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PSR Part B Chapter 5 Reactor Supporting Facilities

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1	Second Issue to Regulators to support PSR v1

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5.1 INTRODUCTION

The Fundamental Purpose of the Generic Design Assessment (GDA) Safety, Security and Environment Case (SSEC) is to demonstrate that the generic Small Modular Reactor (SMR)-300 can be constructed, commissioned, operated, and decommissioned on a generic site in the United Kingdom (UK) to fulfil the future licensee's legal duties to be safe, secure and protect people and the environment, as defined in Part A Chapter 1 [1].

The Fundamental Purpose is achieved through the Fundamental Objective of the Preliminary Safety Report (PSR), which is to summarise the safety standards and criteria, safety management and organisation, claims, arguments and intended evidence to demonstrate that the generic SMR-300 design risks to people are likely to be tolerable and As Low as Reasonably Practicable (ALARP) [1].

Part B Chapter 5 of the PSR presents the Claims, Arguments and Evidence (CAE) for the Reactor Supporting Facilities.

5.1.1 Purpose and Scope

The Overarching SSEC Claims are presented in Part A Chapter 3.

This chapter (Part B Chapter 5) links to the overarching claim through Claim 2.2:

Claim 2.2: The design of the systems and associated processes have been developed taking cognisance of relevant good practice and substantiated to achieve their safety and non-safety functional requirements.

As set out in Part A Chapter 3, Claim 2.2 is further decomposed across several engineering disciplines which are responsible for development of the design of relevant Structures, Systems and Components (SSC).

This chapter principally presents the Reactor Supporting Facilities aspects for the generic SMR-300 and therefore directly supports Claim 2.2.13.

Claim 2.2.13: The Reactor Supporting Facilities are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

In addition to this, a second Level 3 claim is presented in the chapter, concerning the design and architecture of the in-scope Heating, Ventilation and Air Conditioning (HVAC) systems.

Claim 2.2.18: The overall design and architecture of heating, ventilation and air conditioning SSCs ensure that safety functions and non-safety functions are delivered and faults arising from failures of the SSCs are minimised.

Additionally, SSCs presented herein contribute towards the arguments and evidence supporting Claim 2.2.3. PSR Part B Chapter 1 [2] also supports this claim (see Table 3).

Claim 2.2.3: Adequate provision for the control of radiation exposure and control of release of radioactive material is incorporated into the design.

Further discussion on how the Level 3 claims are broken down into Level 4 claims and how the Level 4 claims are demonstrated is provided in sub-chapter 5.3.

The scope of this chapter covers a variety of SMR-300 systems as set out in sub-chapter 5.2.

Sub-chapter 5.4 covers the codes and standards associated with Reactor Supporting Facilities.

Sub-chapters 5.5 - 5.8 cover the arguments and evidence in support of the chapters principal claim, 2.2.13. Descriptions of the systems are provided along with their functions. Claim 2.2.3 is addressed in the relevant systems descriptions that support the claim, and 2.2.18 is discussed in section 5.8.1. The Reactor Supporting Facilities are broken down into the following four main categories:

- Auxiliary Systems (sub-chapter 5.5).
- Steam and Power Conversion Systems (sub-chapter 5.6).
- Mechanical Handling Systems (sub-chapter 5.7).
- HVAC Systems (sub-chapter 5.8).

Finally, sub-chapter 5.9 provides a technical summary of how the claims for this chapter have been achieved, together with a summary of key contributions from this chapter to the overall ALARP. Sub-chapter 5.9 also discusses any GDA Commitments that have arisen.

The information presented within this chapter is aligned with the project Design Reference Point (DRP). The DRP is set out in PSR Part A Chapter 2 [3] and it includes updated documentation since revision 0 of this chapter.

Excluded from the Part B Chapter 5 scope is the Security Systems HVAC System. This system has not been developed to a suitable maturity to enable PSR inclusion and is not considered necessary for the fundamental assessment. From Revision 0 of this chapter, the Radioactive Waste Building HVAC has been removed due to the incorporation of this building into the Reactor Auxiliary Building (RAB).

Table 1: Part B Chapter 5 Summary of In-Scope SSCs

System Group	SSC Description	System Acronym	Chapter Sub-section	Reference Document	Document Type
Auxiliary Systems	Combustible Gas Control System	**CGC**	5.5.1	HI-2135829 [4]*	SDD
	Chemical and Volume Control System	**CVC**	5.5.2	HI-2240166 [5]	SDD
	Fire Protection System	**FPS**	5.5.3	HI-2220555 [6]*	SDD
	Primary Sampling System	**PSL**	5.5.4	HI-2240168 [7]	SDD
	Residual Heat Removal System	**RHR**	5.5.5	HI-2240154 [8]	SDD
	Spent Fuel Pool Cooling System	**SFC**	5.5.6	HI-2240167 [9]	SDD
Steam and Power Conversion Systems	Main Feedwater System	**MFS**	5.6.1	HI-2240180 [10]	SDD
	Main Steam System	**MSS**	5.6.2	HI-2240179 [11]	SDD
Mechanical Handling Systems	Overhead Heavy Load Handling System	**CSH**	5.7.1	PS-8002-0002 [12]	PS
	Light Load Handling System	**LLH**	5.7.2	PS-8002-0001 [13]	PS
	Reactor Auxiliary Building Truck Bay Crane	**RBH**	5.7.3	PS-8002-0003 [14]	PS
HVAC	Containment Ventilation System	**CBV**	5.8.2	HI-2240583 [15]	SDD
	Radiologically Controlled Area HVAC System	**RCV**	5.8.3	Not currently available	N/A

**SMR-160 document.*

SDD – System Description Document; DS – Design Specification; PS – Purchase Specification.

A master list of definitions and abbreviations relevant to all PSR Chapters can be found in Part A Chapter 2 [3].

5.1.2 Assumptions

Assumptions which relate to this topic have been formally captured in the Commitments, Assumptions and Requirements process [16]. Further details of this process are provided in Part A Chapter 4.

5.1.3 Interfaces with other SSEC Chapters

The Reactor Supporting Facilities chapter interfaces with several other SSEC chapters. The following highlights the key interfaces.

PSR Part B Chapter 1 ‘Reactor Coolant System and Engineered Safety Features’ [2] presents systems and components that interface directly with Reactor Supporting Facilities. For example, the CVC interfaces directly with the Reactor Coolant System (RCS) to provide chemical and volume control. The RHR removes decay heat from the RCS to reduce reactor coolant temperature during normal shutdown and refuelling operations. The MFS and MSS interface with the Steam Generator (SGE) to transfer heat from the primary coolant to the secondary system. Additionally, Claim 2.2.3 is supported with arguments and evidence across systems presented in Part B Chapter 1 [2]; this claim is also supported by systems within this chapter. The Containment Isolation System (CIS) is described in Part B Chapter 1 and several of the systems within this chapter directly interface with this system.

Part B Chapter 2 Reactor [17] presents an overview of the reactor fuel and core design. The CVC controls the concentration of soluble boron in the RCS which controls the core reactivity.

Part B Chapter 4 Control and Instrumentation Systems [18] - systems in the scope of this chapter have control and instrumentation that is supported by Part B Chapter 4. Similarly, the electrical aspects of the SSCs are supported by Part B Chapter 6 Electrical Engineering [19].

The SMR-300 approach to Examination, Inspection, Maintenance and Testing (EIMT) in general is laid out in PSR Part B Chapter 9 Description of Operational Aspects and Conduct of Operations [20]. Several aspects are discussed so as to manage or mitigate ageing and degradation for through-life reliability of SSCs – including those presented in this chapter.

Part B Chapter 19 Mechanical Engineering [21] presents the design basis, quality aspects and, codes and standards used for the mechanical features within systems presented in this chapter.

Part B Chapter 20 Civil Engineering [22] describes the Containment Structure, the integrity of which is supported by the CGC. Several systems within this chapter penetrate the containment structure and have containment integrity claims against them.

The CVC, as presented in this chapter, controls the RCS water chemistry which is presented Part B Chapter 23 Reactor Chemistry [23].

The Mechanical Handling Systems support the transport aspects in Part B Chapter 24 Fuel Transport and Storage [24]. The SFC also supports fuel storage.

5.2 OVERVIEW OF REACTOR SUPPORTING FACILITIES

The Reactor Supporting Facilities are divided into four groups as listed in section 5.1.1. These are listed below with a brief description of the systems they encompass.

5.2.1 Auxiliary Systems

The plant Auxiliary Systems are designed to support and protect the plant during normal and transient reactor operating states. Several Auxiliary Systems are within the scope of the PSR and are comprised of:

- Combustible Gas Control System.
  - Provides monitoring and control of the hydrogen concentrations inside containment in order to maintain containment integrity against hydrogen combustion.
- Chemical and Volume Control System.
  - Controls RCS chemistry, inventory, auxiliary Pressuriser spray and seal injection/return flows to the Reactor Coolant Pumps (RCP).
- Fire Protection System.
  - Provides fire detection and suppression throughout Nuclear Island (NI).
- Primary Sampling System
  - Obtains samples from primary plant systems to provide analytical information on the performance of SSCs.
- Residual Heat Removal System.
  - Removes decay heat from the reactor core and RCS sensible heat to reduce coolant temperature during normal shutdown and refuelling operations.
- Spent Fuel Pool Cooling System.
  - Provides cooling and cleanup of the SFP during all modes of plant operation.

5.2.2 Steam and Power Conversion Systems

The steam and power conversion systems are designed to remove heat from the RCS via the SGE, which is then converted to electrical power via turbine and generator. The PSR scope is limited to the following two systems:

- MFS.
  - Supplies feedwater to the SGE at the required temperature, pressure and flowrate.
- MSS.
  - Delivers steam to various components in the appropriate state.

5.2.3 Mechanical Handling Systems

Mechanical Handling systems comprise of equipment designed to safely lift, move and position items including fuel and heavy components. The systems in GDA scope cover the following:

- Overhead Heavy Load Handling System.
  - Consists of polar crane which is used in containment for fuel movements, facility maintenance, and construction tasks inside containment.
- Light Load Handling System.

    - Provides fuel handling capabilities inside containment.
- Reactor Auxiliary Truck Bay Crane.
    - Provides fuel handling capabilities inside the RAB.

5.2.4 Heating, Ventilation and Air Conditioning Systems

The HVAC systems within the SMR-300 provide temperature and humidity control, ventilation and air conditioning. The HVAC systems in GDA scope are:

- Containment Ventilation System.
    - Provides containment temperature control, humidity control and purge air.
- Radiologically Controlled Area HVAC System
    - Provides ventilation to radiologically controlled areas within the RAB.

5.2.5 Reliability of Systems

The safety functional requirements for plant safety measures, and therefore the reliability requirements of the SSCs which deliver those safety measures, are defined through safety assessment. A methodology for identification and assessment of fault conditions for the SMR-300 has been performed based on the approach used in the US. Further discussion on the methodologies and approach used can be found in the Safety Assessment Handbook [25]. This will be expanded to be in-line with UK Relevant Good Practice (RGP) and the relevant Office for Nuclear Regulation (ONR) Safety Assessment Principles (SAPs) and Technical Assessment Guides (TAGs), as presented in Part B Chapter 14 Safety and Design Basis Accident Analysis [26]. At the time of PSR Revision 1, limited UK specific DBAA has been conducted. This has identified category A safety functions for RCPB integrity and containment boundary integrity; functions which are partially delivered by some of the systems within the scope of this chapter. As such, the relevant parts of these subsystems pertaining to the delivery of the category A safety functions have a Class 1 requirement on them and the reliability implications that come from this.

Reliability requirements will also be dictated by the outcomes of analysis presented in Probabilistic Safety Analysis [27], BDBA and Severe Accident Analysis [28], and Internal Hazards [29].

Additionally, SSCs are designed with consideration of EIMT requirements, taking into account aspects such as access, capacity to replace, scheduling and more. These EIMT considerations are more generally discussed in Part B Chapter 9 [20].

5.3 REACTOR SUPPORTING FACILITIES CLAIMS, ARGUMENTS AND EVIDENCE

This chapter presents the Reactor Supporting Facilities for the generic SMR-300 and therefore supports Claims 2.2.13, 2.2.3 and 2.2.18.

5.3.1 Claim 2.2.13

Claim 2.2.13: The Reactor Supporting Facilities are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

Claim 2.2.13 has been further decomposed within Part B Chapter 5 into the four sub-claims with each claim covered in the chapter. Table 2 shows the breakdown of Claim 2.2.13 and identifies in which sub chapter these claims are demonstrated to a maturity appropriate for PSR v1.

Table 2: Decomposition of Claim 2.2.13

Claim No.	Claim	Chapter Section
2.2.13.1	The Auxiliary Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.	5.5 Auxiliary System
2.2.13.2	The Steam and Power Conversion Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.	5.6 Steam and Power Conversation Systems
2.2.13.3	The Mechanical Handling systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.	5.7 Mechanical Handling Systems
2.2.13.4	The Heating, Ventilation and Air Conditioning Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.	5.8 Heating, Ventilation and Air Conditioning Systems

5.3.2 Claim 2.2.3

Claim 2.2.3: Adequate provision for the control of radiation exposure and control of release of radioactive material is incorporated into the design of the reactor systems, supporting facilities, engineered safety features, and fuel and core design.

Claim 2.2.3, as shown above, is associated with and supported by systems that span across the scopes of both Part B Chapters 1, 2 and 5. The claim is decomposed into 6 subclaims with the relevant supporting chapter sections highlighted below.

Table 3: Decomposition of Claim 2.2.3

Claim No.	Claim	Chapter Section
2.2.3.1	The RCS and Engineered Safety Feature (ESF) SSCs ensure the integrity of the Reactor Coolant Pressure Boundary following credible initiating events in all plant states.	Part B Chapter 1 [2]
2.2.3.2	The RCS and ESF SSCs ensure the integrity of the Containment Structure following credible initiating events in all plant states.	Part B Chapter 1 [2]
2.2.3.3	Habitability of the main control room is ensured following credible initiating events in all plant states.	Part B Chapter 1 [2]
2.2.3.4	Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Pressure Boundary following credible initiating events in all plant states.	5.5.2 CVC 5.5.4 PSL 5.5.5 - RHR
2.2.3.5	Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.	5.5.2 CVC 5.5.4 PSL 5.5.5 RHR 5.5.6 SFC 5.6.1 MFS 5.6.2 MSS 5.8.2 CBV
2.2.3.6	The fuel rod clad integrity is maintained during normal operation and Anticipated Operational Occurrences (AOO).	Part B Chapter 2 [17]

5.3.3 Claim 2.2.18

Claim 2.2.18: The overall design and architecture of heating, ventilation and air conditioning SSCs ensure that safety functions and non-safety functions are delivered and faults arising from failures of the SSCs are minimised.

Claim 2.2.18 does not have any supporting level 4 claims but is solely demonstrated in Section 5.8 to a maturity appropriate for PSR Revision 1.

Appendix A provides a full CAE mapping for Part B Chapter 5, which includes any lower-level claims, arguments and evidence needed to support the claims in the tables above. This includes identification of evidence available at PSR Revision 1 and aspects for future development of evidence to support these claims beyond PSR Revision 1.

5.4 REACTOR SUPPORTING FACILITIES CODES AND STANDARDS

5.4.1 Codes and Standards

Relevant codes and standards are selected based on the Holtec International categorisation and safety classification of the SSCs used within the Reactor Supporting Facilities. The SSC classification methodology for SMR-300 is codified within the SSC Classification Standard [30].

For each system, the codes and standards used in their design are detailed in the respective SDDs. Claims, arguments and evidence relating to the codes and standards used, including assessment of the appropriateness of these with respect to RGP and operational experience (OPEX), are made in supporting PSR chapters:

- Part B Chapter 4 – Control and Instrumentation [18].
- Part B Chapter 6 – Electrical Engineering [19].
- Part B Chapter 19 – Mechanical Engineering [21].
- Part B Chapter 20 – Civil Engineering [22].
- Part B Chapter 23 – Reactor Chemistry [23].
- Part B Chapter 24 – Fuel Transport and Storage [24].

The SSC classification methodology, currently applied to the SMR-300, [30], utilises the approach described in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.26, Revision 6 [31] and related guidance documents. This methodology is further summarised in Part A Chapter 2, Subchapter 3.1 [3], which describes RG 1.26 Quality Groups A through D, and corresponding SSC Classification Standard “SMR Class”.

