

In Chapter 30, the ALARP assessment of commissioning activities has been analysed from the aspects of organisation, documentation, personnel and schedule. It has been concluded that the chosen approach complies with international and the UK recognised RGPs in this chapter. In PCSR Chapter 6, 7, 8, 9, 10, 11, the system design process will complete the ALARP assessment, considering the commissioning test scheme. As mentioned in Sub-chapter 30.5.6, CGN has rich experience in the commissioning of nuclear power plants to ensure that the risks in the execution of commissioning are controlled to the optimal level. Based on the above considerations, the risks of the entire commissioning process (including test design and commissioning activities) are optimised. At present, no gaps have been identified.

30.7 Concluding Remarks

According to *New nuclear reactors: Generic Design Assessment Guidance to Requesting Parties for the UK HPR1000*, Reference [19] and *General Nuclear System Limited, Scope for UK HPR1000 GDA Project*, Reference [20], during GDA, only the requirements and arrangements for commissioning should be provided in this chapter.

Therefore, the processes of the overall plant commissioning programme have been outlined in this chapter, and they will be further developed during the nuclear site licensing phase. This chapter provides adequate support that the arguments supporting the safety claim have been made.

30.8 References

- [1] The Stationery Office, Nuclear Installations Act 1965, 1965.
- [2] ONR, Training and Assuring Personnel Competence, Nuclear Safety Technical Assessment Guide, NS-TAST-GD-027, Revision 6, July 2017.
- [3] CGN, General Principles for Application of Laws, Regulations, Codes and Standards, GHX00100018DOZJ03GN, Revision H, October 2020.
- [4] IAEA, Safety of Nuclear Power Plants: Commissioning and Operation, IAEA

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 23 / 24

Safety Standards Series No.SSR-2/2, Rev.1, 2016.

- [5] IAEA, Commissioning for Nuclear Power Plants, IAEA Safety Standards Series No.SSG-28, 2014.
- [6] CGN, Structure and Compilation Principles of Documentation for Commissioning, GHX210CP002DOYX45GN, Revision A, August 2019.
- [7] CGN, Methodology of Design for System Commissioning Programme, GHX26SCPC00DOYX45GN, Revision B, September 2019.
- [8] ONR, Safety Assessment Principles for Nuclear Facilities, 2014 Edition, Revision 1, January 2020.
- [9] CGN, General Safety Requirements, GHX00100017DOZJ03GN, Revision F, November 2019.
- [10] CGN, Division and Utilization of Commissioning Phases, GHX210CP003DOYX45GN, Revision A, August 2019.
- [11] CGN, Strategy of Electrical Power System Commissioning and Test, GHX05000026DEDQ45GN, Revision B, January 2021.
- [12] CGN, Topic Report on Commissioning Chemistry, GHX00100102DCHS03GN, Revision D, November 2020.
- [13] CGN, Topic Report on the Commissioning Requirements of Radioactive Waste Management Systems, GHX71200001DNFF03GN, Revision A, July 2019.
- [14] CGN, Commissioning Strategy for I&C Systems, GHX06002001DIYK45GN, Revision A, November 2019.
- [15] ONR, Control and Instrumentation Aspects of Nuclear Plant Commissioning, Nuclear Safety Technical Assessment Guide, NS-TAST-GD-028, Revision 6, October 2019.
- [16] ONR, LC23: Operating Rules, Nuclear Safety Technical Inspection Guide, NS-INSP-GD-023, Issue 6.1, March 2021.
- [17] ONR, LC21: Commissioning, Nuclear Safety Technical Inspection Guide, NS-INSP-GD-021, Revision 7, January 2021.
- [18] ONR, LC24: Operating Instructions, Nuclear Safety Technical Inspection Guide, NS-INSP-GD-024, Revision 6, September 2019.
- [19] ONR, New nuclear reactors: Generic Design Assessment Guidance to Requesting Parties for the UK HPR1000, ONR-GDA-GD-001, Revision 4, October 2019.
- [20] General Nuclear System Limited, Scope for UK HPR1000 GDA Project,

UK HPR1000 GDA	Pre-Construction Safety Report Chapter 30 Commissioning	UK Protective Marking: Not Protectively Marked	
		Rev: 002	Page: 24 / 24

HPR/GDA/REPO/0007, Revision 001, July 2019.