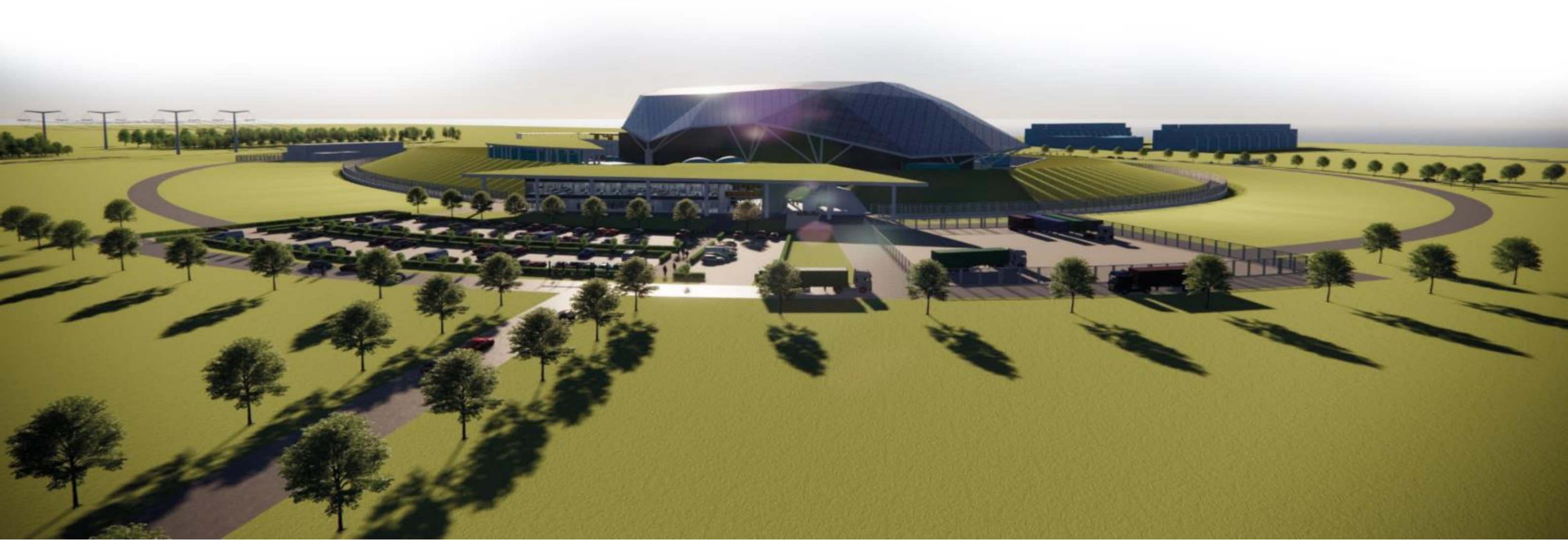
Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Chapter 10: Steam and Power Conversion Systems



Record of Change

Date	Revision Number	Status	Reason for Change
March 2023	1	Issue	First issue of E3S Case
February 2024	2	Issue	It incorporates revisions and new design developments of the Steam and Power Conversion Systems based on Reference Design 7, aligned to Design Reference Point 1, including: • Additional designs details and developments on systems included in the first issue • Design of the Auxiliary Feedwater System [LJ] • Design of the Common Systems of the Main Turbine Generator System [MU] • Design of the Turbine Island Closed Cooling Water System [PG]
May 2024	3	Issue	Updated to correct revision history status at Issue 2. Chapter changes include: • Updates to HAZID assessment details for the Steam Generator Relief System and the Steam System for Reactor Island (sections 10.2.2.10 and 10.2.3.10) • Additional detail on the Steam Generator Purification System [LCQ] (section 10.5.2.3) • Additional detail within conclusion section for how arguments and evidence presented meet the generic E3S objective Also minor template/editorial updates for overall E3S Case consistency.

Executive Summary

Chapter 10 of the generic Environment, Safety, Security, and Safeguards (E3S) Case presents the Steam and Power Conversion Systems of the Rolls-Royce Small Modular Reactor (RR SMR).

The chapter outlines the arguments and evidence to underpin the high-level claim that the RR SMR Steam and Power Conversion Systems are conservatively designed and verified to deliver E3S functions through-life, in accordance with the E3S design principles, to reduce risks to as low as reasonably practicable (ALARP), apply best available techniques (BAT) and ensure secure by design and safeguards by design.

The systems covered include the Feedwater System [LA], Auxiliary Feedwater System [LJ], Steam System [LB], Condensate System [LC], Steam Turbine System [MA], Generator System [MK], Common Systems of the Main Turbine Generator System [MU], and the Turbine Island Closed Cooling Water System [PG], as well as associated sub-systems.

For each system, the safety functions to be delivered by each SSC are presented, with the assignment of safety categorised functional requirements to achieve them. Non-functional system requirements derived from the E3S design principles are also presented. The design definition presented for each system is developed based on relevant good practice (RGP) and operating experience (OPEX), with design to codes and standards according to the safety classification, and down-selection of options in accordance with criteria to ensure risks are reduced to ALARP, apply BAT, and are secure by design and safeguards by design. This provides confidence that claims can be met when the full suite of arguments and evidence is developed. No functional requirements for environment, security and safeguards are identified for the SSCs within Turbine Island [T01].

Version 2 of the generic E3S Case is developed in support of the reference design 7 (RD7) design, corresponding to design reference point 1 (DRP1) for the generic design assessment (GDA). Further arguments and evidence are to be developed to underpin the top-level claim, including development of a complete set of E3S requirements and their associated verification and validation activities, and continued design development in conjunction with vendors.

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10.0 Introduction

10.0.1 Introduction to Chapter

Chapter 10 of the Rolls-Royce Small Modular Reactor (RR SMR) generic Environment, Safety, Security and Safeguards (E3S) Case presents the overarching summary and entry point to the design and E3S information for the Turbine Island [T01] Steam and Power Conversion Systems of the RR SMR.

10.0.2 Scope and Maturity

The list of structures, systems, and components (SSCs) that are included in the scope of this chapter is provided in Appendix B (section 10.9).

Version 2 of the generic E3S Case is based on reference design 7 (RD7), corresponding to design reference point 1 (DRP1) for the generic design assessment (GDA). At DRP1/RD7, the safety functions to be delivered by each SSC are presented, with the assignment of safety categorised functional requirements to achieve them. No functional requirements for environment, security and safeguards are identified for SSCs in the scope of chapter 10 at DRP1/RD7, noting SSCs are designed in accordance with E3S and engineering processes that include development against principles for environment, security, and safeguards. The design definition presented is based on the design maturity of each respective SSC at DRP1/RD7. Verification and validation activities for SSCs within this chapter are still to be established through detailed design and as part of future vendor engagement.

10.0.3 Claims, Arguments and Evidence Route Map

The overall approach to claims, arguments, evidence (CAE) and the set of fundamental E3S claims to achieve the E3S fundamental objective are described in E3S Case Version 2, Tier 1, Chapter 1: Introduction [1]. The associated top-level claim for E3S Case Version 2, Tier 1, Chapter 10: Steam and Power Conversion Systems is:

Claim 10: Steam and Power Conversion Systems are conservatively designed and verified to deliver E3S functions through-life, in accordance with the E3S design principles, to reduce risks to ALARP, apply BAT and in line with Secure-by-Design and Safeguards-by-Design.

A decomposition of this claim into sub-claims and mapping to the relevant Tier 2 and Tier 3 information containing the detailed arguments and evidence, is presented in the E3S Case Route Map [2]. Given the evolving nature of the E3S Case alongside the maturing design, the underpinning arguments and evidence may still be developed in at detailed design; the trajectory of this information, where possible, is also illustrated in the route map.

A proportionate summary of the arguments and evidence from lower tier information, available at the current design stage, is presented within this chapter. A mapping of the claims to the corresponding sections that summarise the arguments and/or evidence is provided in Appendix A (section 10.8).

10.0.4 Applicable Regulations, Codes and Standards

The SSCs summarised in this chapter are designed in accordance with the E3S design principles [3], which are developed based on United Kingdom (UK) and international regulations, guidance, and practices, as described in E3S Case Version 2, Tier 1, Chapter 3: E3S Objectives and Design Rules for SSCs [4].

The mechanical systems and components summarised in this chapter are designed in accordance with their safety classification. Relevant codes and standards are identified in Table 10.0-1.

Table 10.0-1: Mechanical Components Code and Standards

Component	Codes and Standards
Piping	BS EN 13480:2017
	BS EN 10216
Pumps	BS EN 809
	ISO 9905
	ASME B73.2
Tanks and vessels	BS EN 13445
	ASME BPVC (2019)
	Pressure Equipment Directive 2014/68/EU
	Pressure Equipment (Safety) Regulations 2016
	Machinery Directive 2006/42/EC
	BS EN 60045-1
	ASME TDP-2
Heat exchangers	HEI 2622
	HEI 2629
Valves	BS EN 12516
	IEC 60034
Motors	ASME B73.2
Materials	ASME BPVC Section II
Supports	ASME BPVC III NF

The selection of appropriate standards will be refined, finalised and presented in Version 3 of the generic E3S Case.

10.1 Role and General Description

10.1.1 Turbine Island Overview

The Turbine Island [T01] includes the facilities Steam, Water, Condensate System [L] and Main Turbine Generator System [M].

10.1.1.1 Steam, Water, Condensate System [L]

The main plant sub-systems within the Steam, Water, Condensate Systems [L] include:

- Feedwater System [LA]
- Steam System [LB]
- Condensate System [LC]
- Condensate Polishing System [LD]
- Emergency Feedwater System [LJ]
- Steam, Water, Condensate System Control and Protection [LY].

Heat from the reactor is transferred from the primary circuit to the secondary circuit in the three Steam Generators (SGs) [JEA]. Feedwater present in the SGs [JEA] is converted to steam which is then routed by the Steam System [LB] through the High Pressure (HP) Turbine [MAA] and Low Pressure (LP) Turbine [MAC]. The turbines are coupled to and rotate a generator, thereby generating the plant's electrical output. The steam leaving the LP Turbines [MAC] is condensed by heat exchange with the cooling water in the Main Cooling Water System (MCWS) [PA] system. The resulting condensate is then deaerated, pre-heated, and fed back into the SGs [JEA].

There is a bleed from the SGs [JEA] through the Steam Generator Purification System (SGPS) [LCQ] to control impurities in the secondary circuit. Concentrate from this unit is routed to the liquid waste treatment system, and the cleaned water is returned to the secondary circuit. Feedwater is provided from the demineraliser plant.

10.1.1.2 Main Turbine Generator System [M]

The Main Turbine Generator System [M] is housed within a dedicated turbine hall along with other turbine equipment. Its purpose is to convert steam into mechanical energy through technical rotation action. The key systems include the Steam Turbine System [MA], the Generator System [MK], Auxiliary Systems [MU] and Control and Protection System [MY].

The Steam Turbine Systems' [MA] HP Turbine [MAA] expands the steam from the SGs [JEA], which is exhausted into the Moisture Separator Reheater (MSR) [LBJ]. The MSR [LBJ] removes moisture and superheats the steam before it is transferred to the LP Turbines [MAC]. The steam is further expanded and is then exhausted into the Condensing System [MAG].

The Condensing System [MAG] converts the exhaust steam into saturated water, which is transferred for reuse through the feedwater system [LA] back into the SG. The Generator System

[MK] converts mechanical energy of the steam turbine to electrical energy for onward distribution to the grid. The Auxiliary Systems [MU] support the control function of the turbine and generator operation.

The Turbine Island [T01] architecture is shown in Figure 10.1-1. The major equipment associated with the Steam, Water, Condensate System [L] and Main Turbine Generator System [M] is illustrated in Figure 10.1-2.