The SSC Classification Standard [30] designates the Quality classification of SSCs. An overview of the classification of the Reactor Supporting Facilities SCCs is shown in Appendix B.

Table 4 displays a summary of the construction codes and standards for SMR-300 components, based on their Quality Group.

Table 4: Summary of Codes and Standards for SMR-300 Components [30]

Component	Quality Group A	Quality Group B	Quality Group C	Quality Group D
Pressure Vessels	American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), Section III, Division 1, Subsection NB: **Class 1**, Nuclear Power Plant Components	ASME BPV Code, Section III, Division 1, Subsection NC: **Class 2**, Nuclear Power Plant Components	ASME BPV Code, Section III, Division 1, Subsection ND: **Class 3**, Nuclear Power Plant Components	ASME Boiler and Pressure Vessel Code, Section VIII, Division 1
Piping	Class 1 (NB)	Class 2 (NC)	Class 3 (ND)	American National Standards Institute (ANSI) B31.1 Power Piping
Pumps	Class 1 (NB)	Class 2 (NC)	Class 3 (ND)	Manufacturer's standards
Valves	Class 1 (NB)	Class 2 (NC)	Class 3 (ND)	ANSI B31.1 Power Piping and ANSI B16.34
Atmospheric Storage Tanks	N/A	Class 2 (NC)	Class 3 (ND)	American Petroleum Institute (API)-650, American Water Works Association (AWWA) D100, or ANSI B96.1
0-15 psig Storage Tanks	N/A	Class 2 (NC)	Class 3 (ND)	API-620
Supports	Subsection NF provisions for Class 1 supports	Subsection NF provisions for Class 2 supports	Subsection NF provisions for Class 3 supports	Manufacturer's standards
Metal Containment Components	N/A	Subsection NE provisions for Class MC components	N/A	N/A
Core Support Structures	N/A	Subsection NG provisions for Class CS components	N/A	N/A
Electrical	IEEE 603 Class 1E (Safety Related)	IEEE 603 Class 1E (Safety Related)	IEEE 603 Class 1E (Safety Related)	IEEE 603 non-Class 1E (non-Safety Related)

5.4.2 Summary

The supporting chapters listed in Section 5.4.1 address claims within them that support the use of codes and standards within the design of Reactor Supporting Facilities. Although not directly justified within this chapter, the use of codes and standards underpins the ability to design systems and SSCs to deliver the relevant safety functions and ensure reliability and integrity of systems during credible events which is justified within the CAE structure of Part B Chapter 5.

5.5 AUXILIARY SYSTEMS

Claim 2.2.13.1: The Auxiliary Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

The plant Auxiliary Systems consist of the following systems:

- Combustible Gas Control System.
- Chemical and Volume Control System.
- Fire Protection System.
- Primary Sampling System.
- Residual Heat Removal System.
- Spent Fuel Pool Cooling System.

The sections below present details of each system and form the basis of the argument as to why Claim 2.2.13.1 is demonstrated. Design documentation that supports the information in this chapter provides the evidence to substantiate the claim.

In addition to Claim 2.2.13.1 above, some subsections feature systems that support the Reactor Coolant Pressure Boundary (RCPB), and containment integrity Claims 2.2.3.4 and 2.2.3.5 respectively (see section 5.3.2). These are highlighted at the beginning of each relevant subsection.

5.5.1 Combustible Gas Control System

In addition to supporting claim 2.2.13.1 above, the CGC supports the claims below:

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.5-A1: The concentration of combustible gases in the containment volume is adequately limited following a design basis accident.

5.5.1.1 System Overview

The CGC permits monitoring and mitigation of the combustible gas concentration in the SMR-300 containment, following a Beyond Design Basis Accident (BDBA) involving up to 100% fuel clad-coolant reaction, to maintain containment integrity.

Combustible gases can be generated inside the containment through the following phenomena, after a Severe Accident (SA) or BDBA event:

- Radiolysis of water in the core.
- Radiolysis of water in the containment.
- Metal-water reaction in the core at elevated temperature following core uncovering.
- Chemical reaction with metal in containment including molten core-concrete interaction following reactor vessel/fuel failure.
- De-gassing of hydrogen dissolved in reactor coolant.

The CGC is designed to limit the concentrations of combustible gas (hydrogen) inside the containment structure to less than 10% by volume to prevent a deflagration or detonation that could threaten containment integrity. The system will ensure that other essential accident mitigation functions can be performed following an accident involving core damage that leads to the production of hydrogen or other combustible gases.

The system is designed to limit the global containment hydrogen concentration to less than 10% by volume by the use of a number of Passive Autocatalytic Recombiners (PAR). The local accumulation of combustible gases that could threaten containment integrity, or operation of equipment in localised compartments, can be mitigated by the use of the natural circulation ventilation or by the use of PARs in that location.

5.5.1.2 System Functions

5.5.1.2.1 Safety Functions

The safety functions of the CGC are to:

- **Limit the concentration of combustible gases (e.g., hydrogen) in the containment atmosphere following their postulated release during an accident involving significant core damage.**
  The CGC maintains resulting hydrogen concentrations less than 10% by volume in the containment atmosphere.

5.5.1.2.2 Non-Safety Functions

There are no non-safety related functions defined for this system at Revision 1.

5.5.1.3 System Description

Combustible gas (e.g., hydrogen) can be generated during a small Loss of Coolant Accident (LOCA) by degassing of hydrogen dissolved in reactor coolant, radiolysis of water in the core and in the containment well, corrosion, and core metal/water reaction at elevated temperature following core uncovering. Larger amounts of combustible gas (e.g., hydrogen) can be generated during a BDBA involving significant fuel damage wherein a reaction between the fuel cladding and the reactor coolant (100% core metal/water reaction), or a reaction between a molten reactor core and concrete has occurred.

If a sufficient amount of combustible gas is generated it may react with oxygen in a non-inerted containment atmosphere at a rate rapid enough to create a combustible concentration that theoretically could, if ignited, cause a breach of containment or damage to systems or components essential to control of the post-accident conditions. Accordingly, the need for a reliable CGC is essential. The SMR-300 design employs PARs to limit the hydrogen concentration inside containment.

The function of monitoring hydrogen concentration is performed by the Hydrogen Monitoring System (HMS).

The information presented in this section at Revision 1 is based on the SMR-160 design. This is considered acceptable at this stage as the claims and function of the CGC are not anticipated to fundamentally change; it is expected that the PARs will remain unchanged in function.

5.5.1.4 System Reliability

The CGC components (PARs) are non-safety related but must be capable of performing their function in the harsh post-accident containment environment. The materials of construction shall be suitable for the normal and post-accident containment conditions.

See also section 5.2.5.

5.5.1.5 System Interfaces

Table 5: CGC Interfacing Systems

System	Description	Function	PSR Chapter
HMS	Hydrogen Monitoring System	Works in conjunction with the CGC to monitor containment hydrogen concentration.	Not in GDA scope
CS	Containment Structure	PARs are mounted within the containment structure.	Part B Chapter 20 [22]

5.5.2 Chemical and Volume Control System

In addition to supporting claim 2.2.13.1 above, the CVC supports the claims below:

Claim 2.2.3.4: Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Pressure Boundary following credible initiating events in all plant states.

This claim is supported in this subsection by the following arguments:

Argument 2.2.3.4-A1: The CVC contains valves to isolate the charging line and the letdown line following credible initiating events.

Argument 2.2.3.4-A2: The portions of the CVC that interface with the RCS assure the integrity of the RCPB as a fission product barrier and have provisions to isolate the CVC from the RCS.

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.5-A2: The CVC containment penetrations are provided with isolation to preserve the integrity of the containment envelope.

5.5.2.1 System Overview

The CVC controls RCS inventory and chemistry by performing letdown, charging, purification, chemical addition, chemical shim, degasification, and corrosion control functions. Additionally, CVC provides auxiliary Pressuriser spray, as well as seal injection and seal return flows to the RCPs.

The CVC contains isolation valves to maintain the integrity of the RCPB and containment envelope. Portions of the CVC are isolated on safety signals from the Plant Safety System (PSS) to prevent overfilling or draining of the RCS inventory during accident conditions.

5.5.2.2 System Functions

5.5.2.2.1 Safety Functions

The safety functions of the CVC are to:

- **Maintain Reactor Coolant Pressure Boundary Integrity.**
  The portions of the CVC that interface with the RCS ensure the integrity of the RCPB as a fission product barrier and have provisions to isolate the CVC from the RCS using redundant isolation valves in series. Portions of the CVC that may be exposed to RCS conditions are rated to full RCS design pressure and temperature.
- **Maintain Containment Boundary Integrity.**
  The CVC containment penetrations are provided with isolation to preserve the integrity of the containment envelope.

- **Provide Chemical and Volume Control System Charging Isolation.**
  The CVC contains valves to isolate the charging line to prevent excess radiological release from the RCS at higher pressure during a Steam Generator Tube Rupture (SGTR) accident, and to prevent overfilling and over pressurisation of the RCS.
- **Provide Chemical and Volume Control System Letdown Isolation.**
  The CVC contains valves to isolate the letdown line to maintain the RCS inventory in the event of a LOCA.
- **Prevent Uncontrolled Dilution of the RCS.**
  The CVC has isolation valves to automatically terminate inadvertent dilution of the boron concentration in the RCS during makeup operation.

5.5.2.2.2 Non-Safety Functions

The non-safety functions of the CVC are to:

- **Maintain Reactor Coolant Inventory.**
  The CVC maintains reactor coolant inventory within the specified design limits during normal operation. The CVC also has the capability to supply makeup water to the RCS during small leaks.
- **Provide Auxiliary Pressuriser Spray Flow.**
  The charging pumps provide auxiliary Pressuriser spray flow to control Pressuriser pressure as a backup for the RCP, which provides normal spray flow.
- **Purify Reactor Coolant Inventory.**
  The CVC provides reactor coolant purification using a cation demineraliser, a de-borating bed demineraliser, mixed bed demineralisers, and reactor coolant filters to maintain the reactor coolant purity, suspended solids, and activity level within acceptable limits.
- **Provide Reactor Coolant Chemistry Control.**
  The charging pumps inject chemicals from the chemical mixing tank into the RCS to control reactor coolant chemistry. The CVC controls the concentration of oxygen in the RCS during startup by injecting an oxygen scavenger into the Volume Control Tank (VCT). A nitrogen cover gas is supplied to the VCT before a shutdown or refuelling to remove dissolved gases in the reactor coolant.
- **Supply Makeup for Passive Core Makeup Water System, Spent Fuel Pool Cooling System, and Effluent Holdup Tank.**
  The effluent makeup pump, high pressure makeup pump, and the boric acid recirculation pumps supply makeup water at various boron concentrations to the PCM accumulators, Passive Core Makeup Water Tank (PCMWT), the Refuelling Water Storage Tank (RWST), and the effluent holdup tanks.
- **Perform Pressure Testing of the Reactor Coolant System.**
  The CVC can fill and pressure test the RCS. A temporary connection for a hydrostatic test pump is provided for this function.
- **Reactivity Control.**
  The CVC increases or reduces the concentration of soluble boron in the RCS by introducing blended makeup of demineralised water and boric acid at different concentrations and flow rates. The system also provides a diverse and independent means to shut down the reactor and to maintain the core subcritical under limiting reactivity conditions.

- **Degasification of the Reactor Coolant System.**
  The CVC is capable of removing hydrogen and fission product gases from the for processing by the Gaseous Radwaste System (GRW).
- **Reactor Coolant Pump Seal Injection and Seal Return.**
  The CVC Supplies purified coolant to the RCP seals. The CVC accepts and reuses return flow from the RCP seals.

5.5.2.3 System Description

The CVC (see Figure 1, Figure 2, and Figure 3) equipment is located inside containment and the RAB. The CVC is designed to control RCS inventory and chemistry, provide auxiliary Pressuriser pressure control, water for RCP seal injection, accept seal return flow, and reactivity control.

5.5.2.3.1 Letdown, Purification, and Charging

The CVC letdown lines connect to the RCS cold legs at the discharge of the RCP. The major CVC equipment for reactor coolant purification and letdown is located inside containment and the RAB and includes one regenerative heat exchanger, two letdown orifices (in parallel), one letdown heat exchanger, two mixed bed demineralisers, one cation bed demineraliser, one deborating bed demineraliser, two reactor coolant filters, a VCT, and two charging pumps.

The high differential pressure between the RCS and the VCT drives flow through the heat exchangers, letdown orifices, demineralisers, and filters to the VCT. When the RCS is depressurised and RCPs are secured, a connection to the RHR system allows RHR pumps to drive flow through CVC purification equipment. The charging pumps, normally aligned with one pump in operation and the other provided for redundancy, charge reactor coolant through the regenerative heat exchanger and back to the RCS cold leg through one of two connections at the suction of the RCPs. The regenerative heat exchanger reduces the temperature of the reactor coolant coming into CVC from the RCS by transferring heat to the purified coolant returning to the RCS. The letdown orifices reduce the pressure of the letdown flow before it exits containment in order to reduce risk of high-pressure line breaks outside containment and to maintain a low pressure in the VCT. A relief valve inside containment protects the piping downstream of the letdown orifices from overpressure. The cooled letdown flow is then routed outside containment to the letdown heat exchanger where component cooling water reduces the temperature to the operating temperature of the demineraliser resin. A backpressure control valve is used at the outlet of the letdown heat exchanger in order to maintain a set backpressure through the heat exchanger and downstream purification equipment.

Parallel trains of demineralisers and reactor coolant filters are located downstream of the letdown heat exchanger. During normal operations, one demineraliser and filter remove fission products, corrosion products, resin fines, and particulates from the purification flow while the other train remains in standby for redundancy. The cation bed demineraliser may be operated intermittently to remove lithium and caesium isotopes from the coolant. The reduction of lithium concentration in the RCS also serves to control pH. The deborating bed demineraliser may be operated intermittently towards the end of core life to reduce the boron concentration of the RCS. This counteracts the reactivity effect of fuel burnup in the core and reduces the volume of demineralised water needed to accomplish chemical shim. Each demineraliser and reactor coolant filter has its own maintenance isolations. The radioactive waste generated from the purification process is transferred to the Solid Radwaste System (SRW).

The volume control tank serves as a surge tank to the RCS. This tank continually receives letdown flow from the purification equipment and provides purified coolant to the suction of the charging pumps. The VCT has a cover gas of either hydrogen or nitrogen, depending on the mode of operation. If the VCT level rises too high, letdown flow is automatically diverted to the effluent holdup tanks. The VCT also strips hydrogen and radioactive dissolved gases from the reactor coolant into the VCT vapor space. Gases in the VCT vapor space are removed by opening the vent to the GRW and raising level in the VCT to push the gas bubble out.

The letdown flowrate is selected by which letdown orifice is placed into service. The charging flowrate is controlled by the Plant Control System (PCS) to maintain balance of pressuriser water level.

The reactor coolant is pumped from the VCT through the charging pumps to normal operating pressure of the RCS. The regenerative heat exchanger heats the returning flow to the RCS to prevent thermal stresses on the RCS piping and nozzles.

5.5.2.3.2 Inventory Control

Inventory control of the RCS is accomplished by balancing letdown and charging flowrates. The normal operating flowrate is dictated by the required turnover rate (Electric Power Research Institute (EPRI) recommends a maximum RCS turnover time of 8 hours).

The VCT provides surge capacity for the CVC. If VCT level decreases below the relevant setpoint, the CVC automatically initiates makeup to the VCT at the same boron concentration as the RCS. The boric acid flow control valve and the demineralised water flow control valve open to send blended flow to either the charging pump suction piping or to the VCT inlet, whichever is selected based on the makeup modes. A mixing tee downstream of the flow control valves ensures thorough mixing of boric acid and demineralised water. If VCT level increases above the corresponding setpoint, the three-way valve upstream of the VCT automatically diverts purified letdown flow to the effluent Holdup Tanks (HUT) to restore VCT level to normal. The charging pumps can also take suction from the HUTs or the RWST, if necessary.

5.5.2.3.3 Chemistry Control

The CVC controls reactor coolant chemistry to minimise corrosion in the RCS. The Reactor Chemistry is described in PSR Part B Chapter 23 [23]. The chemical mixing tank connects to the piping downstream of the VCT and upstream of the charging pump suction. Chemicals are added and mixed in the tank, then flushed out using demineralised water and charged into the RCS via the charging pumps. The CVC can also control pH in the RCS by intermittently operating the cation bed demineraliser in order to vary the lithium-ion concentration of the coolant.

