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PSR Part B Chapter 5 Reactor Supporting Facilities

Proprietary Classification

This record does not contain commercial or business sensitive information.

Export Control Status

Export Control restrictions do not apply to this record.

Revision Log

Revision	Description of Changes
0	Initial Issue.

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[1] PFD's and P&IDs included at Rev. 0 are watermarked to preclude material ordering/fabrication/etc. from proceeding until the drawings have been completed, these will be updated for Rev. 1.

5.1 INTRODUCTION

Part B Chapter 5 of the Preliminary Safety Report (PSR) presents the overarching summary of the Reactor Supporting Facilities (RSF) of the Generic SMR-300 plant that lie within the scope of Generic Design Assessment (GDA). Claims, Arguments and Evidence (CAE) are presented that will demonstrate that the Generic SMR-300 design satisfies the PSR Fundamental Objective found in PSR Part A Chapter 1 [1], and presents that risk is tolerable and As Low As Reasonably Practicable (ALARP).

5.1.1 Purpose and Scope

The Generic SMR-300 Plant design information presented in this version of the PSR is based on the Generic Plant Design, as seen in PSR Part A Chapter 2 [2]. Where SSCs have achieved a level of design maturity to reasonably articulate safety and system function, those safety and functional requirements are defined herein, with supporting information to demonstrate the design comports with Generic Design Assessment GDA requirements and Relevant Good Practices (RGPs), to demonstrate that risks are ALARP.

The objective of this chapter is to describe the SSCs of the RSF in scope of the GDA and identify their claimed safety functions, evidencing that Recognised Good Practice has been employed during their design, and that the risk to life has been reduced to ALARP.

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 SSCs. This chapter presents the Reactor Supporting Facilities topic for the Generic SMR-300 to support Level 3 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."

Part B Chapter 5 of the PSR relates to the Reactor Supporting Facilities included within the scope of the Generic SMR-300 GDA. These cover Mechanical Handling systems and Heating, Ventilation, and Air Conditioning (HVAC). Also included in this chapter for the PSR are Auxiliary Systems and Steam and Power Conversion Systems. The systems in scope for Chapter B5 are shown in Table 1 and the GDA scope can be found in Holtec SMR GDA Scope [3].

Table 1: Chapter B5 Summary of In-Scope SSCs

System Group	SSC Description	System Acronym	B5 Chapter Sub-section	Reference Document	Document Type
Auxiliary Systems	Combustible Gas Control System	**CGC**	5.4.2	HI-2135829 [4]*	SDD
	Chemical and Volume Control System	**CVC**	5.4.3	HI-2240166 [5]	SDD

System Group	SSC Description	System Acronym	B5 Chapter Sub-section	Reference Document	Document Type
	Fire Protection System	**FPS**	5.4.4	HI-2220555 [6]*	SDD
	Primary Sampling System	**PSL**	5.4.5	HI-2240168 [7]	SDD
	Residual Heat Removal System	**RHR**	5.4.6	HI-2240154 [8]	SDD
	Spent Fuel Pool Cooling System	**SFC**	5.4.7	HI-2240167 [9]	SDD
Steam and Power Conversion Systems	Main Feedwater System	**MFS**	5.5.2	HI-2240180 [10]	SDD
	Main Steam System	**MSS**	5.5.3	HI-2240179 [11]	SDD
Mechanical Handling Systems	Overhead Heavy Load Handling System	**CSH**	5.6.2	PS-8002-0002 [12]	PS
	Light Load Handling System	**LLH**	5.6.3	PS-8002-0001 [13]	PS
	Reactor Auxiliary Building Truck Bay Crane	**RBH**	5.6.4	PS-8002-0003 [14]	PS
HVAC	Containment Ventilation System	**CBV**	5.7.2	HI-2240583 [15]	SDD
	Radioactive Waste Building HVAC System	**RBV**	5.7.3	No document currently available	N/A
	Radiologically Controlled Area HVAC System	**RCV**	5.7.4	No document currently available	N/A
	Security Facilities HVAC System	**SFV**	5.7.5	No document currently available	N/A

**SMR-160 document.*

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

The standard project glossary of terms, abbreviations, and plant systems is provided in HI-2230643, SMR-300 Plant Breakdown Structure, Acronyms, and Glossary of Terms [16].

5.1.2 Assumptions

At this stage of the Generic SMR-300 design, assumptions have been made in the design of SSCs presented within this chapter. These assumptions can be found in the design documentation referenced in Table 1 and the lower-level documents that support these.

5.1.3 Interfaces With Other PSR Chapters

Systems within Chapter B5 interface with several other systems. Interfaces are detailed for each individual system covered in Sections 5.4 - 5.7. The major interfacing chapters are detailed below.

The generic design aspects are reported in Part A Chapter 2 [2]. SSCs in this chapter form part of the generic design.

SSCs in the RSF scope interface with systems described in Part B Chapter 1 ‘Reactor Coolant System and Engineered Safety Features’ [17] and Part B Chapter 2 ‘Reactor’ [18].

SSC claims are supported by information given in Part B Chapter 4 ‘Control and Instrumentation Systems’ [19], Part B Chapter 6 ‘Electrical Engineering’ [20], Part B Chapter 10 ‘Radiological Protection’ [21], Part B Chapter 17 ‘Human Factors’ [22], Part B Chapter 19 ‘Mechanical Engineering’ [23], Part B Chapter 23 ‘Reactor Chemistry’ [24] and Part B Chapter 24 ‘Fuel Transport and Storage’ [25].

This chapter also interfaces with elements of the Preliminary Environmental Report (PER). The Best Available Technique (BAT) demonstration for the SMR-300 generic design will be developed within Step 2, in line with BAT Approach [26] and GDA Scope [3], to indicate how radioactive waste will be prevented and minimised to reduce the impact on the members of the public and environment As Low As Reasonably Achievable (ALARA). Chapter B5 will help to ascertain which options are BAT and identify where design or operational changes may be required to achieve BAT, in support of the Approach and Application of BAT Demonstration. PSR Part B Chapter 11, Environmental Protection [27], serves as the interface between PSR and PER, and mainly summaries the PER and the approach of BAT for the Generic SMR-300 GDA, including an overview of legislation, policy, environmental claims, arguments and evidence relevant to this new nuclear development.

5.2 CLAIMS, ARGUMENTS, EVIDENCE

The primary purpose of a CAE approach is to capture the golden thread of a safety case narrative to demonstrate how plant and operational evidence is brought together and to justify that a high-level or fundamental claim is true. In the context of the GDA of the Generic SMR-300, that is how the Fundamental Purpose of the overarching Safety, Security and Environmental Case (SSEC, presented in PSR Part A Chapter 1 ‘Introduction’ [1]) is achieved.

The Fundamental Purpose follows a golden thread throughout the SSEC to CAE via the objectives of the PSR, the PER and the Generic Security Report (GSR). The overarching SSEC claims and the philosophy for their architecture is presented in PSR Part A Chapter 3 ‘Claims, Arguments & Evidence’ [28].

Part B Chapter 5 of the PSR presents the Claims, Arguments and intended Evidence of the design of Reactor Supporting Facilities, SSCs that underpin the SSEC of the Generic SMR-300.

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 SSCs. A Part B Chapter 5 specific claim on the Reactor Supporting Facilities is therefore made in 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 PSR Part B Chapter 5, across the different groups of supporting facilities, namely auxiliary systems, steam and power conversion systems, mechanical handling systems and heating, ventilation and air conditioning systems. Claim 2.2.13 is therefore broken into four further sub-claims.

Table 2 shows in which section of this PSR chapter these claims are demonstrated to be met.

Table 2: Claims and PSR Part B Chapter 5 Sections Supporting 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.	5.4 Auxiliary Systems
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.	5.5 Steam and Power Conversion 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.	5.6 Mechanical Handling Systems

Claim No	Claim	Chapter Section
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.	5.7 Heating, Ventilation and Air Conditioning Systems

In addition to these claims on their overall design and substantiation, several Reactor Supporting Facilities also comprise of a number of important supporting systems which primarily interface with the Reactor Coolant System and Engineered Safety Features described in PSR Part B Chapter 1 [17]. Claims relating to the plant's critical safety functions (2.2.1, 2.2.2, 2.2.3) are supported across several topic chapters. These are shown in Figure 1 - Figure 3, with the claims supported by this chapter (B5) highlighted. There are no SSCs within the ESF scope of PSR Part B Chapter 5 that directly support the demonstration of claim 2.2.2.

PSR Part B Chapter 5 supports demonstration of Claim 2.2.1 (Figure 1) relating to the control of reactivity:

Claim 2.2.1: Adequate provision for the control of reactivity is incorporated into the design.

Specifically, PSR Part B Chapter 5 contributes to the demonstration of Claim 2.2.1 through the level four claim:

Claim 2.2.1.1: There is provision in the design to ensure that the reactor can be shutdown, via boron control in the RCS, in plant modes A through E.

At PSR Revision 0, claim 2.2.1.1 is presented in this chapter and supported primarily by the CVC. See the Technical Summary in Section 5.8.1 for details on development and decomposition of this claim.

The ESF SSCs have an important role in control of radiation exposure and control of release of radioactive material (e.g. supporting integrity of the reactor coolant pressure boundary). PSR Part B Chapter 5 therefore also supports demonstration of Claim 2.2.3 (Figure 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.

Specifically, Part B Chapter 5 contributes to the demonstration of Claim 2.2.3 through three level four claims:

Claim 2.2.3.1: Integrity of the reactor coolant pressure boundary is ensured following credible initiating events in all plant states.

Claim 2.2.3.2: The Containment Structure integrity is ensured following credible initiating events.

Claim 2.2.3.10: The concentration of combustible gases in the containment volume is adequately limited following a design basis accident.

