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PSR Part B Chapter 25 Construction and Commissioning Approach

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Revision Log

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25.1 INTRODUCTION

This Preliminary Safety Report (PSR) chapter demonstrates that generic Small Modular Reactor (SMR-300) can be safely constructed and commissioned to ensure that all necessary substantiation evidence can be gathered to support the nuclear safety justification, and that construction and commissioning can be done in a way to safely manage people and plant.

This chapter supports the generic SMR-300 lifecycle claim that the entire reactor lifecycle has been considered in the design and safety assessment. Design and safety decisions that will impact the construction and commissioning stages are being planned now, so that these phases transition smoothly. Holtec International is developing a detailed construction and commissioning programme, following a structured format based on the generic SMR-300 plant design and safety requirements. Further to this, any lessons learned from the Palisades programme (see HI-2240333, Holtec SMR GDA PSR Part A Chapter 2 General Design Aspects and Site Characteristics [1]) will inform the construction and commissioning programme.

A high-level construction and commissioning programme has been included which is indicative at this stage and will be developed in more detail during and beyond the Generic Design Assessment (GDA).

25.1.1 Purpose and Scope

The Overarching Safety, Security and Environmental Case (SSEC) Claims are presented in HI-2240334, Holtec SMR GDA PSR Part A Chapter 3 Claims, Arguments and Evidence [2].

This chapter (Part B Chapter 25) supports the overarching claim through Claim 2.3:

Claim 2.3: The design and safety assessment of the generic Holtec SMR-300 considers the entire reactor lifecycle.

As set out in PSR Part A Chapter 3 [2], Claim 2.3 is further decomposed across several disciplines which support the development of through-life management arrangements. This chapter presents the construction and commissioning aspects for the generic SMR-300 and therefore directly supports a claim focused on the appropriate arrangements to safely manage people and plant, Claim 2.3.1.

Claim 2.3.1: Appropriate arrangements to safely manage people and plant during the construction, commissioning and operation of the generic Holtec SMR-300 are suitably mature for a generic design.

Further discussion on how the Level 3 claim is broken down into Level 4 claims and how the Level 4 claims are met is provided in Subchapter 25.2.

A master list of definitions and abbreviations relevant to all PSR Chapters can be found in PSR Part A Chapter 2 General Design Aspects and Site Characteristics [1].

25.1.2 Assumptions

No assumptions are identified in this revision.

25.1.3 Interfaces with other SSEC Chapters

The Construction and Commissioning PSR chapter interfaces with multiple areas across the Project.

HI-2240335, Holtec SMR GDA PSR Part A Chapter 4 Lifecycle Management of Safety and Quality Assurance [3] covers design change control, configuration management, lifecycle management of safety, quality assurance and organisational development. Design change control and configuration management will inform the procedure for managing changes in design configurations, as well as during installation, construction, and commissioning phases. Lifecycle management of safety will explain how the SSEC evolves during construction and commissioning phases. Lastly, organisational development interfaces with construction and commissioning as these sections will describe how the design authority, intelligent customer and other key roles are maintained.

Many engineered safety features of the reactor rely on SSC design that will be substantiated by the commissioning programme. Interface with HI-2240337, Holtec SMR GDA PSR Part B Chapter 1 Reactor Coolant System and Engineered Safety Features [4] is necessary to demonstrate that the plant meets the design intent, as claimed in the overall safety case.

Similarly, the arrangements and requirements for commissioning align with systems, structures and components design requirements, as shown in: HI-2240776, Holtec SMR GDA PSR Part B Chapter 2 Reactor Fuel and Core [5], HI-2240338, Holtec SMR GDA PSR Part B Chapter 4 Control and Instrumentation Systems [6], HI-2240340, Holtec SMR GDA PSR Part B Chapter 9 Conduct of Operations [7], HI-2240344, Holtec SMR GDA PSR Part B Chapter 13 Radioactive Waste Management [8], HI-2240356, Holtec SMR GDA PSR Part B Chapter 19 Mechanical Engineering [9] and HI-2240353, Holtec SMR GDA PSR Part B Chapter 24 Fuel Transport and Storage [10].

The non-radiological safety and fire regulations and Relevant Good Practice (RGP) will be considered in the construction and commissioning programme, as in HI-2240343, Holtec SMR GDA PSR Part B Chapter 12 Nuclear Site Health and Safety and Conventional Fire Safety [11]. In particular, the approach to compliance with the Construction, Design and Management (CDM) 2015 regulations [12] are covered there.

The commissioning programme will also substantiate Structural integrity, Civil Structures and Civil Engineering SSCs, from HI-2240349, Holtec SMR GDA PSR Part B Chapter 18 Structural Integrity [13] and HI-2240357, Holtec SMR GDA PSR Part B Chapter 20 Civil Engineering [14] which topic area teams will engage on to identify and capture.

Commissioning tests for various discipline-specific SSCs support the Internal Hazards claims, as shown in HI-2240351, Holtec SMR GDA PSR Part B Chapter 22 Internal Hazards [16], by the substantiation of the SSCs.

HI-2240352, Holtec SMR GDA PSR Part B Chapter 23 Reactor Chemistry [17] provides the objectives for commissioning from the chemistry and material aspects. This PSR chapter provides the arrangements and requirements for commissioning according to these objectives.

25.2 CONSTRUCTION AND COMMISSIONING CLAIMS, ARGUMENTS AND EVIDENCE (CAE)

The primary purpose of a Claims, Arguments, Evidence (CAE) approach is to capture the golden thread of a safety case narrative demonstrating how plant and operational evidence is brought together to justify that a high-level or fundamental claim is true. In the context of the generic SMR-300, that is how the Fundamental Purpose of the SSEC, presented in PSR Chapter A1 [19], is achieved.