During normal operation, the VCT is used to add hydrogen to scavenge oxygen in the reactor coolant. In preparation for a shutdown or refuelling, a nitrogen cover blanket and spray nozzle strip dissolved gases, such as hydrogen, and other fission products from the reactor coolant. The gases are then removed by opening the vent to the GRW and raising the water level, which pushes the gas bubble out of the VCT.

5.5.2.3.4 Pressuriser Pressure Control

The discharge pressure of the RCPs drives normal Pressuriser spray flow. The CVC provides auxiliary Pressuriser spray flow if the RCPs are unavailable. Auxiliary Pressuriser spray flow piping branches from the normal charging header downstream of the Regenerative Heat Exchanger. When CVC is providing auxiliary spray flow, the auxiliary spray isolation valve is manually opened and the normal charging connections to the RCS cold leg are manually closed in order to direct as much flow as possible to the pressuriser.

5.5.2.3.5 Reactivity Control

The CVC controls the concentration of boron in the RCS. During power operations, equilibrium boron concentration in the RCS decreases over the course of a fuel cycle and the CVC removes boron from the RCS to maintain criticality. During the transition from hot operating to cold shutdown conditions, the CVC adds boron to counteract the increase in reactivity associated with cooldown. The CVC adds boron before refuelling to achieve required shutdown margin and removes boron after refuelling in preparation for return to power operations. During the return to power operations the CVC removes boron to counteract the decrease in reactivity associated with warm up.

The CVC adjusts RCS boron levels by removing water at RCS boron concentration using letdown and adding water at a different boron concentration using the charging pumps. Boration occurs when adding water at boron concentrations higher than the RCS. Dilution occurs when adding water at boron concentrations lower than the RCS. The boron concentration of water added to the RCS is controlled by mixing water from the Boric Acid Storage Tank (BAST) with Demineralised Water into a blended flow using flow control valves. Blended flow can be sent either to the VCT inlet through the spray nozzle or directly to the charging pump suction. Blended flow sent to the VCT picks up hydrogen to control oxygen in the RCS but takes longer to change RCS boron concentration because it must drain from the top of the VCT down to the charging pump suction before reaching the RCS. Sending blended flow directly to the charging pump suction decreases the time for a dilution or boration to take effect but could lead to increased RCS oxygen concentrations.

The BAST is filled with borated water by adding boric acid and demineralised water through the boric acid mixing hopper. The boric acid recirculation pumps provide the pressure to send the borated water through the associated flow control valve, to the mixing tee, and then either the VCT or directly to the charging pump suction. A filter downstream of the boric acid recirculation pumps collects particulates from the boric acid solution before being added to the RCS. A bypass valve is opened to maintain boric acid flow if the filter is clogged or isolated for maintenance. The BAST contains an electric heater and is continually recirculated to prevent boron precipitation.

The CVC can add concentrated boric acid from the BAST to the RCS as an alternative to control rod insertion to insert negative reactivity to assure that the reactor can be shutdown. While CVC is not credited for accident mitigation in the Deterministic Safety Analysis, this non-safety related function provides defence-in-depth. The boric acid storage tank contains enough boric acid at sufficient concentration to bring the reactor subcritical within the shutdown margin, assuming that the most reactive control rod is withdrawn. This safety analysis and the CVC classification is subject to review in the UK context for GDA – see section [REDACTED].

5.5.2.3.6 Seal Injection and Return

The RCPs require cool, purified, seal injection flow to prevent damage to their seals. A portion of the CVC charging flow is diverted upstream of the regenerative heat exchanger from the normal flow path back to the RCS. The seal flow passes through a seal injection filter before reaching the RCPs inside containment. A portion of the seal injection flows down through the pump seals into the RCS and the remainder leaves the pump through a controlled leak-off path. This seal return flow is directed to the VCT via the seal return filter.

[REDACTED]

Figure 1: Chemical and Volume Control System Process Flow Diagram 1 of 3 [32].

[REDACTED]

Figure 2: Chemical and Volume Control System Process Flow Diagram 2 of 3 [32].

[REDACTED]

Figure 3: Chemical and Volume Control System Process Flow Diagram 3 of 3 [32].

5.5.2.4 System Reliability

Two centrifugal charging pumps, each sized to deliver system design flow, provide redundancy and operational flexibility.

Two boric acid recirculation pumps, each sized to deliver system design flow, provide redundancy and operational flexibility.

Two reactor coolant filters, each sized for system design flow, provide redundancy and operational flexibility.

Two trains of mixed bed demineralisers, each sized for system design flow, provide redundancy and operational flexibility.

Two seal injection filters, each sized for full RCP seal injection design flow, provide redundancy and operational flexibility.

All Air Operated Valves (AOV) fail in the safe position. In cases where the fail position of a valve is not important to safety, it must be the position most likely to keep the CVC operating.

See also section 5.2.5.

5.5.2.5 System Interfaces

Table 6: CVC Interfacing Systems

System	Description	Function	PSR Chapter
CAI	Instrument and Service Air System	CAI provides an air supply to control valves with diaphragm actuators.	Not in GDA scope
CCW	Component Cooling Water System	CCW provides cooling water to the components in the CVC including the shell side of the letdown heat exchanger.	Not in GDA scope
CIS	Containment Isolation System	CVC valves that form a part of the containment barrier also form part of the CIS.	Part B Chapter 1 [2]
DAS	Diverse Actuation System	The DAS controls the safety-related valves upon PSS failure.	Part B Chapter 4 [18]
DCE	Direct Current (DC) Power Distribution System	The containment isolation valves with actuators are powered by the DCE.	Part B Chapter 6 [19]
DWS	Demineralised Water System	The DWS provides water for ion exchanger resin transfers, RCS chemical additions, and RCS boron dilution.	Not in GDA scope
GRW	Gaseous Radwaste System	Hydrogen and other fission gases in the reactor coolant are vented to the GRW from the VCT. The effluent holdup tanks are also vented to the GRW.	Part B Chapter 13 [33]
Hydrogen Tank	Hydrogen	The Hydrogen is supplied to the VCT for corrosion control during power operations.	Not in GDA scope
ICE	Instrumentation and Control (I&C) Power Distribution System	The AOVs and instruments performing non-safety-related functions are powered by the non-safety-related portion of the ICE. AOVs performing safety-related functions are powered by the safety-related portion of the ICE.	Part B Chapter 6 [19]
LRW	Liquid Radwaste System	The LRW receives effluents stored in the CVC HUTs ready for waste processing and disposal.	Part B Chapter 13 [33]
LVE	Low Voltage Alternating Current (AC) Distribution System	The Pump motors are powered by the non-safety portion of the LVE.	Part B Chapter 6 [19]
N2S	Nitrogen Supply System	The system provides a cover gas for the effluent holdup tanks and the VCT when required.	Not in GDA scope
PAM	Post-Accident Monitoring System	The PAM interfaces with safety-related components of the CVC to monitor essential plant parameters.	Part B Chapter 4 [18]
PCM	Passive Core Makeup Water System	The CVC provides the capability to add makeup water to the PCMWT and the PCM accumulators. PCMWT recirculation uses CVC piping. The pressure relief valve on the CVC letdown line discharges to the PCMWT.	Part B Chapter 1 [2]
PCS	Plant Control System	The Control system for the non-safety portions of the CVC.	Part B Chapter 4 [18]
PSL	Primary Sampling System	The PSL samples demineraliser influent and effluent flow to monitor the performance of the demineralisers. The system is also used to sample the VCT water and gas spaces.	Part B Chapter 5 [2]
PSS	Plant Safety System	The Control system for the safety-related portions of the CVC.	Part B Chapter 4 [18]
RCS	Reactor Coolant System	The CVC maintains the RCS reactor coolant inventory and chemistry requirements while maintaining the RCPB.	Part B Chapter 1 [2]
RHR	Residual Heat Removal System	The RHR provides flow through the CVC purification equipment during low pressure operations in the RCS.	Part B Chapter 5
SFC	Spent Fuel Pool Cooling System	The CVC provides normal borated makeup water to maintain the refuelling water storage tank and SFP levels. The RWST can also be used as a source for makeup to the charging pumps and effluent makeup pumps.	Part B Chapter 5

System	Description	Function	PSR Chapter
SRW	Solid Radwaste System	The SRW collects and processes spent resins from the demineralisers. Spent resin and filter cartridges are sent to the SRW for storage, processing, and disposal.	Part B Chapter 13 [33]

5.5.3 Fire Protection System

5.5.3.1 System Overview

The FPS provides fire detection and suppression capabilities to meet life-safety and asset protection needs. The FPS is also designed to provide fire detection and suppression throughout NI areas, as identified in the Fire Hazards Analysis [34] and depicted on Fire Protection System Drawings [6].

The information presented in this section at Revision 1 is based on the SMR-160 design. This is considered acceptable at GDA Step 2 as the claims and function of the FPS are not anticipated to fundamentally change. References are made to US design standards; it is intended that systems will be designed to these standards and adjustments made where necessary to align with UK local practice beyond step 2 timescales. This is discussed in Part B Chapter 12 “Nuclear Site Health and Safety and Conventional Fire Safety” [35].

5.5.3.2 System Functions

5.5.3.2.1 Safety Functions

The FPS has no safety related functions defined at PSR Revision 1. This is subject to formal assessment beyond GDA Step 2 where safety functions may be identified. This will be predominantly informed by fault studies work discussed in PSR Part B Chapter 14 [26].

5.5.3.2.2 Non-Safety Functions

The non-safety functions of the FPS are:

- **Provide fire alarm and detection as an early warning fire notification system.**
  Through smoke and heat detection devices detect indication of a fire and report back to the Fire Alarm Control Panel (FACP) identification of a fire event.
- **Provide location for central monitoring of the FPS.**
  Fire alarm, trouble, and supervisory signals report back to a continuously supervised and monitored location.
- **Provide a fire water system.**
  Provide a fire water source (fire water tanks), supply mechanism (fire pumps), and a distribution system (fire main and appurtenances) throughout the site.
- **Provide indication of fire water components.**
  The FACP shall be integral with the fire water system components including fire pumps, water supply capacity, system pressure, and suppression system actuation.
- **Provide manual fire suppression capabilities.**
  Fire hose stations (standpipes) and portable fire extinguishers provided for fighting fires.
- **Provide automatic fire suppression.**
  Where required, protect spaces with automatic water-based or automatic gaseous suppression systems.

5.5.3.3 System Description

5.5.3.3.1 Fire Protection Water Supply

The fire protection water supply is a fresh water source dedicated for FPS use only. The water supply system is designed in accordance with National Fire Protection Association (NFPA) 20, "Standard for the Installation of Stationary Pumps for Fire Protection" [36], NFPA 22, "Standard for Water Tanks for Private Fire Protection" [37], and NFPA 24, "Standard for the Installation of Private Fire Service Mains and Their Appurtenances" [38].

Fire Main

The FPS fire water main is a buried system encircling the site in a loop configuration and is provided with sectionalising isolation valves to permit maintenance or repair without impacting supplies to areas protecting equipment important to safety. If multiple SMR-300 units are deployed on a site, sectional control valves are provided to permit independence of loops around individual units. Portions of the FPS supporting NI locations are designed to AWWA standards and ASME B31.1 [39] consistent with the response Safe Shutdown Earthquake (SSE) spectra for the plant location. The fire water main system and its appurtenances (isolation valves, hydrants) will conform to NFPA 24 [38].

Fire Protection Tanks

The fire water supply is provided by two 100% capacity tanks that are installed and interconnected so that the fire pumps can take suction from either or both tanks. A failure in one tank will not cause both tanks to drain. The tanks are capable of being refilled in 8 hours or less. The tanks are sized to provide the largest expected flow rate for a minimum of 2 hours, but the size of the supplies are not less than 300,000 gallons. The flow rate is based on the largest flow demand from a single fire suppression system or multiple systems that have the potential for operating simultaneously, plus 500 gpm for hose streams. The fire water storage tanks will conform to NFPA 22 [37].

Fire Pumps

Fire water pumps are provided. The fire pumps will conform to NFPA 20 [36]. Consistent with NFPA 13, each pump is capable of delivering the demand from the largest sprinkler or deluge system plus an additional 500 gpm for fire hose streams. The fire pumps meet the following criteria:

- Fire pumps are provided so that failure of one pump will not affect the ability of the remaining pump to supply 100% rated capacity to the fire distribution system. The fire pumps are two 100% capacity fire pumps, one electric and one diesel.
- Individual fire pump connections to the yard fire main loop are separated with sectionalising valves between connections.
- Each fire pump and its driver and controls are separated the other by a fire barrier having a minimum 3-hour fire rating.
- The fire pumps are housed in the Firewater Building, which is seismically designed based on SSE response spectra for the plant location.

5.5.3.3.2 Automatic Fire Suppression Systems

Fire suppression systems are installed as informed by regulation and/or guidance documents, the Fire Hazards Analysis [34], or to address asset protection or life-safety needs.

Water-Based Suppression Systems

Automatic sprinkler and water spray systems may be used to protect a variety of hazards such as cable areas, lubrication oil hazards, transformers, and other areas as determined by the Fire Hazards Analysis [34]. The FPS additionally provides suppression to meet life-safety and asset protection needs of other site structures. Automatic sprinkler systems are installed in accordance with NFPA 13, “Standard for the Installation of Sprinkler Systems” [40]. Automatic water spray systems are installed in accordance with NFPA 15, “Standard for Water Spray Fixed Systems for Fire Protection” [41].

Clean Agent Suppression Systems

Clean agents are chosen based on the Fire Hazards Analysis [34] and whether total flooding or local application systems are desired. Where provided, clean agent fire suppression systems are designed and installed in accordance with NFPA 2001, "Standard for Clean Agent Fire Suppression Systems” [42].

5.5.3.3.3 Manual Fire Suppression

Manual suppression is provided for all areas of the plant. Standpipe and hose systems are designed and installed in accordance with NFPA 14, "Standard for the Installation of Standpipe and Hose Systems" [43] for sizing, spacing and pipe support requirements for Class III standpipes. At least two standpipes and hose connections are provided for manual firefighting in areas containing SSCs required for safe plant shutdown. The piping is analysed for SSE loading and provided with supports to ensure system pressure integrity. The piping and valves for these seismically analysed standpipes satisfy ASME B31.1 [39].

Interior hose stations are placed to be capable of reaching areas in the NI with 100 feet of hose and an effective hose stream. The length of hose stream is dependent on the type of nozzle being used but is generally 30 feet. Electrically safe nozzles are available to the fire brigade.

Portable fire extinguishers are provided in accordance with NFPA 10, “Standard for Portable Fire Extinguishers” [44] for the proper sizing and type.

5.5.3.3.4 Fire Alarm and Detection Systems

Fire alarm and detection systems comply with the requirements of NFPA 72 [45] and NFPA 70 [46]. Areas that contain or present fire exposure to equipment with safety-related or risk-significant functions and those for asset protection are provided with fire detection that alarms in the main control room.

The fire alarm system includes addressable fire alarm and detection devices. Manual pull stations and combination horns/strobes are provided for personnel safety. The fire alarm control panel is provided with battery backup for system operation in the event of power failure.

5.5.3.4 System Reliability

See section 5.2.5.

5.5.3.5 System Interfaces

Table 7: FPS Interfacing Systems

System	Description	Function	PSR Chapter
CIS	Containment Isolation System	FPS valves that form a part of the containment barrier also form part of the CIS.	Part B Chapter 1 [2]
LVE	Low Voltage AC Distribution System	LVE provides power to the electric fire pump.	Part B Chapter 6 [19]
ICE	Instrument and Control Power Distribution System	ICE provides power for the fire alarm and detection system.	Part B Chapter 6 [19]
HVAC	HVAC	HVAC will require shutdown for gaseous suppression actuation to main agent concentration.	Part B Chapter 5

5.5.4 Primary Sampling System

In addition to supporting claim 2.2.13.1 above, the PSL supports the claims below:

Claim 2.2.3.4: Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Pressure Boundary following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.4-A3: Sample lines connected to the RCS within the CS boundary have remotely operated isolation valves to maintain the RCPB integrity.

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.5-A3: The PSL penetrates the CS boundary and provides the containment isolation function.