Claim 2.2.3.10 is supported by the combustible gas system and is presented in sub-section 5.4.2 "Combustible Gas Control System (CGC)”.

Claims 2.2.3.1 and 2.2.3.2 are applicable across both chapters B1 and B5 and thus are decomposed one level further to be specific to this chapter. The level five claims directly supported by chapter B5 are:

Claim 2.2.3.1.2: Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Boundary following credible initiating events in all plant states.

Claim 2.2.3.2.2: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events.

These two level five claims are applicable to multiple systems within this chapter.

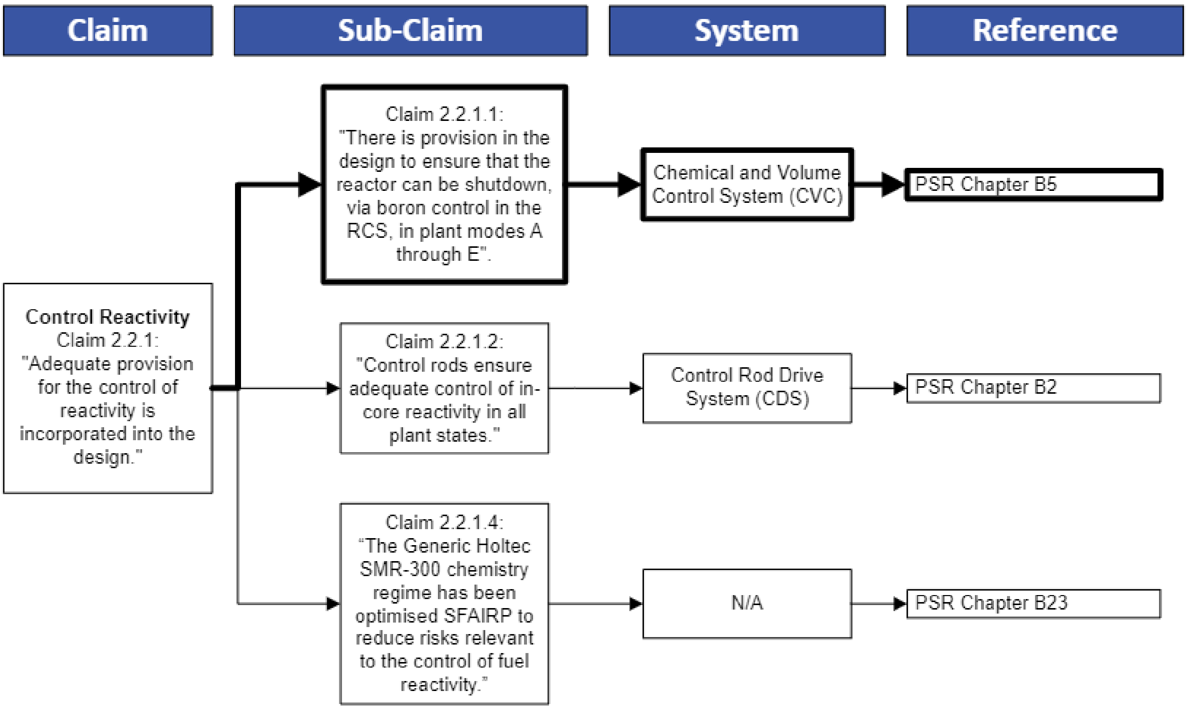

Figure 1: Claim 2.2.1 Decomposition

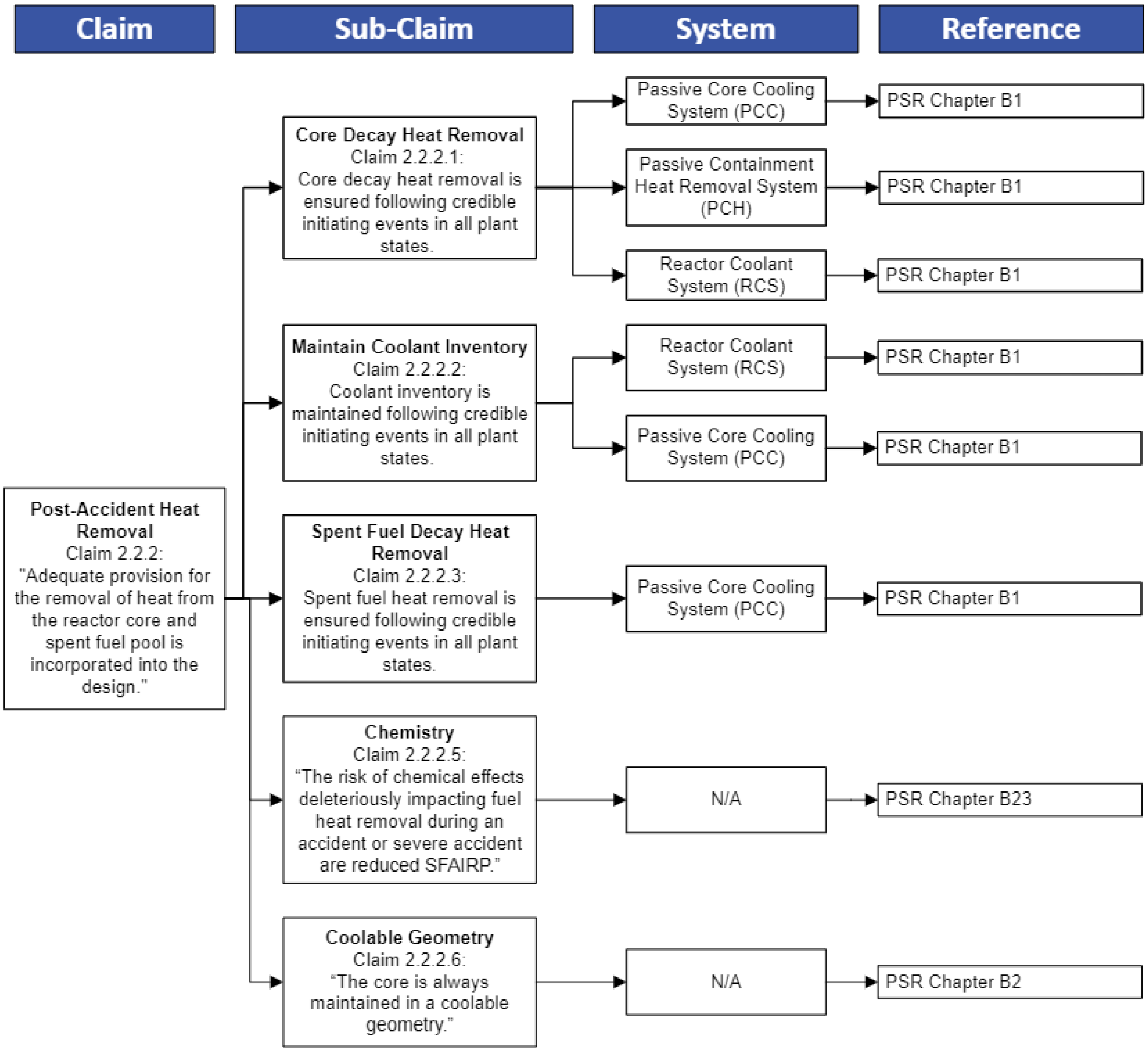

Figure 2: Claim 2.2.2 Decomposition[2]

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[2] Chapter B5 has no SSCs which directly support claim 2.2.2.