The Fundamental Purpose follows a golden thread throughout the SSEC to CAE via the objectives of the PSR, Preliminary Environmental Report (PER) and Generic Safety Report (GSR). The overarching SSEC claims and the philosophy for their architecture are presented in Part A Chapter 3 [2].

This chapter contributes directly to Claim 2.3, which is focused on the demonstration that the design and safety assessment are developed, and this chapter links to the overarching claims through High level Claim 2.3:

Claim 2.3: The design and safety assessment of the generic Holtec SMR-300 considers the entire reactor lifecycle.

As set out in PSR Part A Chapter 3 [2], Claim 2.3 is further decomposed across several disciplines which support the development of through-life management arrangements. This chapter presents the construction and commissioning aspects focused on demonstrating that the Generic SMR-300 design has considered the construction and commissioning stages of the reactor lifecycle, and therefore directly supports Claim 2.3.1.

Claim 2.3.1: Appropriate arrangements to safely manage people and plant during the construction, commissioning and operation of the generic Holtec SMR-300 are suitably mature for a generic design.

Claim 2.3.1 has been further decomposed within PSR Part B Chapter 25 to provide confidence that the substantiation evidence requirements relevant to safety are identified, will be demonstrated and controlled in accordance with appropriate arrangements throughout the conduct of construction and commissioning.

Claim 2.3.1.1: The approach to construction and commissioning ensures all required substantiation evidence is generated whilst ensuring nuclear safety related risks are appropriately controlled.

The generic SMR-300 design should also be shown to be constructable in a safe manner, and that the approach to construction and commissioning will be undertaken in a manner that reduces risks As Low As Reasonably Practicable (ALARP).

Claim 2.3.1.2: The generic SMR-300 is constructable and the construction and commissioning sequence supports the reduction of risks to ALARP

Table 1 presents which subchapters support the demonstration of these claims.

Table 1: Chapter Sub-Claims

Claim No	Claim	Chapter Section
2.3.1.1	The approach to construction and commissioning ensures all required substantiation evidence is generated whilst ensuring nuclear safety related risks are appropriately controlled.	**25.3 -** Codes, Standards and Methodology
2.3.1.2	The generic SMR-300 is constructable and the construction and commissioning sequence supports the reduction of risks to ALARP	**25.4 -** Construction and Commissioning Programme and Arrangements

A summary of the current CAE route map for PSR Part B Chapter 25 is provided in Appendix A and a further update on claim decomposition, argument development and evidence maturity will be provided in the subsequent update of the Chapter.

25.3 CODES, STANDARDS AND METHODOLOGY

Claim 2.3.1: Appropriate arrangements to safely manage people and plant during the construction, commissioning and operation of the generic Holtec SMR-300 are suitably mature for a generic design.

This subchapter outlines the methodology followed in the Generic SMR-300 design process to assure that all safety related design requirements will be identified in accordance with the relevant codes and standards and that Quality Assurance (QA) processes will be in place to ensure that these requirements are managed and demonstrated during construction and commissioning. It also outlines the United Kingdom (UK) regulations that are relevant for the construction and commissioning of the Generic SMR-300 that will be followed in accordance with UK RGP.

25.3.1 Generic SMR-300 Design Codes, Standards and Methodologies

PSR Chapter A Part 2 [1] demonstrates the US codes, standards and design philosophy that constitutes the Generic SMR-300 design.

In the US, the Construction Permit Application (CPA) required under 10 Code of Federal Regulations (CFR) 50 [20] grants permission to construct the reactor if the application is in conformity with and acceptable under the criteria in paragraphs 50.31 through 50.38, and the standards in paragraphs 50.40 through 50.43, as applicable. The acceptable codes and standards for construction of the reactor plant are listed in 10 CFR 50 paragraph 55 ‘Codes and Standards’. The principal codes and standards that include construction and commissioning requirements for the SSCs are summarised in PSR Chapter A Part 2 [1] and not repeated here.

Construction and commissioning arrangements will need to ensure the substantiation evidence to support compliance with chosen codes and standards, can be generated during these phases. Holtec Quality Assurance arrangements (see Section 25.3.2.2), will ensure that this is achieved, though the maturity of these arrangements for these later project phases is still in development.

25.3.2 Generic SMR-300 Design and Substantiation Requirements

The design and substantiation requirements relevant to safety are identified by the generic SMR-300 design process, as set out in PSR Part A Chapter A4 [3]. The application of the categorisation and classification methodology is a key determinant step in deriving the design requirements in accordance with nuclear safety. The classification of the SSCs is used to identify which codes and standards are applicable, which in turn determines the applicable QA requirements for construction and commissioning. This will include appropriate QA procedures to ensure that these requirements will be managed accordingly throughout the construction and commissioning process.

This subchapter provides a summary of this process and how it interfaces with construction and commissioning arrangements.

25.3.2.1 Categorisation and Classification of Systems, Structures and Components

PSR Part A Chapter 2 [1] describes how the classification methodology of the generic SMR-300 [21] aligns and complies with US NRC Regulatory Guide 1.26 [22] and 10 CFR 50 [23] Section 55a 'Codes and Standards' subparts (c), (d), and (e). The classification methodology of the SMR-300 addresses these GDC by classifying SSCs in a manner that imparts requirements to ensure safety functions can be reliably performed during design basis events. It also uses the general classification process described in the US industry consensus standard American National Standards Institute / American Nuclear Society (ANSI/ANS)-58.14 [24] and defines classifications appropriate for the SMR-300 design that are similar to other light water pressurised reactors.

Application of the classification methodology will derive safety requirements for the Generic SMR-300 design that require demonstration during the manufacture, construction, and commissioning process.