5.5.4.1 System Overview

The PSL is designed to obtain samples throughout the primary plant to provide the analytical information necessary to monitor the performance of components and systems and adjust operating parameters. Closely monitoring and controlling chemical concentrations helps limit the effects of corrosion and erosion mechanisms, reduce areal and personnel dose, and promotes a longer service life of the plant. Primary sampling is accomplished using the primary sampling panel and local grab sample provisions.

The PSL provides a means for grab sampling collection. Data obtained from sample analyses provides the necessary information to monitor and evaluate the performance of primary plant equipment, and systems.

The PSL can deliver liquid and gaseous samples from various points in containment and the RAB to a centralised location. Where practical, local sampling points are provided to reduce piping and dose to the general area. Radiation exposure is kept ALARP using shielding to minimise radiation exposure and reduce the potential for contamination of the general work areas. Radioactive waste generation is also minimised by returning sample purge and recirculation back to their system of origin, as practical.

The design of the system is under further development following the identification of gaps between UK and US regulatory requirements [47]. [REDACTED]. Further work is required to meet boron monitoring requirements which is captured by GDA Commitment C_Reac_075 in Part B Chapter 23 [23].

5.5.4.2 System Functions

5.5.4.2.1 Safety Functions

The safety functions of the PSL are:

- **Maintain the Reactor Coolant Pressure Boundary Integrity.**
  Sample lines connected to the RCS within the CS boundary have remotely operated isolation valves to maintain the RCPB integrity.
- **Maintain the Containment Boundary Integrity.**
  The PSL penetrates the CS boundary and provides the containment isolation function.

5.5.4.2.2 Non-Safety Functions

The non-safety functions of the PSL are:

- **Obtain Representative Samples for Chemical and Radiochemical Analyses.** The PSL is designed to obtain liquid and gaseous samples from systems throughout the primary plant for laboratory analysis.
- **Provide the Capability for Post-Accident Sampling.**
  The PSL provides the capability to obtain samples following an accident without the need for a system dedicated exclusively to post-accident sampling.
- **Provide Protection Against Exposure and Contamination During Collection.** The PSL provides engineering information based on sound radiation protection principles to maintain occupational doses and doses to members of the public as low as is reasonably practicable.

5.5.4.3 System Description

5.5.4.3.1 Primary Sampling Panel

The Primary Sampling Panel (Figure 4) is designed to receive and route samples of primary process fluids from various points within the CS and RAB. The primary sampling panel is designed to permit sampling during all modes of plant operation, including power generation, shutdown, refuelling, startup, and post-accident conditions without requiring access to containment. The primary sampling panel consists of conditioning equipment, sample panels, analysers, sample sinks, instrumentation, the associated pipework and valves, and local sample points. Radiation exposure is kept ALARP using shielding to minimise radiation exposure and reduce the potential for contamination of the general work areas. Radioactive waste generation is also minimised by returning sample purge volumes back to their system of origin, as practical. Data obtained from sample analyses provides the necessary information to monitor and evaluate the performance of the plant, equipment, and systems. The analytical results from samples supports and guides plant operations to operate the plant in accordance with the licence and to meet chemistry requirements.

Results of analyses from the primary sampling panel are used to:

- Ensure fuel rod integrity.
- Evaluate ion exchanger and filter performance.
- Specify chemical additions to the various systems.
- Maintain acceptable hydrogen levels in the RCS.
- Detect radioactive material leakage.

5.5.4.3.2 Local Grab Sampling

For normally accessible locations throughout the plant, local sample connections are provided for manually collecting samples directly from the source. These local sample system connections reduce sample line tubing, provides shielding, maintains radiation exposure ALARP, and reduces volume inputs to LRW – see PSR Part B Chapter 13 [33].

5.5.4.3.3 Post-Accident Sampling

The PSL provides the analytical and confirmatory information necessary to monitor post-accident conditions using existing PSL equipment. The post-accident sampling capability is not associated with any design function which is required to mitigate the consequences of a design basis event and is not considered safety related.

During post-accident conditions the arrangement of the PSL is configured to provide contingency sample points for obtaining and analysing highly radioactive samples from the RCS, containment sump, and containment atmosphere.

[REDACTED]

Figure 4: PSL Piping and Instrumentation Diagram [48][1]

5.5.4.4 System Reliability

The SSCs that perform a safety function shall be designed in accordance with the Design Standard for Application of Single Failure Criterion [49] to ensure safety functions required for design basis events can be accomplished. They are also designed in accordance with the SMR-300 Design Standard for Grouping and Separation [50] to provide sufficient redundancy, separation, and independence for SSCs important to safety.

See also section 5.2.5.

[1] PSL P&ID was updated for inclusion to latest DRP1.1 compared with PSR Revision 0 to incorporate improved redundancy in the system and additional containment isolation valves.

5.5.4.5 System Interfaces

Table 8: PSL Interfacing Systems

System	Description	Function	PSR Chapter
CIS	Containment Isolation System	PSL valves that form a part of the containment barrier also form part of the CIS.	Part B Chapter 1 [2]
CVC	Chemical and Volume Control System	The PSL monitors parameters from the CVC letdown and Boric Acid Storage tanks	Part B Chapter 5
LRW	Liquid Radwaste System	The PSL monitors parameters from the LRW tanks, filters, and sump pump. The LRW also receives input from the sink drainage and purging operations from the PSL.	Part B Chapter 13 [33]
GRW	Gaseous Radwaste System	The PSL monitors parameters from the charcoal beds of the GRW.	Part B Chapter 13 [33]
PCC	Passive Core Cooling System	The PSL monitors parameters from the Passive Core Makeup Water Tanks and Accumulator Tanks of the PCC.	Part B Chapter 1 [2]
RCS	Reactor Coolant System	The PSL monitors parameters from the RCS Hot Leg and Pressuriser.	Part B Chapter 1 [2]
SRW	Solid Radwaste System	The PSL monitors parameters in the Spent Resin Tank.	Part B Chapter 13 [33]
CCW	Component Cooling Water System	Water from the CCW is used to cool samples in the sample heat exchanger.	Not in GDA scope
DCE	DC Power Distribution System	The DCE supplies power to safety-related SOVs of the PSL.	Part B Chapter 6 [19]
DWS	Demineralised Water System	The DWS supplies demineralised water for dilution, purging, and sampling activities for the PSL.	Not in GDA scope
ICE	I&C Power Distribution System	The ICE supplies power to the instrumentation and SOVs of the PSL.	Part B Chapter 6 [19]
PAM	Post-Accident Monitoring System	The PSL provides post-accident confirmatory sampling information to support the PAM.	Part B Chapter 4 [18]
PCS	Plant Control System	The PCS monitors and controls the PSL equipment and components with non-safety functions. The PSL instrumentation provides signals to PCS.	Part B Chapter 4 [18]
PSS	Plant Safety System	The PSS monitors and controls the PSL equipment and components with safety functions. PSL instrumentation provides signals to PSS.	Part B Chapter 4 [18]
RCV	Radiologically Controlled Area HVAC	The sample hoods in the PSL vent to the RCV.	Part B Chapter 5
RHR	Residual Heat Removal System	The PSL monitors parameters from both trains in the RHR.	Part B Chapter 5
RMS	Radiation Monitoring System	The RMS provides area radiation monitoring for locations in the PSL, including from the PSL into CCW.	Part B Chapter 4 [18]
RDS	Radioactive Drain System	Sample sinks and leakage from the PSL drains to the RWDS.	Part B Chapter 13 [33]
SFC	Spent Fuel Pool Cooling System	The PSL monitors parameters in the SFP and Refuelling Water Storage Tank (RWST).	Part B Chapter 5

5.5.5 Residual Heat Removal System

In addition to supporting claim 2.2.13.1 above, the RHR supports the claims below:

Claim 2.2.3.4: Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Pressure Boundary following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.4-A4: The portions of the RHR that interface with the RCS assure the integrity of the RCPB as a fission product barrier and have provisions to isolate the RHR from the RCS.

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.5-A4: The RHR penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.

5.5.5.1 System Overview

The RHR removes decay heat from the reactor core, and RCS sensible heat, to reduce the reactor coolant temperature during normal shutdown and refuelling operations. The RHR interfaces with the RCS and is designed to maintain the RCPB up to and including the RCPB isolation valves. The RHR consists of two trains in parallel, each train with one RHR pump and one RHR heat exchanger. Normally, both trains operate during shutdown. The inability to use one train does not preclude the ability to reach cold shutdown but lengthens the time required to cool down and reach cold shutdown mode. The RHR is not required to operate during a Design Basis Accident (DBA).

The majority of the RHR system is located in the RAB, while a portion of it is located inside containment. The portions of the system inside containment, up to and including the RCPB isolation valves, are designed for full RCS pressure. The rest of the RHR system is designed such that the ultimate rupture strength of the piping will not be exceeded at full RCS pressure.

The RHR is a low-pressure system and is normally isolated from the high-pressure RCS. The inlet to the RHR branches from an RCS hot leg. Within containment, the RHR suction line has two RCPB isolation valves in series to ensure a single valve failure will not result in a loss of RCPB isolation. Outside containment, the common pump suction line has a containment isolation valve and then splits into two parallel trains, each having an RHR pump and heat exchanger. The outlet lines of the RHR heat exchangers combine into one common return line that penetrates containment, with a containment isolation valve outside containment and three RCPB isolation check valves inside containment, to return cooled reactor coolant to an RCS cold leg.

5.5.5.2 System Functions

5.5.5.2.1 Safety Functions

The safety functions of the RHR are:

- **Maintain the Reactor Coolant Pressure Boundary Integrity.**
  The portions of the RHR that interface with the RCS assure the integrity of the RCPB as a fission product barrier and have provisions to isolate the RHR from the RCS.
- **Maintain the Containment Boundary Integrity.**
  The RHR penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.

5.5.5.2.2 Non-Safety Functions

The non-safety functions of the RHR are:

- **Provide Normal Shutdown Heat Removal.**
  The RHR removes heat from the reactor core and the RCS during normal shutdown/refuelling operations.
- **Provide Low Temperature Overpressure Protection.**
  The RHR provides Low Temperature Overpressure Protection (LTOP) for the RCS during normal shutdown and startup operations.
- **Provide Spent Fuel Pool Backup Cooling.**
  The RHR provides backup cooling for the SFP when the RHR is not needed for heat removal.
- **Transfer water to and from the Refuelling Water Storage Tank.**
  During refuelling, the RHR pumps can drain and fill the RCS by transferring water to and from the RWST.
- **Shutdown Purification.**
  The RHR provides a flow path to the CVC demineralisers for reactor coolant system purification during low pressure operations.

5.5.5.3 System Description

A process flow diagram for the RHR can be found in Figure 5.

5.5.5.3.1 Normal Shutdown Heat Removal

As previously mentioned in section 5.5.5.1, the RHR removes decay heat from the core and RCS sensible heat to reduce the reactor coolant temperature during normal shutdown and refuelling operations. The RHR is a low-pressure system and is normally isolated from the high-pressure RCS. The inlet to the RHR connects to an RCS hot leg. Within containment, the RHR suction line has two RCPB isolation valves in series to ensure a single valve failure will not result in a loss of RCPB isolation. Outside containment, the common pump suction line has a containment isolation valve and then splits into two parallel trains, each train has an RHR pump and heat exchanger. The outlet lines of the RHR heat exchangers combine into one common return line that penetrates containment, with a containment isolation valve outside containment and three RCPB isolation check valves inside containment, to return cooled reactor coolant to an RCS cold leg.

5.5.5.3.2 Low Temperature Overpressure Protection

A relief valve in the RHR provides LTOP for the RCS during normal shutdown, refuelling, and startup operations. The relief valve is located downstream of the RCPB isolation valves, within containment in the common RHR pumps suction line. This function provides protection to the RCS from an inadvertent over pressurisation during low temperature conditions, where a brittle failure is possible while the plant is starting up from shutdown/refuelling.

5.5.5.3.3 Spent Fuel Pool Backup Cooling

The RHR can perform backup cooling of the SFP. A line from the SFC connects to the common suction line outside containment upstream of the RHR pumps. Water returns to the SFC through a connection from the common RHR pump discharge line to the SFC located in the RAB. Cross connections are provided so that if RHR is needed for backup cooling of the SFP while RHR is also needed for decay heat removal, one train of RHR could be isolated from the RCS and aligned to the SFP for cooling, while the other train can remain aligned to the RCS. One of the RHR trains is aligned to the SFP to support cooling the maximum SFP decay heat load when a full core is offloaded into the SFP.

5.5.5.3.4 Transfer of Water to and from the Refuelling Water Storage Tank

The RHR interfaces with the SFC to transfer reactor coolant from the RCS to the RWST during refuelling to drain the RCS using the RHR pumps. One train of RHR is used to divert flow to the RWST through the control valve in the RHR branch to the RWST while the other train remains aligned to the RCS to maintain core cooling. To fill the RCS, the RHR pumps transfer water from the RWST to the RCS.

5.5.5.3.5 Shutdown Purification

During shutdown and refuelling, when the RCS is at low pressure, either RHR pump can be used to divert flow to the CVC demineralisers for the reactor coolant system purification.

5.5.5.3.6 RCS Makeup

During a LOCA, the RHR pumps have the capability to supply makeup water from the RWST to the RCS (as a non-credited defence-in-depth function), if the RCS pressure is reduced to the RHR operating pressure and the RHR is available. The RHR does not perform a safety function for supplying makeup water and does not interfere with operation of the PCM or any other systems operating during a LOCA. This is not a primary function of the RHR and is only employed during a DBA for mitigation actions, or during a BDBA.

5.5.5.3.7 Post-Accident Recovery

The RHR can be aligned to the RCS to remove decay heat with the RCPB intact during post-accident conditions. Similar to the normal shutdown, the RHR can be put in service after the RCS pressure is reduced to the RHR's operating pressure. The RHR has the capability to supply long-term, post-accident makeup water as a non-safety function. The RHR can supply makeup water from the RWST for RCS makeup and cooling (post-LOCA).

5.5.5.3.8 Diverse and Flexible Coping Strategies

A connection at the common discharge header is located outside containment and supports strategies for Diverse and Flexible Coping Strategies (FLEX). An external water source can be connected to support post-accident makeup to the RCS. The isolation valve is locked and closed to prevent inadvertent opening of the connection.

[REDACTED]

Figure 5: Residual Heat Removal Process Flow Diagram [32]

5.5.5.4 System Reliability

The components of the RHR with safety functions are designed against a single failure with redundancy and independence for system reliability.

The RHR equipment and components located outside containment can be tested for system operability before plant shutdown to assure system availability.

Reactor Coolant Pressure Boundary Isolation

The RCPB isolation safety function of the RHR is achieved in the suction line by using two redundant valves in series. The RCPB valves have permissive signals that prevent the opening of the valves above a high RCS pressure setpoint for shutdown cooling. The RHR RCPB isolation valves are normally closed and de-energised during normal plant operations and loss of power will not change the position of the valves.

The RCPB is also maintained in the return line within containment by using one stop check and two redundant swing check valves in series. This arrangement minimises operator action inside containment while providing redundancy.

Containment Boundary Isolation

The containment isolation safety function of the RHR is achieved by using Containment Isolation Valves (CIV) located outside the containment boundary in series with the RCPB isolation valves.

The CIV in the supply line outside the containment boundary, is locked closed during normal power operation to ensure that no spurious actuation takes place. The CIV in the discharge line outside containment, is normally closed during normal power operation. In case of an actuation failure, both valves will be supplied with a handwheel for manual operation.

Normal Cooldown

When the RHR is used for cooling: two redundant trains are available. Single failure criterion is demonstrated through protection against:

- Single active failure
- Spurious valve actuation
- Damage from fire, flood, and dynamic effects
- Environmental effects

The inability to use one train does not result in a loss of total cooling but does reduce the rate of heat removal. The trains will be separated into two different rooms inside the RAB to enhance reliability.

See also section 5.2.5.