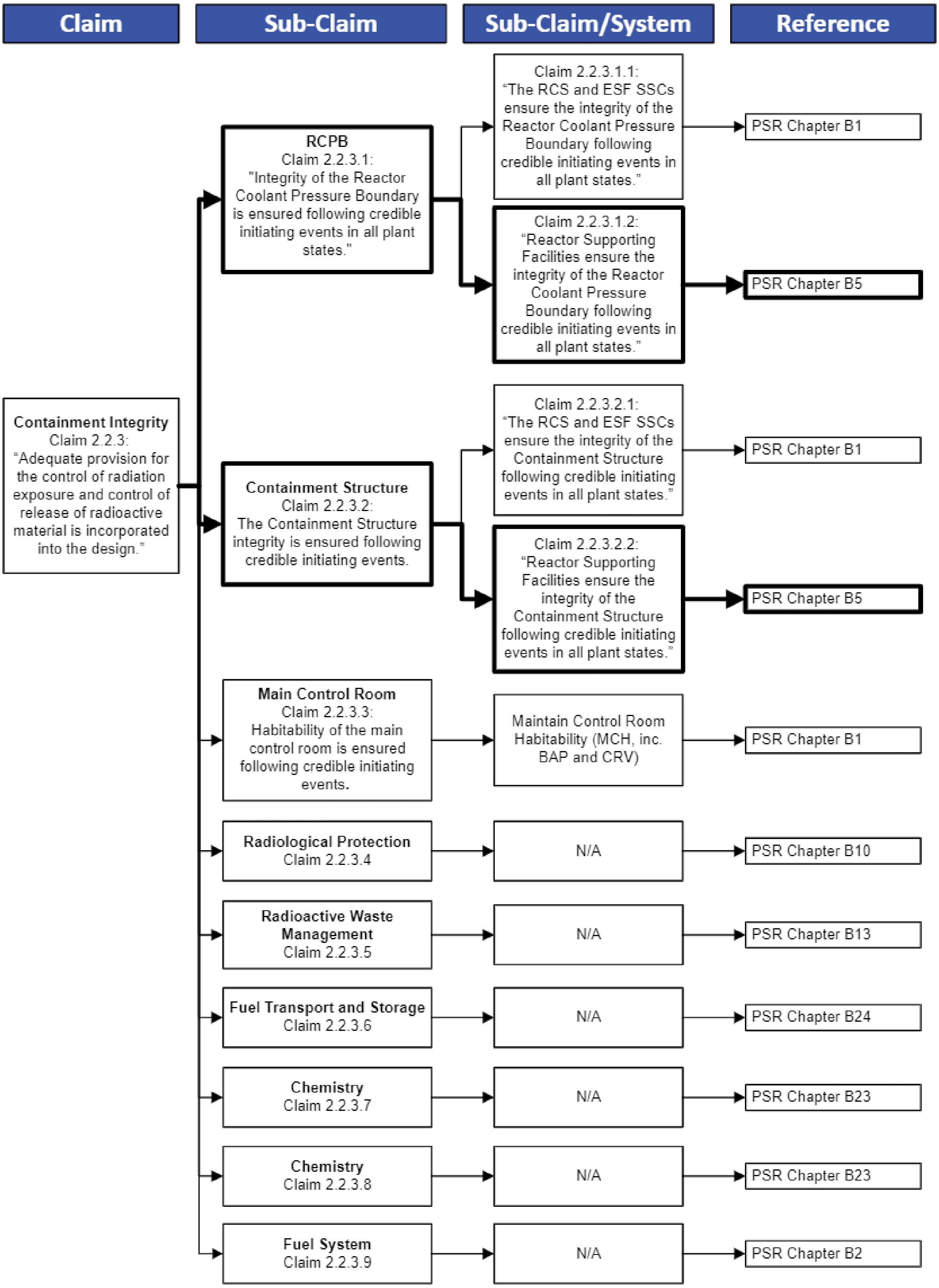

Figure 3: Claim 2.2.3 Decomposition

The Generic SMR-300 Overarching SSEC Claim Route map is presented in Appendix A of PSR Part A Chapter 3 [28]. A further update on claim decomposition, argument development and evidence maturity will be provided in the subsequent update of the chapter.

5.3 CODES, STANDARDS AND METHODOLOGY

Relevant codes and standards are selected based on the Holtec International seismic 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 [29], and utilises the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.26, Revision 6 [30] and related guidance documents. This methodology is described in PSR Part A Chapter 2, Subchapter 3.1 [2], which describes RG 1.26 Quality Groups A through D, and corresponding SSC Classification Standard “SMR Class”. An overview of the SMR Classes is shown in Table 3.

Table 3: Holtec SMR Class [29]

SMR Class	Safety Classification	10 CFR 50 Appendix B Applies (Y/N)	RG 1.26 Quality Group
A	Safety-related	Y	A
B	Safety-related	Y	B
C	Safety-related	Y	C
D	Non-safety-related	N	D
E	Non-safety-related	N	D
F	Non-safety-related	N	N/A

The SSC Classification Standard [29] designates the Quality classification of SSCs. An overview of the classification of the Reactor Supporting Facilities SCCs is shown in Appendix A.

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 [29]

Component	Quality Group A	Quality Group B	Quality Group C	Quality Group D
Pressure Vessels	ASME BPV Code, 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)	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)	API-650, AWWA D100, or ANSI B96.1

Component	Quality Group A	Quality Group B	Quality Group C	Quality Group D
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

ANSI/IEEE-603-1991 [31] gives the basic criteria for safety-related electrical and Instrumentation and Control (I&C) systems and equipment. Electrical and I&C system equipment and components are classified as Class 1E or Non-Class 1E in accordance with definitions stated in IEEE 603 Standard. In general, the equipment and components that perform safety-related functions are designated as Class 1E and the equipment and components that do not perform any safety-related function are designated as Non-Class 1E. IEEE-603 Standard is endorsed by Regulatory Guide 1.153 [32] as a method acceptable to the USNRC for complying with 10 CFR 50 [33] Appendix A General Design Criteria, 10 CFR 50.49, and 10 CFR 50.55a, with respect to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of safety systems for nuclear power plants. Further details of Electrical and I&C systems codes and standards is provided in PSR Part B Chapter 6 'Electrical Engineering' [20] and PSR Part B Chapter 4 'Control and Instrumentation Systems' [19].

The Requesting Party (RP) acknowledge the existence of differences in the approach to safety categorisation and classification between the NRC regulatory guides and the UK expectations. The GDA for the Generic SMR-300 will require the adoption of the UK approach, so far as is reasonably practicable, so that it is fit for use as the starting point for a future licensee's site-specific project. This Forward Action is described in PSR Part A Chapter 2, Subchapter 8 [4].

5.4 AUXILIARY SYSTEMS

5.4.1 Auxiliary Systems Overview

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 (CGC).
- Chemical and Volume Control System (CVC).
- Fire Protection System (FPS).
- Primary Sampling System (PSL).
- Residual Heat Removal System (RHR).
- Spent Fuel Pool Cooling System (SFC).

5.4.2 Combustible Gas Control System (CGC)

5.4.2.1 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 percent 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) to less than 10 percent by volume to prevent a deflagration or detonation that could threaten non-inerted 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 (REDACTED) by the use of a number of Passive Auto-catalytic Recombiners (PARs). 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.

5.4.2.2 System Functions

5.4.2.2.1 CAE

The safety claim and argument that the CGC supports are as follows:

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

***Sub-claim 2.2.3.10**: "The concentration of combustible gases in the containment volume is adequately limited following a design basis accident."*

***Argument**: "The CGC employs Passive Autocatalytic Recombiners (PARs) to maintain hydrogen concentrations less than 10% by volume in the containment atmosphere following their postulated release during an accident involving significant core damage."*

5.4.2.2.2 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 (REDACTED) in the containment atmosphere.

5.4.2.2.3 Non-Safety Functions

There are no non-safety related functions defined for this system at Revision 0.

5.4.2.3 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. For the SMR-300, such an event is conservatively considered in the design due to the fuel and containment design. Accordingly, the need for a reliable CGC is essential. The SMR-300 design employs Passive Autocatalytic Recombiners (PARs) to limit the hydrogen concentration inside containment.

Containment structures shall be arranged to promote mixing via natural circulation to ensure a mixed atmosphere during design basis and beyond design basis accidents.

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

The information presented in this section at Revision 0 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. Updates based on any changes to the system in the Generic SMR-300 design will be included at Revision 1 and beyond.

5.4.2.4 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.

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.4.2.5 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 ICS structure.	B20 [35]

5.4.3 Chemical and Volume Control System (CVC)

5.4.3.1 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 Reactor Coolant Pumps (RCPs).

The CVC contains isolation valves to maintain the integrity of the Reactor Coolant Pressure Boundary (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.

5.4.3.2 System Functions

5.4.3.2.1 CAE

The safety claims and arguments that the CVC supports are as follows:

***Claim 2.2.1:** "Adequate provision for the control of reactivity is incorporated into the design."*

***Claim 2.2.1.1:** "There is provision in the design to ensure that the reactor can be shutdown, via boron control in the RCS, in plant modes A through E."*

***Argument**: "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."*[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."*

***Sub-claim 2.2.3.1.2**: "Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Pressure Boundary following credible initiating events in all plant states."*

***Argument 1**: "The CVC contains valves to isolate the charging line and the letdown line following credible initiating events."*

***Argument 2**: "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."*

***Sub-claim 2.2.3.2.2**: "Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events."*

***Argument**: "The CVC containment penetrations are provided with isolation to preserve the integrity of the containment envelope."*

5.4.3.2.2 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 overpressurisation 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.

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[3] Reactivity control is currently listed as a non-safety function but supports the demonstration of Claim 2.2.1.1. See Technical Summary in Section 5.8.1 for further detail.

5.4.3.2.3 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 (PCM), 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, tanks (PCMWTs), 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.

5.4.3.3 System Description

The CVC (see Figure 4, Figure 5, and Figure 6) equipment is located inside containment and the Reactor Auxiliary Building (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.

5.4.3.3.1 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 reliability. 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 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.

5.4.3.3.2 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 (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 to restore VCT level to normal. The charging pumps can also take suction from the effluent holdup tanks (HUTs) or the RWST, if necessary. However, it is not guaranteed that the HUTs will be at a higher boron concentration than the current RCS boron concentration.

5.4.3.3.3 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 [24]. 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.

5.4.3.3.4 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.

5.4.3.3.5 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 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.

5.4.3.3.6 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 4: REDACTED

REDACTED

Figure 5: REDACTED

REDACTED

Figure 6: REDACTED

5.4.3.4 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 AOVs 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 CVCS operating.

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.4.3.5 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.	B1 [17]
DAS	Diverse Actuation System	The DAS controls the safety-related valves upon PSS failure.	B4 [19]
DCE	DC Power Distribution System	The containment isolation valves with actuators are powered by the DCE.	B6 [20]
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.	B13 [36]
Hydrogen Tank	Hydrogen	The Hydrogen is supplied to the VCT for corrosion control during power operations.	Not in GDA scope
ICE	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.	B6 [20]
LRW	Liquid Radwaste System	The LRW receives effluents stored in the CVC HUTs ready for waste processing and disposal.	B13 [36]
LVE	Low Voltage AC Distribution System	The Pump motors are powered by the non-safety portion of the LVE.	B6 [20]
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.	B4 [19]
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.	B1 [17]
PCS	Plant Control System	The Control system for the non-safety portions of the CVC.	B4 [19]
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.	B5
PSS	Plant Safety System	The Control system for the safety-related portions of the CVC.	B4 [19]
RCS	Reactor Coolant System	The CVC maintains the RCS reactor coolant inventory and chemistry requirements while maintaining the RCPB.	B1 [17]
RHR	Residual Heat Removal System	The RHR provides flow through the CVC purification equipment during low pressure operations in the RCS.	B5

System	Description	Function	PSR Chapter
SFC	Spent Fuel Pool Cooling System	The CVC provides normal borated makeup water to maintain the refuelling water storage tank and spent fuel pool levels. The RWST can also be used as a source for makeup to the charging pumps and effluent makeup pumps.	B5
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.	B13 [36]

5.4.4 Fire Protection System (FPS)

5.4.4.1 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 Nuclear Island (NI) areas, as identified in the Fire Hazards Analysis (FHA) and depicted on Fire Protection System Drawings.