Regulatory Guide (1.26) [22] sets out this guidance which comprises four distinct quality (for safety) groups, as applicable to PWRs, Quality Groups, A, B, C and D. These are discussed further in PSR Part A Chapter 2 [1], including Quality Groups for seismic category and electrical category, with an example being that Quality Group A are those components that must meet the requirements for Class 1 components in Section III of the ASME BPV Code.

PSR Chapter A Part 2 [1] presents the overall approach to be taken for application of the UK Categorisation and Classification methodology, which is captured as a GDA gap at this stage. This will therefore demonstrate the robustness of the classification methodology applied to the Generic SMR-300 and will identify any potential gaps that require further consideration during the manufacture, construction, and commissioning process.

25.3.2.2 Holtec Quality Assurance

PSR Chapter A4 Management of Safety and Quality Assurance (MSQA) [3] identifies the QA requirements to be applied to the design, construction and commissioning, procurement, manufacture, operation and testing activities to ensure the safety-related work is performed in accordance with approved QA procedures as described in the in HI-2230815, Topical report on the Quality Assurance Program (QAP) [25].

During the design process, measures are in place to manage inputs, outputs, changes, interfaces, and records within Holtec and its suppliers, subject to the provisions of the QAP [25] . These controls ensure that design inputs are accurately translated into design outputs, with the final design output referencing suitable acceptance criteria that allows for verification through inspection and testing as necessary. These QAP manage those design and safety requirements that require demonstration through the construction and commissioning programme.

25.3.3 UK Regulations

To ensure compliance with relevant applicable UK regulations for nuclear site construction and commissioning activities, several statutory instruments and licence conditions have been identified in Table 2, which represent RGP. This is covered in further detail in PSR Part B Chapter 12 [11].

Table 2: UK Principal Regulations and Guidance for Construction and Commissioning

Label	Title	Revision/ Date
Energy Act, Part 2 Nuclear Regulation [26]		2013
Nuclear Installations Act 1965 [27]		1965
The Health and Safety at Work etc. Act (HSWZ74) [28]		1974
The Management of Health and Safety at Work Regulations 1999 [29] **(MHSW99)**		1999
Construction, Design and Management (CDM) Regulations, 2015 [12]		2015
Pressure Systems Safety Regulations 2000 (PSSR) [30]		2000
L153	Managing Health and Safety in construction [12]	2015
The Confined Spaces Regulations 1997 (CSR97) [31]		1997
L101	Safe work in confined spaces [32]	3
Lifting Operations and Lifting Equipment Regulations 1998 (LOLER98) [33]		1998
L113	Safe use of lifting equipment [33]	2
L122	Safety of pressure systems [34]	2014
L5	Control of substances hazardous to health [35]	6
The Building Regulations (with amendments) [36]		2010
Nuclear site commissioning is a key part of the thirty-six Nuclear Site Licence Conditions (LCs). A duty holder/ licensee must comply with:		
LC19	Construction or installation of new plant [37] and TIG-019 [38]	7.1
LC20	Modification to design of plant under construction [39] and TIG-020 [39]	7.1
LC21	Commissioning [40] and TIG-021 [41]	7.1

25.3.3.1 The Health and Safety at Work etc. Act (HSWA) 1974

The Health and Safety at Work etc. Act 1974 (HSWA74) sect. 6 requires that any person who designs, manufactures imports or supplies any article for use at work:

- Must ensure, so far as is reasonably practicable, that the article is designed and constructed as to be safe and without risk to health when properly used.
- Must carry out or arrange for the carrying out of such testing and examination as may be necessary to comply with the above duty.
- Must provide adequate information about the use for which it is designed and has been tested to ensure that, when used it will be safe and without risk to health.

The HSWA defines the general duties of everyone from employers and employees to owners, managers and maintainers of work premises for maintaining health and safety within the workplace. The act itself is a primary piece of legislation set out by the government. Other regulations which implement the requirements of HSWA74 in more detail for certain types of work activities are often known as secondary or delegated legislation. The secondary legislation in respect of construction and commissioning activities is the most relevant to this chapter and is referred to below.

25.3.3.2 The Construction, Design and Management Regulations 2015 (CDM15)

CDM15 Regulations cover pre-construction, design, construction, commissioning and demolition. The goal of these regulations and Health & Safety Executive (HSE) guide L153 [12] is to promote the use of best industry practice on complex construction sites. As reported in PSR Chapter B12 'Nuclear Site Health and Safety and Conventional Fire Safety' [11], Holtec's CDM15 strategy is currently under development and will progress over the next GDA step. Once developed key duty holders will be identified and appointed to ensure that the generic design will facilitate good construction practice in line with the requirements of CDM15.

The CDM strategy will identify key duty holders who will plan, manage and monitor during pre-construction and throughout the project lifecycle. It will also manage hazards, risks, apply the General Principles of Prevention, and ensure that nuclear site health and safety substantiation is present throughout the design. A health and safety file will be completed for Holtec's project, alongside training of key personnel on CDM and design safety.

These regulations place duties on clients, designers (including engineers), and principal contractors of construction projects of a certain duration and complexity. A Licence Applicant (LA) wishing to build the generic SMR-300 on a GB site must be able to demonstrate the ability to understand, monitor and direct the nuclear safety aspects of construction work; in short the LA must demonstrate Intelligent Customer (IC) capability.

These duties are detailed in Supply Chain Management Arrangements for the Procurement of Nuclear Safety Related Items or Services, NS-TAST-GD-077, [42]. Once the site is licensed then the Licensee will be expected to manage the site in accordance with its responsibilities as the Design Authority, see TAG 079 [43]. Prior to Licence grant, the Licence Applicant will have to demonstrate the capability to act in this regard. It is useful for the RP to be able to demonstrate many of the elements of a DA, especially in relation to technical competence and IC capability in respect of suppliers. If and when a generic SMR-300 design is taken forward for construction on a GB site, the Licence Applicant will relate to the RP and the "Responsible Designer", see TAG 079, section 2 [43].