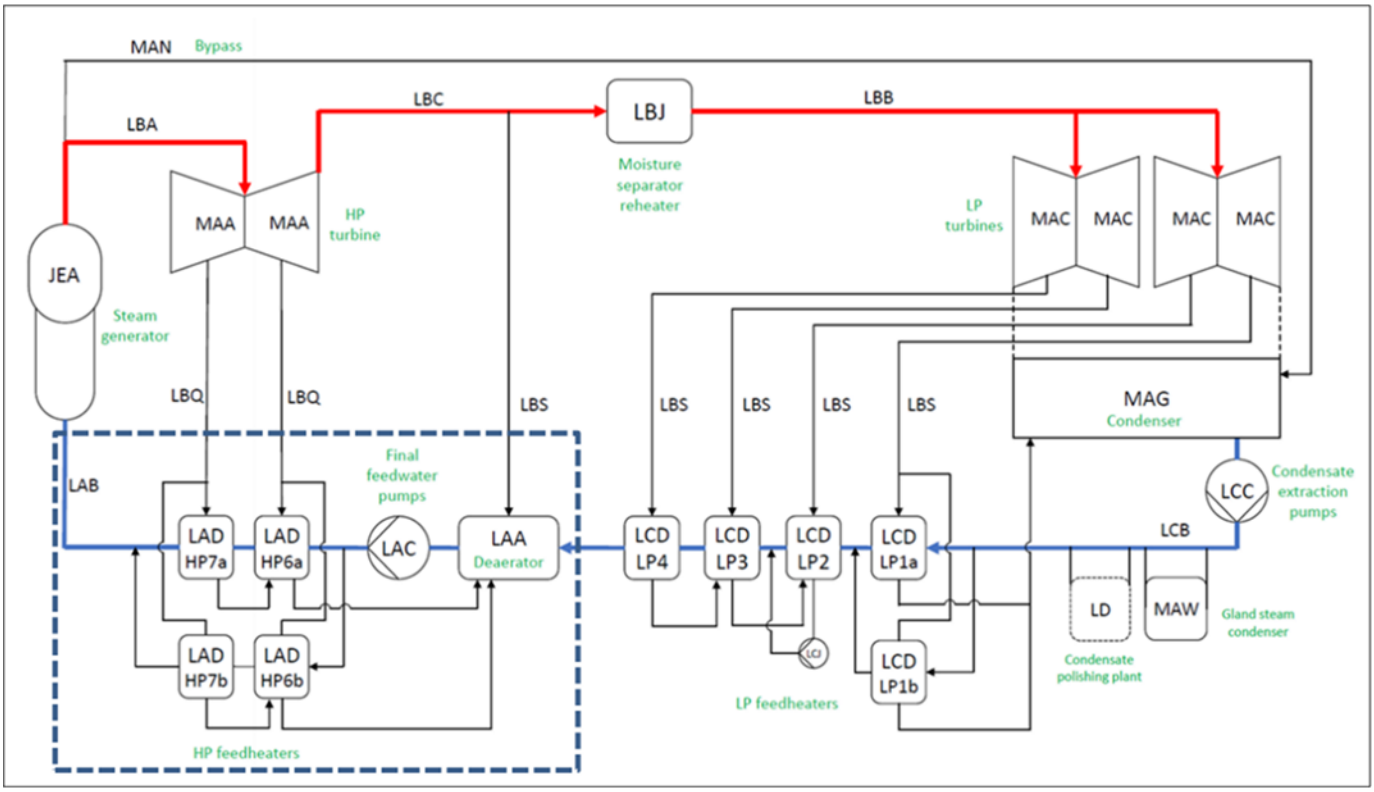

Figure 10.1-1: Turbine Island [T01] Architecture

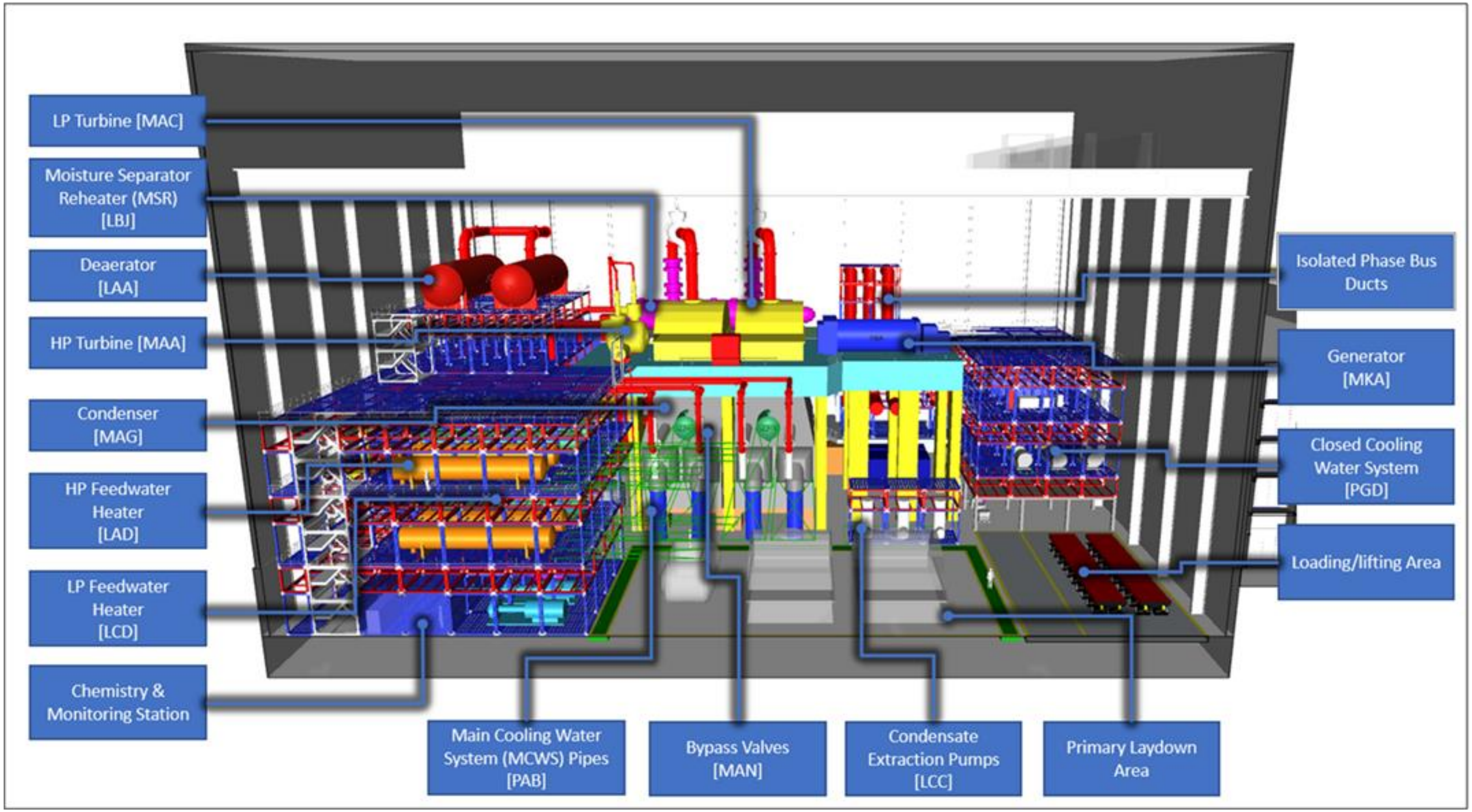

Figure 10.1-2: Major Turbine Island [T01] Systems

10.2 Main Steam Supply System

10.2.1 Steam System for Turbine Island

10.2.1.1 System and Equipment Functions

The Steam System [LB] within the Turbine Island [T01] has the following primary functions:

- Distribute and manage the main steam flow route from the steam generator outlets to the high-pressure steam turbine inlet. Subsequently distribute the high-pressure turbine outlet steam through the Moisture Separator Reheater (MSR) and finally into the low-pressure turbines
- Distribute extraction steam from the turbine sections to the feedwater heaters
- Distribute and manage auxiliary steam supplied by the Auxiliary Boiler [QH] into the relevant secondary circuit systems.

10.2.1.2 Design Bases

10.2.1.2.1 Functional Requirements

The Steam System [LB] contains sub-systems and components which facilitate delivery of High Level Safety Functions (HLSFs). The deterministic safety analysis presented in E3S Case Version 2, Tier 1, Chapter 15: Safety Analysis, [5], provides a systematic evaluation of the credible Postulated Initiating Events (PIEs). HLSFs are identified in the Fault Schedule [6] and assigned to each PIE to deliver the four Fundamental Safety Functions (FSFs): Control of Reactivity (CoR), Control of Fuel Temperature (CoFT), Confinement of Radioactive Material (CoRM), and Control of Radiation Exposure (CoRE).

The Steam System [LB] within the Turbine Island facilitates delivery of CoFT during normal operation and abnormal conditions. The Steam System [LB] provides support to enable the High Temperature Heat Removal (HTHR) [JN03] variant 1 duty function and HTHR variants 2-4 HLSF; 'variants' of the HTHR [JN03] safety measure refer to HTHR relying on different sets of SSCs to provide CoFT following different PIEs as described within the fault schedule. Safety categorised functional requirements specified for the Steam System [LB] based on the HLSFs they deliver, including the applicable plant states and operating modes, are presented in Table 10.2-1.

Table 10.2-1: Main Steam Supply System [LB] Safety Categorised Functional Requirements

Requirement ID	Functional Requirement	Plant State(s)	Mode(s) of Operation	Safety Category
L-LB-1259	The Steam System [LB] shall distribute steam supplied by the Reactor Coolant System [JE]	DBC-1 DBC-2i	1 to 4a	C
L-LB-1306	The Steam system [LB] shall distribute steam from the Steam turbine system [MA]	DBC-1 DBC-2i	1 to 4a	C

Non-functional performance requirements associated with the safety categorised functional requirements are also allocated in the RR SMR requirements management database Steam System [LB] requirements module, including the rationale for their selection, which are not repeated here.

10.2.1.2.2 Non-Functional System Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Version 2, Tier 1, Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the Steam System [LB]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.2.1.2.3 Safety Classification

The highest category of HLSF that the Steam System [LB] support is category C. In accordance with the SMR E3S Categorisation and Classification Method [7], the Steam System [LB] is a safety class 3 system.

10.2.1.2.4 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Version 2, Tier 1, Chapter 3: E3S Objectives and Design Rules [4].

10.2.1.3 Description

The Steam System [LB] comprises of the following sub-systems:

- Main Steam Piping System [LBA], connecting between the SG outlet and HP Turbine [MAA] inlet to distribute steam. The three steam generator outlet pipes leave the Reactor Island and join a common header just after entering the Turbine Hall [UMA]. From the common main steam header, several take-off branches are made for further steam distribution.

- Hot Reheat Piping System [LBB], connecting the MSR [LBJ] exit to LP Turbine [MAC] inlet. Two equal flow pipes supply the steam to the inlet valve combination of each turbine low pressure section (one pipe to each LP turbine).

- Cold-Reheat Piping System [LBC], connecting the HP Turbine [MAA] exhaust to the MSR [LBJ] inlet. Two equal flow pipes supply the steam to the MSR the flows of which carry through and connect with the two pipes on the hot-reheat side.

- Auxiliary Steam Piping System [LBG], which delivers steam to the Gland Sealing System [MAW] and the Deaerator [LAA] from either the Auxiliary Steam Generating System [QH] or the Main Steam System [LBA] during startup/shutdown operations. It includes pressure set control valves to ensure steam is supplied at the required pressure.

- MSR [LBJ], which is a large heat exchanger vessel that sits between the HP Turbine [MAA] and LP Turbines [MAC]. Its function is to remove moisture from the Cold Reheat Piping System [LBC] steam and reheat the steam before it is exhausted to the Hot Reheater Piping System [LBB] and distributed to the two LP Turbines [MAC].

- Extraction Steam Piping System for Feedwater Preheating System [LBQ], which covers the two high-pressure extraction systems from the HP Turbine [MAA] to the Feedwater Preheating System [LAD] heaters.

- Extraction Steam Piping System for Main Condensate Preheating System [LBS], which covers the four LP extraction systems from the LP Turbine [MAC] to the Main Condensate Preheating System [LCD] heaters.

- The Extraction piping system [LBD], which provides extraction of the steam on the main steam piping system [LBA].

- Overpressure Suppression and Safety Device System [LBF], which provide an overpressure relief to the Moisture Separator Reheater [LBJ]. The line contains a safety rated pressure relief valve.

The key performance and design parameters are presented in Table 10.2-2.

Table 10.2-2: Key Performance and Design Parameters for the Main Steam Supply System [LB]

Parameter	Value	Units
Main Steam Piping System [LBA]		
Nominal Pressure	7.4	MPa(a)
Nominal Temperature	289.6	°C
Nominal Enthalpy	2764.2	kJ/kg
Nominal Mass Flow	766	kg/s
Hot Reheat Piping System [LBB]		
Nominal Pressure	0.9186	MPa(a)
Nominal Temperature	274.8	°C
Nominal Enthalpy	3000	kJ/kg
Nominal Mass Flow	491	kg/s
Cold Reheat Piping System [LBC]		
Nominal Pressure	0.9551	MPa(a)
Nominal Temperature	177.9	°C
Nominal Enthalpy	2471.7	kJ/kg
Nominal Mass Flow	606	kg/s
Auxiliary Steam Piping System [LBG]*		
Nominal Pressure	1.3	MPa(a)
Nominal Temperature	194	°C
Nominal Enthalpy	TBD	kJ/kg
Nominal Mass Flow	4.72	kg/s

Parameter	Value	Units
*Based on auxiliary boiler outlet conditions		
Moisture Separator Reheater [LBJ]		
Nominal Pressure (heated side, inlet)	0.9551	MPa(a)
Nominal Temperature (heated side, inlet)	177.9	°C
Nominal Enthalpy (heated side, inlet)	2473.3	kJ/kg
Nominal Mass Flow (heated side, inlet)	574.1	kg/s
Nominal Pressure (heated side, reheater 1 inlet)	0.9491	MPa(a)
Nominal Temperature (heated side, reheater 1 inlet)	177.6	°C
Nominal Enthalpy (heated side, reheater 1 inlet)	2765.1	kJ/kg
Nominal Mass Flow (heated side, reheater 1 inlet)	491	kg/s
Nominal Pressure (heated side, reheater 1 outlet)	0.9397	MPa(a)
Nominal Temperature (heated side, reheater 1 outlet)	226.3	°C
Nominal Enthalpy (heated side, reheater 1 outlet)	2892.7	kJ/kg
Nominal Mass Flow (heated side, reheater 1 outlet)	491	kg/s
Nominal Pressure (heated side, reheater 2 outlet)	0.9186	MPa(a)
Nominal Temperature (heated side, reheater 2 outlet)	274.8	°C
Nominal Enthalpy (heated side, reheater 2 outlet)	3000	kJ/kg
Nominal Mass Flow (heated side, reheater 2 outlet)	491	kg/s
Nominal Pressure (moisture separator drain)	0.9491	MPa(a)
Nominal Temperature (moisture separator drain)	177.6	°C
Nominal Enthalpy (moisture separator drain)	752.7	kJ/kg
Nominal Mass Flow (moisture separator drain)	83.07	kg/s

Parameter	Value	Units
Nominal Pressure (heating side, reheater 1 inlet)	3.099	MPa(a)
Nominal Temperature (heating side, reheater 1 inlet)	235.7	°C
Nominal Enthalpy (heating side, reheater 1 inlet)	2639	kJ/kg
Nominal Mass Flow (heating side, reheater 1 inlet)	38.92	kg/s
Nominal Mass Flow (heating side, reheater 1 outlet)	30.38	kg/s
Nominal Temperature (heating side, reheater 1 outlet)	234.6	°C
Nominal Enthalpy (heating side, reheater 1 outlet)	1011.7	kJ/kg
Nominal Mass Flow (heating side, reheater 1 outlet)	38.92	kg/s
Nominal Pressure (heating side, reheater 2 inlet)	7.15	MPa(a)
Nominal Temperature (heating side, reheater 2 inlet)	287.3	°C
Nominal Enthalpy (heating side, reheater 2 inlet)	2764.2	kJ/kg
Nominal Mass Flow (heating side, reheater 2 inlet)	35.55	kg/s
Nominal Pressure (heating side, reheater 2 outlet)	7.01	MPa(a)
Nominal Temperature (heating side, reheater 2 outlet)	285.9	°C
Nominal Enthalpy (heating side, reheater 2	1268	kJ/kg
Nominal Mass Flow (heating side, reheater 2)	35.55	kg/s
Extraction steam piping system for feedwater preheating system [LBQ]		
HP extraction 2 - Nominal Pressure	3.099	MPa(a)
HP extraction 2 - Nominal Temperature	235.7	°C
HP extraction 2 - Nominal Enthalpy	2639	kJ/kg
HP extraction 2 - Nominal Mass Flow	46.15	kg/s

Parameter	Value	Units
HP extraction 1 - Nominal Pressure	1.845	MPa(a)
HP extraction 1 - Nominal Temperature	208.3	°C
HP extraction 1 - Nominal Enthalpy	2566.7	kJ/kg
HP extraction 1 - Nominal Mass Flow	38.13	kg/s
Extraction steam piping system for main condensate preheating system [LBS]		
Deaerator Extraction - Nominal Pressure	0.9551	MPa(a)
Deaerator Extraction - Nominal Temperature	177.9	°C
Deaerator Extraction - Nominal Enthalpy	2473.9	kJ/kg
Deaerator Extraction - Nominal Mass Flow	31.92	kg/s
LP extraction 4 - Nominal Pressure	0.4635	MPa(a)
LP extraction 4 - Nominal Temperature	205.8	°C
LP extraction 4 - Nominal Enthalpy	2870	kJ/kg
LP extraction 4 - Nominal Mass Flow	22.51	kg/s
LP extraction 3 - Nominal Pressure	0.2252	MPa(a)
LP extraction 3 - Nominal Temperature	136.7	°C
LP extraction 3 - Nominal Enthalpy	2739.1	kJ/kg
LP extraction 3 - Nominal Mass Flow	34.66	kg/s
LP extraction 2 - Nominal Pressure	0.05139	MPa(a)
LP extraction 2 - Nominal Temperature	82	°C
LP extraction 2 - Nominal Enthalpy	2521.2	kJ/kg
LP extraction 2 - Nominal Mass Flow	19.49	kg/s
LP extraction 1 - Nominal Pressure	0.01733	MPa(a)
LP extraction 1 – Nominal Temperature	57	°C
LP extraction 1 - Nominal Enthalpy	2387.6	kJ/kg
LP extraction 1 - Nominal Mass Flow	19.33	kg/s

The Steam System [LB] is located within the Turbine Island [T01]. Most components for the Steam system will be located within the Turbine Island Structures and Areas [U02]. The main architecture will be located within the Turbine Hall [UMA]. Some of the Main Steam Piping System [LBA] is currently located within the Reactor Island Structures and Areas [U01]. A full description of the Steam System [LB] and associated sub-systems within Turbine Island [T01] is provided in the System Design Description [8].

10.2.1.4 Materials

Materials will be confirmed in Version 3 of the generic E3S Case.

10.2.1.5 Interfaces with Supporting Systems

The Steam System [LB] functional and physical interfaces are described above, noting the major system interfaces are the SGs [JEA] and the Main Turbine Generator Systems [M]. These are identified and managed within RR SMR requirements management database, including flow down of functional requirements.

10.2.1.6 System and Equipment Operation

The RR SMR Power Station Operating Philosophy [9] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode.

An analysis of the system operation in all modes of operation has been conducted to develop an initial Steam System [LB] operating philosophy. This initial operating philosophy defines the operational sequences and actions the system is required to undertake and will help identify key claims for operators or automated actions in the future. The initial operating philosophy for each mode of operation can be found in the System Design Description for the Steam System [LB] [8]. The operating philosophy will be developed and amended with vendor input in the future.

10.2.1.7 Instrumentation and Control

The functions that are allocated to the Control and Protection Systems - Feedwater, Steam and Condensate [LY] by the Steam System [LB] are:

- Alarms and Warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. The Alarms and Warnings for the Steam System [LB] are still being developed and will be developed with vendor engagement.
- Control Logic
    - Within the Main Steam Piping System [LBA], temperature and pressure monitoring instrumentation interface and coordinate with the steam generator [JEA], steam turbine [MA], bypass system [MAN], drain systems and auxiliary systems.
    - Within the Hot Reheat Piping System [LBB], temperature and pressure monitoring instrumentation interface with the steam turbine, moisture separator reheater [LBJ] and drain systems.
    - Within the Cold Reheat Piping System [LBC], temperature and pressure monitoring instrumentation interface with the steam turbine [MA], extraction to the deaerator [LBS], moisture separator reheater [LBJ] and drain systems.
    - Within the Auxiliary Steam Piping System [LBG], temperature and pressure monitoring instrumentation interface with the Auxiliary Boiler [QHA], Main Steam Piping System [LBA], the Cold Reheat Piping System [LBC], Steam Turbine System [MA] and the Deaerator [LAA].
    - Interface and coordination are required between the pressure relief valves of the MSR and the High-Pressure Turbine [MAA] inlet valves and Low-Pressure Turbine [MAC] inlet valves. Interface and coordination are required with the drain line control of

valves and pumps on the Reheater Drains System [LCS] and Moisture Separator Drains System [LCT].