The information presented in this section at Revision 0 is based on the SMR-160 design. This is considered acceptable at this stage as the claims and function of the FPS are not anticipated to fundamentally change. Updates based on any changes to the system in the Generic SMR-300 design will be included at Revision 1 and beyond. (REDACTED).

5.4.4.2 System Functions

5.4.4.3 CAE

The claims which the FPS supports have not been developed at the time of Revision 0. These will be developed for inclusion in Revision 1 of this chapter.

5.4.4.3.1 Safety Functions

The FPS has no safety related functions defined at the time of Revision 0. These will be developed for inclusion in Revision 1 of this chapter.

5.4.4.3.2 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.

5.4.4.4 System Description

5.4.4.4.1 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 NFPA 20, "Standard for the Installation of Stationary Pumps for Fire Protection" [37], NFPA 22, "Standard for Water Tanks for Private Fire Protection" [38], and NFPA 24, "Standard for the Installation of Private Fire Service Mains and Their Appurtenances" [39].

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 [40] 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 [39].

Fire Protection Tanks

The fire water supply is provided by two 100 percent 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 (REDACTED). 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 [38].

Fire Pumps

Fire water pumps are provided. The fire pumps will conform to NFPA 20 [37]. 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 percent rated capacity to the fire distribution system. The fire pumps are two 100 percent 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.

5.4.4.4.2 Automatic Fire Suppression Systems

Fire suppression systems are installed as informed by regulation and/or guidance documents, the FHA, 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 FHA. 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” [41]. Automatic water spray systems are installed in accordance with NFPA 15, “Standard for Water Spray Fixed Systems for Fire Protection” [42].

Clean Agent Suppression Systems

Clean agents are chosen based on the FHA 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” [43].

5.4.4.4.3 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" [44] 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 [40].

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” [45] for the proper sizing and type.

5.4.4.4.4 Fire Alarm and Detection Systems

Fire alarm and detection systems comply with the requirements of NFPA 72 [46] and NFPA 70 [47]. 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.

5.4.4.5 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.4.4.6 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.	B1 [17]
LVE	Low Voltage AC Distribution System	LVE provides power to the electric fire pump.	B6 [20]
ICE	Instrument and Control Power Distribution System	ICE provides power for the fire alarm and detection system.	B6 [20]
HVAC	HVAC	HVAC will require shutdown for gaseous suppression actuation to main agent concentration.	B5

5.4.5 Primary Sampling System (PSL)

5.4.5.1 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.

5.4.5.2 System Functions

5.4.5.2.1 CAE

The safety claims and arguments that the PSL supports are as follows:

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

Sub-claim 2.2.3.1.2*: "Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Pressure Boundary following credible initiating events in all plant states."*

Argument*: "Sample lines connected to the RCS within the Containment Structure (CS) boundary have remotely operated isolation valves to maintain the RCPB integrity."*

Sub-claim 2.2.3.2.2*: "Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events."*

Argument*: "The PSL penetrates the CS boundary and provides the containment isolation function."*

5.4.5.2.2 Safety Functions

The safety functions of the PSL are:

- **Maintain the Reactor Coolant Pressure Boundary Integrity.**
  Sample lines connected to the RCS within the Containment Structure (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.

5.4.5.2.3 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.

5.4.5.3 System Description

5.4.5.3.1 Primary Sampling Panel

The Primary Sampling Panel 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 tubing 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.

5.4.5.3.2 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 Liquid Radioactive Waste (LRW) – see PSR Part B Chapter 13 [36].

5.4.5.3.3 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.

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Figure 7: REDACTED

5.4.5.4 System Reliability

The SSCs that perform a safety function shall be designed in accordance with the SMR-300 Design Standard for Application of Single Failure Criterion 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 to provide sufficient redundancy, separation, and independence for SSCs important to safety.

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.4.5.5 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.	B1 [17]
CVC	Chemical and Volume Control System	The PSL monitors parameters from the CVC letdown and Boric Acid Storage tanks	B5
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.	B13 [36]
GRW	Gaseous Radwaste System	The PSL monitors parameters from the charcoal beds of the GRW.	B13 [36]
PCC	Passive Core Cooling System	The PSL monitors parameters from the Passive Core Makeup Water Tanks and Accumulator Tanks of the PCC.	B1 [17]
RCS	Reactor Coolant System	The PSL monitors parameters from the RCS Hot Leg and Pressuriser.	B1 [17]
SRW	Solid Radwaste System	The PSL monitors parameters in the Spent Resin Tank.	B13 [36]
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.	B6 [20]
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.	B6 [20]
PAM	Post-Accident Monitoring System	The PSL provides post-accident confirmatory sampling information to support the PAM.	B4 [19]
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.	B4 [19]
PSS	Plant Safety System	The PSS monitors and controls the PSL equipment and components with safety functions. PSL instrumentation provides signals to PSS.	B4 [19]
RCV	Radiologically Controlled Area HVAC	The sample hoods in the PSL vent to the RCV.	B5
RHR	Residual Heat Removal System	The PSL monitors parameters from both trains in the RHR.	B5
RMS	Radiation Monitoring System	The RMS provides area radiation monitoring for locations in the PSL.	B4 [19]
RDS	Radioactive Drain System	Sample sinks and leakage from the PSL drains to the RWDS.	B13 [36]
SFC	Spent Fuel Pool Cooling System	The PSL monitors parameters in the Spent Fuel Pool (SFP) and Refuelling Water Storage Tank (RWST).	B5

5.4.6 Residual Heat Removal System (RHR)

5.4.6.1 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.

5.4.6.2 System Functions

5.4.6.2.1 CAE

The safety claim and argument that the RHR supports are as follows:

> ***Claim 2.2.3****: “Adequate provision for the control of radiation exposure and control of release of radioactive material is incorporated into the design.”*
>
> ***Sub-claim 2.2.3.1.2****: “Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Pressure Boundary following credible initiating events in all plant states.”*
>
> ***Argument****: “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.”*

5.4.6.2.2 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.

5.4.6.2.3 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.

5.4.6.3 System Description

A process flow diagram for the Residual Heat Removal System can be found in Figure 8.

5.4.6.3.1 Normal Shutdown Heat Removal

As previously mentioned in section 5.4.6.1, 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. See Figure 8 for the system diagram.

5.4.6.3.2 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 overpressurisation during low temperature conditions, where a brittle failure is possible while the plant is starting up from shutdown/refuelling.

5.4.6.3.3 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.

5.4.6.3.4 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.

5.4.6.3.5 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.

5.4.6.3.6 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.

5.4.6.3.7 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).

5.4.6.3.8 Diverse and Flexible Coping Strategies

A connection at the common discharge header is located outside containment and supports strategies for FLEX (Diverse and Flexible Coping Strategies). 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 8: REDACTED

5.4.6.4 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 CIVs 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.

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.4.6.5 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	B1 [17]
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.	B1 [17]
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.	B5
PCM	Passive Core Makeup Water System	The RHR provides LTOP for the RCS by using a relief valve that drains into the PCMWT	B1 [17]
PSS	Plant Safety System	The PSS provides the isolation signal to close the CIVs.	B4 [19]
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.	B6 [20]
ICE	I&C Power Distribution System	The ICE supplies power to non-safety related MOVs and pumps in the RHR.	B6 [20]
LVE	Low Voltage AC Distribution System	The LVE supplies power to non-safety related MOVs and pumps in the RHR.	B6 [20]
PCS	Plant Control System	The PCS monitors and controls the RHR equipment and components with non-safety functions. RHR instrumentation provides signals to PCS.	B4 [19]
PAM	Post-Accident Monitoring System	RHR instrumentation supports accident monitoring and post-accident monitoring.	B4 [19]
LRW	Liquid Radwaste System	The relief valve in the RHR discharge line discharges to the containment sump in the LRW.	B13 [36]
CVC	Chemical and Volume Control System	The RHR provides a path to the CVC for purification during low pressure conditions.	B5

5.4.7 Spent Fuel Cooling System (SFC)

5.4.7.1 System Overview

The SFC consists of the Spent Fuel Pool (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.

5.4.7.2 System Functions

5.4.7.2.1 CAE

The safety claim and argument that the SFC supports are as follows:

> ***Claim 2.2.3***: *"Adequate provision for the control of radiation exposure and control of release of radioactive material is incorporated into the design."*
>
> ***Sub-claim 2.2.3.2.2***: *"Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events."*
>
> ***Argument***: *"The SFC penetrates containment and performs a containment isolation function to maintain the containment pressure boundary."*

5.4.7.2.2 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.

5.4.7.2.3 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 demineralised water system (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.

5.4.7.3 System Description

A process flow diagram of the Spent Fuel Pool Cooling System can be found in Figure 9.

5.4.7.3.1 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 below the normal SFP water level. This maintains adequate 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.

5.4.7.3.2 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.

5.4.7.3.3 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 ALARA 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.

5.4.7.3.4 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 9: REDACTED

5.4.7.4 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:

- One 100% capacity SFC pump
- One 100% capacity SFC heat exchanger
- One 100% capacity SFC demineraliser and filter
- Cross connected piping with RHR train

- During Refuelling Operation: One of the RHR trains and SFC train will be in operation during refuelling to handle increased SFP heat load from a full core off-load. In the event of a failure in the SFC, both RHR trains will be aligned to cool the SFP. In the event of failure of working RHR train, the other RHR train will be aligned to cool down the SFP.

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.