25.3.3.3 UK Relevant Good Practice

Office for Nuclear Regulation (ONR) Guidance documents and other sources of RGP, such as the International Atomic Energy Agency (IAEA) and Western European Nuclear Regulators Association (WENRA) will be reviewed and considered in line with ONR Safety Assessment Principle (SAP) and Technical Assessment Guide (TAG) guidance to ensure that the construction and commissioning process will be consistent with UK good practice, these are shown within Table 3.

Table 3: UK RGP for Construction and Commissioning

Label	Title	Revision /Date
IAEA Documentation		
IAEA SSG-28	Commissioning for Nuclear Power Plants, [44]	1
IAEA NP-T-2.10	Nuclear Energy Series: Commissioning Guidelines for Nuclear Power Plants, Reference [45]	1
SSR-2/2	Safety of Nuclear Power Plants: Commissioning and Operation, [46]	1
WENRA Guidance		
-	Safety Reference Levels for Existing Reactors [47]	2021
-	Report on Safety of new NPP [48]	2013
-	WENRA Statement on Safety Objectives for New Nuclear Power Plants [49]	2010
ONR Technical Assessment Guides (TAGs)		
NS-TAST-GD-051	The purpose, scope, and content of Nuclear Safety Cases [50]	2022
NS-TAST-GD-057	Design Safety Assurance [51]	2023
NS-TAST-GD-077	Supply Chain Management Arrangements for the Procurement of Nuclear Safety Related Items or Services [42]	2024
NS-TAST-GD-017	Civil Engineering [52]	2022
NS-INSP-GD-021	Commissioning [53]	2021
NS-TAST-GD-098	Asset Management [54]	2022
ONR Safety Assessment Principles (SAPs) [55]		
SAP ECE.25	**Provision for construction** Items important to safety should be designed so that they can be manufactured, constructed, assembled, installed, and erected in accordance with established processes that ensure the achievement of the design specifications and the required level of safety. The effects of construction hazards on any nearby safety related SSCs should be considered.	1
SAP ECS.3	**Codes and Standards** Structures, systems, and components that are important to safety should be designed, manufactured, constructed, installed, commissioned, quality assured, maintained, tested, and inspected to the appropriate codes and standards.	1
SAP EGR.5	**Manufacturing records** A record should be made of the manufacturing case histories.	1
SAP RL.8	**Land Quality Management** Radioactively contaminated land should be remediated and controlled as appropriate before any construction of new facilities upon it.	1
SAP ECE.16	**Materials** The construction materials used should comply with the design methodologies employed and be shown to be suitable for enabling the design to be constructed and then operated, inspected, and maintained throughout the life of the facility.	1
SAP ECE.17	**Provision of defects** The construction should use appropriate materials, proven techniques and a quality management system to minimise defects that might affect the required integrity of structures.	1
SAP ECE.18	**Inspection during construction** Provision should be made for inspection and testing during construction to demonstrate that appropriate standards of workmanship etc have been achieved.	1
SAP ECE.19	**Non-conformities** Where construction non-conformities or identified, defects are judged to have a significant detrimental effect on integrity, remedial measures should be applied to ensure the original design intent is still achieved.	1

Label	Title	Revision /Date
SAP EGR.6	**Location records** A record should be made of the position of individual components in the structure during construction.	1
SAP ECE.24	**Settlement** There should be arrangements to monitor civil engineering structures during and after construction to check the validity of predictions of performance made during the design and for feedback into design reviews.	1
SAP ECM.1	**Commissioning testing** Before operating any facility or process that may affect safety it should be subject to commissioning tests defined in the safety case. The commissioning tests should: Demonstrate that, as built, the design intent claimed in the safety case has been achieved. Collect baseline data for equipment and systems for future reference. Validate those operating instructions (etc) for which the commissioning tests Provide representative activities and/or conditions; and Familiarise the operators with the operation of the facility or process.	1
SAP EPE.5	**Process design and commissioning** The process design and commissioning should provide inputs to operational safety parameters defining limits and conditions necessary in the interests of safety (operating rules).	1
SAP EMT.5	**Procedures** Commissioning and in-service inspection and test procedures should be adopted that ensure initial and continuing quality and reliability.	1

25.3.4 Lessons Learnt

25.3.4.1 Palisades Programme Learning From Experience

The Palisades build program will provide valuable LfE to be used in any future UK deployment of the SMR-300 beyond the GDA process. Information from the Construction Permit Application can be used to inform the UK Site Specific Design. Construction, commissioning, and operational information from the Operating License Application can be used to the associated site-specific design phases. This information flow is captured in Chapter A4 ‘Lifecycle management of Safety and Quality Assurance‘ [3].

25.3.4.2 Extant ROs and RIs

As part of the review against RGP, a number of sources for lessons learnt have been reviewed, these include both from within GDA guidance and from previous GDA Submission Regulatory Observation (RO) and Regulatory Issue (RI). The below subchapters present the lessons learnt from these sources.

Table 4: Extant ROs and RIs for Construction and Commissioning

HPR1000	ABWR	AP1000	EPR
RO-UKHPR1000-0024	RO-ABWR-0047	GI-AP1000-CE-01	GI-UKEPR-CE-02
	RO-ABWR-0072	GI-AP1000-CE-02	
	RO-ABWR-0024	GI-AP1000-CE-03	
	RO-ABWR-0033		

From the above reviewed items, the following common themes have been identified from their respective ROs and RIs:

- Management Systems and Quality Assurance
  - RO-UKHPR1000-0024

- The ONR identified the need to ensure alignment between the safety case and the reference design throughout GDA. Both the ONR and EA expect to have adequate written arrangements in place for identifying, reviewing, authorising, and implementing changes to designs. These arrangements needed to include information on how ONR and EA were notified of any design changes and how they were provided, in a timely manner, with sufficient information on any proposed changes so that the regulators could determine whether the design change could be brought within the scope of GDA. Chapter A4 'Lifecycle management of Safety and Quality Assurance' [3] considers these lessons learnt.