- Within the Extraction Steam Piping System for Feedwater Preheating System [LBQ], temperature and pressure monitoring instrumentation interface with the High-Pressure Turbine [MAA] and Feedwater Preheating System [LAD]
- Within the Extraction Steam Piping System for Main Condensate Preheating System [LBS], temperature and pressure monitoring instrumentation interface with the valves of each turbine extraction line, the Steam Turbine System [MA] and Main Condensate Preheating System [LCD].

10.2.1.8 Monitoring, Inspection, Testing and Maintenance

The maintenance tasks and procedures, specific to the Steam System [LB] environment and operating context are still being developed.

Maintenance activities considered will include:

- Safety derived tasks (In Service Inspection (ISI))
- Design derived tasks (Supplier provided)
- Reliability derived tasks (Reliability Centred Maintenance (RCM)/Preventative Maintenance)
- Industry best practice/OPEX (Electric Power Research Institute (EPRI) Preventative Maintenance Basis Database PMBD)
- Non-Product Breakdown Structure (PBS) (Module, Site Facility).

10.2.1.9 Radiological Aspects

No significant radiological aspects associated with the Steam System [LB] have been identified during design decisions up to DRP1/RD7.

10.2.1.10 Performance and Safety Evaluation

Hazard Identification (HAZID) assessments are carried out on the Turbine Island [T01]. The design of the Steam System [LB] at DRP1/RD7 considers internal hazards from the Turbine Island HAZID report which have the potential to cause damage to the Steam System [LB], and identifies any protections/barriers/mitigations, as detailed in the System Design Description for the Steam System [LB] [8].

Verification activities to substantiate the E3S requirements set for the Steam System [LB] are still to be determined.

10.2.1.11 Installation and Commissioning

The overall strategy for the RR SMR commissioning programme is presented in E3S Case Tier 1 Chapter 14: Plant Construction and Commissioning [10]. An outline installation and commissioning plan for the Steam System [LB] has been developed during the current design phase to confirm viability of the proposed system to function as intended.

Installation requirements for the Steam System [LB] are detailed in the requirements specification for the Turbine Island [T01] in the RR SMR requirements management database. Installation requirements and allocated requirements will be developed further by the vendors.

A comprehensive commissioning plan will be developed during detailed design. As part of the modularisation and build certainty strategy, with an aim to reduce cost and commissioning time, factory commissioning activities will be utilised where possible to reduce on site commissioning. It is anticipated that system architecture performing a system function will need to undergo an approved functional test. Further commissioning and testing activities may be required to satisfy a safety function, should one be allocated to architecture or components in the Steam System [LB] during detail design.

10.2.2 Steam System for Reactor Island

10.2.2.1 System and Equipment Functions

The primary function of the Main Steam Piping System for Reactor Island (RI) [LBA20] is to transfer steam from the Steam Generation System [JEA] to the Turbine Island (TI) during operating modes 1 – 4a. During faulted operations the system provides a means to transfer steam to support the successful operation of safety measures including: HTHR [JN03] (category C), Passive Decay Heat Removal (PDHR) [JN02] (category B) and Emergency Core Cooling (ECC) [JN01] (category A). The system also provides a means of isolating the steam route between RI and TI to support safety measure operation. The safety measures requiring this isolation function include PDHR [JN02] (category B), ECC [JN01] (category A), Automatic Shutdown Function (ASF) [JD02] (category B) and Containment Isolation [JM01] (category A).

10.2.2.2 Design Bases

10.2.2.2.1 Functional Requirements

The Main Steam Piping System for RI [LBA20] contains sub-systems and components which facilitate delivery of CoFT, CoR and CoRM. Safety categorised functional requirements specified for the Main Steam Piping System for RI [LBA20] are based on the HLSFs they deliver, including the applicable plant states and operating modes, are presented in Table 10.2-3.

Table 10.2-3: Main Steam Piping System for Reactor Island [LBA20] Safety Categorised Functional Requirements

ID	Functional Requirement	Plant State(s)	Mode(s) of Operation	Safety Category
LBA20-R-1375	Isolate all main steam lines on demand	DBC-2ii to DBC-4	1 to 4a	A
LBA20-R-1524	Sense steam pressure	DBC-2ii to DBC-4	1 to 4a	A
LBA20-R-1410	Isolate all main steam lines on demand during an SGTR	DBC-2ii to DBC-4	1 to 4a	A

ID	Functional Requirement	Plant State(s)	Mode(s) of Operation	Safety Category
LBA20-R-1382	Transfer steam from the Steam Generating System [JEA] to the SG Relief System [LBK10]	DBC-2ii to DBC-4	1 to 4a	A
LBA20-R-1383	Transfer steam from the Steam Generating System [JEA] to the Passive Steam Condensing System [JNB]	DBC-2ii to DBC-4	1 to 4a	B
LBA20-R-1386	Isolate main steam lines on demand	DBC-2ii to DBC-4	1 to 4a	B
LBA20-R-1389	Sense steam pressure	DBC-2ii to DBC-4	1 to 4a	B
LBA20-R-1405	Isolate casualty main steam line on demand during a SGTR	DBC-2ii to DBC-4	1 to 4a	B
LBA20-R-1397	Sense steam gamma radiation	DBC-2ii to DBC-4	1 to 4a	B
LBA20-R-1364	Transport steam to TI	DBC-1 DBC-2i	1 to 4a	C
LBA20-R-1370	Sense steam flowrate	DBC-1 DBC-2i	1 to 4a	C
LBA20-R-1426	Transfer heat from the Steam Generating System [JEA] to TI	DBC-1 DBC-2i	1 to 4a	C

10.2.2.2.2 Non-Functional Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Tier 1 Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the Main Steam Piping System for RI [LBA20]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.2.2.2.3 Safety Classification

Table 10.2-4 provides an overview of the safety classification assigned to key components within the Main Steam Piping System for Reactor Island [LBA20].

Table 10.2-4: Main Steam Piping System for Reactor Island [LBA20] Components Safety Classification

Component	Subcomponent	Safety Class
Pipework	Pipework Upstream Pipework (large bore)	1
	Upstream Pipework (small bore)	1
	Downstream Pipework	3

Component	Subcomponent	Safety Class
Valves	MSIV	1
	MISV bypass	1
Instrumentation	Pressure Sensor (Narrow Range)	1
	Pressure Sensor (Wide Range)	2
	Flow Sensor	3
	Gamma Radiation Sensor	3
	Condensate Level Sensor	3
	Valve Position Sensor	3

10.2.2.2.4 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules [4].

10.2.2.3 Description

The Main Steam Piping System for RI [LBA20] comprises of the following sub systems:

- Main Steam Piping System for RI Train 1 [LBA21]
- Main Steam Piping System for RI Train 2 [LAD22]
- Main Steam Piping System for RI Train 3 [LBA23]

Each subsystem includes equipment for temperature, radiation, pressure and flow monitoring. These instruments provide input parameters to support the operation and initiation of safety measures including HTHR [JN03], PDHR [JN02] and Scram [JD01], as well as supporting plant monitoring and control.

The baseline architecture for the Main Steam Piping System for RI [LBA20] consists of three Main Steam Lines (MSL), one per Steam Generator (SG). Each MSL includes a singular Main Steam Isolation Valve (MSIV) and an MSIV bypass valve. Each MSL discharges to the inlet of a combined steam header which forms the system and island boundary. Instrumentation located on each MSL provides input parameters for the initiation and operation of plant safety measures, as well as plant control and monitoring.

A full description of the Main Steam Piping System for RI [LBA20] and associated sub-systems within Turbine Island [T01] is provided in the System Design Description [11].

10.2.2.4 Materials

The initial Functional Bill of Martial for the Main Steam Piping System for RI [LBA20] [12] provides the allocated requirements and material specification to all components within the system. In in the

System Design Description [11] a SA335M Grade P22 material is specified for MSL pipes and MSIV valves.

10.2.2.5 Interfaces with Supporting Systems

Within containment, the system interfaces with the steam outlet at the top of each SG, on the secondary side. The SGs are located asymmetrically around the Reactor System [JA]. The system pipework leaves the containment through penetrations that provide the shortest route possible to reduce the length and volume of pipework located within containment. Outside the containment vessel, a valve module assembly is provided for each of the three subsystems. Each module assembly contains the corresponding subsystem MSIV and MSIV bypass valve, as well as the valves associated with the corresponding SG Relief System [LBK10] and ASD System [LBK50] trains.

Interfaces for the Main Steam Piping System for RI [LBA20] are identified and managed within the requirements specification for the system in the RR SMR requirements management database.

10.2.2.6 System and Equipment Operation

The RR SMR Power Station Operating Philosophy [9] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode.

An analysis of the system operation in all modes of operation has been conducted to develop an initial Main Steam Piping System for RI [LBA20] operating philosophy. This initial operating philosophy defines the operational sequences and actions the system is required to undertake and will help identify key claims for operators or automated actions in the future. The initial operating philosophy for each mode of operation can be found in the System Design Description for the Main Steam Piping System for RI [LBA20] [11].

10.2.2.7 Instrumentation and Control

The functions that are allocated to the Control and Protection Systems - Feedwater, Steam and Condensate [LY] by the Steam System [LB] are:

- Alarms and Warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. A list of the alarms related to o instrumentation present on the Main Steam Piping System for RI [LBA20] at 100 % full power, can be found in [11].

- Control Logic:

  - The flow instrumentation provided to the Main Steam Piping System for RI [LBA20] is used to provide input to the SG level control.

  - The drain line to Clean Drains System for RI [LCM20] will be automatically opened on condensate level reaching the setpoint to prevent condensate build up in the MS.

10.2.2.8 Monitoring, Inspection, Testing and Maintenance

The maintenance tasks and procedures, specific to the Main Steam Piping System for RI [LBA20] environment and operating context are still being developed.

Maintenance activities considered will include:

- Safety derived tasks (ISI)
- Design derived tasks (Supplier provided)
- Reliability derived tasks (RCM/Preventative Maintenance)
- Industry best practice/OPEX (EPRI PMBD)
- Non-PBS (Module, Site Facility).

10.2.2.9 Radiological Aspects

Under normal operation the system will be non-radioactive. The radiological impact of degraded operation including operation with a minor primary to secondary leak are to be considered during detailed design.

10.2.2.10 Performance and Safety Evaluation

HAZID assessment was carried out on the Steam Generation System [JEA], which includes the Main Steam Piping System for RI [LBA20]. No actions were recorded as part of the Main Steam Piping System for Reactor Island [LBA20]. A HAZOP 2 study was also undertaken at RD/DRP1 on the Steam Generation System [JEA], actions arising have been captured in a HAZOP action register and detailed in the System Design Description [11].

At RD7/DRP1, the system definition mitigates the risk of hazards through the requirements allocated to layout for separation and segregation of redundant trains, integrity classification of components and system location; with implicit claims on aseismic bearing, hazard shield, etc. Internal and external hazards will be assessed and described in Version 3 of the generic E3S Case.

Verification activities to substantiate the E3S requirements set for the Main Steam Piping System for RI [LBA20] are still to be determined.

10.2.2.11 Installation and Commissioning

The overall strategy for the RR SMR commissioning programme is presented in E3S Case Tier 1 Chapter 14: Plant Construction and Commissioning [10]. An outline of the Main Steam Piping System for RI [LBA20] installation and commissioning plan will be included in Version 3 of the generic E3S Case.

10.2.3 Steam Generator Relief System

10.2.3.1 System and Equipment Functions

The primary function of the SG relief system [LBK10] is to provide overpressure protection to the steam generation system [JEA] and aspects of the main steam system [LB]. The system interfaces directly with the Main Steam Line (MSL) [LBA] upstream of the Main Steam Isolation Valve (MSIV) [LBA] and outside of the containment structure [JMA].

The SG relief system [LBK10] provides a means of rejecting nuclear heat and decay heat during faulted operation from the primary circuit whilst preventing the overpressure of secondary circuit SSCs. During cold shutdown and outages, the SG relief system [LBK10] will continue to provide protection against overpressure from sources such as external fire.

The SG relief system [LBK10] delivers a safety function in support of the ECC [JN01] safety measure to transfer residual heat from the SG to the environment.

Due to the system being located upstream of the MSIVs, the system forms part of the reactor containment boundary during Steam Generator Tube Rupture (SGTR) transients and as such there is a functional claim on the system isolation components to isolate containment and contain the reactor inventory during an SGTR. This function supports the ECC [JN01] and containment [JM01] safety measures.

10.2.3.2 Design Bases

10.2.3.2.1 Functional Requirements

The SG relief system [LBK10] contains sub-systems and components which facilitate delivery of CoFT, CoR and CoRM during fault conditions. The SG relief system [LBK10] is primarily reliant on the Main Steam Safety Valves (MSSVs) for successful sub-system function, to provide overpressure protection, and as part of the ECC [JN01] and containment isolation [JM01] safety measures. Safety categorised functional requirements specified for the SG relief system [LBK10] are based on the HLSFs they deliver, including the applicable plant states and operating modes, are presented in Table 10.2-5.

Table 10.2-5: SG relief system [LBK10] Safety Categorised Functional Requirements

ID	Functional Requirement	Plant State(s)	Mode(s) of Operation	Safety Category
LBK10-R-1267	Provide Secondary Side Overpressure Protection	DBC-2ii to DBC-4	1 to 4a	A
LBK10-R-1448	The SG Relief System [LBK10] shall transfer residual heat from the Steam Generator [JEA] to the environment	DBC-2ii to DBC-4	1 to 4a	A
LBK10-R-1449	The SG Relief System [LBK10] shall reseat and provide containment isolation	DBC-2ii to DBC-4	1 to 4a	A
LBK10-R-1382	The SG Relief System [LBK10] shall transfer residual heat from the Steam Generator [JEA] to the environment	DBC-2ii to DBC-4	1 to 4a	A
LBK10-R-1271	The SG Relief Valves [LBK10] shall reseat to re-establish containment isolation after lifting	DBC-2ii to DBC-4	1 to 4a	A
LBK10-R-1473	The SG Relief System [LBK10] shall contain the secondary coolant at the system's design conditions	DBC-2ii to DBC-4	1 to 4a	B

The full requirement set for the SG relief system [LBK10] is listed in the requirements specification module for the SG relief system [LBK10] in RR SMR the RR SMR requirements management database.

10.2.3.2.2 Non-Functional Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Tier 1 Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the SG relief system [LBK10]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.2.3.2.3 Safety Classification

The SG relief system [LBK10] fulfils category A safety functions. In accordance with the SMR E3S Categorisation and Classification Method [7], highest classification of components within the system is Class 1 and the overall safety classification of the SG relief system [LBK10] is Class I.

The components within the SG relief system [LBK10] are classified as follows:

- MSSVs: Class 1 in relation to the category A functional requirements to: provide overpressure protection, remove heat in support of the ECC [JN01] safety measure and provide a containment isolation [JM01] function in the event of an SGTR

- MSSV inlet and outlet pipework: Class 1 in support of the category A functions delivered by the MSSVs

- Drainage pipework and valves: Class 3 as they support a category A function but are not essential for its successful operation

- Temperature and valve position indication: Class 3 as they support a category A function but are not essential for its successful operation.

10.2.3.2.4 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules [4].

10.2.3.3 Description

There is a separate SG relief sub-system for each SG, for a total of three per SMR. The architecture for the SG relief system [LBK10] consists of two relief trains, each with an MSSV and an outlet to atmosphere via a silencer. Each relief line also contains a low point drain downstream of the MSSV that discharges accumulated liquids to the Reactor Island (RI) wastewater sub collection system [GMA]. The purpose of this is to remove accumulated condensate and rainwater to reduce or eliminate the effects of backpressure, and steam and water hammer in the vent line.