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.4.7.5 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	B1 [17]
AR	Annular Reservoir	The AR dissipates heat added to containment from the SFP to the atmosphere when the SFC is not available	B1 [17]
SRW	Solid Radwaste System	Spent demineraliser resins are collected and processed by the SRW	B13 [36]
LLH	Light Load Handling System	SFC supports refuelling operations. However, there is no physical interface between LLH and SFC.	B5
PSS	Plant Safety System	Control system for the safety portions of SFC, including the CIVs.	B4 [19]
PCS	Plant Control System	Control system for the non-safety portions of the SFC.	B4 [19]
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	B1 [17]
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.	B5
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.	B5
CIS	Containment Isolation System	SFC valves that form a part of the containment barrier also form part of the CIS.	B1 [17]
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.	B5

System	Description	Function	PSR Chapter
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.	B6 [20]
ICE	I&C Power Distribution System	The DCE supplies power to safety related MOVs of the SFC.	B6 [20]
LVE	Low Voltage AC Distribution System	The LVE supplies power to non-safety related MOVs and pumps in the SFC.	B6 [20]

5.4.8 Auxiliary Systems Summary

The Steam and Power Conversion 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. Further substantiation of this claim shall be provided in Revision 1 of this chapter and in supporting engineering chapters. Information on Codes and Standards are described in PSR Part B Chapter 19 ‘Mechanical Engineering’ [23].

The CVC supports demonstration of claim 2.2.1.1:

Claim 2.2.1.1: There is provision in the design to ensure that the reactor can be shutdown, via boron control in the RCS, in plant modes A through E.

This claim is demonstrated by the provision in the CVC to control boron concentration in the RCS and its ability to provide and independent means for the shutdown of the reactor.

Additionally, the CVC, PSL and RHR support and demonstrate claim 2.2.3.1.2:

Claim 2.2.3.1.2: Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Boundary following credible initiating events in all plant states.

This is demonstrated in all systems with isolation measures to RCPB integrity.

The CVC, PSL, RHR and SFC support and demonstrate claim 2.2.3.2.2:

Claim 2.2.3.2.2: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events.

This is demonstrated in all systems with isolation measures to preserve containment boundary integrity.

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

5.5 STEAM AND POWER CONVERSION SYSTEMS

5.5.1 Steam and Power Conversion Systems Overview

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:

- Main Feedwater System (MFS)
- Main Steam System (MSS)

5.5.2 Main Feedwater System (MFS)

5.5.2.1 System Overview

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

5.5.2.2 System Functions

5.5.2.2.1 CAE

The safety claims and arguments that the MSL supports are as follows:

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

Sub-claim 2.2.3.2.2: *“Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events.”*

Argument: *“The MFS penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.”*

5.5.2.2.2 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.

5.5.2.2.3 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 [48].
- **Provide cooling water to the Turbine Bypass System (TBS)**
  The MFS supplies water to the spray nozzle of the desuperheaters in the TBS, see reference [48]. The TBS is not in GDA scope.

5.5.2.3 System Description

A process flow diagram of the Main Feedwater System can be found in Figure 10.

5.5.2.3.1 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 [35]).

The condensate pumps take suction from the condenser hotwell 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 SG.

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 (MFCVs) and one start-up flow control valve are provided. Two

MFCV's 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.

REDACTED

Figure 10: REDACTED

5.5.2.4 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

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. 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 URD [49].

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.

5.5.2.5 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.	B5
RCS	Reactor Coolant System	The MFS provides feedwater to the SGE to remove heat from the RCS.	B1 [17]
PSS	Plant Safety System	The PSS provides the main feedwater isolation signal to close the MFIV.	B4 [19]
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.	B1 [17]
DCE	DC Power Distribution System	The DCE supplies power to safety-related motor-operated valves of the MFS.	B6 [20]
ICE	I&C Power Distribution System	The ICE supplies power to the instrumentation and AOVs of the MFS.	B6 [20]
LVE	Low Voltage AC Distribution System	The LVE supplies power to non-safety valve motors in the MFS.	B6 [20]
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.	B4 [19]
SDH	Secondary Decay Heat Removal System	The supply piping for SDH is in the MFS discharge header to the Steam Generator.	B1 [17]
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

5.5.3 Main Steam System (MSS)

5.5.3.1 System Overview

The role of the Main Steam System 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 Turbine Bypass System (TBS) but these functions are not credited in safety analysis.

The MSS connects the secondary side of the steam generator 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 feedwater heaters (FWH) in the MFS to improve plant efficiency.

5.5.3.2 System Functions

5.5.3.2.1 CAE

The safety claims and arguments that the MSS supports are as follows:

> ***Claim 2.2.3**: "Adequate provision for the control of radiation exposure and control of release of radioactive material is incorporated into the design."*
>
> ***Sub-claim 2.2.3.2.2**: "Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events."*

***Argument**: "The MSS containment penetration is provided with isolation capabilities to preserve the integrity of the containment boundary."*

5.5.3.2.2 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.

5.5.3.2.3 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 Secondary Sampling System (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 overpressurisation. 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 Residual Heat Removal System (RHR) can be placed in service.

5.5.3.3 System Description

The MSS (Figure 13) 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. The Radioactive Monitoring System (RMS), Main Steam Safety Valves (MSSVs), Atmospheric Dump Valve (ADV), a low-point drain, and Main Steam Isolation Bypass Valve (MSIBV) are connected to the main steam header in the Intermediate Building 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 Intermediate Building (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 11: REDACTED

5.5.3.4 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.5.3.5 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.	B1 [17]
DCE	DC Power Distribution System	The DCE supplies power to the safety-related valve motors in the MSS.	B6 [20]
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.	B6 [20]

System	Description	Function	PSR Chapter
LVE	Low Voltage AC Distribution System	The LVE supplies power to non-safety valve motors in the MSS	B6 [20]
MFS	Main Feedwater System	The MSS provides extraction steam for the heating of the feedwater in the MFS.	B5
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.	B4 [19]
PCS	Plant Control System	The PCS monitors and controls the MSS equipment and components with non-safety functions. MSS instrumentation provides signals to PCS.	B4 [19]
PSS	Plant Safety System	The PSS monitors and controls the MSS equipment and components with safety functions. MSS instrumentation provides signals to PSS.	B4 [19]
RCS	Reactor Coolant System	The SGE in the RCS provides the main steam to the MSS.	B1 [17]
RMS	Radiation Monitoring System	The RMS provides area radiation monitoring in the MSS.	B4 [19]
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

5.5.4 Steam and Power Conversion Systems 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 for each system are described above and, in addition, detail is provided on how the design of the system delivers these safety features. Further substantiation of this claim shall be provided in Revision 1 of this chapter and in supporting engineering chapters. Information on Codes and Standards are described in PSR Part B Chapter 19 ‘Mechanical Engineering’ [23].

Additionally, the MFS and MSS both support and demonstrate claim 2.2.3.2.2:

Claim 2.2.3.2.2: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events.

This is demonstrated in both systems with isolation measures to preserve containment boundary integrity.

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.

5.6 MECHANICAL HANDLING SYSTEMS

5.6.1 Mechanical Handling Systems Overview

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 (CSH)
- Light Load Handling System (LLH)
- Reactor Auxiliary Building Truck Bay Crane (RBH)

5.6.2 Overhead Heavy Load Handling System (CSH)

5.6.2.1 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 0 of this chapter, the system's design is in development and the RP are working with suppliers/manufacturers for the Polar Crane design. It will be designed in line with requirements outlined in Section 5.6.2.3.

5.6.2.2 System Functions

5.6.2.2.1 CAE

The Overhead Heavy Load Handling system supports claim 2.2.3.6. This claim is outlined in PSR Part B Chapter 24 'Fuel Transport and Storage' [25].

Claim 2.2.3.6: SSCs which support operational fuel activities are designed to ensure safety functions and measures are delivered and radiation exposure and release of radioactive material are minimised So Far As Is Reasonably Practicable (SFAIRP).

5.6.2.2.2 Safety Functions

The safety related functions the system of the CSH will be developed for Revision 1 of this chapter.

5.6.2.2.3 Non-Safety Functions

The non-safety related functions the system of the CSH will be developed for Revision 1 of this chapter.

5.6.2.3 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 / 10 CFR 21. The Polar Crane shall comply with the design criteria ASME NOG 1 [50] and applicable sections of design standards referenced within the aforementioned standards.

The Polar Crane lifting system 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

5.6.2.4 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.6.2.5 System Interfaces

The system interfaces of the CSH will be developed for Revision 1 of this chapter. See also PSR Part B Chapter 19 ‘Mechanical Engineering’ [23] and Part B Chapter 24 ‘Fuel Transport and Storage’ [25] for additional supporting information on this system.

5.6.3 Light Load Handling System (LLH)

5.6.3.1 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 (FA), Spent Fuel Assemblies (SFA), Rod Cluster Control Assemblies (RCCA) and Burnable Poison Rod Assembly (BPRA) within the spent fuel pool.

Similar to the CSH, at the time of Revision 0 of this chapter, the LLH 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 5.6.3.3.

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

5.6.3.2 System Functions

5.6.3.2.1 CAE

The Light Load Handling system supports claim 2.2.3.6. This claim is outlined in Part B Chapter 24 ‘Fuel Transport and Storage’ [25].

Claim 2.2.3.6: SSCs which support operational fuel activities are designed to ensure safety functions and measures are delivered and radiation exposure and release of radioactive material are minimised So Far As Is Reasonably Practicable (SFAIRP).

5.6.3.2.2 Safety Functions

The safety related functions of the system of the LLH will be developed for Revision 1 of this chapter.

5.6.3.2.3 Non-Safety Functions

The non-safety related functions of the LLH will be developed for Revision 1 of this chapter.