25.3.5 CAE Summary

The generic SMR-300 design is aligned to international codes and standards to ensure that the design can be realised.

The application of categorisation and classification methodology will derive the design requirements in accordance with nuclear safety, including the QA requirements for construction and commissioning. Quality Assurance requirements will be applied to the design, construction and commissioning, procurement, manufacture, operation and testing to ensure the safety-related work is performed in accordance with approved QA procedures as described in HI-2230815 Quality Assurance Programme [25], further summarised within PSR Chapter A4 (MSQA) [3].

The SMR-300 design can and will be shown to be compliant with UK regulations relevant to construction and commissioning.

- A CDM strategy will identify key duty holders who will plan, manage and monitor during pre-construction and throughout the project lifecycle. It will also manage hazards, risks, apply the General Principles of Prevention, and ensure that nuclear site health and safety substantiation is present throughout the design. A health and safety file will be completed for Holtec's project, alongside training of key personnel on CDM and design safety.

Lessons learnt relevant to construction and commissioning are identified and will inform the construction and commissioning process of the SMR-300. LfE will also be gained from the Palisades build programme.

25.4 CONSTRUCTION AND COMMISSIONING PROGRAMME AND ARRANGEMENTS

Claim 2.3.1.2: The generic Holtec SMR-300 is constructable and the construction and commissioning sequence supports the reduction of risks to ALARP

This section of the chapter discusses the construction and commissioning programme of Holtec's generic SMR-300.

25.4.1 Generic SMR-300 Constructability

The constructability philosophy outlined in Chapter A Part 2 of the PSR [1] emphasises the approach taken in the design development of the generic SMR-300 to ensure simplicity in plant design and construction for improved safety and economy.

The design includes the minimum number of systems and equipment, consistent with essential functional requirements. Specifically, material, system, and operation simplification efforts include:

- A minimum number of types and grades of materials, where practical, consistent with service conditions and design performance requirements.
- A minimum amount of instrumentation, control functions and control loops, consistent with the essential functional requirements of the systems, availability, maintainability, and testing capability. The number of divisions and channels for electrical, instrumentation, and control systems should reflect the minimum required to achieve licensing and other plant safety objectives while reducing maintenance requirements.
- A minimum number of valves, pumps, heat exchangers, snubbers, and other mechanical components, consistent with the essential functional requirements of the systems, availability, maintainability, and testing capability.
- Simplified operations during all modes of operation, including operator actions to diagnose and manage abnormal and accident conditions.

The generic SMR-300 design will use standardised component sizes, types, and installation details to improve construction, maintenance, and operations. "Off-the-shelf" components as opposed to "special-order/design" components are utilised to the maximum extent practical.

Prefabrication, preassembly, and modularisation will be used to the maximum extent practical to reduce capital cost and construction time. Provisions for simplification and facilitation of construction and startup include provisions of good crane and material handling access, adequate space and access for construction activities, and provision for temporary construction buildings and equipment. All of these considerations mitigate onsite risk to personnel.

25.4.2 Generic SMR-300 Construction Sequence

Using a three-way Memorandum of Understanding (MoU), Holtec, Hyundai Engineering & Construction (HDEC) and Balfour Beatty have worked to establish likely construction and assembly timelines for the SMR-300. The estimates include grading and excavation durations which are required prior to the first pour of nuclear concrete and well as initial site mobilisation. An example deployment schedule for a dual unit SMR-300 plant is shown in Figure 1.

The full generic Holtec SMR-300 construction programme is in development and will be refined through design and be informed by the progress of the NRC Construction Permit Application regulatory activities for the Palisades SMR-300 reference plant in the US. The specific site chosen for the deployment of the first generic SMR-300 in the United Kingdom may have its own challenges, and this is not reflected in the timescales presented here.

The sequence and assumed durations for the construction and commissioning programme are as follows:

- Following the completion of the GDA and the selection of a site, a Development Consent Order (DCO) is applied for. The DCO process starts when an application is formally accepted by the National Infrastructure Planning Unit and lasts approximately 12-15 months. The process, however, is front-loaded with a number of pre-application consultation requirements, which, depending on the complexity of the project, can take a number of years to carry out. The indicative duration of this phase is 30 months.
- Environmental permitting and site setup is conducted concurrently with the DCO process. The indicative durations of environmental permitting and site setup are both 9 months.
- Licence Application is pursued with the ONR. Certain site activities can be conducted, such as site clearance, fencing, certain groundworks and non-nuclear safety activities[1]. During this period, ONR's expectations on permissioning certain construction and commissioning stages will be accommodated in the construction schedule.
- Enabling works, groundworks, grading and excavations for the site will be initiated once the DCO has been granted. The indicative duration of this is 18 months.
- Concrete pouring for foundations is expected to take place as soon as the site setup allows and after the Final Investment Decision (FID) has been made. The indicative duration of this is 32 months. Nuclear safety construction activities, including First Nuclear Safety Concrete, will need a Site Licence to be granted and ONR permissions obtained as per the staged construction schedule.
- Installation and non-nuclear commissioning of equipment works will include the installation and fit-out of all the site structures, including SSCs and other equipment both below grade and above grade. This is grouped into mechanical /electrical equipment, piping, electrical/Instrumentation & Control (I&C), steel/siding/roofing works phases. The duration for the installation and non-nuclear commissioning works is 24 months.
- Cold/hot nuclear commissioning begins on nuclear systems and follows the commissioning test sequence outlined in Figure 1. The duration for the nuclear commissioning phase (including fuel load and start-up) is 9 months.
- Commercial operation (CO) begins at the end of the hot commissioning and start-up phase as the reactor successfully completes its commissioning tests and is permitted to enter operation under LC21. The first SMR-300 then will begin its CO and the construction and commissioning phase has ended.