5.5.5.5 System Interfaces

Table 9: RHR Interfacing Systems

System	Description	Function	PSR Chapter
RCS	Reactor Coolant System	The RHR cools the reactor coolant in the RCS during normal shutdown	Part B Chapter 1 [2]
CCW	Component Cooling Water System	The CCW supplies cooling water to the shell side of the RHR heat exchangers	Not in GDA Scope
CIS	Containment Isolation System	RHR valves that form a part of the containment barrier also form part of the CIS.	Part B Chapter 1 [2]
SFC	Spent Fuel Pool Cooling System	The RHR provides backup cooling of the SFP. The RHR ties into interconnecting piping between the RWST and SFC.	Part B Chapter 5
PCM	Passive Core Makeup Water System	The RHR provides LTOP for the RCS by using a relief valve that drains into the PCMWT	Part B Chapter 1 [2]
PSS	Plant Safety System	The PSS provides the isolation signal to close the CIVs.	Part B Chapter 4 [18]
CAI	Instrument Air and Service Air System	The CAI provides an air supply to control valves with diaphragm actuators.	Not in GDA Scope
DCE	DC Power Distribution System	The DCE supplies power to the instrumentation and AOVs of the RHR.	Part B Chapter 6 [19]
ICE	I&C Power Distribution System	The ICE supplies power to non-safety related MOVs and pumps in the RHR.	Part B Chapter 6 [19]
LVE	Low Voltage AC Distribution System	The LVE supplies power to non-safety related MOVs and pumps in the RHR.	Part B Chapter 6 [19]
PCS	Plant Control System	The PCS monitors and controls the RHR equipment and components with non-safety functions. RHR instrumentation provides signals to PCS.	Part B Chapter 4 [18]
PAM	Post-Accident Monitoring System	RHR instrumentation supports accident monitoring and post-accident monitoring.	Part B Chapter 4 [18]
LRW	Liquid Radwaste System	The relief valve in the RHR discharge line discharges to the containment sump in the LRW.	Part B Chapter 13 [33]
CVC	Chemical and Volume Control System	The RHR provides a path to the CVC for purification during low pressure conditions.	Part B Chapter 5

5.5.6 Spent Fuel Pool Cooling System

In addition to supporting claim 2.2.13.1 above, the SFC supports the claims below:

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.5-A5: The SFC penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.

5.5.6.1 System Overview

The SFC consists of the SFP, one SFC pump, one SFC heat exchanger, one demineraliser, one demineraliser filter, the RWST and the RWST purification pump. The main function of the SFC is to provide cooling and cleanup of the SFP during all modes of plant operation. The system also maintains the water quality within specified chemistry, radioactivity, and clarity limits.

In addition to SFP cooling and cleanup, the SFC is used to transfer water to and from the RWST and PCMWT to support refuelling operations and to purify the water in the RWST and PCMWT.

5.5.6.2 System Functions

5.5.6.2.1 Safety Functions

The safety related functions of the SFC are to:

- **Maintain the containment boundary integrity.**
  The SFC penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.

5.5.6.2.2 Non-Safety Functions

Further non-safety related functions of the SFC are to:

- **Provide cooling to the SFP.**
  The system is designed to remove the maximum decay heat load from the SFP to maintain the temperature within the normal operating limits during all modes of operation with spent fuel in the SFP.
- **Provide normal, non-safety makeup to the SFP.**
  A non-safety normal make-up water connection is provided from the DWS to maintain the SFP water level. A non-safety normal make-up water connection is provided from the CVC to add borated water to the SFP.
- **Maintain the SFP, PCMWT and the RWST water quality.**
  The SFC maintains the SFP, RWST and PCMWT water within specified chemistry, radioactivity, and clarity limits during all modes of operation. A skimmer connection in parallel to the normal SFC suction ensures surface water is also filtered and maintained within limits.
- **Transfer refuelling water between the PCMWT and SFP and RWST and SFP.**
  The PCMWT and RWST are refuelling water sources for SFP. The PCMWT water is transferred by gravity drain line to the SFP via a bidirectional line directly connecting PCMWT and SFP. Additional water from the RWST is added by gravity drain or by using the SFC pump to reach refuelling level in the pool. Following refuelling, the SFC pump returns water from the SFP to the PCMWT through the same bidirectional line used for initial SFP fill and the rest of the water is returned to RWST.

5.5.6.3 System Description

A process flow diagram of the Spent Fuel Pool Cooling System can be found in Figure 6.

5.5.6.3.1 Provide Cooling to the SFP

The SFC is a non-safety system that removes decay heat from the SFP while maintaining the temperature and chemistry of the SFP during all modes of plant operation. The SFC consists of one mechanical train of equipment which includes one SFC pump and one SFC heat exchanger. The RHR is cross connected with the SFC train so that the RHR can function as back up to SFC during both normal and refuelling operations. The RHR system has two mechanical trains; each consists of one RHR pump and RHR heat exchanger. During partial core off load, one RHR train can act as back up to the SFC train and during full core off load, one RHR train is operated in parallel with SFC train to share the increased heat load. In case of single system failure during full core offload, both RHR trains will cool the SFP.

A strainer at the inlet of the suction line provides protection to the SFC pumps from any debris in the pool. A skimmer suction near the top of the normal SFP level ensures turnover of the water near the surface for cooling and cleanup. The skimmer piping connects to the main suction header inside containment. The main suction header penetrates the containment and supplies water to the SFC pump and heat exchanger. In the common line downstream of the heat exchangers is a control valve used to direct a portion of the cooling flow through the demineraliser. The purification train (demineraliser and the filter) is used to maintain the SFP water chemistry, radioactivity levels, and clarity. The full flow is then discharged back to the SFP.

The inlet and outlet piping connections to the SFP for normal SFP cooling are located above the minimum required SFP water level to preclude draining below this level. The SFC pump discharge piping includes a hole above the SFP minimum water level to prevent siphoning. All SFC equipment for SFP cooling and purification (pump, heat exchanger, and demineraliser with filter) are in the RAB. They are located blow the normal SFP water level. This maintains adequate Net Positive Suction Head (NPSH) for the pump. Physical separation and shielding requirements will be determined during detailed design. The RWST is also located in the RAB. The RWST purification pump is also located inside the RAB and has sufficient NPSH available for purifying the RWST and PCMWT water.

The cooling capacity of the SFC design accounts for the maximum expected heat load for the SFP. The maximum heat load for the SFP is based on decay heat generated by the accumulated maximum number of fuel assemblies stored in the fuel pool, including one full core placed in the pool after shutdown. The time during the plant operating cycle at which the design full core off-load occurs is chosen to conservatively maximise SFC heat load.

When the SFP is flooded up to the refuelling level, the SFC pump takes suction from a piping header connected to the upper portion of the SFP near the refuelling water level that is normally isolated. By taking suction from the upper SFP area, higher temperature SFP water is pumped through the SFC heat exchanger and cooler temperature water is returned to the lower SFP area to prevent stratification of the SFP. One RHR train and SFC train are operating while the other RHR train is available as a backup. During refuelling, a temporary filter is used, in addition to the permanent demineraliser and filter will be used to properly clean the total SFP water volume.

As a result of flooding, fuel movement and draining, the refuelling pool walls of SFP typically become contaminated. A temporary demineralised water system is used to wash off the contamination on wall surfaces of the SFP.

5.5.6.3.2 Provide Makeup to the SFP

A non-safety makeup water connection is provided from the DWS to maintain the SFP water level. The non-safety makeup line isolation valve and piping connected to the SFP maintain the integrity of the SFP boundary. The DWS is the normal makeup water source for the SFP to replace losses from evaporation.

A non-safety normal makeup water connection is provided from CVC to add borated water to SFP when necessary.

The PCMWT provides a safety-related, seismic category I source of makeup water. The PCMWT can supply inventory to the SFP through the long-term cooling line from PCMWT.

A flex connection is also provided in the discharge header to potentially connect to supplemental water tanks to accommodate beyond design basis scenarios like SFP draining which involve filling of SFP with raw water to ensure spent fuel assemblies are covered with water.

5.5.6.3.3 Maintain the SFP, PCMWT and RWST Water Quality

The purification train in SFC is designed to purify the SFP water volume during normal operations. When the SFP is flooded with refuelling water, a temporary filter is operated along with the permanent purification train to maintain the water quality. Purification of the SFP inventory is performed by directing a portion of the main flow downstream of the SFC heat exchanger using a flow control valve, to the demineralisers to remove radioactive materials, solid materials, and dissolved impurities.

During normal operation, one pump supplies flow to the demineraliser to adequately clean the normal SFP water volume. During refuelling operation, the SFC purification train and a temporary filter may be in service to support cleaning the flooded volume of the SFP. A filter is provided downstream of the demineraliser for removal of solid materials, including resin should it escape from the demineraliser. A manual bypass is provided to allow system operation if the flow control valve used to divert water to the demineraliser is not available.

The RWST and PCMWT water quality is maintained by recirculating the tanks through the purification train using the RWST purification pump.

SFP, PCMWT and RWST water chemistry is maintained in accordance with the EPRI guidelines.

The SFC purification piping and components are designed to minimise radioactive contamination such that radiation exposure is minimised to meet “As Low as Reasonably Achievable” program requirements. The purification piping and components are also designed to maintain water clarity, such that fuel handling operations can be safely and efficiently conducted within the SFP.

5.5.6.3.4 Transfer Refuelling Water Between the PCMWT, SFP and RWST

The refuelling volume of SFP is filled using water from PCMWT by gravity drain. After filling with the PCMWT water, the remaining volume of SFP during refuelling is filled by water from RWST by gravity or by using the SFC pumps.

Transfer between PCMWT and SFP: The water from PCMWT is transferred to SFP through a direct line connecting PCMWT and SFP. After refuelling operation, the water is transferred back to the PCMWT through the same line using SFC pump.

Transfer between RWST and SFP: The RWST water is transferred to SFP by gravity drain or by using SFC pumps. When water is transferred by gravity drain, the SFP cooling is suspended to allow refuelling water to flow freely through the common piping header into the SFP. The SFP cooling resumes after the refuelling water transfer is complete. The actuation valve for gravity drain from the RWST is located upstream of the tee at the SFP cooling line and does not interfere with SFP cooling during any plant mode. When water is transferred using the SFC pump, the piping connection from the RWST to the pump suction is used. Refuelling water in the SFP is returned to the RWST using the SFC pump. The SFP cooling through the SFC heat exchanger resumes after all refuelling water is returned to the RWST.

[REDACTED]

Figure 6: Spent Fuel Pool Cooling System Process Flow Diagram [32].

5.5.6.4 System Reliability

The safety portions of the SFC ensure containment isolation in the event of a postulated DBA. This is demonstrated through protection against:

- Single failure.
- Spurious valve actuation.
- Damage from fire, flood, dynamic effects.
- Environmental effects.

The non-safety portion of the SFC is designed to ensure reliability during all operating modes.

This is provided by incorporating the following:

During Normal Operation: The SFC train is 100% capacity during normal operation. It is backed up by one RHR train for normal operation. The SFC train includes:

- [REDACTED].

The refuelling water volume is purified using SFC demineraliser and both permanent filter and temporary filter. The redundancy is ensured in the following manner:

- One SFC pump.
- One SFC heat exchanger.
- One SFC demineraliser and filter.
- Temporary filter arrangement (on as needed basis).
- Cross connected piping with RHR train.

Electric power supply for RHR trains and SFC train is separate which will assure higher system availability.

See also section 5.2.5.

5.5.6.5 System Interfaces

Table 10: SFC Interfacing Systems

System	Description	Function	PSR Chapter
PCH	Passive Containment Heat Removal System	The PCH provides a means for steam to condense and drain back to the refuelling cavity when the SFC is rendered inoperable	Part B Chapter 1 [2]
AR	Annular Reservoir	The AR dissipates heat added to containment from the SFP to the atmosphere when the SFC is not available	Part B Chapter 1 [2]
SRW	Solid Radwaste System	Spent demineraliser resins are collected and processed by the SRW	Part B Chapter 13 [33]
LLH	Light Load Handling System	SFC supports refuelling operations. However, there is no physical interface between LLH and SFC.	Part B Chapter 5
PSS	Plant Safety System	Control system for the safety portions of SFC, including the CIVs.	Part B Chapter 4 [18]
PCS	Plant Control System	Control system for the non-safety portions of the SFC.	Part B Chapter 4 [18]
PCM	Passive Core Makeup Water System	The passive core makeup water tanks (PCMWT) are the safety makeup water source for the SFP. The SFC supports recirculation and purification of the PCMWT	Part B Chapter 1 [2]
RHR	Residual Heat Removal System	The RHR provides backup cooling for the SFP. The RHR ties into interconnecting piping between the RWST and the SFP.	Part B Chapter 5
CCW	Component Cooling Water System	The CCW supplies cooling water to the SFC heat exchanger to cool SFP water.	Not in GDA scope
CBV	Containment Building Ventilation System	The CBV removes heat load from SFP water evaporation and maintains humidity level inside Containment.	Part B Chapter 5
CIS	Containment Isolation System	SFC valves that form a part of the containment barrier also form part of the CIS.	Part B Chapter 1 [2]
DWS	Demineralised Water System	The DWS provides demineralised water for non-safety makeup to the SFP and for flushing the resin from the demineraliser.	Not in GDA scope
CVC	Chemical and Volume Control System	The CVC provides non-safety borated makeup water to the SFP.	Part B Chapter 5
CAI	Instrument Air and Service Air System	The CAI provides air supply to the control valves in SFC.	Not in GDA scope
DCE	DC Power Distribution System	The DCE supplies power to safety related MOVs of the SFC.	Part B Chapter 6 [19]
ICE	I&C Power Distribution System	The DCE supplies power to safety related MOVs of the SFC.	Part B Chapter 6 [19]
LVE	Low Voltage AC Distribution System	The LVE supplies power to non-safety related MOVs and pumps in the SFC.	Part B Chapter 6 [19]

5.5.7 CAE Summary

The Auxiliary Systems, as described in the preceding subsections, demonstrate claim 2.2.13.1:

Claim 2.2.13.1: The Auxiliary Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

The safety features for each system are described above and, in addition, detail is provided on how the design of the system delivers these safety features. This claim is considered to be fundamentally evidenced by the description of the features of the systems and by the codes and standards to which they are designed to ensure their reliable functionality, with further substantiation provided by lower tier design documentation. In most cases this lower tier documentation is not included in the SMR-300 GDA Design Reference Point, and so the substantiation will follow beyond submission of step 2 of the GDA.

Substantiation is also provided by other topic area PSR chapters and GDA submissions – see supporting chapters listed in section 5.4.1.

UK specific categorisation and classification work is ongoing which may drive differences with what is presented at PSR Revision 1 and will continue beyond GDA Step 2. This further work will contribute to the arguments and evidence for claim 2.2.13.1 and is discussed further in section [REDACTED].

In addition to the chapter claim, the CVC, PSL and RHR also support and demonstrate claim 2.2.3.4:

Claim 2.2.3.4: Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Boundary following credible initiating events in all plant states.

Argument 2.2.3.4-A1: The CVC contains valves to isolate the charging line and the letdown line following credible initiating events.

Argument 2.2.3.4-A2: The portions of the CVC that interface with the RCS assure the integrity of the RCPB as a fission product barrier and have provisions to isolate the CVC from the RCS.

Argument 2.2.3.4-A3: Sample lines connected to the RCS within the CS boundary have remotely operated isolation valves to maintain the RCPB integrity.

Argument 2.2.3.4-A4: The portions of the RHR that interface with the RCS assure the integrity of the RCPB as a fission product barrier and have provisions to isolate the RHR from the RCS.

The systems listed above supporting this claim are designed to ensure RCPB integrity following credible initiating events by provision of sufficient isolation measures and equipment classification. Following further UK safety analysis, a definitive list of initiating events will be produced. However, utilising preliminary UK analysis [51] and US-based work, confidence is provided that this claim will be fully demonstrated throughout the next phase of safety case development. This claim is currently assessed as demonstrated to a maturity appropriate for PSR.

The CGC, CVC, PSL, RHR and SFC support and demonstrate claim 2.2.3.5:

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events.

Argument 2.2.3.5-A1: The concentration of combustible gases in the containment volume is adequately limited following a design basis accident.

Argument 2.2.3.5-A2: The CVC containment penetrations are provided with isolation to preserve the integrity of the containment envelope.

Argument 2.2.3.5-A3: The PSL penetrates the CS boundary and provides the containment isolation function.

Argument 2.2.3.5-A4: The RHR penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.

Argument 2.2.3.5-A5: The SFC penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.

Through the arguments above and supported by the system safety functions and SDDs (see Table 1), it is assessed the above claim is demonstrated to a maturity appropriate at PSR. The importance of maintaining a secure containment structure is paramount to nuclear safety in all plant states during all credible events. To further demonstrate the importance of the containment structure to nuclear safety, the Containment Structure Safety Justification document has been produced [52] which provides a holistic view regarding the integrity of the containment structure and the role ESF play in maintaining a secure structure.