The MSSVs are conventional, spring-loaded relief valves designed to open at a set pressure to prevent the pressure in the SG or MSL from exceeding 110 % of their design pressures in all postulated overpressure scenarios. Each MSSV is sized to handle 100 % of the relieving duty required of that train for all design basis conditions, providing redundancy in case of a failure to open of any individual MSSV.

A full description of the SG relief system [LBK10] and associated components is provided in the System Design Description for the SG relief system [LBK10] [13].

10.2.3.4 Materials

Material will be confirmed as the design develops.

10.2.3.5 Interfaces with Supporting Systems

The SG relief system [LBK10] interfaces directly with the Main Steam Line (MSL) [LBA] upstream of the Main Steam Isolation Valve (MSIV) [LBA] and outside of the containment structure [JMA].

Interfaces for the SG relief system [LBK10] are identified and managed within the requirements specification for the system in the RR SMR requirements management database.

10.2.3.6 System and Equipment Operation

The RR SMR Power Station Operating Philosophy [9] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode.

An analysis of the system operation in all modes of operation has been conducted to develop an initial the SG relief system [LBK10] philosophy. This initial operating philosophy defines the operational sequences and actions the system is required to undertake and will help identify key claims for operators or automated actions in the future. The initial operating philosophy for each mode of operation can be found in the System Design Description for the SG relief system [LBK10].

10.2.3.7 Instrumentation and Control

The functions that are allocated to the control and protection systems by the SG relief system [LBK10] are:

- Alarms and Warnings to support the safe operation of the SG relief system [LBK10] by providing alarms and warnings to indicate that an MSSV is passing or open. These will be developed as the design develops.

- Monitoring and Indication:

  - To support the safe operation and control of the system, the reactor C&I system [JY] is required to monitor a range of key system parameters and provide indication of these to the operator in the control room and, during emergencies, Emergency Response Centre.

  - An increase in temperature downstream of an MSSV is indicative of material passing through from the MSL. The downstream temperature is correlated with the flow rate through an open or partially open MSSV and can be used to indicate the degree of passing for the measured valve. Therefore, temperature indication is required to inform operators of a passing MSSV.

  - Remote monitoring of MSSV relief valve position through a position indicator is provided.

A summary of the key monitoring and indication requirements for the SG relief system [LBK10] is presented in [13].

10.2.3.8 Monitoring, Inspection, Testing and Maintenance

The maintenance tasks and procedures, specific to the SG relief system [LBK10] environment and operating context are still being developed.

Maintenance activities considered will include:

- Safety derived tasks (ISI)
- Design derived tasks (Supplier provided)
- Reliability derived tasks (RCM/Preventative Maintenance)
- Industry best practice/OPEX (EPRI PMBD)
- Non-PBS (Module, Site Facility).

10.2.3.9 Radiological Aspects

No significant radiological aspects associated with the Steam Generation System [JEA] have been identified during design decisions up to DRP1/RD7. The radiological impact of potential MSSV lifts during SGTR transients and following primary to secondary leaks are to be considered during detailed design.

10.2.3.10 Performance and Safety Evaluation

HAZID assessment was carried out on the Steam Generation System [JEA], which includes SG relief system [LBK10]. The SG relief system [LBK10] was also assessed as part of the Reactor Coolant System [JE] HAZOP. Actions arising from the hazard identification assessments and their responses are detailed in the System Design Description for the SG relief system [LBK10] [13].

Verification activities to substantiate the E3S requirements set for the SG relief system [LBK10] are still to be determined.

10.2.3.11 Installation and Commissioning

The overall strategy for the RR SMR commissioning programme is presented in E3S Case Tier 1 Chapter 14: Plant Construction and Commissioning [10]. An outline of the SG relief system [LBK10] installation and commissioning plan be included in Version 3 of the generic E3S Case.

10.3 Feedwater System

10.3.1 Feedwater System

10.3.1.1 System and Equipment Functions

The primary function of the Feedwater System [LA] is to provide secondary circuit cooling to the SGs [JEA] for removal of heat from the reactor core. The equipment contained within the system allows for the conditioning of the water supply to ensure the feedwater is in line with the steam generator requirements.

The Feedwater System [LA] includes the Feedwater Piping System [LAB], which interfaces with both Reactor Island [R01] and Turbine Island [T01]. All aspects of the Feedwater System [LA] up to the connections to SGs [JEA] are covered in this section, noting the Reactor Island [R01] aspects are still in development at DRP1/RD7.

10.3.1.2 Design Bases

10.3.1.2.1 Functional Requirements

The Feedwater System [LA] within the Turbine Island facilitates delivery of CoFT during normal operation. The Steam Feedwater System [LA] contains sub-systems and components which facilitate the safety functional requirements associated with HTHR [JN03]. Safety categorised functional requirements specified for the Feedwater System [LA] based on the HLSFs they deliver, are allocated in the RR SMR requirements management database Feedwater System [LA] Requirements modules. Non-functional performance requirements associated with the safety categorised functional requirements are also allocated in the RR SMR requirements management database modules, including the rationale for their selection.

10.3.1.2.2 Non-Functional System Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Tier 1 Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the Feedwater System [LA]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.3.1.2.3 Safety Classification

The highest category of the Steam Feedwater System [LA] functions fulfilling HLSF is category C. In accordance with the SMR E3S Categorisation and Classification Method [7], Feedwater System [LA] is a safety class 3 system. It is anticipated that the RI side of the of the Steam Feedwater System [LA], which is to be further developed post DRP1/RD7, will fulfil category A functions for containment isolation.

10.3.1.2.4 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules [4].

10.3.1.3 Description

The Feedwater System [LA] comprises the following sub-systems:

- Deaerator and Feedwater Storage System [LAA], which removes dissolved gasses from the feedwater through contact with heating steam. The feedwater will be heated close to the saturation temperature by the LP feedwater heaters and steam, reducing the solubility of dissolved gas within the water.

- Feedwater Piping System [LAB], which contains pipework to transport the water to the steam generator system to provide cooling for the Reactor Island [R01]. Feedwater Piping System [LAB] contains a wide variety of valves to ensure safe operation of the RR SMR.

- Feedwater Conveying System [LAC], which supplies pressurised feedwater to the steam generators. The pumps provide feedwater flow up to approximately 720 kg/s over various operating modes. The pumps are currently driven by variable speed drives, however, the architecture and technology will be superseded with vendor design as the design matures.

- High Pressure Feedwater Heating System [LAD], which provides feedwater preheating, to improve the thermodynamic efficiency of the secondary circuit. The HP feed heaters are set out in two parallel trains of first stage and second stage feed heating. The first stage of HP feed heating takes bled steam from the HP turbine as well as receiving condensate from the second stage HP heating. The second stage HP feed heating takes bled steam from the HP turbine as well as receiving waste condensate from the MSR [LBJ]. The two paths converge and supply the feedwater discharge heater.

The key performance and design parameters are presented in Table 10.3-1.

Table 10.3-1: Key Performance and Design Parameters for the Feedwater System [LA]

Parameter	**Value**	**Units**
Deaerator Operating Conditions [LAA]		
Water Supply Temperature	147	°C
System Pressure	0.9	MPa(a)
Storage tank water temperature	176	°C
Volume	Approx. 360	m^3 (water)
Feed Pumps (Main and Booster) Operation [LAC]		
Suction Pressure	0.9	MPa(a)
Discharge Pressure	8.4	MPa(a)
Flow Rate	766	kg/s
Drive	Electric Variable Speed Drive	N/A
Type	Multi-stage centrifugal	N/A
HP Feed Heater Operation [LAD]		
Stage 1 Outlet Temperature	203	°C

Parameter	Value	Units
Stage 2 Outlet Temperature	230	°C

Further description of the Feedwater System [LA] and associated sub-systems is provided in System Design Description for the Feedwater System [LA] [14].

10.3.1.4 Materials

Materials will be confirmed in Version 3 of the generic E3S Case.

10.3.1.5 Interfaces with Supporting Systems

The major system interfaces of the Feedwater System [LA] are the Condensate System [LC], the SGs [JEA] and the Auxiliary Feedwater System [LJ], which provides feedwater flow under start-up and faulted conditions. The interfaces for the Feedwater System [LA] are all identified and managed within the RR SMR requirements management database, including flow down of functional requirements.

10.3.1.6 System and Equipment Operation

The RR SMR Power Station Operating Philosophy [9] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode.

An analysis of the system operation in all modes of operation has been conducted to develop an initial Feedwater System [LA] operating philosophy. This initial operating philosophy defines the operational sequences and actions the system is required to undertake and will help identify key claims for operators or automated actions in the future. The initial operating philosophy for each mode of operation can be found in the System Design Description for the Feedwater System [LA] [14]. The operating philosophy will be developed and amended with vendor input in the future.

10.3.1.7 Instrumentation and Control

The functions that are allocated to the Control and Protection Systems - Feedwater, Steam and Condensate [LY] by the Feedwater System [LA] are:

- Alarms and Warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. The Alarms and Warnings for the Feedwater System [LA] are still being developed and will be developed with vendor engagement.

- Control Logic:

    - Control of the deaerator feedwater temperature to ensure correct deaerator operation. During start up, the feedwater temperature is controlled through the rate of auxiliary steam being fed into the deaerator. During normal operation, the condensate is pre-heated to close to saturation temperature by the low-pressure feedwater heaters in the condensate system. This can be controlled by the rate of steam entering the LP heaters.

- Control of deaerator level through balancing the inlet and outlet flows. The condensate inlet is controlled by a control valve downstream of the condensate extraction pumps. A level transmitter from the deaerator signals this valve controller. The steam inlet from the auxiliary steam system is controlled via a valve which is signalled from a pressure transmitter on the deaerator. The main feedwater outlet flow is controlled by the main feedwater control valves in the Reactor Island portion of the secondary circuit. These are signalled by the SG level transmitters. Finally, there is an overflow line which opens back to the condenser on a high level signalled from the transmitter. Ultimately the level in the deaerator will fluctuate depending on the operating mode but during normal operating the level is fundamentally controlled using the forward flow condensate control valves downstream of the deaerator.

- Control of the final feed water temperature at the feedwater outlet of the high-pressure feedwater heat exchangers. During normal operation, the HP feedwater heat exchanger outlet temperature is controlled by the rate of HP turbine steam extraction in normal operation. During start-up, the HP heaters are bypassed, and the final feedwater temperature is a function of the deaerator outlet temperature. The deaerator temperature in start-up is controlled through steam supply from the auxiliary steam system.

- Control logic of chemical injection and sampling is to be defined with vendor design.

10.3.1.8 Monitoring, Inspection, Testing and Maintenance

The maintenance tasks and procedures, specific to the Feedwater System [LA] environment and operating context are still being developed.

Maintenance activities considered will include:

- Safety derived tasks (ISI)
- Design derived tasks (Supplier provided)
- Reliability derived tasks (RCM/Preventative Maintenance)
- Industry best practice/OPEX (EPRI PMBD
- Non-PBS (Module, Site Facility).

10.3.1.9 Radiological Aspects

No significant radiological aspects associated with the Feedwater System [LA] have been identified during design decisions up to DRP1/RD7.

10.3.1.10 Performance and Safety Evaluation

HAZID assessments are carried out on the Turbine Island [T01]. The design of the Feedwater System [LA] at DRP1/RD7 considers internal hazards from the Turbine Island HAZID report which have the potential to cause damage to the Feedwater System [LA], and identifies any protections/barriers/mitigations, as detailed in the System Design Description for the Feedwater System [LA] [14].

Verification activities to substantiate the E3S requirements set for the Feedwater System [LA] are still to be determined.

10.3.1.11 Installation and Commissioning

The overall strategy for the RR SMR commissioning programme is presented in E3S Case Tier 1 Chapter 14: Plant Construction and Commissioning [10]. An outline installation and commissioning plan for the Feedwater System [LA] has been developed during the current design phase to confirm viability of the proposed system to function as intended.

Installation requirements for the Feedwater System [LA] are detailed in the requirements specification for the Turbine Island [T01] in the RR SMR requirements management database. Installation requirements and allocated requirements will be developed further by the vendors.

A comprehensive commissioning plan will be developed during detailed design. As part of the modularisation and build certainty strategy, with an aim to reduce cost and commissioning time, factory commissioning activities will be utilised where possible to reduce on site commissioning. It is anticipated that system architecture performing a system function will need to undergo an approved functional test. Further commissioning and testing activities may be required to satisfy a safety function, should one be allocated to architecture or components in the Feedwater System [LA] during detail design.

10.3.2 Auxiliary Feedwater system

10.3.2.1 System and Equipment Functions

The primary function of the Auxiliary Feedwater System [LJ] is to provide an auxiliary supply of feedwater to the steam generator [JE] for removal of heat from the reactor core in the event of, High Temperature Heat Removal Variant 2, faulted Condenser Decay Heat Removal, and Variant 3, Atmospheric Steam Dump Decay Heat Removal, and start-up situations. The connections to the Auxiliary Feedwater System [LJ] allows for the conditioning of the water supply to ensure compliance with the guidance documents.

The Auxiliary Feedwater System [LJ] includes the Auxiliary Feedwater System for nuclear steam generator [LJA], which interfaces with both Reactor Island [R01] and Turbine Island [T01]. All aspects of the Auxiliary Feedwater System [LJ] up to the connections to SGs [JEA] are covered in this section, noting the Reactor Island [R01] aspects are still in development at DRP1/RD7.

10.3.2.2 Design Bases

10.3.2.2.1 Functional Requirements

The Auxiliary Feedwater System [LJ] within the Turbine Island facilitates delivery of CoFT during normal operation and abnormal conditions. The Auxiliary Feedwater System [LJ] is required to support a series of safety categorised functional requirements relating to HTHR [JN03]. Safety categorised functional requirements specified for the Auxiliary Feedwater System [LJ] based on the HLSFs they deliver, including the applicable plant states and operating modes, are presented in Table 10.3-2.

Table 10.3-2: Auxiliary Feedwater System [LJ] Safety Categorised Functional Requirements

ID	Functional Requirement	Plant State(s)	Mode(s) of Operation	Safety Category
LJ-R-1473	The Auxiliary Feedwater System [LJ] shall convey auxiliary feedwater	DBC-1 DBC-2i	1 to 4a	C
LJ-R-1475	The Auxiliary Feedwater System [LJ] shall distribute auxiliary feedwater	DBC-1 DBC-2i	1 to 4a	C
LJ-R-1276	The Auxiliary Feedwater System [LJ] shall distribute low voltage electrical power to the Auxiliary Feedwater System [LJ]	DBC-1 DBC-2i	1 to 4a	C
LJ-R-2052	The Auxiliary Feedwater System [LJ] shall distribute high voltage electrical power to the Auxiliary Feedwater System [LJ]	DBC-1 DBC-2i	1 to 4a	C
LJ-R-1599	During Faulted Condenser Decay Heat Removal operation, the Auxiliary Feedwater System [LJ] shall supply feedwater to the Steam Generators [JEA]	DBC-1 DBC-2i	1 to 4a	C
LJ-R-1597	During Atmospheric Steam Dump Decay Heat Removal operation, the Auxiliary Feedwater System [LJ] shall supply feedwater to the Steam Generators [JEA]	DBC-1 DBC-2i	1 to 4a	C
LJ-R-2059	During HTHR Variant 4 - Atmospheric Steam Dump and Condenser Decay Heat Removal (CDHR), Full Load Rejection operation, the Auxiliary Feedwater System [LJ] shall be on standby to supply feedwater to the Steam Generators [JEA]	DBC-1 DBC-2i	1 to 4a	C
LJ-R-1601	During Atmospheric Steam Dump and Condenser Decay Heat Removal operation (Full Load Rejection), the Auxiliary Feedwater System [LJ] shall supply feedwater to the Steam Generators [JEA]	DBC-1 DBC-2i	1 to 4a	C

Non-functional performance requirements associated with the safety categorised functional requirements are also allocated in the RR SMR requirements management database Auxiliary Feedwater System [LJ] requirements module, including the rationale for their selection, which are not repeated here.

10.3.2.2.2 Non-Functional Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Tier 1 Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the Auxiliary Feedwater System [LJ]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.3.2.2.3 Safety Classification

The highest category of the Auxiliary Feedwater System [LJ] functions fulfilling HLSF is category C. In accordance with the SMR E3S Categorisation and Classification Method [7], Auxiliary Feedwater System [LJ] is a safety class 3 system.