- [1] Generally, the construction of nuclear safety structures cannot proceed until after Nuclear Site Licence grant and permissoning consent is obtained from the ONR.

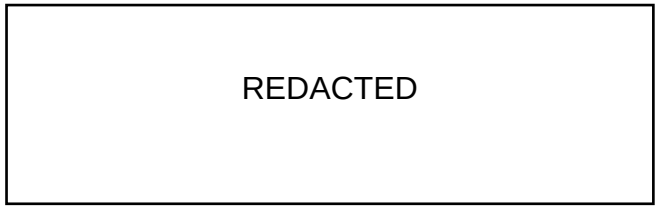

Figure 1: REDACTED

Figure 2 shows that, with similar construction sequence and timescales for Unit 2, all major construction activities of the Unit 2 reactor are expected to be complete prior to Unit 1 Fuel Load. This is inferred from the time between the commencement of Cold Functional Testing on Unit 1 and Fuel Load on Unit 1, read backwards from Fuel Load on Unit 2. This shows a major deconfliction with regards to construction hazards having the potential to result in radiological risk.

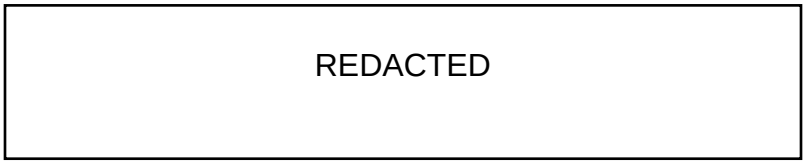

Figure 2: REDACTED

25.4.3 Generic SMR-300 Commissioning Sequence

Commissioning means the process during which plant components and systems, having been constructed, are made operational and verified to be in accordance with design assumptions and to have met the appropriate safety criteria (Licence Condition 1, The ONR, Licence Condition Handbook, [57]).

The objective of the commissioning process is to demonstrate assurance that Holtec's generic SMR-300 has been constructed in accordance with the design, and that systems perform in a consistent, reliable manner. A preliminary equivalence study has been carried within HI-2240124, UK GDA Gap Analysis Report [58] to identify key regulatory differences between the US and UK. Within the revision 1 updates to PSR chapters in Step 2 of the GDA, a topic specific review shall be undertaken to ensure that any codes and standards used in the US construction verification programme have been demonstrated to be acceptable for use in the UK. The commissioning phase follows the construction and installation phases. Verification of the construction and installation of components and systems will be performed during construction and installation commissioning.

During commissioning, the licensee has the responsibility under Licence Condition 21 [40] to 'make and implement adequate arrangements for the commissioning of any plant or process which may affect safety'. These arrangements will apply to the licensee's processes for the management of commissioning activities rather than the commissioning activities needed for a specific SSC. It is good practice to undertake commissioning in a number of phases, these typically take on the following phases:

- Factory Acceptance Tests (FAT)
    - These are tests undertaken within production of equipment to ensure it meets the requirements specified.
- Site Acceptance Tests (SAT).
    - These tests are undertaken on plant and typically occur when the number of FATs becomes excessively onerous or interactions between equipment is required to be investigated.

- Site supervision
    - During build phase, site supervision is required for in-situ construction processes.

For both the above types of tests, the ONR may wish to place a “hold-point” on the outcome of these tests and should the hold-point not be satisfied, progression to the next is not allowable, an example of this would be that the ONR specifies that active commissioning should not proceed until ONR consent to it. That consent could be based on the successful outcome of in-active commissioning.

In accordance with LC 20, Modification to Design of Plant under Construction [59], the licensee is required to ensure that management arrangements are in place to maintain design integrity and to define a baseline statement for the safety of the plant through the remaining life cycle of the facility.

The full generic Holtec SMR-300 commissioning programme is in development and will be refined through design. It will follow IAEA’s Commissioning Guidelines, [46], as summarised below:

- Preoperational tests (also called non-nuclear tests or preliminary tests) are performed before fuel loading, after turnover from construction to commissioning and verification of prerequisite fulfilment of all construction objectives and milestones. They typically include:
    - Individual system tests.
    - Integrated functional system tests in cold conditions (without fuel present within the core), including primary circuit cold hydrostatic test and secondary hydrostatic test.
    - Integrated functional system tests in hot conditions (fuel is present within the core).
- Operational tests (also called nuclear tests), which start with fuel loading, typically include:
    - Core loading tests.
    - Pre-critical tests.
    - First criticality and low power tests.
    - Power ascension tests ending with full power tests and acceptance tests. CAE Summary

The generic SMR-300 design is aligned to international codes and standards to ensure that the design can be realised.

25.4.4 Nuclear Site Licensee

Holtec International will ensure that the objectives of construction and commissioning will be in line with the licensee’s expectations, recognising it is the licensee who will be responsible for implementing adequate arrangements for the commissioning of the generic SMR-300 plant and all processes and systems that are safety related. This includes that Unit 1 and Unit 2 will be at differing lifecycle stages during the construction and commissioning stages.