5.6.3.3 System Description

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:

- FA from Multi-Purpose Canister (MPC) to SFA storage.
- FA 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 Burnable Poison Rod Assembly movements.
- Support reactor disassembly/reassembly during refuelling activities.
- Other operations.

Additionally, the LLH shall be used for movements of miscellaneous loads and tools to support the SMR-300 operations and maintenance processes within the spent fuel pool.

The LLH 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 spent fuel pool 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 operates 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 LLH 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.

The LLH will be designed in line with the applicable requirements of ASME NOG-1 [50], ASNI/ANS57.1 [51] and NUREG-0554 [52].

5.6.3.4 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.6.3.5 System Interfaces

The system interfaces of the LLH will be developed for Revision 1 of this chapter. See also Part B Chapter 19 'Mechanical Engineering' [23] and Part B Chapter 24 'Fuel Transport and Storage' [25] for additional supporting information on this system.

5.6.4 Reactor Auxiliary Truck Bay Building Crane (RBH)

5.6.4.1 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 0, 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 5.6.4.3.

5.6.4.2 System Functions

5.6.4.2.1 CAE

The Reactor Auxiliary Building Crane system supports claim 2.2.3.6. This claim is outlined in Chapter B24 'Fuel Transport and Storage' [25].

Claim 2.2.3.6: SSCs which support operational fuel activities are designed to ensure safety functions and measures are delivered and radiation exposure and release of radioactive material are minimised So Far As Is Reasonably Practicable (SFAIRP).

5.6.4.2.2 Safety Functions

The safety related functions the system of the RBH will be developed for Revision 1 of this chapter.

5.6.4.2.3 Non-Safety Functions

The non-safety related functions the system of the RBH will be developed for Revision 1 of this chapter.

5.6.4.3 System Description

The RAB crane is designed as a Seismic Category II. Its design will adhere to the criteria outlined in CMAA Specification 70 [53]; ANSI/ASME B30.2 [54] and ANSI/ANS 57.1 [51], 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 Reactor Auxiliary Building, 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 Reactor Auxiliary Building.

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.
- Reactor Coolant Pump (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 Reactor Auxiliary Building.

5.6.4.4 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.6.4.5 System Interfaces

The system interfaces of the RBH will be developed for Revision 1 of this chapter. See also PSR Part B Chapter 19 ‘Mechanical Engineering’ [23] and Part B Chapter 24 ‘Fuel Transport and Storage’ [25] for additional supporting information on this system.

5.6.5 Mechanical Handling Systems Summary

The Mechanical Handling Systems, as described in the preceding subsections, 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.

Some safety features have been identified but at this stage of the design of Mechanical Handling Systems, full safety functions and substantiation are not yet mature. As the GDA process continues and the design of these systems mature, this claim will be demonstrated. This also applies to the contribution these systems make to claims made in other PSR chapters, namely Part B Chapter 24 'Fuel Transport and Storage' [25] and Claim 2.2.3.6. Information on Codes and Standards are described in PSR Part B Chapter 19 'Mechanical Engineering' [23].

Therefore as the design and safety case progresses, it will be shown that the Mechanical Handling Systems demonstrate claim 2.2.13.3.

5.7 HEATING, VENTILATION AND AIR CONDITIONING SYSTEMS

5.7.1 HVAC Systems Overview

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 (CBV)
- Radioactive Waste Building HVAC System (RBV)
- Radiologically Controlled Area HVAC System (RCV)
- Security Facilities HVAC System (SFV)

5.7.2 Containment Ventilation System (CBV)

5.7.2.1 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.

5.7.2.2 System Functions

5.7.2.2.1 CAE

The safety claim and argument that the CBV supports are as follows:

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

Sub-claim 2.2.3.2.2*: "Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events."*

Argument*: "The parts of the CBV that penetrate containment maintain the containment integrity."*

The Containment Ventilation System also supports claim 2.2.3.4.4. This claim is outlined in Part B Chapter 10 Radiological Protection [25].

Claim 2.2.3.4.4: Ventilation and containment systems are designed to meet Radiation Protection Requirements and minimise exposures.

5.7.2.2.2 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.

5.7.2.2.3 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.

5.7.2.3 System Description

The Containment Ventilation System 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.

5.7.2.3.1 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 Passive Containment Heat Removal System (see PSR Part B Chapter 1 [17]).

5.7.2.3.2 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 supply (REDACTED) to meet ANS 56.6 [55] requirements. Outside air is heated to (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 Radiation Monitoring System) to prevent unmonitored releases. The containment penetrations are 8-inch diameter consistent with ANS 56.6 [55] 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. (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.

5.7.2.4 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.7.2.5 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.	B6 [20]
PSS	Plant Safety System	Control system for the safety portions of the CBV, including the CIVs.	B4 [19]

PCS	Plant Control System	Control system for the non-safety portions of the CBV.	B4 [19]
CIS	Containment Isolation System	Isolation valves on CBV lines penetrating the containment shall close on containment isolation signal.	B1 [17]
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.	B6 [20]
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.	B6 [20]
RMS	Radiation Monitoring System	The RMS receives input from the purge exhaust radiation monitor.	B4 [19]
RDS	Radioactive Drain System	Condensate from the cooling AHUs and water from the exhaust purge charcoal filter fire suppression will drain to the RDS.	B13 [36]

See also PSR Part B Chapter 19 ‘Mechanical Engineering’ [23] and Part B Chapter 10 ‘Radiological Protection’ [21] for additional supporting information on this system.

5.7.3 Radioactive Waste Building HVAC System (RBV)

5.7.3.1 System Overview

The system overview of the RBV will be developed for Revision 1 of this chapter.

5.7.3.2 System Functions

5.7.3.2.1 CAE

The Radioactive Waste Building HVAC System supports claim 2.2.3.4.4. This claim is outlined in PSR Part B Chapter 10 ‘Radiological Protection’ [21].

Claim 2.2.3.4.4: Ventilation and containment systems are designed to meet Radiation Protection Requirements and minimise exposures.

5.7.3.2.2 Safety Functions

The safety related functions the system of the RBV will be developed for Revision 1 of this chapter.

5.7.3.2.3 Non-Safety Functions

The non-safety related functions the system of the RBV will be developed for Revision 1 of this chapter.

5.7.3.3 System Description

The system description of the RBV will be developed for Revision 1 of this chapter.

5.7.3.4 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [17].

5.7.3.5 System Interfaces

The system interfaces of the RBV will be developed for Revision 1 of this chapter. See also PSR Part B Chapter 19 'Mechanical Engineering' [23] and Part B Chapter 10 'Radiological Protection' [21] for additional supporting information on this system.

5.7.4 Radiologically Controlled Area HVAC System (RCV)

5.7.4.1 System Overview

The system overview of the RCV will be developed for Revision 1 of this chapter.

5.7.4.2 System Functions

5.7.4.2.1 CAE

The Radiologically Controlled Area HVAC System supports claim 2.2.3.4.4. This claim is outlined in PSR Part B Chapter 10 'Radiological Protection' [25].

Claim 2.2.3.4.4: Ventilation and containment systems are designed to meet Radiation Protection Requirements and minimise exposures.

5.7.4.2.2 Safety Functions

The safety related functions the system of the RCV will be developed for Revision 1 of this chapter.

5.7.4.2.3 Non-Safety Functions

The non-safety related functions the system of the RCV will be developed for Revision 1 of this chapter.

5.7.4.3 System Description

The system description of the RCV will be developed for Revision 1 of this chapter.

5.7.4.4 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.7.4.5 System Interfaces

The system interfaces of the RCV will be developed for Revision 1 of this chapter. See also PSR Part B Chapter 19 'Mechanical Engineering' [23] and Part B Chapter 10 'Radiological Protection' [21] for additional supporting information on this system.

5.7.5 Security Facilities HVAC System (SFV)

5.7.5.1 System Overview

The system overview of the SFV will be developed for Revision 1 of this chapter.

5.7.5.2 System Functions

5.7.5.2.1 CAE

The Security Facilities HVAC System supports claim 2.2.3.4.4. This claim is outlined in PSR Part B Chapter 10 ‘Radiological Protection’ [25].

Claim 2.2.3.4.4: Ventilation and containment systems are designed to meet Radiation Protection Requirements and minimise exposures.

5.7.5.2.2 Safety Functions

The safety related functions the system of the SFV will be developed for Revision 1 of this chapter.

5.7.5.2.3 Non-Safety Functions

The non-safety related functions the system of the SFV will be developed for Revision 1 of this chapter.

5.7.5.3 System Description

The system description of the SFV will be developed for Revision 1 of this chapter.

5.7.5.4 System Reliability

Reliability requirements for safety related systems are discussed in PSR Part B Chapter 14 [34].

5.7.5.5 System Interfaces

The system interfaces of the SFV will be developed for Revision 1 of this chapter. See also PSR Part B Chapter 19 ‘Mechanical Engineering’ [23] and Part B Chapter 10 ‘Radiological Protection’ [21] for additional supporting information on this system.

5.7.6 HVAC Systems Summary

The Heating, Ventilation and Air Conditioning Systems, as described in the preceding subsections, demonstrate claim 2.2.13.4:

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 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. Further substantiation of this claim shall be provided in Revision 1 of this chapter and in supporting engineering chapters. For the RBV, RCV, and SFV, the safety features and substantiation are not available at this stage of the GDA process and will be elaborated on in future work whereupon it will be demonstrated that the claim 2.2.13.4 is demonstrated by these systems. Information on Codes and Standards are described in PSR Part B Chapter 19 ‘Mechanical Engineering’ [23].

Additionally, the CBV also supports and demonstrates claim 2.2.3.2.2:

Claim 2.2.3.2.2: Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events.

This is demonstrated in the CBV with isolation measures to preserve containment boundary integrity.