10.3.2.2.4 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules [4].

10.3.2.3 Description

The Auxiliary Feedwater System [LJ] comprises the following sub-systems:

- Auxiliary Feedwater System for Nuclear Steam generator [LJA], which transfers the feedwater provided by the Auxiliary Feedwater System on Feedwater Side of Nuclear Steam generator [LJK] to the Steam Generators [JEA] in Reactor Island [R01]

- The Auxiliary Feedwater System on Feedwater Side of Nuclear Steam generator [LJK], which transfers feedwater to the Auxiliary Feedwater System for Nuclear Steam generator [LJA] to the Steam Generators [JEA] in Reactor Island [R01].

The key performance and design parameters are presented in Table 10.3-3.

Table 10.3-3: Key Performance and Design Parameters for the Auxiliary Feedwater System [LJ]

Parameter	**Value**	**Units**
Auxiliary Feedwater Minimum Temperature	5	°C
Auxiliary Feedwater Maximum Temperature	176	°C
Auxiliary Feedwater Nominal Pressure	8.4	MPa(a)
Auxiliary Feedwater Minimum Flow Rate	25	kg/s
Auxiliary Feedwater Maximum Flow Rate	38	kg/s
Auxiliary Feedwater Number of Pumps	2	-
Auxiliary Feedwater Pump Capacity per pump	100 %	-
Auxiliary Feedwater Pump Motor Power (Estimated)	654	kW
Auxiliary Feedwater System Min. Feedwater Supply Volume	500	m^3
Auxiliary Feedwater System Min. Feedwater Supply Head	1	m

Auxiliary Feedwater System Max. Feedwater Supply Head	5	m

Further description of the Auxiliary Feedwater System [LJ] and associated sub-systems is provided in the System Design Description for the Auxiliary Feedwater System [LJ] [15].

10.3.2.4 Materials

Materials will be confirmed in Version 3 of the generic E3S Case.

10.3.2.5 Interfaces with Supporting Systems

The major system interfaces of the Auxiliary Feedwater System [LJ] are the Feedwater System [LA] and the SGs [JEA]. The interfaces for the Feedwater System [LA] are all identified and managed within the RR SMR requirements management database, including flow down of functional requirements.

10.3.2.6 System and Equipment Operation

The RR SMR Power Station Operating Philosophy [9] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode.

An analysis of the system operation in all modes of operation has been conducted to develop an initial Auxiliary Feedwater System [LJ] operating philosophy. This initial operating philosophy defines the operational sequences and actions the system is required to undertake and will help identify key claims for operators or automated actions in the future. The initial operating philosophy for each mode of operation can be found in the System Design Description for the Auxiliary Feedwater System [LJ] [15]. The operating philosophy will be developed and amended with vendor input in the future.

10.3.2.7 Instrumentation and Control

The functions that are allocated to the Control and Protection Systems - Feedwater, Steam and Condensate [LY] by the Auxiliary Feedwater System [LJ] are:

- Alarms and Warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. The Alarms and Warnings for Auxiliary Feedwater System [LJ] are still being developed and will be developed with vendor engagement.

- Control Logic:

    - The Auxiliary Feedwater System [LJ] duty and standby pumps are fixed speed pumps delivering up to 38 kg/s. To protect the pumps, feedwater can be routed back to the supply storage location. The recirculation line contains a control valve which modulates based on input from a flow indicator into a flow controller. The isolation valve configuration will ensure that the excess feedwater is returned to the water storage location that the pump is being supplied from.

- Steam generator level is maintained through the rate of feedwater delivery. This is controlled by flow control valves either on the Auxiliary Feedwater Pipework or Main Feedwater pipework on Reactor Island [R01] side, depending on if the Auxiliary Feedwater System [LJ] is operating during faulted operation or startup operations.

- Further work is needed on developing storage level control and maintaining minimum supply temperature, which will be carried out with vendor design support.

10.3.2.8 Monitoring, Inspection, Testing and Maintenance

The maintenance tasks and procedures, specific to the Auxiliary Feedwater System [LJ] environment and operating context are still being developed.

Maintenance activities considered will include:

- Safety derived tasks (ISI)
- Design derived tasks (Supplier provided)
- Reliability derived tasks (RCM/Preventative Maintenance)
- Industry best practice/OPEX (EPRI PMBD)
- Non-PBS (Module, Site Facility).

10.3.2.9 Radiological Aspects

No radiation assessment has been carried out for the Auxiliary Feedwater System [LJ], however it is not expected to contain significant radioactive sources.

10.3.2.10 Performance and Safety Evaluation

HAZID assessments are carried out on the Turbine Island [T01]. The design of the Auxiliary Feedwater System [LJ] at DRP1/RD7 considers internal hazards from the Turbine Island HAZID report which have the potential to cause damage to Auxiliary Feedwater System [LJ] and identifies any protections/barriers/mitigations, as detailed in the System Design Description for the Auxiliary Feedwater System [LJ] [15].

Verification activities to substantiate the E3S requirements set for the Auxiliary Feedwater System [LJ] are still to be determined.

10.3.2.11 Installation and Commissioning

The overall strategy for the RR SMR commissioning programme is presented in E3S Case Tier 1 Chapter 14: Plant Construction and Commissioning [10]. An outline installation and commissioning plan for the Auxiliary Feedwater System [LJ] has been developed during the current design phase to confirm viability of the proposed system to function as intended.

Installation requirements for the Auxiliary Feedwater System [LJ] are detailed in the requirements specification for the Turbine Island [T01] in the RR SMR requirements management database. Installation requirements and allocated requirements will be developed further by the vendors.

A comprehensive commissioning plan will be developed during detailed design. As part of the modularisation and build certainty strategy, with an aim to reduce cost and commissioning time, factory commissioning activities will be utilised where possible to reduce on site commissioning. It is anticipated that system architecture performing a system function will need to undergo an approved functional test. Further commissioning and testing activities may be required to satisfy a safety function, should one be allocated to architecture or components in the Auxiliary Feedwater System [LJ] during detail design.

10.4 Turbine Generator

10.4.1 Design Bases

The primary functions of the Generator System [MK] are to:

- Convert mechanical rotational energy to electrical energy in the form of high voltage, three-phase AC electricity
- Provide auxiliary support systems to the main generator equipment to ensure proper function.

The Generator System [MK] is connected to the shaft of the high pressure (HP) and low pressure (LP) turbines in the Steam Turbine System [MA]. The Generator System [MK] supplies the converted electrical energy to the Transmission System [MS] for the main purpose of exporting to the grid.

10.4.1.1 Functional Requirements

The Steam Generator System [MK] contains sub-systems and components which facilitate the safety functional requirements associated with HTHR. Therefore, the highest category of the Generator System [MK] functions fulfilling HLSF is category C. The safety categorised functional requirement for the Generator System [MK] will be specified for the design in generic E3S Case Version 3.

10.4.1.2 Non-Functional Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Tier 1 Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the Generator System [MK]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.4.1.3 Safety Classification

In accordance with the SMR E3S Categorisation and Classification Method [7], Generator System [MK] is a safety class 3 system.

10.4.1.4 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules [4].

10.4.2 Description

The Generator System [MK] is mainly responsible for the conversion of rotational mechanical energy to electrical energy within the Turbine Island [T01] secondary circuit. It comprises the following sub-systems:

- Generator [MKA], which converts mechanical rotational energy, received from the Steam Turbine [MA] through direct rotor coupling connection, into electrical energy in the form of three phase high-voltage AC electricity, supplying the Transmission System [MS]

- Generator Exciter Set System [MKC], which generates the electromagnetic field in the generator rotor to induce electrical voltage

- Bearing System [MKD], which enables rotation of the turbine rotor train by receiving and returning lubrication oil through the interface with the Generator System Lubricant System [MKV]. It also provides support to, and is responsible for, keeping the turbine rotor train within axial and radial displacement limits.

- Rotor Hydrogen Cooling System [MKG], which manages and distributes hydrogen between the generator and the cooling heat exchangers that interface with the Turbine Island Closed Cooling Water System [PG]

- Exhaust Gas System [MKQ], which is responsible for venting off gases from the Generator [MKA] and auxiliaries

- Generator System Lubricant System [MKV], which supplies lubricant to the Bearing System [MKD]

- Generator System Sealing Fluid System [MKW], which manages and distributes generator sealing oil at the generator shaft seals, to prevent the hydrogen within the generator from escaping through the generator seals to atmosphere.

Key performance and design parameters for the system are presented in Table 10.4-1.

Table 10.4-1: Key Performance and Design Parameters for the Generator System [MK]

Parameter	Value	Units
Generator Speed	3000	rpm
Generator Output Maximum Voltage	18-23	kV (AC)
Generator Output Frequency	50	Hz
Generator Exciter Input Voltage	TBD	V
Rotor Cooling Hydrogen Pressure	TBD	MPa(a)
Rotor Cooling Hydrogen Temperature	TBD	°C
Rotor Cooling Hydrogen Rate	TBD	kg/s
Oil Viscosity	TBD	cSt
Lubrication Oil Flow Rate	TBD	kg/s
Sealing Oil Flow Rate	TBD	kg/s
Sealing Oil Pressure at Pump Inlet	TBD	MPa(a)
Sealing Oil Pressure at Pump Outlet	TBD	MPa(a)
Sealing Oil Temperature at Seals	TBD	°C
Seal Oil Pump Power	TBD	kW

The Generator System [MK] is in the Turbine Building [UMA]. Further details of the Generator System [MK] and its sub-systems and components are presented in the System Design Description [16].

10.4.3 Turbine Rotor Integrity

The integrity of the Generator System [MK] will be demonstrated as the design develops and vendors are engaged, and requirements are verified and validated.

10.5 Turbine and Condenser Systems

10.5.1 Steam Turbine System

10.5.1.1 System and Equipment Functions

The Steam Turbine System [MA] is mainly responsible for the conversion of steam energy to mechanical rotational energy within the Turbine Island secondary circuit. The system receives high pressure steam into the High Pressure Turbine [MAA], which is a double-flow configuration. The high-pressure turbine distributes extraction steam to the Steam System [LB] feedwater heaters, and exhausts to the two Low Pressure Turbines [MAC], which are also double-flow configuration, via the Cold Reheat Piping System [LBC], Moisture Separator and Reheater System [LBJ] and Hot Reheat Piping System [LBB].

10.5.1.2 Design Bases

10.5.1.2.1 Functional System Requirements

The Steam Turbine System [MA] facilitates delivery of CoFT during normal operation and abnormal conditions. The Steam Turbine System [MA] contains sub-systems and components which facilitate the safety categorised functional requirements associated with HTHR [JN03]. Safety categorised functional requirements specified for the Steam Turbine System [MA] based on the HLSFs they deliver, including the applicable plant states and operating modes, are presented in Table 10.5-1.

Table 10.5-1: Steam Turbine System [MA] Safety Categorised Functional Requirements

ID	Functional Requirement	Plant State(s)	Mode(s) of Operation	Safety Category
M-MA-1334	The Steam Turbine System [MA] shall supply condensate to the Condensate System [LC].	DBC-1 DBC-2i	1 to 4a	C
M-MA-1333	The Steam Turbine System [MA] shall distribute condensate from the Condensate System [LC]	DBC-1 DBC-2i	1 to 4a	C

Non-functional performance requirements associated with the safety categorised functional requirements are also allocated in the RR SMR requirements management database Steam Turbine System [MA] requirements module, including the rationale for their selection, which are not repeated here.

10.5.1.2.2 Non-Functional System Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Tier 1 Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the Steam Turbine System [MA]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.5.1.2.3 Safety Classification

The highest category of the Steam Turbine System [MA] functions fulfilling HLSF is category C. In accordance with the SMR E3S Categorisation and Classification Method [7], Steam Turbine System [MA] is a safety class 3 system.

10.5.1.3 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules [4].

10.5.1.4 Description

The Steam Turbine System [MA] comprises the following sub-systems:

- High Pressure Turbine [MAA], which receives steam from the Main Steam Piping System [LBA], where it is fed to two inlet valve combinations, expanded through the two opposing flow paths, and exhausted to the Cold Reheat Piping System [LBC]. It sits on the same rotor train as the Low Pressure Turbines [MAC] and the Generator [MKA] in a single axis tandem compound arrangement all operating at full speed rotation (3000 rpm).

- Low Pressure Turbines [MAC], which is made up to two turbine sections, each receiving nominally equal steam conditions from the Hot Reheat Piping System [LBB] to convert steam energy to mechanical rotational energy. Expanded steam is then exhausted to the Condensing System [MAG].

- Bearing System [MAD], which enables rotation of the turbine rotor train by receiving and returning lubrication oil through the interface with the Steam Turbine Lubricant System [MAV]. It also provides support to, and is responsible for, keeping the turbine rotor train within axial and radial displacement limits.

- Condensing System [MAG] comprises of two separate waterboxes, one per Low Pressure Turbine [MAC]. The primary function of the Condensing System [MAG] is to decrease the exhaust pressure of the steam extracted from the Low Pressure Turbines [MAC] to below atmosphere, improving the efficiency of the power plant. The cooling water supply from the Main Cooling Water System [PA] for the two waterboxes is arranged in series.

- Air Removal and Evacuation System [MAJ], responsible for extracting and venting off non-condensable gases from the Condensing System [MAG] and ensures the Main Condenser shells are kept at the required pressure during start-up and normal operating modes. Cooling is provided by the heat exchangers that interface with the Turbine Island Closed Cooling Water System [PG].

- Transmission gear (shaft turning gear) [MAK], responsible for maintaining a rotational speed (~1 Hz) of the turbine and generator rotor train when transitioning in preparation for start-up or shutdown

- Drain and Vent System [MAL], responsible for receiving and collecting drains and vents from the Turbine Island [T01] and distributing them accordingly either back into the Condensing system [MAG] or discharging to Balance of Plant [B01]

- Leak-off Steam System [MAM], responsible for receiving and collecting leak-off steam from a selection of the major valves in the Turbine Island [T01] and distributing them either back into the Condensing System [MAG] via the gland steam condenser as part of the Steam Turbine Sealing System [MAW], or discharging to Balance of Plant [B01]

- Turbine Bypass Station [MAN], which provides bypass capability for steam received from the Main Steam Piping System [LBA] to be diverted around the steam turbine and sent directly to the Condensing System [MAG] during start-up/shut down operations, transient load changes or during major fault modes

- Vent system [MAQ], responsible for providing venting to the steam turbine system auxiliary equipment. The Vent System [MAQ] allows venting of the main lubrication oil tank of the Steam Turbine Lubricant System [MAV]

- Steam Turbine Lubricant System [MAV], which supplies lubricant to the Bearing System [MAD]

- Steam Turbine Sealing System [MAW], responsible for managing and distributing steam turbine sealing steam between the Steam Turbine System [MA] and the Auxiliary Steam Piping System [LBG] (used during start-up, low-load, and shutdown).

The key performance and design parameters are presented in Table 10.5-2.