The licensee's commissioning activities will include:

1. Verify through commissioning that the as-built installed SSCs operate in accordance with the design intent stated in the SSEC, through all relevant operating modes and operating range.
2. Demonstrate for which the commissioning tests provide representative activities and/or conditions, that emergency operating procedures, operating rules, operating instructions, and examination, inspection, maintenance, and testing requirements are validated as claimed in the SSEC.
3. Ensure suitably qualified and experienced station and operations staff are directly involved at all levels and in all areas in the commissioning activities to allow them to gain physical plant experience ahead of the generic SMR-300 operation.
4. Facilitate the collection of baseline data for SSCs for retention by the Responsible Designer and the licensee for future reference.
5. Implement programme hold points, which will be required to ensure ordered and sequential progress between defined steps within the commissioning programme.
6. Verify main design parameters, including compliance with applicable codes, standards, and the quality assurance requirements.

PSR Chapter A Part 4, Lifecycle Management and Safety Assurance, details the lifecycle management of safety process that Holtec will follow to ensure that the SSEC evolves appropriately, using design change control and quality assurance to produce a Pre- Construction Safety Report (PCSR). PSR Chapter A4 [3] also contains the requirements on the licensee in future stages of Holtec's generic SMR 300 production, and how this interface with Holtec will be managed and roles assigned. Roles such as design authority, responsible designer, intelligent customer and nuclear site licensee interfaces are described in the organisational development sections.

25.4.5 CAE Summary

The generic SMR-300 is designed to enable safe construction. The constructability philosophy results in prefabrication, preassembly, and modularisation being used to the maximum extent practical. This, alongside provisions made within the design for construction, such as good crane and material handling access, adequate space and access for construction activities, and provision for temporary construction buildings and equipment will mitigate onsite risk to personnel.

The construction and commissioning approach aims to minimise radiological risk, where it is shown that the Unit 2 construction activities are expected to be completed prior to Unit 1 Fuel Load. This shows a major deconfliction with regards to construction hazards having the potential to result in radiological risk and that the potential risk of latent hazards being introduced into the SSC that as a result of failures or errors during construction and commissioning is minimised.

- A formal construction sequence, with details on the construction modular aspects of the SMR plant to meet buildability requirements and RGP, is required from Holtec Britain to meet UK regulatory approach.

An update to Figure 1 is required to reflect Holtec's generic SMR-300, such as:

- Inclusion of key permits and consents required prior to deployment, detailed in Great British Nuclear (GBN's) Procurement for Small Modular Reactor Technology Partners ISIT, Volume 3 – GBN Requirements [47].
- Inclusion further milestones such as 'ONR consent for the start of nuclear safety related construction'.
- Example deployment schedule refers to 4-unit. This should reflect the twin unit design for generic SMR-300.

The construction and commissioning process includes activities that enable the capture of the required substantiation evidence. Evidence will be gathered from FAT, SAT and site supervision for in-situ construction processes. The commissioning test sequence demonstrates that system or multi-system level safety requirements will be verified through preoperational and operational testing.

The objectives of construction and commissioning will be in line with the licensee's expectations, recognising it is the licensee who will be responsible for implementing adequate arrangements for the commissioning of the generic SMR-300 plant and all processes and systems that are safety related. Appropriate arrangements will be in place to ensure that the SSEC evolves appropriately, using design change control and quality assurance.

25.5 CHAPTER SUMMARY AND CONTRIBUTION TO ALARP

This sub-chapter provides an overall summary and conclusion of the Construction and Commissioning Chapter and how this Chapter contributes to the overall demonstration of ALARP for the generic SMR-300. HI-2240336, Holtec SMR GDA PSR Part A Chapter 5 Summary of ALARP [60] sets out the overall approach for demonstration of ALARP and how contributions from individual Chapters are consolidated.

This subchapter therefore consists of the following elements:

- Technical Summary
- ALARP Summary
    - Review against Relevant RGP.
    - Risk Reduction Options.
    - GDA Commitments and Forward Actions.
- Conclusion.

A review against these elements is presented below under the corresponding headings.

25.5.1 Technical Summary

This chapter directly supports Claim 2.3.1.

Claim 2.3.1: Appropriate arrangements to safely manage people and plant during the construction, commissioning and operation of the Generic Holtec SMR-300 are suitably mature for a generic design.

The generic SMR-300 design is aligned to international codes and standards to ensure that the design can be realised.

The generic SMR-300 is designed to enable safe construction. The constructability philosophy results in prefabrication, preassembly, and modularisation being used to the maximum extent practical. This, alongside provisions made within the design for construction, such as good crane and material handling access, adequate space and access for construction activities, and provision for temporary construction buildings and equipment will mitigate onsite risk to personnel.

The application of categorisation and classification methodology will derive the design requirements in accordance with nuclear safety, including the QA requirements for construction and commissioning. Quality Assurance requirements will be applied to the design, construction and commissioning, procurement, manufacture, operation and testing to ensure the safety-related work is performed in accordance with approved QA procedures as described in the Quality Assurance Programme [25], further summarised within PSR Chapter A4 (MSQA) [3].

The generic SMR-300 design will be shown to be compliant with UK codes and standards relevant to construction and commissioning.

A CDM strategy will identify key duty holders who will plan, manage and monitor during pre-construction and throughout the project lifecycle. It will also manage hazards, risks, apply the General Principles of Prevention, and ensure that nuclear site health and safety substantiation is present throughout the design. A health and safety file will be completed for Holtec's project, alongside training of key personnel on CDM and design safety.

The generic SMR-300 is designed to enable safe construction. The constructability philosophy results in prefabrication, preassembly, and modularisation being used to the maximum extent practical. This, alongside provisions made within the design for construction, such as good crane and material handling access, adequate space and access for construction activities, and provision for temporary construction buildings and equipment will mitigate onsite risk to personnel.

The construction and commissioning approach aims to minimise radiological risk, where it is shown that the Unit 2 construction activities are expected to be completed prior to Unit 1 Fuel Load. This shows a major deconfliction with regards to construction hazards having the potential to result in radiological risk and that the potential risk of latent hazards being introduced into the SSC that as a result of failures or errors during construction and commissioning is minimised.