The Auxiliary Systems are therefore shown to demonstrate the claims made against them insofar as is possible at this stage of the GDA.

5.6 STEAM AND POWER CONVERSION SYSTEMS

Claim 2.2.13.2: The Steam and Power Conversion Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

The plant Steam and Power Conversion Systems within GDA scope consist of the following:

- MFS.
- MSS.

In addition to claim 2.2.13.2 above, the MFS and MSS both support the containment integrity claim 2.2.3.5 (see section 5.3.2). The claim and respective arguments are presented in the subsections.

5.6.1 Main Feedwater System

In addition to supporting claim 2.2.13.2 above, the MFS supports the claims below:

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.5-A6: The MFS penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.

5.6.1.1 System Overview

The MFS supplies feedwater at the required temperature, pressure, and flow rate to the SGE. Condensate is pumped from the main condenser hot well by the condensate pumps and is sent through a condensate polisher package, gland steam condenser, deaerator, and four low-pressure Feedwater Heaters (FWH) before being pumped by the feedwater pumps through 2 high-pressure FWHs to the SGE. The MFS includes all lines and components between the deaerator and the SGE.

5.6.1.2 System Functions

5.6.1.2.1 Safety Functions

The safety related functions of the MFS are to:

- **Maintain the containment boundary integrity.**
  The MFS penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.
- **Isolate Main Feedwater in the event of a failure.**
  Main Feedwater Isolation mitigates the effect of large steam line or feedline breaks and prevents further damage to other systems.

5.6.1.2.2 Non-Safety Functions

The non-safety related functions of the MFS are to:

- **Provide the required feedwater flow to the SGE during startup, shutdown, and normal operating conditions.**
  The feedwater flow to the SGE is automatically controlled to support power operations.
- **Preheat the feedwater entering the SGE.**

  Six FWHs increase the temperature of the feedwater entering the SGE to increase the thermal efficiency of the power conversion cycle. This includes the recovery of heat from the turbine extraction steam flows, turbine gland steam exhaust flow, and the moisture separator/reheater drains. See reference [53].
- **Provide cooling water to the Turbine Bypass System (TBS)**

  The MFS supplies water to the spray nozzle of the desuperheaters in the TBS, see the MFS SDD [53]. The TBS is not in GDA scope.

5.6.1.3 System Description

A process flow diagram of the MFS can be found in Figure 7.

5.6.1.3.1 Main Feedwater System

The MFS is designed to provide feedwater at the required flow rate, pressure, temperature, and water chemistry to the SGE during initial fill, hot standby, start-up, normal, and shutdown conditions. The major equipment and components of the MFS are located in the turbine building, and the safety portions of the system are located in the Intermediate Building (IB) and inside containment (see PSR Part B Chapter 20 [22]).

The condensate pumps take suction from the condenser hot well and send water through the condensate polisher package, gland steam condenser, and four low-pressure feedwater heaters in series. Condensate then passes into the deaerator along with water from the Moisture Separator-Reheater. Water from the deaerator (now called feedwater) is then pumped by the feedwater pumps through two high-pressure feedwater heaters in series, flow control valves, a Main Feedwater Isolation Valve (MFIV), and a Main Feedwater Isolation Check Valve (MFICV) before it enters the SGE.

A pump recirculation line is provided at each pump discharge to ensure minimum required flow through the pump during all operations. Additionally, a bypass line around the feedwater pumps is provided from the feedwater header upstream of the pumps to the combined pump discharge header downstream of the pumps. This bypass line allows the condensate pumps to be used on the long path recirculation line without the feedwater pumps running. The long path recirculation line is provided downstream of the last feedwater heater. This recirculation line is used to flush MFS components and piping downstream of the gland steam condenser. All recirculation lines return to the condenser.

Three flow control valves in parallel automatically regulate the feedwater flow to the SG. Two Main Feedwater Control Valves (MFCV) and one start-up flow control valve are provided. Two

MFCVs control feedwater flow during normal power operations. The startup flow control valve is used when low feedwater flowrates are required, such as during startup and shutdown.

The MFS piping penetrates the Containment Structure below grade and therefore does not pass through the AR.

[REDACTED]

Figure 7: MFS Process Flow Diagram (1 of 3) [32].

[REDACTED]

Figure 7: MFS Process Flow Diagram (2 of 3) [32].

[REDACTED]

Figure 7: MFS Process Flow Diagram (3 of 3) [32].

5.6.1.4 System Reliability

The safety-related portion of the MFS is designed with a high level of robustness in components to ensure the required reliability of the containment isolation safety function. This is demonstrated through consideration of the following elements in the design of components:

- Single active component failure.
- Physical damage from fire, flood, dynamic effects of high energy pipe rupture.
- Seismic and environmental effects.

The MFS uses three 33% feedwater pumps to supply the total full power feedwater demand (see Feedwater Pump Configuration design decision paper for reference [54]). These pumps can ramp up to runback level flowrates in the event of a single pump failure. This meets the requirements set out in EPRI Utility Requirements Document (URD) [55].

Two 100% MFCVs provide redundancy and operational flexibility allowing online maintenance and testing of the flow control valves operating in challenging process conditions. The MFCVs also provide a non-safety backup to the MFIVs for isolation of the MFS.

System bypasses are provided to allow temporary operation while equipment is being tested or maintained.

See also section 5.2.5.

5.6.1.5 System Interfaces

Table 11: MFS Interfacing Systems

System	Description	Function	PSR Chapter
MSS	Main Steam System	The MSS provides extraction steam to the FWHs for feedwater preheating. The MFS provides spray water to the turbine bypass valves in the MSS.	Part B Chapter 5
RCS	Reactor Coolant System	The MFS provides feedwater to the SGE to remove heat from the RCS.	Part B Chapter 1 [2]
PSS	Plant Safety System	The PSS provides the main feedwater isolation signal to close the MFIV.	Part B Chapter 4 [18]
SSS	Secondary Sampling System	The SSS samples and monitors the chemistry of the MFS	Not in GDA scope
DWS	Demineralised Water System	The DWS provides rinse water for backwashing the resins from the condensate polisher package.	Not in GDA scope
CAI	Instrument and Service Air System	The CAI provides service air to the condensate polisher package to aid in mixing and fluidising the resin bed. The CAIS also provides an air supply to control valves with diaphragm actuators	Not in GDA scope
CIS	Containment Isolation System	MFS valves that form a part of the containment barrier also form part of the CIS.	Part B Chapter 1 [2]
DCE	DC Power Distribution System	The DCE supplies power to safety-related motor-operated valves of the MFS.	Part B Chapter 6 [19]
ICE	I&C Power Distribution System	The ICE supplies power to the instrumentation and AOVs of the MFS.	Part B Chapter 6 [19]
LVE	Low Voltage AC Distribution System	The LVE supplies power to non-safety valve motors in the MFS.	Part B Chapter 6 [19]
MVE	Medium Voltage AC Distribution System	The MVE supplies power to the main feedwater pumps	Not in GDA scope
PCS	Plant Control System	The PCS monitors and controls the MFS equipment and components with non-safety functions. MFS instrumentation provides signals to PCS.	Part B Chapter 4 [18]
SDH	Secondary Decay Heat Removal System	The supply piping for SDH is in the MFS discharge header to the Steam Generator.	Part B Chapter 1 [2]
SGB	Steam Generator Blowdown System	The SGB is used to drain the SGE during shutdown and to maintain level in SGE during startup	N/A

5.6.2 Main Steam System (MSS)

In addition to supporting claim 2.2.13.2 above, the MSS supports the claims below:

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.5-A7: The MSS containment penetration is provided with isolation capabilities to preserve the integrity of the containment boundary.

5.6.2.1 System Overview

The role of the MSS is to deliver steam at the appropriate state to a variety of different components. The safety related portion of the system also ensures the integrity of the containment boundary. Main Steam Safety Valves (MSSVs) provide over pressure protection for both the safety related portions of the system and the secondary side of the steam generator. The MSS can also be used to remove heat from the RCS using the Atmospheric Dump Valve (ADV) and/or TBS, but these functions are not credited in safety analysis.

The MSS connects the secondary side of the SGE to the Main Turbine System (MTS) and other systems. Normally the MSS supplies steam to the MTS for power generation. The MSS can send steam directly to the condenser or discharge steam to the atmosphere to support load following or removing heat from the RCS. Safety valves in the MSS protect the shell side of the steam generator and safety related portion of the MSS from overpressure. The MSS contains a Moisture Separator Reheater and multiple extraction steam lines that supply FWH in the MFS to improve plant efficiency.

5.6.2.2 System Functions

5.6.2.2.1 Safety Functions

The safety related functions of the MSS are to:

- **Maintain the containment boundary integrity.**
  The MSS containment penetration is provided with isolation capabilities to preserve the integrity of the containment boundary.
- **Provide Overpressure Protection during Design Basis Events.**

  The MSS provides overpressure protection to ASME BPVC Class 2 portions of the SGE and the pressure containing components of the MSS during design basis events.

5.6.2.2.2 Non-Safety Functions

Further non-safety related functions of the MSS are to:

- **Supply Steam to the Main Turbine System.**
  The MSS provides a flow path for steam from the SGE to the main turbine. The MSS provides the steam required to warm up the turbines, bring them up to rated speed, and operate them at all power levels.
- **Provide Auxiliary Steam to Secondary System Components.**
  The MSS has connections to supply steam to the Auxiliary Steam System (AXS), Gland Seal System (GSS), Moisture Separator Reheater (MSR), and SSS.
- **Dumping Steam to the Atmosphere.**
  The MSS can dump steam to the atmosphere to remove heat from the RCS and relieve MSS pressure. This function does not require the MTS or main condenser to be operational.
- **Distribute Steam from the Auxiliary Boiler System for Heatup.**
  The AXS connection can be used to supply steam to the MSS during heatup. The MSS distributes the auxiliary steam to support heating up the secondary system.
- **Provide Bypass for Main Steam.**

  The TBS provides the ability to bypass the MTS and send steam from the MSS header directly to the condenser. This supports the plant’s ability to load follow. During load rejections and turbine trips this function helps prevent over pressurisation. This function is not credited for safety analysis.

- **Cool the RCS During the First Stages of Shutdown.**

  The TBS cools the RCS during shutdown operations until RCS temperatures are low enough that the RHR can be placed in service.

5.6.2.3 System Description

The MSS (Figure 8) is designed to transfer steam from the SGE to the MTS, and other secondary system components. The MSS provides overpressure protection to the secondary system during all modes of operation. The MSS also removes decay heat during initial shutdown operations. The safety-related portions of the MSS are designed to perform their required functions during normal operating conditions and design basis events, including a total loss of electrical power.

The two main steam headers connect to steam nozzles on the SGE shell. The main steam headers run from each SGE nozzle through the containment boundary and into the Intermediate Building. As in the MFS, these penetrations are below grade and do not pass through the AR. The Radioactive Monitoring System (RMS), MSSVs, ADV, a low-point drain, and Main Steam Isolation Bypass Valve (MSIBV) are connected to the main steam header in the IB upstream of the Main Steam Isolation Valve (MSIV) on each header.

Downstream of the MSIV, each main steam header runs through a seismic restraint and divider wall separating the safety related and non-safety related sections of the IB before entering the Turbine Building (TB), where the remainder of the system components are located. Inside the TB, a line is provided to equalize pressure between the two steam headers and connections are provided from the main steam headers to the AXS, GSS, MSR, SSS, and TBS. The main steam headers continue towards the MTS to interface with Main Turbine.

Multiple low point drains in the MSS prevent damage to MSS components and water induction into the MTS. The drain line provided between the SGE and MSIV ensures adequate drainage of piping upstream of the MSIV when the MSIV is shut. Moisture collects in drain pots, passes through shuttle valves, and flows to the Condensate System (CNS). If the shuttle valve fails, the operator can open the bypass valve to drain the condensate manually.

[REDACTED]

Figure 8: MSS Process Flow Diagram [32].

5.6.2.4 System Reliability

See section 5.2.5.

5.6.2.5 System Interfaces

Table 12: MSS system interfaces

System	Description	Function	PSR Chapter
AXS	Auxiliary Steam System	MSS provides steam to and uses steam from the AXS under various conditions for various purposes.	Not in GDA scope
CAI	Instrument and Service Air System	The CAI provides an air supply to the control valves with diaphragm actuators.	Not in GDA scope
CIS	Containment Isolation System	MSS valves that form a part of the containment barrier also form part of the CIS.	Part B Chapter 1 [2]
DCE	DC Power Distribution System	The DCE supplies power to the safety-related valve motors in the MSS.	Part B Chapter 6 [19]
GSS	Gland Seal System	The MSS supplies steam to the GSS for turbine gland seals.	Not in GDA scope
HDS	Heater Drain System	The MSS drains at various points to the HDS.	Not in GDA scope
ICE	I&C Power Distribution System	The ICE supplies power to the instrumentation and air-operated valves in the MSS.	Part B Chapter 6 [19]
LVE	Low Voltage AC Distribution System	The LVE supplies power to non-safety valve motors in the MSS	Part B Chapter 6 [19]
MFS	Main Feedwater System	The MSS provides extraction steam for the heating of the feedwater in the MFS.	Part B Chapter 5
MTS	Main Turbine System	The MSS protects and provides steam to the MTS. Steam is extracted from the MTS using the ESS.	Not in GDA scope
PAM	Post-Accident Monitoring System	The MSS includes instrumentation to monitor post-accident conditions in the plant.	Part B Chapter 4 [18]
PCS	Plant Control System	The PCS monitors and controls the MSS equipment and components with non-safety functions. MSS instrumentation provides signals to PCS.	Part B Chapter 4 [18]
PSS	Plant Safety System	The PSS monitors and controls the MSS equipment and components with safety functions. MSS instrumentation provides signals to PSS.	Part B Chapter 4 [18]
RCS	Reactor Coolant System	The SGE in the RCS provides the main steam to the MSS.	Part B Chapter 1 [2]
RMS	Radiation Monitoring System	The RMS provides area radiation monitoring in the MSS.	Part B Chapter 4 [18]
SSS	Secondary Sampling System	The SSS collects samples for analysis from the main steam line, MSR drain tank, and extraction steam from the LP turbine.	Not in GDA scope

5.6.3 CAE Summary

The Steam and Power Conversion Systems, as described in the preceding subsections, demonstrate claim 2.2.13.2:

> **Claim 2.2.13.2:** The Steam and Power Conversion Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

The safety features and functions for each system are described above and, in addition, detail is provided on how the design of the system delivers these safety features. This claim is considered to be fundamentally evidenced by the description of the features of the systems, with further substantiation provided by lower tier design documentation. In most cases this lower tier documentation is not included in the SMR-300 GDA Design Reference Point [56], and so the evidence will follow beyond submission of step 2 of the GDA.

Substantiation is also provided by other topic area PSR chapters and GDA submissions (section 5.4.1), particularly PSR Part B Chapter 19 'Mechanical Engineering' [21].

Additionally, the MFS and MSS both support and demonstrate claim 2.2.3.5:

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events.

Argument 2.2.3.5-A6: The MFS penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.

Argument 2.2.3.5-A7: The MSS containment penetration is provided with isolation capabilities to preserve the integrity of the containment boundary.

Through the arguments above and supported by the system safety functions and SDDs (Table 1), it is assessed the above claim is demonstrated to a maturity appropriate at PSR. The importance of maintaining a secure containment structure is paramount to nuclear safety in all plant states during all credible events. To further demonstrate the importance of the containment structure to nuclear safety, the Containment Structure Safety Justification document has been produced [52] which provides a holistic view regarding the integrity of the containment structure and the role ESF play in maintaining a secure structure.

The Steam and Power Conversion Systems are therefore shown to demonstrate the claims made against them insofar as is possible at this stage of the GDA.

5.7 MECHANICAL HANDLING SYSTEMS

Claim 2.2.13.3: The Mechanical Handling Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

The plant Mechanical Handling Systems within GDA scope consist of the following:

- Overhead Heavy Load Handling System.
- Light Load Handling System.
- Reactor Auxiliary Building Truck Bay Crane.