Table 10.5-2: Key Performance and Design Parameters for the Steam Turbine System [MA]

Parameter	Value	Units
Steam Turbine Nominal Speed	3000	rpm
HP Turbine - Inlet Steam Pressure	7.15	MPa(a)
HP Turbine - Inlet Steam Temperature	287.3	°C
HP Turbine - Inlet Steam Flow Rate	730.4	kg/s
HP Turbine - Outlet Steam Pressure	0.955	MPa(a)
HP Turbine - Outlet Steam Temperature	177.9	°C
HP Turbine - Outlet Steam Flow Rate	606	kg/s
LP Turbine 1 - Inlet Steam Pressure	0.905	MPa(a)
LP Turbine 1 - Inlet Steam Temperature	274.6	°C
LP Turbine 1 - Inlet Steam Flow Rate	245.5	kg/s
LP Turbine 1 - Outlet Steam Pressure	0.0056	MPa(a)
LP Turbine 1 - Outlet Steam Temperature	35	°C
LP Turbine 1 - Outlet Steam Flow Rate	197.9	kg/s
LP Turbine 2 - Inlet Steam Pressure	0.905	MPa(a)
LP Turbine 2 - Inlet Steam Temperature	274.6	°C
LP Turbine 2 - Inlet Steam Flow Rate	245.5	kg/s
LP Turbine 2 - Outlet Steam Pressure	0.0036	MPa(a)

Parameter	Value	Units
LP Turbine 2 - Outlet Steam Temperature	27	°C
LP Turbine 2 - Outlet Steam Flow Rate	198	kg/s
Condenser 1 Outlet Pressure	0.0056	MPa(a)
Condenser 1 Outlet Temperature	34	°C
Condenser 1 Outlet Flow Rate	217	kg/s
Condenser 2 Outlet Pressure	0.0036	MPa(a)
Condenser 2 Outlet Temperature	26	°C
Condenser 2 Outlet Flow Rate	198	kg/s
Turning Gear Shaft Speed	60	rpm
Bypass Steam Inlet Pressure	7.15	MPa(a)
Bypass Steam Inlet Temperature	287.3	°C
Bypass Steam Outlet Pressure	TBD	MPa(a)
Bypass Steam Outlet Temperature	TBD	°C
Bypass Steam Max Flow Rate	536.2	kg/s
HP Sealing Steam Pressure	TBD	MPa(a)
HP Sealing Steam Temperature	TBD	°C
LP Sealing Steam Pressure	TBD	MPa(a)
LP Sealing Steam Temperature	TBD	°C
Sealing Steam Flow Rate	TBD	kg/s

The Steam Turbine System [MA] is in the Turbine Building [UMA]. Further details of the Steam Turbine System [MA] and its sub-systems are presented in the System Design Description for the Steam Turbine System [17].

10.5.1.5 Materials

Materials will be confirmed in Version 3 of the generic E3S Case.

10.5.1.6 Interfaces with Supporting Systems

The Steam Turbine System [MA] functional and physical interfaces are described above. These are identified and managed within the RR SMR requirements management database, including flow down of functional requirements.

10.5.1.7 System and Equipment Operation

The RR SMR Power Station Operating Philosophy [9] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode.

An analysis of the system operation in all modes of operation has been conducted to develop an initial Steam Turbine System [MA] operating philosophy. This initial operating philosophy defines the operational sequences and actions the system is required to undertake and will help identify key claims for operators or automated actions in the future. The initial operating philosophy for each mode of operation can be found in the System Design Description for the Steam Turbine System [MA] [17].The operating philosophy will be developed and amended with vendor input in the future.

10.5.1.8 Instrumentation and Control

The functions that are allocated to the Control and Protection Systems - Turbine Island [MY] by the Steam Turbine System [MA] are:

- Alarms and warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. Alarms and warnings for the Steam Turbine System [MA] are still being developed and will be developed with vendor engagement.

- Control Logic:

    - The High Pressure Turbine [MAA] and Low Pressure Turbines [MAC] operation is controlled through interface with monitoring instrumentation within the Steam Generators [JEA], Main Steam Piping System [LBA], Hot Reheat Piping System [LBB], Cold Reheat Piping System [LBC], Turbine Bypass Station [MAN], Condensing System [MAG] and auxiliary support systems.

    - The Condensing System [MAG] hotwell level is controlled through interface and coordination with the Main Condensate Piping System [LCB], Turbine Bypass Station [MAN], Demineralised Water Control and Protection System [GCY] from Balance of Plant [B01] and the condensate extraction pumps, as part of the Main Condensate Conveying System [LCC].

    - The Condensing System [MAG] hotwell pressure and temperature control will interface with the Cooling Water Island control systems to control the cooling water supply to the Condensing System [MAG].

    - The Air removal and Evacuation System [MAJ] interfaces with the Condensing System [MAG] to control the removal of non-condensable gasses from the Condensing System [MAG].

    - Turbine Bypass Station [MAN] control is required to ensure bypass operation when required during start-up/shut down operations, transient load changes or during major fault modes associated with decay heat removal. The system is controlled through input from monitoring on the Steam Generators [JEA], Main Steam Piping System [LBA], Hot Reheat Piping System [LBB], Cold Reheat Piping System [LBC] Steam Turbine System [MA], the Condensing System [MAG] and auxiliary support systems. The Turbine Bypass Valves can also be controlled through input from monitoring the pressure and temperature of the turbine bypass lines.

    - The control of the Steam Turbine Sealing System [MAW] is managed through controlling the steam supplied from the Auxiliary Steam Piping System [LBG] and the Auxiliary Steam Generating System [QH]. The sealing steam low pressure supply is controlled through feedback to supply control valves and excess steam control valves, which vent to the Low Pressure Heaters [LCD]. The temperature of the steam within the Steam Turbine Sealing System [MAW] is controlled through temperature indication feedback to a control valve, that modulates the flow of steam through a steam cooler. This recovered heat from the drained steam from the Steam Turbine Sealing System [MAW].

- Control logic definition of the Steam Turbine Lubricant System [MAV] is in early development and will be developed with vendor design. Its control will ensure supply of lubrication and jacking oil to the steam turbine bearings in response to shaft speed.

- Control logic surrounding the Drain and Vent System [MAL], Leak-off Steam System [MAM] and Vent system [MAQ] is still in the early stages of development and will be developed with vendor design.

10.5.1.9 Monitoring, Inspection, Testing and Maintenance

The maintenance tasks and procedures, specific to the Steam Turbine System [MA] environment and operating context are still being developed.

Maintenance activities considered will include:

- Safety derived tasks (ISI)
- Design derived tasks (Supplier provided)
- Reliability derived tasks (RCM/Preventative Maintenance)
- Industry best practice/OPEX (EPRI PMBD)
- Non-PBS (Module, Site Facility).

10.5.1.10 Radiological Aspects

No significant radiological aspects associated with the Steam Turbine System [MA] have been identified during design decisions up to DRP1/RD7.

10.5.1.11 Performance and Safety Evaluation

HAZID assessments are carried out on the Turbine Island [T01]. The design of the Steam Turbine System [MA] at DRP1/RD7 considers internal hazards from the Turbine Island HAZID report which have the potential to cause damage to the Steam Turbine System [MA] and identifies any protections/barriers/mitigations, as detailed in the System Design Description for the Steam Turbine System [MA] [17].

Verification activities to substantiate the E3S requirements set for the Steam Turbine System [MA] are still to be determined.

10.5.1.12 Installation and Commissioning

The overall strategy for the RR SMR commissioning programme is presented in E3S Case Tier 1 Chapter 14: Plant Construction and Commissioning [10]. An outline installation and commissioning plan for the Steam Turbine System [MA] will be developed during the further design phases to confirm viability of the proposed system to function as intended. The installation requirements for the Steam Turbine System [MA] will be developed by the Turbine Island vendors. A comprehensive commissioning plan will be developed during detailed design. As part of the modularisation and build certainty strategy, with an aim to reduce cost and commissioning time, factory commissioning activities will be utilised where possible to reduce on site commissioning. It is anticipated that the system architecture performing a system function will need to undergo an approved functional test. Further commissioning and testing activities may be required to satisfy a safety function, should one be allocated to architecture or components in the Steam Turbine System [MA] Steam Turbine System [MA] during detail design.

10.5.2 Condensate System

10.5.2.1 System and Equipment Functions

The Condensate System [LC] forms part of the main water return system of the secondary circuit and comprises of the systems and sub-systems associated with the management of condensate extracted from the condenser and delivered to the feedwater system [LA]. The system primarily consists of condensate extraction pumps, low pressure feedwater heaters, interconnecting pipework and instrumentation along with any condensate drains throughout the main steam supply system train which feed back into the main feedwater circuit.

10.5.2.2 Design Bases

10.5.2.2.1 Functional Requirements

The Condensate System [LC] is responsible for delivering CoFT HLSF during normal operation and abnormal conditions. The Condensate System [LC] contains sub-systems and components which facilitate the safety functional requirements associated with HTHR [JN03]. Safety categorised functional requirements specified for the Condensate System [LC] based on the HLSFs they deliver, including the applicable plant states and operating modes, are presented in Table 10.5-3.

Table 10.5-3: [LC] Safety Categorised Functional Requirements

ID	Functional Requirement	Plant State(s)	Mode(s) of Operation	Safety Category
L-LC-1276	The Condensate System [LC] shall distribute high voltage electrical power to the internal Condensate System [LC] Systems	DBC-1 DBC-2i	1 to 4a	C
L-LC-1335	The Condensate System [LC] shall distribute low voltage electrical power to the internal Condensate System [LC] Systems	DBC-1 DBC-2i	1 to 4a	C

10.5.2.2.2 Non-Functional System Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Tier 1 Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the Condensate System [LC]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.5.2.2.3 Safety Classification

The highest category of the Condensate System [LC] functions fulfilling HLSF is category C. In accordance with the SMR E3S Categorisation and Classification Method [7], Condensate System [LC] is a safety class 3 system.

10.5.2.2.4 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules [4].

10.5.2.3 Description

The Condensate System [LC] forms part of the main water return system of the secondary circuit and comprises of the systems and sub-systems associated with the management of condensate extracted from the Main Condenser [MAG] and delivered to the Feedwater System [LA]. It comprises of the following sub-systems:

- Main Condensate Piping System [LCB], made up of a piping network used to convey the condensate from the condenser hotwell to the deaerator feedwater tank inlet [LAA]
- Main Condensate Conveying System [LCC], which extracts the condensate from the condenser hotwell and discharges it through the LP heaters to the HP Feedwater System [LA]
- Main Condensate Pre-Heating System [LCD], which uses heaters to pre-heat the condensate and improve thermodynamic efficiency
- Condensate De-Superheating Spray System [LCE], which refers to the attemperation water taken directly from the Condensate System [LC] to spray down the bypass steam [MAN] to within acceptable temperature limits prior to the steam being injected into the Main Condensers [MAG]
- Condensate System of Feedwater Pre-Heating Drains [LCH], used to drain condensate to the deaerator feedwater tank [LAA] before being pumped back to the main Feedwater System [LA]
- Pre-Heating Condensate Drain System [LCJ], which recirculate the condensate formed by the Shell and Tube Type feedwater heaters [LCD] back into the Main Condensate and Feedwater Supply to the SGs [JEA]
- Clean Drains System [LCM], which is responsible for receiving turbine island drains from within the secondary circuit for re-distribution
- Auxiliary Steam Condensate System [LCN], still to be developed
- Steam Generator Purification System [LCQ], which is located in the Reactor Island [R01], integrates with the Condensate System [LC]. The Condensate System will supply cooling water [LCB] to the SG Blowdown Heat exchangers in the Steam Generator Purification System [LCQ]. The return line from the heat exchangers will be fed back to the main condensate pipework [LCB]

- Re-Heater Drains System [LCS], where steam and condensate exiting the re-heater heat exchanger in the MSR [LBJ] is collected and transferred to the HP feedwater heaters [LAD]. The condensate formed will be pumped back to the deaerator feedwater tank [LAA] via the feedwater pre-heating drains system [LCH]

- MSR Drains System [LCT], where water drained by gravity from MSR [LBJ] and Cold Re-Heat Pipes [LBC] is collected in a drains tank and pumped to the deaerator [LAA].

The key performance and design parameters are presented Table 10.5-4.

Table 10.5-4: Key Performance and Design Parameters for the Condensate System [LC]

Parameter	**Value**	**Units**
Max Flow Rate	492.2	Kg/s
Highest Operating Temperature (at Deaerator [LAA] inlet)	147	°C
Highest Operating Pressure	1.69	MPa(a)
Main Condensate Pump System [LAC]		
Temperature at pump Inlets	27	°C
Pressure at pump Inlets	0.00357	MPa(a)
Temperature at pump Outlets	30.01	°C
Pressure at pump Outlets	1.691	MPa(a)
Mass Flow Rate through pumps	415.2	kg/s
Main Condensate Pre-Heating System [LCD]		
LP Heater stage 1a & 1b Outlet Temperature	30	°C
LP Heater stage 1a & 1b Outlet Pressure	1.686	MPa(a)
LP Heater stage 1a & 1b Outlet Flow Rate	415.6	kg/s
LP Heater stage 2 Outlet Temperature	55.29	°C
LP Heater stage 2 Outlet Pressure	1.424	MPa(a)
LP Heater stage 2 Outlet Flow Rate	417	kg/s
LP Heater stage 3 Outlet Temperature	82.63	°C
LP Heater stage 3 Outlet Pressure	1.236	MPa(a)
LP Heater stage 3 Outlet Flow Rate	493.1	kg/s
LP Heater stage 4 Outlet Temperature	122.5	°C

Parameter	Value	Units
Max Flow Rate	492.2	Kg/s
Highest Operating Temperature (at Deaerator [LAA] inlet)	147	°C
Highest Operating Pressure	1.69	MPa(a)
LP Heater stage 4 Outlet Pressure	1.036	MPa(a)
LP Heater stage 4 Outlet Flow Rate	493.1	kg/s

The Condensate System [LC] is located within Turbine Island [T01] and the Turbine Hall [UMA]. A full description of the Condensate System [LC] and associated subsystems is provided in the System Design Description [18].

The key system equipment of the Steam Generator Purification System [LCQ] at DRP1/RD7 is located within the containment interspace region in the Reactor Island, with some pipework and valves located within the containment building. The primary function of the Steam Generator Purification System [LCQ] is to maintain the secondary chemistry within specified limits during Modes 1-4a, as well as during certain abnormal conditions such as primary to secondary Steam Generator Tube Leaks. The system provides the capability for continuous blowdown of up to 1 % of the main steam flow rate from all three SGs. The system receives blowdown coolant from each steam generator, which is cooled and depressurised before being filtered and processed to remove soluble and insoluble impurities. A full description of the Steam Generator Purification System [LCQ] and associated subsystems is provided in the System Design Description [19].

10.5.2.4 Materials

Materials will be confirmed in Version 3 of the generic E3S Case.

10.5.2.5 Interfaces with Supporting Systems

The Condensate System [LC] functional and physical interfaces are described above, including the HP Feedwater System [LA]. These are identified and managed within the RR SMR requirements management database, including flow down of functional requirements.

Further, the Steam Generator Purification System [LCQ] is an interface which provides capability for continuous hot blowdown of secondary side SGs [JEA], with condensate returned to the cycle via the Condensing System [MAG]. The Steam Generator Purification System [LCQ] is part of Reactor Island [R01].

10.5.2.6 System and Equipment Operation

The RR SMR Power Station Operating Philosophy [9] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode.

An analysis of the system operation in all modes of operation has been conducted to develop an initial Condensate System [LC] operating philosophy. This initial operating philosophy defines the operational sequences and actions the system is required to undertake and will help identify key claims for operators or automated actions in the future. The initial operating philosophy for each mode of operation can be found in the System Design Description for the Condensate System [LC] [18].The operating philosophy will be developed and amended with vendor input in the future.

10.5.2.7 Instrumentation and Control

The functions that are allocated to the Control and Protection Systems - Feedwater, Steam and Condensate [LY] by the Condensate System [LC] are:

- Alarms and Warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. The Alarms and Warnings for the Condensate System [LC] are still being developed and will be developed with vendor engagement.
- LP Heaters Control Logic:
  - The isolation valves in steam extraction lines and the low-pressure condensate recovery pump shall be operated from the control room.
  - The assisted swing check valves in steam extraction lines, the isolation valves in the extraction drain lines and the bypass valves of the low-pressure condensate recovery pump shall be controlled automatically.
  - During normal operation, the condensate drain valves for the normal and emergency recovery tank and the normal and backup condensate drain valves should be under regulation.
  - The regulation concerns the condensate recovery tank level and the level of the feedwater heater LP heater stage 3.
- Condensate Extraction Control Logic:
  - Each pump can be isolated at the inlet and outlet by means of isolation valves, and each pump discharge shall include a check valve to prevent backflow.
  - The discharge piping of each pump shall be equipped with a diaphragm or venturi flow meter to measure the flow of condensate to the low-pressure heaters. The flow meter shall include a wide range sensor, a narrow range sensor, and a test sensor.
  - The purpose is to control the water level in the feedwater tank. The level varies with the load and with changes in water density.
  - The discharge piping of each pump shall be equipped with a diaphragm or venturi flow meter to measure the flow of condensate to the low-pressure heaters. The flow meter shall include a wide range sensor, a narrow range sensor, and a test sensor.
  - The control variable is the extracted condensate flowrate. Throttle valves are used in conjunction with a single speed pump motor to control the flow rate.
  - The pumps shall be vertical and shall be driven by single speed asynchronous motors that are located above them and are anchored to an upper floor of the installation.