The construction and commissioning process includes activities that enable the capture of the required substantiation evidence. Evidence will be gathered from FAT, SAT and site supervision for in-situ construction processes. The commissioning test sequence demonstrates that system or multi-system level safety requirements will be verified through preoperational and operational testing.

Lessons learnt relevant to construction and commissioning are identified and will inform the construction and commissioning process of the SMR-300. LfE will also be gained from the Palisades build programme.

The objectives of construction and commissioning will be in line with the licensee's expectations, recognising it is the licensee who will be responsible for implementing adequate arrangements for the commissioning of the generic SMR-300 plant and all processes and systems that are safety related. Appropriate arrangements will be in place to ensure that the SSEC evolves appropriately, using design change control and quality assurance.

25.5.2 ALARP Summary

25.5.2.1 Review against Relevant RGP

At this GDA stage, consideration of RGP is focused on ensuring that the design development philosophy has taken due consideration of constructability requirements. Future GDA stages will ensure due cognisance of RGP in the detailed definition of the construction and commissioning process.

More information on the overall ALARP process for the generic SMR-300 can be found in HI-2240125, ALARP Design Process, [61], specific ALARP considerations within this subchapter are described in the following subchapters.

25.5.2.2 Risk Reduction Options

The process for the assessment of risk reduction options is presented in HPP-3295-0017-R0, Holtec SMR-300 Generic Design Assessment Reference Design Process and GDA Prospective Design Change Register [62]. Part A Chapter 5 of this PSR 'ALARP Summary' [60] considers the holistic risk-reduction process for the Generic SMR-300.

Future development of the construction and commissioning approach will ensure that risks will be optimised and reduced ALARP. At this GDA stage, seeking to achieve a construction sequence that ensures the completion of all major Unit 2 construction activities prior to Unit 1 Fuel Load provides a major deconfliction between construction hazards having the potential to result in radiological risk. Arrangements will be developed to manage the construction and commissioning process, optimisation that Unit 1 and Unit 2 will be at differing lifecycle stages during this period.

Optimisation of the construction and commissioning approach will continue beyond the Pre-Construction Safety Report (PCSR) stage, and into the Pre-Commissioning Safety Report stage, where detailed optimisation of the commissioning test sequencing can be undertaken to ensure both conventional and radiological risks are reduced ALARP, and that the potential risk of latent hazards being introduced into the SSC that as a result of failures or errors during construction and commissioning is minimised.

25.5.2.3 GDA Commitment and Forward Actions

The overall safety case aims to provide assurance that the proposed design and methodology meets the requirements of the UK regulator. PSR Chapter B Part 25 is recognised to require further development within the scope of GDA. This includes:

The need to develop a formal construction sequence, with details on the construction modular aspects of the SMR plant to meet buildability requirements and RGP, to meet UK regulatory approach.

A generic SMR-300 deployment schedule is required to reflect:

- Inclusion of key permits and consents required prior to deployment, detailed in Great British Nuclear (GBN's) Procurement for Small Modular Reactor Technology Partners ISIT, Volume 3 – GBN Requirements [47]
- Inclusion of further milestones such as 'ONR consent for the start of nuclear safety related construction'.

A CDM strategy will identify key duty holders who will plan, manage and monitor during pre-construction and throughout the project lifecycle. It will also manage hazards, risks, apply the General Principles of Prevention, and ensure that nuclear site health and safety substantiation is present throughout the design. A health and safety file will be completed for Holtec's project, alongside training of key personnel on CDM and design safety.

PSR Chapter A Part 4 [3] explains the process by which specific forward actions identified across all PSR chapters have been captured and are being managed during the GDA process.

25.5.3 Conclusion

The conclusion of this Chapter of the PSR is that:

- The Chapter Claims identified have been met to a maturity aligned with a preliminary safety report. Further claims, arguments and evidence will be presented in due course as the design develops.
- The generic SMR-300 design is aligned to international codes and standards to ensure that the design can be realised. It is designed to enable safe construction, in accordance with the constructability philosophy with prefabrication, preassembly, and modularisation being used to the maximum extent practical.
- The application of categorisation and classification methodology will derive the design requirements in accordance with nuclear safety, including the QA requirements for construction and commissioning. Quality Assurance requirements will be applied to the design, construction and commissioning, procurement, manufacture, operation and testing to ensure the safety-related work is performed in accordance with approved QA procedures.
- The SMR-300 design will be shown to be compliant with UK codes and standards relevant to construction and commissioning.
- Lessons learnt relevant to construction and commissioning are identified and will inform the construction and commissioning process of the SMR-300, including LfE gained from the Palisades build programme.

Part A Chapter 5 of this PSR 'ALARP Summary' [60] concludes that it can be demonstrated that the Generic SMR-300 reduces risks to ALARP and that the Fundamental Purpose of the SSEC has been fulfilled.

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List of Appendices

Appendix A CAE Route Map Table

Table 5: CAE Route Map Table

Overarching SSEC Claim	Overarching SSEC Sub Claims	Chapter Claim/s
Claim 2.3: Lifecycle The design and safety assessment of the Generic Holtec SMR-300 considers the entire reactor lifecycle	**Claim 2.3.1- Construction, Commissioning and Operation** Appropriate arrangements to safely manage people and plant during the construction, commissioning and operation of the Generic Holtec SMR-300 are suitably mature for a generic design.	**Claim 2.3.1.1** The approach to construction and commissioning ensures all required substantiation evidence is generated whilst ensuring nuclear safety related risks are appropriately controlled.
		Claim 2.3.1.2 The generic SMR-300 is constructable and the construction and commissioning sequence supports the reduction of risks to ALARP