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

5.8 CHAPTER SUMMARY AND CONTRIBUTION TO ALARP

5.8.1 Technical Summary

PSR Part B Chapter 5 demonstrates that the Reactor Supporting Facilities SSCs within the scope of this report will meet the high-level Claims of the SSEC, and that the SSCs' design can be substantiated at Pre-Construction Safety Report (PCSR) stage. This is principally demonstrated through the claim:

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

This claim has been addressed in Sections 5.4 – 5.7 of this chapter. A summary is given below:

- Safety features of the Auxiliary Systems and how they are delivered are described in Section 5.4. This demonstrates the claim with the acknowledgement that further substantiation will follow in later revisions of the PSR.
- Safety features of the Steam and Power Conversion systems and how they are delivered are described in Section 5.5. As with the Auxiliary Systems, further substantiation will follow in future PSR revisions but the truth of the claim has been demonstrated.
- Some safety features have been identified but at this stage of the design of Mechanical Handling Systems, full safety functions and substantiation are not yet mature. As the GDA process continues and the design of these systems mature, this claim will be demonstrated.
- Within HVAC systems, the safety features and how they are delivered are described for the CBV. However, for other systems in the HVAC scope, further details and substantiation will follow in Revision 1 of this chapter.

In addition to the chapter claim above, claim 2.2.1 is supported by the CVC within this chapter:

Claim 2.2.1: "Adequate provision for the control of reactivity is incorporated into the design."

The contribution of the CVC towards the demonstration of claim 2.2.1 is presented in sub-claim 2.2.1.1. This is demonstrated through the ability of the CVC to control boron concentration and provide a means of shutdown independent from the Control Rods. The reactivity control function of the CVC is currently considered non-safety related, as defined by the Holtec International SSC Classification standard [56]. This will be reviewed as part of ongoing UK Categorisation and Classification work for PSR Revision 1 that forms part of PSR Part A Chapter 2 [2]. Future revisions of this chapter will further consider the CVC and its contribution to nuclear safety. PSR Part B Chapter 2 'Reactor' [18] will develop the overall argument and may present an updated position in PSR Revision 1.

Additionally, SSCs within the RSF scope also support and demonstrate 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."

The sub-claims underneath claim 2.2.3 that are relevant to RSF SSCs (pertaining to containment integrity, RCPB integrity and limiting combustible gas concentration) have been discussed where relevant. Preliminary arguments as to why the design of the RSF SSCs supports these claims is given in Appendix B.

At PSR Revision 0, some design detail on systems for the Generic SMR-300 is not available (e.g., Mechanical Handling systems and HVAC systems). It is expected this information will be fully available for PSR Revision 1 as the Generic SMR-300 design progresses. Moreover, where some system descriptions have been written based on SMR-160 information, this will be fully updated to the Generic SMR-300 design information at Revision 1.

Where the design information is at a sufficient level of maturity, the claims made relating to the Reactor Supporting Facilities have been demonstrated as true.

5.8.2 ALARP Summary

PSR Part A Chapter 5 'ALARP Summary' [51] is intended to consider the totality of the Generic SMR-300 design and how it ranks against the ALARP principles. This section presents the ALARP considerations specific to this topic area. The methodology for this is discussed in PSR Part A Chapter 5 and consists of two main elements:

- Design complies with relevant good practice (RGP)
- Options to reduce the risk have been identified and implemented where the effort to do so is not grossly disproportionate to the benefit that would be realised.

The following subsections present the ALARP considerations for the Reactor Supporting Facilities within the scope of this chapter.

5.8.2.1 Demonstration of Relevant Good Practice

Table 2 outlines the RGP used in different areas. At Revision 0, the RGP identified is limited but shall be fully assessed for Revision 1. RGP and ALARP considerations are discussed in engineering chapters (B4 [19], B6 [20], B19 [23]).

Table 14: RGP Identification

Item	RGP
Codes and standards	Codes and standards used to design SSCs in this chapter (e.g., ASME BPVC) are discussed in engineering chapters (B6 [20], B18 [52], B19 [53], B20 [54]). The relevant good practice relating to the codes and standards used is discussed within these chapters.
OPEX	The SMR-300 is an advanced Pressurised Water Reactor (PWR) with a design informed by decades of operating reactor experience and industry lessons-learned.
Redundancy, diversity, and segregation	Systems design incorporate appropriate levels of redundancy, diversity, and segregation.
Containment penetrations and isolation	The number of penetrations through the containment shall be kept to a minimum. Containment isolation valves are provided to maintain containment pressure boundary.

Whilst the plant has been designed to meet NRC NUREG-0800 guidelines [50] a gap analysis has yet to be undertaken to compare this to ONR's IAEA SSG-52 [51]. The SSCs in this chapter contain no novel technology - giving confidence in their ability to perform their functions. Likewise, there are no novel codes or standards used (see Section 5.3 and supporting engineering chapters) in the design of these systems. An RGP assessment of all

SSCs within the scope of this chapter is to be conducted when the design is matured to an extent to enable assessment. It is a fundamental aim of this chapter to describe the systems and to demonstrate why they meet UK RGP; therefore, it is essential to analyse all systems contained within this chapter by the completion of step 2 GDA.

5.8.2.2 Demonstration Against Risk Targets

The numerical targets against which the demonstration of ALARP is considered can be found in PSR Part A Chapter 2 [2]. RSF SSCs, through the defined safety functions, will contribute to the demonstration of ALARP by comparison against the risk targets by fulfilling safety functions for normal operations (Targets 1-3) and by achieving their safety classification as a duty system (Targets 4-9).

5.8.2.2.1 Evaluation of Risk

No risk targets have been identified at Revision 0 of this chapter. At this time, the evaluation of the normal operations and accident risks against Targets 1-9 has not been provided. This information will be presented in PSR Part B Chapter 10 ‘Radiological Protection’ [21] for normal operations, and PSR Part B Chapter 14 ‘Design Basis Accident Analysis’ [34], PSR Part B Chapter 15 ‘Beyond Design Basis and Severe Accident Analysis, and Emergency Preparedness’ [57] PSR Part B Chapter 16 ‘Probabilistic Safety Analysis’ [58] for accident conditions.

5.8.2.2.2 Risk Reduction Option Review

No options for risk reduction are included in this chapter at Revision 0. Risk reduction options are described in the Hazard (B21 [59], B22 [60]) and Fault Studies (B14 [34]) chapters.

The process for the assessment of risk reduction options is presented in HPP-3295-0017, ‘Generic Design Assessment Reference Design Process and GDA Prospective Design Change Register’ [54]. PSR Part A Chapter 5 ‘ALARP Summary’ [23] considers the holistic risk-reduction process for the Generic SMR-300.

5.8.2.2.3 GDA Commitments and Forward Actions

Forward Actions have been collated and are presented in PSR Part A Chapter 4, ‘Lifecycle Management of Safety and Quality Assurance’ [61]. PSR Part A Chapter 5 ‘ALARP Summary’ [62] describes the contribution of the forward actions to the ALARP argument.

5.8.3 Conclusion

Chapter B5 summarises the systems within the GDA scope that constitute the Reactor Supporting Facilities. The chapter supports the SSEC fundamental purpose through claims, arguments and evidence. The claims that have been developed for Revision 0 have had respective arguments developed for each relevant system. This provides the preliminary stages of how the truth of the plant’s fundamental claim will be proved. Revision 1 of this chapter will present fully developed arguments for each relevant claim, either with evidence where available or with a forward plan of how the evidence will be supplied beyond GDA step 2.

The claims made against this chapter have been demonstrated insofar as is possible at this stage of the GDA.

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5.10 LIST OF APPENDICES

Appendix A – SSC Classification

Appendix B – Claims, Arguments, and Evidence

Appendix A SSC Classification

Table A-1: B5 In-scope SSCs Classification [29]

SSC	RG 1.26 Quality Group	SMR Class	Seismic Category	Major Function
Auxiliary Systems				
CVC				
Piping and components in the letdown line from RCS, up to and including the second Reactor Coolant Pressure Boundary (RCPB) Isolation valve	A	A	C-I	RCPB
Piping and components in the makeup line from the inside Containment Isolation valve, including the inside Containment Isolation valve to RCS Cold Leg and Pressuriser	A	A	C-I	1. RCPB 2. Containment Isolation
Piping and components in the return line from the Regenerative Heat Exchanger up to and including the second RCPB Isolation valve	A	A	C-I	RCPB
Containment Isolation valves in the letdown line and the piping and components between the Containment Isolation valves	B	B	C-I	Containment Isolation
Piping and components in the letdown line from the second RCPB Isolation valve to third isolation valve, including the third valve	C	C	C-I	1. Other Functions (Makeup, Purification etc.) 2. RCPB
Piping and components in the Regenerative Heat Exchanger return line from the second RCPB Isolation valve to third isolation valve, including the third valve	C	C	C-I	1. Other Functions (Makeup, Purification etc.) 2. RCPB
Piping and components in the Recirculation and Purification portion of the System (downstream of the third RCS isolation valve in the letdown line and upstream of the third RCS isolation valve in the return line	D	D	C-II	Other Functions (Makeup, Purification etc.)