  - Protecting the pumps from overheating and cavitation problems when the system is in a low load condition shall be achieved by the recirculation line back to the main condenser.

10.5.2.8 Monitoring, Inspection, Testing and Maintenance

The maintenance tasks and procedures, specific to the Condensate System [LC] environment and operating context are still being developed.

Maintenance activities considered will include:

- Safety derived tasks (ISI)
- Design derived tasks (Supplier provided)
- Reliability derived tasks (RCM/Preventative Maintenance)
- Industry best practice/OPEX (EPRI PMBD)
- Non-PBS (Module, Site Facility).

10.5.2.9 Radiological Aspects

No significant radiological aspects associated with the Condensate System [LC] have been identified during design decisions up to DRP1/RD7. Radiological considerations during fault conditions are to be considered during detailed design, including development of the interface with the Steam Generator Purification System [LCQ] and condenser offgas following SGTR.

10.5.2.10 Performance and Safety Evaluation

HAZID assessments are carried out on the Turbine Island [T01]. The design of the Condensate System [LC] at DRP1/RD7 considers internal hazards from the Turbine Island HAZID report which have the potential to cause damage to the Condensate System [LC] and identifies any protections/barriers/mitigations, as detailed in the System Design Description for the Condensate System [LC] [18].

Verification activities to substantiate the E3S requirements set for the Condensate System [LC] are still to be determined.

10.5.2.11 Installation and Commissioning

The overall strategy for the RR SMR commissioning programme is presented in E3S Case Tier 1 Chapter 14: Plant Construction and Commissioning [10]. An outline installation and commissioning plan for the Condensate System [LC] has been developed during the current design phase to confirm viability of the proposed system to function as intended.

Installation requirements for the Condensate System [LC] are detailed in the requirements specification for the Turbine Island [T01] in the RR SMR requirements management database. Installation requirements and allocated requirements will be developed further by the vendors.

A comprehensive commissioning plan will be developed during detailed design. As part of the modularisation and build certainty strategy, with an aim to reduce cost and commissioning time, factory commissioning activities will be utilised where possible to reduce on site commissioning. It is anticipated that system architecture performing a system function will need to undergo an approved functional test. Further commissioning and testing activities may be required to satisfy a safety function, should one be allocated to architecture or components in the Condensate System [LC] during detail design.

10.5.3 Common systems of the Main Turbine Generator System

10.5.3.1 System and Equipment Functions

The Common Systems of the Main Turbine Generator System [MU] is a collection of standalone systems that supports the Main Turbine Generator System (MTGS) operation. The subsystems of the Common Systems of the Main Turbine Generator System [MU] are the Foundation [MUA], the Frame, Support Structure [MUG], the Forced Cooling System [MUR] and the Drying and Layup System [MUS].

10.5.3.2 Design Bases

10.5.3.2.1 Functional Requirements

The Common Systems of the Main Turbine Generator System [MU] facilitates delivery of CoFT during normal operation and abnormal conditions. The Common Systems of the Main Turbine Generator System [MU] contains sub-systems and components which facilitate the safety categorised functional requirements associated with HTHR [JN03]. The highest category of these HLSF is category C.

10.5.3.2.2 Non-Functional Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Tier 1 Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the Main Turbine Generator System [MU]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.5.3.2.3 Safety Classification

In accordance with the SMR E3S Categorisation and Classification Method [7], Common Systems of the Main Turbine Generator System [MU] is a safety class 3 system.

10.5.3.2.4 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules [4].

10.5.3.3 Description

The Common Systems of the Main Turbine Generator System [MU] consist of:

- Foundation [MUA] and the Frame, Support Structure [MUG], which support the MTGS train at height above the Turbine Hall foundations. The design allows the vibrations and dynamic loads generated by MTGS operation to be dissipated.

- Forced Cooling System [MUR], which reduces the cooling time of the steam turbines during turbine shutdown. This is done by supplying cool air to the internals of steam turbines within the outer turbine casings.

- Drying and Layup System [MUS], which prevents pitting, surface corrosion, and the accumulation of deposits on the process components of the secondary circuit within the Turbine Island [T01] when not in operation for extended periods

The key performance and design parameters are presented in Table 10.5-5.

Table 10.5-5: Key Performance and Design Parameters for the Common Systems of the Main Turbine Generator System [MU]

Parameter	Value	Units
Foundation [MUA] / Frame, Support Structure [MUG]		
Turbine Support Structure Material	Steel	N/A
Turbine Support Structure Tabletop Length	39.0	m
Turbine Support Structure Tabletop Width (Turbine Side)	16.0	m
Turbine Support Structure Tabletop Width (Generator Side)	10.8	m
Turbine Support Structure Supporting Equipment Load	9472.5	kN
Forced Cooling System [MUR]		
Steam Turbine Forced Cooling Medium	Air	N/A
Steam Turbine Forced Cooling Duration	50	Hours
Drying and Layup System [MUS]		
Dry Layup Fluid	Nitrogen	N/A
Dry Layup Fluid	Dry Air	N/A
Wet Layup Fluid	Demineralised Water	N/A
Layup Volume (Nitrogen)	595	m^3
Layup Volume (Demineralised Water)	530	m^3

The components for the Common Systems of the Main Turbine Generator System [MU] will be located within the Turbine Island Structures and Areas [U02]. The main architecture and pipework will be located within the Turbine Hall [UMA]. A full description of the Common Systems of the Main Turbine Generator System [MU] and associated subsystems is provided in the System Design Description [20].

10.5.3.4 Materials

Materials will be confirmed in Version 3 of the generic E3S Case. The Frame, Support Structure [MUG] shall be made from steel.

10.5.3.5 Interfaces with Supporting Systems

Interfaces for the Common Systems of the Main Turbine Generator System [MU] are identified and managed within the Requirements Specification for the system in the RR SMR requirements management database.

10.5.3.6 System and Equipment Operation

The RR SMR Power Station Operating Philosophy [9] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode.

A brief analysis of the system operation in all modes of operation has been conducted for to develop the Common Systems of the Main Turbine Generator System [MU] operating philosophy. The operating philosophy defines the key claims and operational sequences and actions the system is required to undertake, and the key claims made on the operator or automated actions. The operating philosophy also supports ongoing Human Factors and safety assessments. Descriptions of the operating philosophy for each mode of operation can be found in the System Design Description for the Common Systems of the Main Turbine Generator System [MU] [20]. A full analysis of the system operation in all modes of operation will be conducted during detailed design with vendor engagement.

10.5.3.7 Instrumentation & Control

The functions that are allocated to the Control and Protection Systems - Turbine Island [MY] by the Common Systems of the Main Turbine Generator System [MU] are:

- Alarms and Warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. The Alarms and Warnings for the Common Systems of the Main Turbine Generator System [MU] are still being developed and will be developed with vendor engagement.

- Control Logic:

    - The Foundation [MUA] / Frame, Support Structure [MUG] requires no control as it is a structural system with no feedback.

    - Following shutdown of the turbines, the Forced Cooling System [MUR] is controlled by temperature indicators in the High Pressure Turbine [MAA] and Low Pressure Turbines [MAC]. Once the required temperature has been achieved in the turbine internals to allow turbine maintenance activities to begin, the Forced Cooling System [MUR] is turned off.

    - The control of the Drying and Layup System [MUS] is dependent upon the expected secondary circuit shutdown duration. The concentrations of the layup substrate measured exiting the component being preserved controls the substrate being distributed into the component. Once the desired concentration is achieved, this indicates the component layup in completed and the Drying and Layup System [MUS] can stop adding additional layup substrate.

- The control and instrumentation for the Forced Cooling System [MUR] and Drying and Layup System [MUS] is in early development and will be developed during detailed design with vendor engagement.

10.5.3.8 Examination, Monitoring, Inspection and Testing

The maintenance tasks and procedures, specific to the Common Systems of the Main Turbine Generator System [MU] environment and operating context are still being developed.

Maintenance activities considered will include:

- Safety derived tasks (ISI)
- Design derived tasks (Supplier provided)
- Reliability derived tasks (RCM/Preventative Maintenance
- Industry best practice/OPEX (EPRI PMBD)
- Non-PBS (Module, Site Facility).

10.5.3.9 Radiological Aspects

No significant radiological aspects associated with the Common Systems of the Main Turbine Generator System [MU] have been identified during design decisions up to DRP1/RD7.

10.5.3.10 Performance and Safety Evaluation

HAZID assessments are carried out on the Turbine Island [T01]. The Common Systems of the Main Turbine Generator System [MU] at DRP1/RD7 considers internal hazards from the Turbine Island HAZID report which have the potential to cause damage to the Common Systems of the Main Turbine Generator System [MU] and identifies any protections/barriers/mitigations, as detailed in the System Design Description for the Common Systems of the Main Turbine Generator System [MU] [20].

Verification activities to substantiate the E3S requirements set for the Common Systems of the Main Turbine Generator System [MU] are still to be determined.

10.5.3.11 Installation and Commissioning

The overall strategy for the RR SMR commissioning programme is presented in E3S Case Tier 1 Chapter 14: Plant Construction and Commissioning [10]. An outline installation and commissioning plan for the Common Systems of the Main Turbine Generator System [MU] has been developed during the current design phase to confirm viability of the proposed system to function as intended.

Installation requirements for the Common Systems of the Main Turbine Generator System [MU] are detailed in the requirements specification for the Turbine Island [T01] in the RR SMR requirements management database. Installation requirements and allocated requirements will be developed further by the vendors.

A comprehensive commissioning plan will be developed during detailed design. As part of the modularisation and build certainty strategy, with an aim to reduce cost and commissioning time, factory commissioning activities will be utilised where possible to reduce on site commissioning. It is anticipated that system architecture performing a system function will need to undergo an approved functional test. Further commissioning and testing activities may be required to satisfy a safety function, should one be allocated to architecture or components in the Common Systems of the Main Turbine Generator System [MU] during detail design.

10.5.4 Turbine Island Closed Cooling Water System

10.5.4.1 System and Equipment Function

The primary function of the Turbine Island Closed Cooling Water System [PG] is to provide a continuous source of cooling water to various secondary circuit system components within the Turbine Building during normal plant operation. The system is a closed loop system in which the heat generated by secondary circuit system components is rejected and dissipated to the Auxiliary Cooling and Makeup System (ACMS) [PE].

10.5.4.2 Design Bases

10.5.4.2.1 Functional Requirements

The Turbine Island Closed Cooling Water System [PG] facilitates delivery of CoFT during normal operation and abnormal conditions. The Turbine Island Closed Cooling Water System [PG] sub-systems and components which facilitate the safety functional requirements associated with HTHR [JN03]. The highest category of these HLSF is category C.

10.5.4.2.2 Non-Functional Requirements

The E3S design principles, described in section 3.1.7 of E3S Case Tier 1 Chapter 3: E3S objective and Design Rules for SSCs [4], are considered as part of the design of the Turbine Island Closed Cooling Water System [PG]. Non-functional system requirements derived from these principles will be specified for the design in generic E3S Case Version 3.

10.5.4.2.3 Safety Classification

In accordance with the SMR E3S Categorisation and Classification Method [7], the Turbine Island Closed Cooling Water System [PG] is a safety class 3 system.

10.5.4.2.4 Seismic Performance Classification

The seismic performance classification of SSCs is still to be assigned in accordance with methodology outlined in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules [4].

10.5.4.3 Description

The Turbine Island Closed Cooling Water System [PG] consist of:

- Conveying System [PGC], which consist of the Turbine Island Closed Cooling Water System Pumps fed from the Turbine Island Cooled Components return header and maintaining a continuous circulation through the Turbine Island Closed Cooling Water System

- Intercooling System [PGD], which consists of Turbine Island Closed Cooling Water System heat exchangers interfacing with the interface with the ACMS [PE] where the heat gained by the Turbine Island Components is rejected

- Make-up Water System [PGR], consisting of one surge tank located at the highest point of the system and to accommodate for any leakage or pressure changes within the ACMS system

- Pressurising System [PGE], which pressurises the surge tank by Nitrogen blanketing

- Piping and Culvert System [PGB]

- Fluid Supply System for Control and Protection System [PGX]

- Blowdown System [PGS]

- Cleaning System for Heat Exchangers [PGH]

- Lubricant System [PGV]

- Control and Protection System [PGY]

The key performance and design parameters are presented in Table 10.5-6.

Table 10.5-6: Key Performance and Design Parameters for the Turbine Island Closed Cooling Water System [PG]

Parameter	Value	Units
PG Heat Exchangers		
Quantity (1x duty, 1x standby)	2 x 100 %	-
Type	Plate	-
Heat Transfer (to ACMS - nominal 100 %)	11	MW
Pump		
Quantity (2x duty, 1x standby)	3 x 50 %	-
Type	Horizontal Centrifugal	-
System Pressure (Pump Discharge – nominal 100 %)	0.6	MPa(a)
System Temperature (Pump Discharge – nominal 100 %)	36	°C
Pump flow rate (nominal at 100 %)	250	kg/s

Descriptions of the Turbine Island Closed Cooling Water System [PG] and associated subsystems up to DRP1/RD7 is provided in the System Design Description [21].

10.5.4.4 Materials

Materials will be confirmed in Version 3 of the generic E3S Case.

10.5.4.5 Interfaces with Supporting Systems

Interfaces for the Common Systems of the Turbine Island Closed Cooling Water System [PG] are identified and managed within the Requirements Specification for the system in the RR SMR requirements management database.

10.5.4.6 System and Equipment Operation

The RR SMR Power Station Operating Philosophy [9] provides the overarching information on how the plant and operator maintain control of key functions across the six defined operating modes, including the operating principles, required actions, means for transitioning between the operating modes, and relevant safety systems for each mode.

A brief analysis of the system operation in all modes of operation has been conducted for to develop the Turbine Island Closed Cooling Water System [PG] operating philosophy. The operating philosophy defines the key claims and operational sequences and actions the system is required to undertake, and the key claims made on the operator or automated actions. The operating philosophy also supports ongoing Human Factors and safety assessments. Descriptions of the operating philosophy for each mode of operation can be found in the System Design Description for the Turbine Island Closed Cooling Water System [PG] [21]. A full analysis of the system operation in all modes of operation will be conducted during detailed design with vendor engagement.

10.5.4.7 Instrumentation and Control

The functions that are allocated to the Cooling Water Systems Control and Instrumentation (C&I) Systems [PY] by the Turbine Island Closed Cooling Water System [PG] are:

- Alarms and Warnings to indicate that key system parameters are outside of the defined performance bands and/or safety limits. The Alarms and Warnings for the Common Systems of the Turbine Island Closed Cooling Water System [PG] are still being developed and will be developed with vendor engagement.

- Pressure Control and Instrumentation

    - Pressure monitoring at the pump inlet and discharge headers. Low discharge pressure automatically starts the stand-by pump without interruption of normal plant operation.

    - Pressure monitoring at the inlet and outlet of each individual Turbine Island component cooler

    - Surge tank pressure monitoring. Low system pressure will automatically activate water supply from the Demin water supply system. A High / low level alarm is activated within the main control room. System pressure is maintained via Nitrogen blanketing within the Surge Tank

- Temperature Control and Instrumentation
    - Temperature monitoring at the inlet and outlet of each Turbine Island Closed Cooling Water System heat exchanger
    - A Turbine Island Closed Cooling Water System heat exchanger bypass Control Valve is used to control the temperature to the Turbine Island component coolers to prevent overcooling. The bypass valve control the outlet cooling water temperature to ensure the temperature supply to the Component Coolers remains constant throughout operation.
    - Temperature monitoring at the inlet and outlet of each individual Turbine Island component cooler
- Flow Control and Instrumentation
    - Flow monitoring at each individual Turbine Island component cooler. The flow is controlled by control valves on each branch line.
    - Pump recirculation control valves ensure minimum flow through the pumps is maintained at all times by directing flow to the surge tank
- Level Control and Instrumentation
    - Surge tank level monitoring Low tank level will automatically activate water supply from the Demin water supply system. A High / low level alarm is activated within the main control room design with vendor engagement.

10.5.4.8 Monitoring, Inspection, Testing and Maintenance

The maintenance tasks and procedures, specific to the Turbine Island Closed Cooling Water System [PG] environment and operating context are still being developed.