5.7.1 Overhead Heavy Load Handling System

5.7.1.1 System Overview

The Overhead Heavy Load Handling system consists of the Polar Crane that is located within the CS. The Polar Crane is used for several lifting purposes, including fuel movements, facility maintenance, and construction tasks. At the time of Revision 1 of this chapter, the system design is in development and the RP is engaging with suppliers/manufacturers for the Polar Crane design. It will be designed in line with requirements outlined in Section 5.7.1.3.

5.7.1.2 System Functions

5.7.1.2.1 Safety Functions

No safety related functions are defined for this system at PSR Revision 1. This is subject to formal assessment beyond GDA Step 2, captured by GDA Commitment C_Mech_094 in Part B Chapter 19 [21], where safety functions may be identified.

5.7.1.2.2 Non-Safety Functions

No other non-safety related functions are defined for this system at PSR Revision 1.

5.7.1.3 System Description

The Polar Crane is a multipurpose lifting system to be installed in the SMR-300 CS building. The crane shall be designed as a Seismic Category II Safety Related lifting system in accordance with 10 CFR 50 Appendix B [57] / 10 CFR 21 [58]. The Polar Crane shall comply with the design criteria ASME NOG 1 [59] and applicable sections of design standards referenced within the aforementioned standards.

The Polar Crane is a single failure proof circular bridge crane. A single trolley with a main hoist, auxiliary hoist, and maintenance jib crane travels the length of the bridge. The runway rail, access platforms, maintenance platforms, electrification, and controls are considered part of the Polar Crane. The major lifting operations to be performed by the Polar Crane are:

- HI-TRAC (loaded).
- Reactor Pressure Vessel Closure Head.
- Control Rod Drive Mechanism Frame.
- Reactor Lower Internals.

- Reactor Upper Internals.
- Reactor reflecting rings.
- Reactor Coolant Pump Motor.
- Reactor Coolant Pump Internals.
- Reactor Core Barrel.
- Other equipment and tools required to service the equipment in CS.
- Special lifts to be conducted during the construction of the SMR-300.
- Maintenance jib for maintenance and repairs of the Polar Crane.

5.7.1.4 System Reliability

See section 5.2.5.

5.7.1.5 System Interfaces

The system interfaces of the CSH are not defined at PSR Revision 1 and will be developed with the ongoing design of the system.

See PSR Part B Chapter 19 ‘Mechanical Engineering’ [21] for further details on mechanical handling systems and Part B Chapter 24 ‘Fuel Transport and Storage’ [24] for supporting information on fuel transport.

5.7.2 Light Load Handling System (LLH)

5.7.2.1 System Overview

The Light Load Handling System is located inside the CS and is designed to carry out operations for the movement of Fuel Assemblies, Spent Fuel Assemblies (SFA), Rod Cluster Control Assemblies (RCCA) and Burnable Poison Rod Assembly (BPRA) within the SFP.

Similar to the CSH, at the time of Revision 1 of this chapter, the LLH design is in development and the RP is working with suppliers/manufacturers for the system design. It will be designed in line with requirements outlined in Section 5.7.2.3.

The LLH is a fuel handling system for the SMR-300 and includes the following major components:

- Fuel Handling Bridge Crane (FHBC) including:
  - Trolley.
  - Main Hoist.
  - Mast Assembly.
  - Auxiliary Hoist and Trolley.
  - Maintenance / work platform(s).
  - Controls.
  - Compressor / air supply for pneumatic grippers.
  - Submerged Video Cameras and Monitor(s).
  - Grippers for Fuel and Control Assemblies (including Fuel Sipping System).
- Runway Rail / Track.
- Fuel Bridge Electrification System.

5.7.2.2 System Functions

5.7.2.2.1 Safety Functions

No safety related functions are defined for this system at PSR Revision 1. This is subject to formal assessment beyond GDA Step 2 where safety functions may be identified.

5.7.2.2.2 Non-Safety Functions

No other non-safety related functions are defined for this system at PSR Revision 1.

5.7.2.3 System Description

The FHBC, as part of the LLH, is located inside the CS and is designed to carry out operations for the movement of Fuel Assemblies, Spent Fuel Assemblies, Rod Cluster Control Assemblies, and Burnable Poison Rod Assemblies, namely:

- Fuel Assemblies from Multi-Purpose Canister (MPC) to SFA storage.
- Fuel Assemblies from reactor core to SFA storage racks.
- SFA transfers from the reactor core to the SFA storage racks.
- SFA transfers from the reactor core to the MPC.
- SFA transfers from the SFA storage racks to the MPC and vice versa.
- Transfer operations for RCCAs movements.
- Transfer operations for BPRA movements.
- Support reactor disassembly/reassembly during refuelling activities.
- Other operations.

Additionally, the FHBC shall be used for movements of miscellaneous loads and tools to support the SMR-300 operations and maintenance processes within the SFP.

The FHBC system handles fuel assemblies and various loads in a safe and efficient manner. It operates like an overhead bridge crane, traveling along the length of the SFP via a rail or track system mounted on each side of the pool. The main hoist and mast mounted on the trolley can move back and forth across the width of the pool. This arrangement allows the gripper mounted to the mast to pick up and manoeuvre loads within the pool.

A second auxiliary hoist and trolley operate on a separate beam or track, enabling it to traverse the length of the FHBC. This auxiliary hoist is designated for conducting miscellaneous maintenance work within the pool.

The FHBC controls facilitate both manual and semi-automatic movement of loads. In the semi-automatic mode, the operator can accurately input load positions, prompting the crane to automatically manoeuvre and travel to the designated location. A precision positioning system allows the operator to make minute adjustments to the load’s position. Real-time monitoring of crucial crane parameters, including load weight, load elevation (including a mechanical backup to verify load elevation), bridge position, and trolley position is provided to the operator. Additional mechanical/visual indicators of the position of the bridge and trolley (e.g. index strips to mark key locations along the travel path) are specified.

The overall interface of the FHBC controls shall be user-friendly, ensuring ease of operation and understanding for the FHBC operator. The controls will deliver a high degree of efficiency, reliability, safety, and precision in managing load movements. It will also be equipped with safety features, such as limit switches, overload protection, and emergency stop mechanisms to ensure safe and efficient operations. The system shall be able to set and, if necessary, change programmable exclusion zones for all crane movements to avoid collisions.

The LLH will be designed in line with the applicable requirements of ASME NOG-1 [59], ASNI/ANS57.1 [60] and NUREG-0554 [61].

5.7.2.4 System Reliability

See section 5.2.5.

5.7.2.5 System Interfaces

The system interfaces of the LLH are not defined at PSR Revision 1 and will be developed with the ongoing design of the system.

See also Part B Chapter 19 ‘Mechanical Engineering’ [21] and Part B Chapter 24 ‘Fuel Transport and Storage’ [24] for additional supporting information on this system.

5.7.3 Reactor Auxiliary Truck Bay Building Crane (RBH)

5.7.3.1 System Overview

The Reactor Auxiliary Truck Bay Building Crane (RBH) is a part of the fuel handling systems in the generic SMR-300, situated in the RAB. As in other handling systems at Revision 1, the RBH design is in development and the RP are working with suppliers/manufacturers for the system design. It will be designed in line with requirements outlined in Section 0.

5.7.3.2 System Functions

5.7.3.2.1 Safety Functions

No safety related functions are defined for this system at PSR Revision 1. This is subject to formal assessment beyond GDA Step 2 where safety functions may be identified.

5.7.3.2.2 Non-Safety Functions

No other non-safety related functions are defined for this system at PSR Revision 1.

5.7.3.3 System Description

The RAB crane is designed as a Seismic Category II. Its design will adhere to the criteria outlined in CMAA Specification 70 [62]; ANSI/ASME B30.2 [63] and ANSI/ANS 57.1 [60], along with the relevant sections of design standards referenced in these documents.

Anticipated to be a double girder overhead electric traveling bridge crane equipped with two hoists and trolleys, the RAB crane will employ hooks for load handling. The main hoist will feature a double shank hook with powered rotation, while the auxiliary hoist will utilise a single shank hook with manual rotation.

The crane's moving and lifting system shall be provided with high positioning accuracy. Every component of the crane will be engineered with a high level of reliability and fault tolerance, aligning with established standards and codes.

Situated in the SMR-300 RAB, the RAB main hoist is designed for lifting operations involving CS equipment. Meanwhile, the RAB auxiliary hoist is specifically engineered for handling New Fuel Assemblies within the RAB.

The following list provides a general overview of the main loads that the RAB crane is expected to transport. Additional items or materials may be included in the scope of its lifting and transportation capabilities as per project requirements:

- SFC components.
- New Fuel Assemblies from New Fuel Storage Rack.
- Upending of New Fuel Assemblies and placement into the new fuel vault.
- MPC Drying Equipment.
- MPC Welding Equipment.
- MPC into in HI-TRAC.
- HI-TRAC Shielding.
- HI-TRAC work platform.
- Forced Helium Dehydration (FHD) system.
- RCP/RCP Motor and Pump Internals.
- HI-TRAC on Low Profile Transporter (LPT).
- HI-TRAC movement to the dry storage preparation area.
- Any other equipment and tools required to service the equipment in RAB.

5.7.3.4 System Reliability

See section 5.2.5.

5.7.3.5 System Interfaces

The system interfaces of the LLH are not defined at PSR Revision 1 and will be developed with the ongoing design of the system.

See also PSR Part B Chapter 19 ‘Mechanical Engineering’ [21] and Part B Chapter 24 ‘Fuel Transport and Storage’ [24] for additional supporting information on this system.

5.7.4 CAE Summary

The Mechanical Handling Systems, as described in the preceding subsections, help demonstrate claim 2.2.13.3:

Claim 2.2.13.3: The Mechanical Handling Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

At PSR Revision 1, system requirements are identified but at this stage of the design of Mechanical Handling Systems, full safety functions and substantiation are not yet fully mature. The design of Mechanical Handling Systems is in the early stages of development and system safety functions will be formalised as part of the ongoing design process. The output of the full UK Fault Schedule will inform the UK safety classification whereupon they will be compared with the Holtec International SMR classifications to determine whether the Mechanical

Handling Systems meet UK reliability requirements. The classification, codes and standards, and reliability requirements are discussed in greater detail in Part B Chapter 19 Mechanical Engineering [21].

A Commitment C_Mech_094 has been raised within the Mechanical Engineering topic area (Part B Chapter 19 [21]) to address differences identified between US and UK lifting expectations. Furthermore, C_Faul_103 has been raised within Fault Studies (Part B Chapter 14 [26]) to conduct full UK safety analysis capturing any safety function requirements and system classifications.

[REDACTED].

An understanding has been developed on the requirements of the mechanical handling systems but safety functions, non-safety functions and a detailed design are under development. Further evidence demonstrating claim 2.2.13.3 will therefore be delivered beyond GDA Step 2 once full safety analysis has been conducted and possible suppliers have been identified.

5.8 HEATING, VENTILATION AND AIR CONDITIONING SYSTEMS

Claim 2.2.13.4: The Heating, Ventilation and Air Conditioning Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

The plant HVAC Systems within GDA scope consist of the following:

- Containment Ventilation System.
- Radiologically Controlled Area HVAC System.
- Main Control Room Habitability System (MCH) .
    - See PSR Part B Chapter 1 [2] for the system description of the MCH.

In addition to claim 2.2.13.2 above, the CBV supports the containment integrity claim 2.2.3.5 (see section 5.3.2). The claim and respective arguments are presented in the subsections.

Claim 2.2.18 regarding the design and architecture of the HVAC system is also addressed within this section.

5.8.1 HVAC System Architecture

Claim 2.2.18: The overall design and architecture of heating, ventilation and air conditioning SSCs ensure that safety functions and non-safety functions are delivered and faults arising from failures of the SSCs are minimised.

The aim of the above claim is to demonstrate that the overall architecture of HVAC systems is suitably designed to fulfil its safety functions and minimises faults arising from failures of HVAC.

A description of the HVAC systems architecture, the individual systems which form the HVAC systems architecture, and the interactions between these and other systems is still being developed and is managed by the HVAC Architecture Design Challenge Paper [64]. This is discussed further and a plan for resolution presented in Part B Chapter 19 Mechanical Engineering [21]. The design of individual HVAC systems, within GDA Scope, are supported by SDDs and are considered in further detail in this section, under Claim 2.2.13.4.

The primary objectives of the HVAC systems architecture are to:

- Maintain internal conditions within acceptable limits (air quality, temperature) for staff and components, and to control movement of contamination by a progressive transfer of contaminated air from clean to a dirty area.
- Protect staff and components against specific risks arising from internal and external hazards.
- Monitor and limit radioactive discharges during normal plant operation and accident conditions (confinement function) by treating effluent prior to final discharge or performing isolation functions.

The plant HVAC Systems within GDA scope are outlined above with MCH discussed in Part B Chapter 1 [2] and is not discussed further in this chapter.

[REDACTED].

The requirements of claim 2.2.18 have been decomposed into four arguments presented below.

Argument 2.2.18-A1: HVAC systems architecture meets relevant safety principles.

The HVAC Architecture Design Challenge Paper [64] identifies the relevant safety principles and requirements are supported by the HVAC systems architecture. In line with the principle to design the SMR-300 to rely on passive safety systems (as described in "SMR-300 Top Level Plant Design Requirements" [32]), the plant has been designed to minimise safety functions required to be delivered by active support systems. Currently, only the containment isolation valves (and the piping between the valves) of the CBV are safety classified with all other HVAC systems considered non-safety related.

In the UK context, the Preliminary Fault Schedule (PFS) has been developed with the aim of providing the expected UK Categorisation and Classification of the SSCs in accordance with IAEA SSR 2/1 [65] and ONR-TAG-094 [66] and as set out in the Holtec Britain Safety Assessment Handbook [25]. The HVAC system is not within the current PFS scope. The HVAC sub systems will be classified through the production of a Fault Schedule and UK Design Basis Accident Analysis (DBAA) post-PSR Revision 1 with any safety functions highlighted.

Argument 2.2.18-A2: HVAC systems architecture meets RGP and accounts for Operational Experience (OPEX).

The HVAC design challenge paper sets out the approach to ensure that the HVAC systems architecture has been designed with due consideration of relevant RGP and considers OPEX gained from other operating (and under construction) stations. The design of the HVAC systems has been carried out in accordance with the codes and standards defined in the SDDs. The appropriateness of these codes and standards is presented in Part B Chapter 19 Mechanical Engineering and differences with UK RGP are discussed. Commitment C_Mech_028 has been raised in Part B Chapter 19 [21] to incorporate UK RGP into the design of HVAC SSCs.

[REDACTED].

Argument 2.2.18-A3: HVAC systems architecture delivers the required HVAC performance.

The HVAC design challenge paper sets out the approach to the modelling of the HVAC systems architecture, to support demonstration that the HVAC systems architecture can maintain conditions within the required criteria. As detailed in the paper, design margins for future increased capacity are incorporated into HVAC systems and selection of equipment will provide additional margins by selecting the next size up where possible. This will ensure that the required HVAC performance is assured [REDACTED].

The architecture of the HVAC systems does not foreclose future design changes to accommodate any increased demands (e.g. more onerous conditions due to climate change), and thus there is a high level of confidence that this argument will be demonstrated.

Argument 2.2.18-A4: HVAC system faults do not compromise delivery of the main safety functions.

Through the development of UK safety assessments (DBAA, PSA), the impact of HVAC plant failures will be assessed using the most onerous design basis fault cases to confirm whether the risks are tolerable. HVAC system initiated faults are assessed through fault studies and PSA, to confirm that these are adequately mitigated. The production of a UK DBAA and PSA incorporating HVAC faults is planned to be produced post-PSR Revision 1 and captured under GDA Commitment C_Faul_103 raised in Part B Chapter 14 [26].

5.8.2 Containment Ventilation System

In addition to supporting claim 2.2.13.4 above, the CBV supports the claims below:

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.

This claim is supported in this subsection by the following argument:

Argument 2.2.3.5-A8: The parts of the CBV that penetrate containment maintain the containment integrity.

5.8.2.1 System Overview

The CBV provides containment temperature control, humidity control, and purge air. The containment coolers remove heat and moisture from the air to ensure compliance with acceptable temperature limits and permit comfortable working conditions during refuelling. The containment purge provides air changes for radiation control and provides pressure control to maintain containment structural integrity and maintain the relative pressure between containment and the environment within approved limits. Purge air is filtered and heated, if necessary, on the supply side. The exhaust side air is filtered prior to release to the environment. Exhaust air can also be heated prior to entering the exhaust Air Handling Unit (AHU) filters to reduce the relative humidity. Portions of the CBV are controlled by the PSS to maintain containment isolation during accident conditions.