SSC	RG 1.26 Quality Group	SMR Class	Seismic Category	Major Function
Piping and components in the makeup line upstream of the outside Containment Isolation valve and Makeup Tank	D	D	C-II	1. Other Functions (Makeup, Purification etc.) 2. Systems that contain or may contain radioactive material
Chemical Mixing Tank and the piping and components	D	E	NS	Systems that contain or may contain radioactive material
Anticipated Transient Without Scram (ATWS) mitigating portion of the CVC (Boron Injection)	D	D	C-II	Other Functions (Makeup, Purification etc.)
Piping and components upstream of the isolation valve between the BWST and Hopper	N/A	F	NS	Other Functions (Makeup, Purification etc.)
Piping and components in the makeup line from the outside Containment Isolation valve, including the outside Containment Isolation valve to inside Containment Isolation valve excluding inside Containment Isolation valve	B	B	C-I	Containment Isolation
Piping and components in the line from RHR to the Letdown Heat Exchanger up to and including the second RCPB Isolation valve	A	A	C-I	RCPB
Piping and components in the line to RHR up to and including the second RCPB Isolation valve	A	A	C-I	RCPB
Piping and components downstream of the second RCPB Isolation valve to the third isolation valve, including the third valve in the line from RHR to the Letdown Heat Exchanger	C	C	C-I	1. Other Functions (Makeup, Purification etc.) 2. RCPB
Piping and components upstream of the second RCPB Isolation valve to the third isolation valve, including the third valve in the line to RHR	C	C	C-I	1. Other Functions (Makeup, Purification etc.) 2. RCPB
PSL				
All Containment Isolation Valves and the piping and components between the Containment Isolation Valves.	B	B	C-I	Containment Isolation

SSC	RG 1.26 Quality Group	SMR Class	Seismic Category	Major Function
Upstream of the Containment Isolation Valve inside Containment	TBD	TBD	TBD	TBD
Downstream of the Containment Isolation Valve outside of containment	TBD	TBD	TBD	TBD
RHR				
Piping and components in the suction line from RCS, up to and including the second RCPB Isolation valve	A	A	C-I	1. RCPB 2. Containment Isolation
Piping and components in the discharge line from the third RCPB Isolation valve (inside Containment Structure), including the third RCPB Isolation valve to RCS	A	A	C-I	1. RCPB 2. Containment Isolation
Piping and components after the second RCPB Isolation valve on the inlet line, up to and including the pressure relief valve and the Containment Isolation valve.	B	B	C-I	1. Containment Isolation 2. Other Functions (Makeup, Purification etc.)
Piping and components on the discharge line, after and including the Containment Isolation valve, up to and including the pressure relief valve, and up to but not including the RCPB Isolation valves.	B	B	C-I	1. Containment Isolation 2. Other Functions (Makeup, Purification etc.)
Equipment (RHR pumps, heat exchangers), piping, and components downstream of the outside Containment Isolation valve in the suction line from RCS and upstream of the outside Containment Isolation valve in the discharge line, excluding the Containment Isolation valves	C	C	C-I	1. Residual heat removal from the reactor and/or from the spent fuel storage pool 2. Other Functions (Makeup, Purification etc.)
SFC				

SSC	RG 1.26 Quality Group	SMR Class	Seismic Category	Major Function
Piping and components inside Containment upstream of the inside Containment Isolation valve in the suction line Piping and components inside Containment downstream of the inside Containment Isolation valve in the discharge line Piping and components in the makeup line from the PCMWT downstream of the isolation valve and RHR-SFC backup cooling line	C	C	C-I	Other Functions (Makeup, Purification etc.)
Containment Isolation valves in the suction line from the spent fuel pool to the pump and the piping and components between the Containment Isolation valves. Containment Isolation valves in the discharge line from the pump to the spent fuel pool and the piping and components between the Containment Isolation valves. Piping and components in the makeup line from the PCMWT upstream of the isolation valve, including the isolation valve	B	B	C-I	1. Containment Isolation 2. Emergency core cooling
Piping and components outside Containment downstream of the outside Containment Isolation valve in the suction line Piping and components outside Containment upstream of the outside Containment Isolation valve in the discharge line	D	E	NS	Systems that contain or may contain radioactive material
Steam and Power Conversion Systems				
MFS				
Main Feedwater Piping and Components from the Main Feedwater Isolation Valve (MFIV) inlet (including the MFIV) to Steam Generator (including the secondary side of the Steam Generator)	B	B	C-I	1. Feedwater Isolation 2. Containment Isolation

SSC	RG 1.26 Quality Group	SMR Class	Seismic Category	Major Function
Main Feedwater Piping and components upstream of the MFIV up to and including the restraint at the interface between the Steam Tunnel and the Turbine Building	C	C	C-I	Other Functions (Makeup, Purification etc.)
Main Feedwater Piping and components in the Turbine Building downstream of the restraint at the interface between the Steam Tunnel and the Turbine Building, except the equipment, piping and components of the Condensate Polisher Package and the interfacing systems that contain or may contain radioactive material	N/A	F	NS	Other Functions (Makeup, Purification etc.)
Equipment, piping and components in the Condensate Polisher Package that contain or may contain radioactive material	D	E	NS	Other Functions (Makeup, Purification etc.)
MSS				
Main Steam Piping and components (1) from SGE up to and including the Main Steam Isolation Valve (MSIV), Main Steam Isolation Bypass Valve (MSIBV), Atmospheric Dump Valve (ADV), and Main Steam Safety Valves (MSSVs); and (2) system drain piping upstream of the MSIV, up to and including the first isolation drain valve.	B	B	C-I	1. Main Steam Isolation 2. Containment Isolation 3. Pressure relief/ depressurisation
Main Steam Piping and components downstream of the MSIV, MSBIV and the first isolation drain valve in the Steam Tunnel up to and including the restraint at the interface between the Steam Tunnel and the Turbine Building.	C	C	C-I	Other Functions (Makeup, Purification etc.)
Main Steam Piping and components in the Turbine Building downstream of the restraint at the interface between the Steam Tunnel and the Turbine Building.	N/A	F	NS	Other Functions (Makeup, Purification etc.)
Main Steam Piping and components downstream of the MSSVs, including the vent stacks up to the Steam Tunnel Roof	C	C	C-I	1. Pressure relief/ depressurisation 2. Other Functions (Makeup, Purification etc.)

SSC	RG 1.26 Quality Group	SMR Class	Seismic Category	Major Function
MSSV Vent Stacks above the Steam Tunnel Roof	D	D	C-I	Pressure relief/ depressurisation
Main Steam Piping and components downstream of the ADV up to the Steam Tunnel Roof	C	C	C-I	Pressure relief/ depressurisation
Main Steam Piping and components downstream of the ADV above the Steam Tunnel Roof	D	D	C-II	Pressure relief/ depressurisation
HVAC Systems				
CBV				
All Containment Isolation Valves and the piping and components between the Containment Isolation Valves.	B	B	C-I	Containment Isolation
Upstream of the Containment Isolation Valve inside Containment	N/A	F	NS	Other Functions (Makeup, Purification etc.)
Downstream of the Containment Isolation Valve outside of containment	N/A	F	NS	Other Functions (Makeup, Purification etc.)

Appendix B Claims, Arguments, and Evidence

Table B1: Chapter B5 Claims and Indicative Arguments

Overarching SSEC Claim	**Overarching SSEC Sub-Claim**	**Chapter Claims**	**Indicative Arguments**	**Associated SSCs**	**Chapter Section**
Claim 2.2 System / Process Design and Substantiation 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.	Claim 2.2.1 Critical Safety Function 1 Adequate provision for the control of reactivity is incorporated into the design.	Claim 2.2.1.1 There is provision in the design to ensure that the reactor can be shutdown, via boron control in the RCS, in plant modes A through E.	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	CVC	Section 5.4.3
	Claim 2.2.3 Critical Safety Function 3 Adequate provision for the control of radiation exposure and control of release of radioactive material is incorporated into the design.	Claim 2.2.3.1.2 Reactor Supporting Facilities ensure the integrity of the Reactor Coolant Pressure Boundary following credible initiating events in all plant states.	The CVC contains valves to isolate the charging line and the letdown line following credible initiating events.	CVC	Section 5.4.3
			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.	CVC	Section 5.4.3
			Sample lines connected to the RCS within the CS boundary have remotely operated isolation valves to maintain the RCPB integrity.	PSL	Section 5.4.5
			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.	RHR	Section 5.4.6
		Claim 2.2.3.2.2 Reactor Supporting Facilities ensure the containment boundary integrity following credible initiating events.	The CVC containment penetrations are provided with isolation to preserve the integrity of the containment envelope.	CVC	Section 5.4.3
			The PSL penetrates the CS boundary and provides the containment isolation function.	PSL	Section 5.4.5
			The RHR penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.	RHR	Section 5.4.6
			The SFC penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.	SFC	Section 5.4.7
			The MFS penetrates containment and performs a containment isolation function to maintain the containment pressure boundary.	MFS	Section 5.5.2

Overarching SSEC Claim	Overarching SSEC Sub-Claim	Chapter Claims	Indicative Arguments	Associated SSCs	Chapter Section
			The MSS containment penetration is provided with isolation capabilities to preserve the integrity of the containment boundary.	MSS	Section 5.5.3
			The parts of the CBV that penetrate containment maintain the containment integrity.	CBV	Section 5.7.2
		Claim 2.2.3.10 The concentration of combustible gases in the containment volume is adequately limited following a design basis accident.	The CGC employs Passive Autocatalytic Recombiners (PARs) to maintain hydrogen concentrations less than 10% by volume in the containment atmosphere following their postulated release during an accident involving significant core damage.	CGC	Section 5.4.2
	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 2.2.13.1 The Auxiliary Systems are designed to ensure they deliver relevant safety features, supported by substantiation which is suitably mature.	Argument to be developed.	CGC, CVC, FPS, PSL, RHR, SFC	Section 5.4
		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.	Argument to be developed.	MFS, MSS	Section 5.5

Overarching SSEC Claim	Overarching SSEC Sub-Claim	Chapter Claims	Indicative Arguments	Associated SSCs	Chapter Section
		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.	Argument to be developed.	CSH, LLH, RBH	Section 5.6
		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.	Argument to be developed.	CBV, RBV, RCV, SFV	Section 5.7