Maintenance activities considered will include:

- Safety derived tasks (ISI)
- Design derived tasks (Supplier provided)
- Reliability derived tasks (RCM/Preventative Maintenance)
- Industry best practice/OPEX (EPRI PMBD)
- Non-PBS (Module, Site Facility).

10.5.4.9 Radiological Aspects

No significant radiological aspects associated with the Turbine Island Closed Cooling Water System [PG] have been identified during design decisions up to DRP1/RD7.

10.5.4.10 Performance and Safety Evaluation

HAZID assessments are carried out on the Turbine Island [T01]. The Turbine Island Closed Cooling Water System [PG] at DRP1/RD7 considers internal hazards from the Turbine Island HAZID report which have the potential to cause damage to the Turbine Island Closed Cooling Water System [PG] and identifies any protections/barriers/mitigations, as detailed in the System Design Description for the Turbine Island Closed Cooling Water System [PG] [21].

Verification activities to substantiate the E3S requirements set for the Turbine Island Closed Cooling Water System [PG] are still to be determined.

10.5.4.11 Installation and Commissioning

The overall strategy for the RR SMR commissioning programme is presented in E3S Case Tier 1 Chapter 14: Plant Construction and Commissioning [10]. An outline installation and commissioning plan for the Turbine Island Closed Cooling Water System [PG] has been developed during the current design phase to confirm viability of the proposed system to function as intended.

Installation requirements for the Turbine Island Closed Cooling Water System [PG] are detailed in the requirements specification for the Turbine Island [T01] in the RR SMR requirements management database. Installation requirements and allocated requirements will be developed further by the vendors.

A comprehensive commissioning plan will be developed during detailed design. As part of the modularisation and build certainty strategy, with an aim to reduce cost and commissioning time, factory commissioning activities will be utilised where possible to reduce on site commissioning. It is anticipated that system architecture performing a system function will need to undergo an approved functional test. Further commissioning and testing activities may be required to satisfy a safety function, should one be allocated to architecture or components in the Turbine Island Closed Cooling Water System [PG] during detail design.

10.6 Conclusions

10.6.1 ALARP, BAT, Secure by Design, Safeguards by Design

The design of all SSCs presented in this chapter are developed in accordance with the systems engineering design process. This includes alignment to relevant good practice (RGP) and operating experience (OPEX), design to codes and standards according to the safety classification, and a systematic optioneering process with down-selection of design options based on assessment against relevant criteria that ensure risks are reduced to ALARP, apply BAT, and are secure by design and safeguards by design, as described in E3S Case Tier 1 Chapter 3: E3S Objectives and Design Rules for SSCs [4]. This provides confidence that claims can be met when the full suite of arguments and evidence is developed.

The overall demonstration of ALARP, BAT, secure by design and safeguards by design at DRP1/RD7 is presented in E3S Case Chapters 24, 27, 32 and 33 respectively.

10.6.2 Assumptions and Commitments on Future Dutyholder / Licensee / Permit Holder

None identified in this revision.

10.6.3 Conclusions and Forward Look

The generic E3S Case objective is ‘to provide confidence that the RR SMR design will be capable of delivering the E3S fundamental objective as it developed from a concept design into a detailed design’. This confidence is built through development and underpinning of top-level claims across each chapter of the E3S Case, through supporting arguments and evidence. The top-level claim for chapter 10 is ‘Steam and Power Conversion Systems are conservatively designed and verified to deliver E3S functions through-life, in accordance with the E3S design principles, to reduce risks to ALARP, apply BAT and in line with Secure-by-Design and Safeguards-by-Design’.

The arguments and evidence presented to meet the generic E3S Case objective at Version 2 include the allocation of safety functions to the Steam and Power Conversion Systems which are aligned to the FSFs and categorised in accordance with the E3S categorisation and classification methodology.

The Steam and Power Conversion Systems SSC design RD7/DRP1 is developed and evaluated in accordance with the E3S design principles through the integrated E3S and engineering processes, including design optioneering, to drive risk reduction to ALARP, and to demonstrate BAT, secure by design and safeguards by design. Environment, security, and safeguards aspects are also considered. For example, the Turbine Island HAZID report includes security related hazards impacting individual Steam and Power Conversion Systems with the hazard mitigation linking to an associated requirements in the E3S requirements set. Such design considerations provide confidence that environment, security, and safeguards functions can be achieved by the design as functional requirements are derived through ongoing and iterative E3S analyses. Given the design of the Steam and Power Conversion Systems at RD7/DRP1 is in line with RGP, this provides further confidence that as the design matures through vendor engagement it will meets the E3S objective.

Further arguments and evidence to underpin claims will be developed in line with the E3S Case Route Map [2] and reported in future revisions of the generic E3S Case, which will further build confidence that the RR SMR can deliver its fundamental E3S objective. This broadly includes refinement of safety requirements, as well as identification of environment, security, and safeguards requirements.

10.7 References

[1] Rolls-Royce SMR Limited, SMR0004924 Issue 3, "Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Chapter 1: Introduction," May 2024.

[2] Rolls-Royce SMR Limited, SMR0002155 Issue 3, "E3S Case CAE Route Map," November 2023.

[3] Rolls-Royce SMR Limited, SMR0001603 Issue 1, "Environment, Safety, Security and Safeguards Design Principles," August 2022.

[4] Rolls-Royce SMR LImited, SMR0004589 Issue 3, "Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Chapter 3: E3S Objectives and Design Rules for SSCs," May 2024.

[5] Rolls-Royce SMR Limited, SMR0003977 Issue 3, "Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Chapter 15: Safety Analysis," May 2024.

[6] Rolls-Royce SMR Limited, SMR0000510 Issue 2, "Rolls-Royce SMR C&I Engineering Schedule," June 2023.

[7] Rolls-Royce SMR Limited SMR0006518 Issue 1, "Environment, Safety, Security and Safeguards Categorisation and Classification Method," July 2023.

[8] Rolls-Royce SMR Limited, SMR0004860 Issue 1, "System Design Description for the Steam System [LB]," May 2023.

[9] Rolls-Royce SMR Limited, SMR0005213 Issue 1, "RR SMR Power Station Operating Philosophy," July 2023.

[10] Rolls-Royce SMR Limited, SMR0003880 Issue 3, "Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Chapter 14: Plant Construction and Commissioning," May 2024.

[11] Rolls-Royce SMR Limited, SMR0009484 Issue 1, "System Design Description for the Main Steam Piping System for Reactor Island [LBA20]," January 2024.

[12] Rolls-Royce SMR Limited, SMR0005219 Issue 1, "Main Steam System [LBA] Functional Bill of Materials," May 2023.

[13] Rolls-Royce SMR Limited, SMR0004574 Issue 2, "System Design Description for the SG Relief System [LBK10]," January 2024.

[14] Rolls-Royce SMR Limited, SMR0004858 Issue 1, "System Design Description for the Feedwater System [LA]," May 2023.

[15] Rolls-Royce SMR Limited, SMR0005792 Issue 1, "System Design Description for the Auxiliary Feedwater System [LJ]," November 2023.

[16] Rolls-Royce SMR Limited, SMR0005086 Issue 1, "System Design Description for the Generator System [MK]," May 2023.

[17] Rolls-Royce SMR Limited, SMR0005085 Issue 1, "System Design Description for the Steam Turbine System [MA]," May 2023.

[18] Rolls-Royce SMR Limited, SMR0005084 Issue 1, "System Design Description for the Condensate System [LC]," May 2023.

[19] Rolls-Royce SMR Limited, SMR0005918 Issue 1, "System Design Description for the Steam Generator Purification System [LCQ]," November 2023.

[20] Rolls-Royce SMR Limited, SMR0006705 Issue 1, "System Design Description for the Common Systems of the Main Turbine [MU]," September 2023.

[21] Rolls-Royce SMR Limited, SMR0007175 Issue 1, “System Design Description for the Turbine Island Closed Cooling Water System [PG],” September 2023.

10.8 Appendix A: Claims, Arguments, Evidence

Table 10.8-1 provides a mapping of the claims to the corresponding sections of the chapter that summarise the arguments and/or evidence. The full decomposition of claims and link to underpinning Tier 2 and Tier 3 information containing the detailed arguments and evidence is presented in the E3S Case Route Map [2]. The route map includes the trajectory of Tier 2 and Tier 3 information as the generic E3S Case develops, which will be incorporated into Tier 1 chapters as it becomes available and in line with generic E3S Case issues described in [1].

Table 10.8-1: Mapping of Claims to Chapter Sections

Claim	Section of Chapter 10 containing arguments / evidence summary
Feedwater System [LA] Non-Functional System Requirements are complete	10.3.1.2.2
Feedwater System [LA] Non-Functional System Requirements are correctly assigned	10.3.1.2.2
Feedwater System [LA] codes and standards are correctly assigned	10.0.4
Safety Requirements for the Feedwater System [LA] are complete	10.3.1.2.1
Environmental Functional Requirements for the Feedwater System [LA] are complete	None at this revision
Security Functional Requirements for the Feedwater System [LA] are complete	None at this revision
Safeguards Functional Requirements for the Feedwater System [LA] are complete	None at this revision
The Feedwater System [LA] is classified correctly	10.3.1.2.3
The Feedwater System [LA] design achieves its E3S functional requirements	Not covered in this revision
The Feedwater System [LA] design achieves its E3S non-functional system requirements	Not covered in this revision
The layout design facilitates the system achieving its E3S requirements	Not covered in this revision
Structural integrity is substantiated commensurate with the SSC classification	Covered in E3S Case Chapter 23
The Feedwater System [LA] design definition is verified to meet its requirements	Not covered in this revision
The implemented Feedwater System [LA] system is validated to meet its E3S functions	Not covered in this revision
Verification of the Feedwater System [LA] system is preserved through its operational life	Not covered in this revision

Claim	**Section of Chapter 10 containing arguments / evidence summary**
Steam System [LB] *claims structure as per Feedwater System [LA] structure*	10.2.1
Condensate System [LC] *claims structure as per Feedwater System [LA] structure*	10.5.2
Steam Generator Purification System [LCQ] *claims structure as per Feedwater System [LA] structure*	10.5.2
Condensate Polishing System [LD] *claims structure as per Feedwater System [LA] structure*	Not covered in this revision
Auxiliary Feedwater System [LJ] *claims structure as per Feedwater System [LA] structure*	10.3.2
Fluid Supply Systems for Control and Protection Systems [LX] *claims structure as per Feedwater System [LA] structure*	Not covered in this revision
Steam Turbine System [MA] *claims structure as per Feedwater System [LA] structure*	10.5.1
Generator System [MK] *claims structure as per Feedwater System [LA] structure*	10.4
Common Systems of the Main Turbine Generator System [MU] *claims structure as per Feedwater System [LA] structure*	10.5.3

10.9 Appendix B: SSCs in Scope of Chapter 10

Table 10.9-1 lists those SSCs that are within the scope of Chapter 10, and the section of the report they are addressed.

Table 10.9-1: SSCs in Scope of Chapter 10

RDS-PP®	SSC	Section in Chapter 10
L	Steam Water Condensate System	Covered by [L_] Sections
LA	Feedwater system	10.3.1
LAA	Deaerator and Feedwater Storage System	
LAB	Feedwater piping system	
LAC	Main Feedwater Pumps	
LAD	High Pressure Feedheaters	
LB	Steam system	10.2
LBA	Main steam piping system	
LBB	Hot reheat piping system	
LBC	Cold reheat piping system	
LBD	Extraction piping system	
LBF	Overpressure suppression and safety system	
LBG	Auxiliary steam piping system	
LBJ	Moisture separator and reheater system	
LBK	Main steam safety/relief system inside reactor containment for single-cycle plant	
LBQ	Extraction steam piping system for feedwater preheating system	
LBS	Extraction steam piping system for main condensate preheating system	
LC	Condensate system	10.5.2
LCB	Main condensate piping system	
LCC	Main condensate conveying system	
LCD	Main condensate preheating system	
LCE	Condensate De-superheating spray system	
LCH	Condensate system of feedwater preheating	
LCJ	Pre-heating condensate drain system	
LCM	Clean drains system	

RDS-PP®	SSC	Section in Chapter 10
LCN	Auxiliary steam condensate system	
LCS	Reheater drains system	
LCT	Moisture separator drains system	
LCQ	Steam Generator Purification System	
LD	Condensate polishing system	Not covered in this revision
LDA	Transfer system condensate	
LDB	Filtering, mechanical cleaning system	
LDF	Ion exchange, reverse osmosis system	
LDK	Piping system, temporary storage, conveying main fluid	
LDL	Storage system outside fluid treatment system (unless part of another system)	
LDN	Chemicals supply system	
LDP	Regeneration, flushing system	
LDQ	Injection system for main fluid	
LDR	Flushing water and residues removal system, including neutralization	
LDV	Lubricant system	
LJ	Auxiliary Feedwater	10.3.2
LJA	Auxiliary Feedwater System for Nuclear Steam generator	10.3.2
LJK	Auxiliary Feedwater System on Feedwater Side of Nuclear Steam generator	10.3.2
LX	Fluid supply systems for control and protection systems	Not covered in this revision
M	Main Turbine Generator System	Covered by [M_] Sections
MA	Steam turbine system	10.5.1
MAA	High pressure turbine	
MAC	Low pressure turbine	
MAD	Bearing	
MAG	Condensing system	
MAJ	Air removal and evacuation system	
MAK	Transmission gear including shaft turning gear	
MAL	Drain and vent system	
MAM	Leak-off steam system	

RDS-PP®	SSC	Section in Chapter 10
MAN	Turbine Bypass system	
MAQ	Vent system	
MAV	Steam turbine lubricant system	
MAW	Gland sealing system	
MK	Generator system	10.4
MKA	Generator	
MKC	Generator exciter set	
MKD	Bearing	
MKG	Rotor hydrogen cooling system	
MKQ	Exhaust gas system	
MKV	Generator system lubricant system	
MKW	Generator system sealing fluid system	
MU	Common Systems of the Main Turbine Generator System	10.5.3
MUA	Foundation	
MUG	Frame support structure	
MUR	Forced cooling system	
MUS	Drying and layup system	

10.10 Abbreviations

AC	Alternating Current
ACOP	Approved Code of Practice and guidance
ACMS	Auxiliary Cooling and Makeup System
ALARP	As Low As Reasonably Practicable
ASF	Automatic Shutdown Function
ASME	American Society of Mechanical Engineers
BAT	Best Available Techniques
BS	British Standard
C&I	Control and Instrumentation
CAE	Claims, Arguments, Evidence
CDHR	Condenser Decay Heat Removal
CoFT	Control of Fuel Temperature
CoR	Control of Reactivity
CoRE	Control of Radiation Exposure
CoRM	Confinement of Radioactive Material
DBC	Design Basis Condition
DOORS	Dynamic Object-Oriented Requirements System
E3S	Environmental, Safety, Security and Safeguards
ECC	Emergency Core Cooling
EDI	Electro de-ionisation
EMIT	Examination, Maintenance, Inspection and Testing
EN	European Standard adopted as a British Standard
EPRI	Electric Power Research Institute
FSF	Fundamental Safety Function
HAZID	Hazard Identification
HEI	Heat Exchange Institute
HLSFs	High-Level Safety Function

HTHR	High Temperature Heat Removal
HP	High-Pressure
ISI	In Service Inspection
LP	Low-Pressure
MCWS	Main Cooling Water System
MSIV	Main Steam Isolation Valve
MSL	Main Steam Lines
MSR	Moisture Separator Reheater
MSSV	Main Steam Safety Valve
MTGS	Main Turbine Generator System
OPEX	Operating Experience
PBS	Product Breakdown Structure
PCD	Preliminary Concept Definition
PCSR	Pre-Construction Safety Report
PDHR	Passive Decay Heat Removal
PMBD	Preventative Maintenance Basis Database
RCM	Reliability Centred Maintenance
RD	Reference Design
RDS-PP®	Reference Designation System – Power Plants
REPPIR	Radiation (Emergency Preparedness and Public Information) Regulations
RGP	Relevant Good Practice
RI	Reactor Island
RPM	Revolutions Per Minute
RR SMR	Rolls-Royce Small Modular Reactor
SG	Steam Generator
SGBS	Steam Generator Blowdown System
SSC	Structure, System and Component
SGTR	Steam Generator Tube Rupture

TBC	To Be Confirmed
TI	Turbine Island
UK	United Kingdom