5.8.2.2 System Functions

5.8.2.2.1 Safety Functions

The safety related functions the system of the CBV are:

- **Maintain the Containment Boundary Integrity.**
  Parts of the system penetrate containment and perform a containment isolation function to maintain the containment pressure boundary.
- **Vacuum Relief.**
  The Containment Purge system supplies makeup air to relieve vacuum pressures that may arise due to containment heat transfer to environment/annulus following a reactor trip with a loss of offsite power resulting in the reduction of pressure in containment below allowable.

5.8.2.2.2 Non-Safety Functions

The non-safety related functions the system of the CBV are:

- **Maintain temperature in containment to below maximum allowable during normal operation.**
  The CBV removes heat from containment and discharges it to the chilled water system. Water vapor is also removed and is discharged to the radioactive drain system.
- **Provide air changes to reduce airborne radioactivity level.**
  The CBV provides air changes when needed during normal operation to reduce radioactivity level for maintenance or other activities/concerns.
- **Adjust the pressure of containment.**
  The CBV system adjusts the pressure within containment to maintain the relative pressure in containment relative to the surroundings within approved limits. Containment purge is capable of both increasing and decreasing containment pressure to maintain the desired pressure.
- **Control and monitor the gaseous radioactive effluent and airborne particulate release.**

  The CBV system treats the exhaust prior to discharge to the plant stack. Radiation Monitors are included in the discharge path to measure radiation levels.

5.8.2.3 System Description

The CBV has several main functions as described above. These are accomplished by two subsystems:

- Containment Cooling System.
  - Provides normal cooling to containment heat loads.
  - Condenses water vapour from containment atmosphere and directs it to the Radioactive Drain System (RDS) for use in leak detection.
- Containment Purge System.
  - Regulates containment pressure, including vacuum relief.
  - Regulates containment airborne radioactivity.
  - Regulates releases to the environment.

5.8.2.3.1 Containment Cooling System

The main functions of the CBV cooling system are providing cooling and water vapor removal from containment. This is accomplished through a pair of 100% capacity HVAC units situated on top of the PCMWT. The HVAC units pull ambient air from containment, condition the air, and distribute the cooled air to cool the major heat loads within containment. The condensed water is directed to the RDS where it is measured and collected for processing.

The containment cooling system is not credited for post-accident heat removal. This function is accomplished by the PCH (see PSR Part B Chapter 1 [2]).

5.8.2.3.2 Containment Purge System

The containment purge system is designed to operate as needed to control airflow into and out of containment for the purpose of pressure regulation and contamination/radioactivity control. The purge system is a low flow purge only with the potential to add a high flow purge at a later date. There is a single 100% unit at each end of the system i.e. a purge supply unit and a purge exhaust unit. The purge system is sized to [REDACTED] to meet ANS 56.6 [67] requirements. Outside air is heated to a minimum of [REDACTED], if necessary, by the supply AHU and is directed throughout containment by the duct system. The exhaust side pulls air from containment and forces it through a prefilter, an upstream High-Efficiency Particulate Air (HEPA) filter, a charcoal filter, and a downstream HEPA to remove carbon fines prior to exiting the facility through the plant stack. Radioactivity level in the exhaust side duct is monitored (through the RMS) to prevent unmonitored releases. The containment penetrations are [REDACTED] diameter consistent with ANS 56.6 [67] recommendations for low flow purge systems. CIVs are located on either side of containment for both the supply side and the exhaust side. The CIVs provide containment isolation and redundancy in the event of a single failure. The plant safety system overrides normal control of the valves to isolate containment in response to a containment isolation signal.

The purge system is not credited with accident recovery; however, it is designed to provide Defence in Depth. Accident conditions are expected to reach as high as [REDACTED] in containment. The purge exhaust system is designed to support accident recovery at temperatures below [REDACTED] at ambient pressure. The max temperature was determined by reviewing manufacturer data for standard filters and the limiting temperature was identified to be the charcoal filters [REDACTED]. Relative humidity over 70% is not expected during normal conditions. However, during accident scenarios relative humidity may exceed 70%. To ensure optimal operation of the exhaust AHU filters, the AHU is equipped with a heater sized to provide a [REDACTED] increase in temperature and a moisture separator, sufficient to reduce relative humidity below 70%. The [REDACTED] temperature limit does not account for heating the purge air to reduce the relative humidity. Therefore, the inlet temperature to the exhaust filter unit will be limited to [REDACTED].

Vacuum relief is accomplished by a pair of motor operated CIVs outside containment and a pair of check valves within containment. Both sets of valves are in parallel to the exhaust penetration CIVs. This allows for vacuum relief to be achieved via opening of the motor operated CIVs. These valves can be operated automatically when low pressure is detected and can also be operated manually by an operator.

5.8.2.4 System Reliability

See section 5.2.5.

5.8.2.5 System Interfaces

Table 13: CBV Interfacing Systems

System	Description	Function	PSR Chapter
CWS	Chilled Water System	The chilled water system provides chilled water for the CBV cooling system AHUs.	Not in GDA scope
CAI	Instrument and Service Air System	The CAI provides an air supply to CIVs with diaphragm actuators.	Part B Chapter 6 [19]
PSS	Plant Safety System	Control system for the safety portions of the CBV, including the CIVs.	Part B Chapter 4 [18]
PCS	Plant Control System	Control system for the non-safety portions of the CBV.	Part B Chapter 4 [18]
CIS	Containment Isolation System	Isolation valves on CBV lines penetrating the containment shall close on containment isolation signal.	Part B Chapter 1 [2]
LVE	Low Voltage AC Distribution System	AHUs, AHU fans, reactor cavity fans, purging AHU radiation monitor, exhaust, and MOVs (not including CIVs) are powered by the non-safety portion of the LVE.	Part B Chapter 6 [19]
DCE	DC Power Distribution System	Power to the solenoid valves for the CIV valves, sensors, and transmitters, is provided by the DCE. The motor operated CIVs for the vacuum relief are also powered class 1-E power from the DCE.	Part B Chapter 6 [19]
RMS	Radiation Monitoring System	The RMS receives input from the purge exhaust radiation monitor.	Part B Chapter 4 [18]
RDS	Radioactive Drain System	Condensate from the cooling AHUs and water from the exhaust purge charcoal filter fire suppression will drain to the RDS.	Part B Chapter 13 [33]

See also PSR Part B Chapter 19 ‘Mechanical Engineering’ [21] and Part B Chapter 10 ‘Radiological Protection’ [68] for additional supporting information on this system.

5.8.3 Radiologically Controlled Area HVAC System

5.8.3.1 System Overview

The system overview of the RCV is not available at Revision 1 of this chapter and will be developed beyond GDA Step 2.

5.8.3.2 System Functions

5.8.3.2.1 Safety Functions

No safety related functions are defined for this system at PSR Revision 1. This is subject to formal assessment beyond GDA Step 2 where safety functions may be identified.

5.8.3.2.2 Non-Safety Functions

No other non-safety related functions are defined for this system at PSR Revision 1.

5.8.3.3 System Description

The system description of the RCV will be developed beyond revision 1 of this chapter as the design progresses.

5.8.3.4 System Reliability

See section 5.2.5.

5.8.3.5 System Interfaces

The system interfaces of the RCV will be beyond GDA Step 2 for the RCV as the design develops. See also PSR Part B Chapter 19 'Mechanical Engineering' [21] and Part B Chapter 10 'Radiological Protection' [68] for additional supporting information on this system.

5.8.4 CAE Summary

The HVAC Systems, as described in the preceding subsections, demonstrate claim 2.2.13.4 for those systems within GDA Scope:

Claim 2.2.13.4: The Heating, Ventilation and Air Conditioning Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

At PSR Revision 1, system requirements for those systems within the GDA Scope of DRP1.1 are understood. However, the identification of safety functions and substantiation are at differing levels of maturity for the HVAC sub systems, which is not unexpected at this stage of design maturity. The safety features for the CBV are described above and, in addition, detail is provided on how the design of the system delivers these safety features. Other systems within the GDA scope are still in development and system safety functions will be formalised as part of the ongoing design process. The output of the full UK Fault Schedule will inform the UK safety classification whereupon they will be compared with the Holtec International SMR classifications to determine whether the HVAC meets UK reliability and performance requirements. The classification, codes and standards, and reliability requirements are discussed in greater detail in PSR Part B Chapter 19 'Mechanical Engineering' [21].

[REDACTED]. The evidence demonstrating claim 2.2.13.4 will therefore be delivered beyond GDA Step 2 once all HVAC system designs have matured and UK-based safety analysis has been conducted. This work is captured through multiple GDA Commitments raised in Part B Chapter 14 [26] (C_Faul_103) and Part B Chapter 19 [21] (C_Mech_028).

Additionally, the CBV also supports and demonstrates claim 2.2.3.5:

Claim 2.2.3.5: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events in all plant states.

Argument 2.2.3.5-A8: The parts of the CBV that penetrate containment maintain the containment integrity.

Through the argument above and supported by the system safety functions and SDDs (Table 1), it is assessed the above claim is demonstrated to a maturity appropriate at PSR. This is demonstrated in the CBV with isolation measures to preserve containment boundary integrity. The importance of maintaining a secure containment structure is paramount to nuclear safety in all plant states during all credible events. To further demonstrate the importance of the containment structure to nuclear safety, the Containment Structure Safety Justification [52] document has been produced which provides a holistic view regarding the integrity of the containment structure and the role ESF play in maintaining a secure structure.

Claim 2.2.18: The overall design and architecture of heating, ventilation and air conditioning SSCs ensure that safety functions and non-safety functions are delivered and faults arising from failures of the SSCs are minimised.

The overall system architecture is still under development for the UK context given the different regulatory requirements to the US. A strategy to address the issues and provide confidence that the HVAC system will meet UK requirements is under development. [REDACTED]. Once planned UK safety assessments have taken place post-PSR, a greater understanding of the impact of HVAC failures on the overall plant will be gained and fed into the design process giving the ability to meet claim 2.2.18. This work is captured through multiple GDA Commitments raised in Part B Chapter 14 [26] (C_Faul_103) and Part B Chapter 19 [21] (C_Mech_028).

5.9 CHAPTER SUMMARY AND CONTRIBUTION TO ALARP

This sub-chapter provides an overall summary and conclusion of the Reactor Supporting Facilities chapter and how this chapter contributes to the overall demonstration of ALARP for the generic SMR-300. Part A Chapter 5 [69] 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.
    - Demonstration of Relevant RGP.
    - Evaluation of Risk and Demonstration Against Risk Targets.
    - Options Considered to Reduce Risk.
- GDA Commitments.
- Conclusion.

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

5.9.1 Technical Summary

Part B Chapter 5 aims to demonstrate the following level 3 claims:

Claim 2.2.13: The Reactor Supporting Facilities are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.

The design of the SMR-300 Reactor Supporting Facilities is outlined through sections 5.5 - 5.8. These are designed using best industry practice nuclear codes and standards as described in supporting engineering PSR chapters. In addition to appropriate codes, each system is principally designed to US Nuclear Regulatory Commission (NRC) requirements, NRC Regulatory guides and EPRI URD requirements. These sources incorporate many reactor years of operational experience to inform the requirements within. This claim is considered to be fundamentally evidenced by the description of the features of the systems, with further substantiation provided by lower tier design documentation. In some cases, as outlined above, the design of systems is in the early stages of development and following UK safety analysis further safety functions and features may be identified. Areas have been identified where additional justification may be required to fully satisfy UK expectations, as discussed in Part B Chapter 19 Mechanical Engineering [21]. This includes identification of design challenges and associated Commitments. At this stage, it is assessed that Claim 2.2.13 is demonstrated to a maturity expected at PSR subject to further work to ensure mechanical handling and HVAC systems are capable of meeting UK regulatory expectations.

Claim 2.2.3: Adequate provision for the control of radiation exposure and control of release of radioactive material is incorporated into the design of the reactor systems, supporting facilities, engineered safety features, and fuel and core design.

The above claim is partially demonstrated from this chapter with other Level 4 claims demonstrated in accordance with Table 3. The supporting Level 4 claims discussed within this chapter are demonstrated to an expected maturity appropriate at PSR by the isolation and integrity safety functions of each system described above.

Claim 2.2.18: The overall design and architecture of heating, ventilation and air conditioning SSCs ensure that safety functions and non-safety functions are delivered and faults arising from failures of the SSCs are minimised.

[REDACTED]. A strategy for HVAC design and architecture is under development to provide confidence that the system will deliver its required safety and non-safety functions. Following UK-based safety analysis, the safety requirements of the HVAC system will be fully understood as well as the impact of any failures and claim 2.2.18 can be fully demonstrated.

[REDACTED]. Commitments and further pertaining to the HVAC systems are raised in Part B Chapter 19 Mechanical Engineering [21].

5.9.2 ALARP Summary

5.9.2.1 Demonstration of RGP

Demonstration of RGP is discussed and presented in supporting engineering chapters:

- Part B Chapter 4 Control and Instrumentation Systems [18].
- Part B Chapter 6 Electrical Engineering [19].
- Part B Chapter 10 Radiological Protection [68].
- Part B Chapter 17 Human Factors [70].
- Part B Chapter 19 Mechanical Engineering [21].
- Part B Chapter 23 Reactor Chemistry [23].
- Part B Chapter 24 Fuel Transport and Storage [24].

5.9.2.2 Evaluation of Risk and Demonstration Against Risk Targets

The numerical targets against which the demonstration of ALARP is considered can be found in PSR Part A Chapter 2 [3].

Reactor Supporting Facilities SSCs, through the defined safety functions, will contribute to the demonstration of ALARP by comparison against the risk targets in two ways:

- By fulfilling safety functions for normal operations (e.g. integrity and isolation), and thereby contributing to achieving Targets 1-3;
- By achieving their safety classification as a duty system or a protection system, where claimed, they will contribute to the achievement of accident risk, Targets 4-9.

Evaluation of risk is not directly applicable to the Reactor Supporting Facilities SSCs. The safety classification of the Reactor Supporting Facilities SSCs will be associated with a Probability of Failure on Demand (PFD) and Probability of Failure per Annum (PFA), which is then used to calculate the overall comparison against the risk targets as described above.

The evaluation of the normal operations and accident risks against Targets 1-9 is summarised in Part A Chapter 5.

5.9.2.3 Options Considered to Reduce Risk

5.9.2.3.1 [REDACTED]

[REDACTED].

5.9.2.3.2 [REDACTED]

[REDACTED].

5.9.3 GDA Commitments

GDA Commitments which relate to this Chapter have been formally captured in the Commitments, Assumptions and Requirements Process [71]. Further details of this process is provided in PSR Part A Chapter 4 [72].

At Revision 1 there are no GDA Commitments being raised by Part B Chapter 5, Reactor Supporting Facilities.

5.9.4 Conclusion

This chapter summarises the high-level design of systems forming the Reactor Supporting Facilities. It identifies the claims, arguments and supporting evidence that will form the basis of the safety case for these systems throughout the lifecycle of SMR-300 to a maturity aligned to a PSR. Supporting engineering chapters provide further claims, arguments and evidence pertaining to these systems and these are referenced where relevant.

As the design and safety case development matures, further evidence will be provided to substantiate these claims and arguments.

Differences between the reference US design and practices in the UK have been identified. The safety categorisation and classification approach, particularly in relation to the classification of the CVC, SFC and RHR, is expected to differ. However, this will be addressed based on the outcome of the UK DBAA whereupon the safety classification of these SSCs may be changed.

The design architecture of the HVAC systems is another area where options are being considered to reduce risk. The review of HVAC design against UK RGP will be conducted post-PSR Revision 1 and a strategy is being developed to manage this.

As outlined in the Technical Summary, while not all claims have been met to the expected maturity for PSR Revision 1, GDA Commitments have been raised (although not directly by this chapter) to underpin the next evolution of the SSEC.

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5.11 LIST OF APPENDICES

Appendix A PSR Part B Chapter 5 CAE Route Map

Table 14: PSR Part B Chapter 5 CAE Route Map

REDACTED

Appendix B High-Level, Safety and Non-Safety Functions for Reactor Supporting Facilities SSCs

[REDACTED].

Table 15: SSCs with Internal Hazard SFRs

[REDACTED]