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UK ABWR Generic Design Assessment

Generic PCSR Chapter 17 : Steam and Power Conversion Systems

Hitachi-GE Nuclear Energy, Ltd.

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Executive Summary

This mechanical systems chapter describes the safety case for the UK ABWR steam and power conversion systems and associated systems. It lists the high level Safety Functional Claims that are made on the systems described in this chapter, together with the Safety Property Claims (SPCs) that come from the Nuclear Safety and Environmental Design Principles (NSEDPs).

The information provided includes: system design; functionality in normal operation and during faults; safety categorisation and classification; important support systems; safety case assumptions, Limits and Conditions for Operation; resistance to hazards; and compliance with the ALARP principle.

The overall PCSR justification that the UK ABWR is safe and satisfies the ALARP principle is underpinned by hazards assessments, design basis analysis, probabilistic safety analysis, beyond design basis analysis and human factors analysis (described in PCSR Chapter 6: External Hazards, Chapter 7: Internal Hazards and Chapter 24: Design Basis Analysis to Chapter 27: Human Factors), which demonstrate that the design of the systems covered by this chapter are fault tolerant. These analysis chapters specify the high level safety functional claims but do not specify requirements for design parameters on individual steam and power conversion systems and associated systems. Instead they apply analysis conditions and assumptions that are based on, and fully consistent with, the design information and safety claims for the systems that are presented in this chapter, in order to substantiate those claims.

The designs of the steam and power conversion systems are well advanced for GDA, being largely based on proven technology from the Japanese ABWR reference design. Additional risk reduction measures have been introduced (with reference to the J-ABWR design) in response to safety assessments undertaken in GDA. These include introduction of a feed-water trip system which prevents chloride ingress to the reactor in the event of a main condenser tube failure.

This chapter demonstrates that the risks associated with the design and operation of the steam and power conversion systems and associated systems for the UK ABWR are ALARP. It is acknowledged that further work will be required post-GDA to develop the design and fully incorporate site specific aspects. This work will be the responsibility of any future licensee.

17.1 Introduction

Chapter 17: Steam and Power Conversion Systems of this Pre-Construction Safety Report (PCSR) presents a high level summary of the safety case for the UK ABWR steam and power conversion systems. It presents an overview of the systems and identifies the applicable design and safety requirements. It goes on to demonstrate how these requirements have been met and how the steam and power conversion systems contribute to the overall safety of UK ABWR.

17.1.1 Background

Steam and power conversion systems are systems that are used to generate electricity. They are primarily located within the Turbine Building and include the Turbine Generator, Turbine Main Steam System, Turbine Bypass System, Condenser, Condensate and Feedwater System and Circulating Water System.

In the UK ABWR, the steam and power conversions systems use reactor coolant outside the reactor coolant pressure boundary, and so they deliver a range of functions that contribute to nuclear safety. These functions are principally associated with containment of reactor coolant, but also include control, radiation protection and coolant purification functions.

The steam generated at the reactor is supplied to the High Pressure Turbine (HP-T) through the Main Stop Valves (MSVs) and Control Valves (CVs). The auxiliary steam is branched from the main steam header at the main steam line to supply Moisture Separator Reheater 2nd stage Reheaters (MSR-2RHs), heating steam and Steam Jet Air Ejector (SJAE) driving steam during Power operation. The Turbine Bypass Valves (TBVs) are connected to the main steam header to directly release excess steam from the reactor to the condenser.

The steam from the High Pressure Turbine (HP-T) exhaust is delivered to the Moisture Separator Reheaters (MSRs), which contain a moisture separating stage and 2 heating stages, then reheated steam is fed to the Low Pressure Turbines (LP-Ts) through Combined Intermediate Valves (CIVs). The generator is driven by the turbine and converts the mechanical energy into electrical energy. The steam from the LP-Ts is condensed in the condenser. The cooling water is supplied by the Circulating Water Pumps (CWPs) to the condensers to cool the turbine exhaust.

The condensate is pumped up from the condenser hotwells by Low Pressure Condensate Pumps (LPCPs), delivered through the SJAE condenser, Gland Steam Condenser (GSC), Condensate Filter (CF), Condensate Demineralizer (CD) and High Pressure Condensate Pumps (HPCPs), heated by the Low Pressure Feedwater Heaters (LP FWHs), to the Reactor Feedwater Pumps (RFPs). The RFPs deliver feedwater to the reactor through High Pressure Feedwater Heaters (HP FWHs).

The extraction steam is supplied from the HP-T and LP-Ts to the FWHs and MSR 1st stage Reheaters (MSR-1RHs). The driving steam of the Reactor Feedwater Pump Turbines (RFP-Ts) is supplied from the cross-around pipe at the MSR outlet. The Gland Steam Evaporator (GSE) heating steam is supplied from the extraction steam line to produce sealing steam to the turbine shaft seal parts and the major valve gland parts.

The HP FWH drain and MSR drain are collected at the High Pressure Drain Tank (HPDT) and recovered on the RFP suction side by High Pressure Drain Pumps (HPDPs). The LP FWH drain is collected at the Low Pressure Drain Tank (LPDT) and recovered on the HPCP suction side by Low Pressure Drain Pumps (LPDPs). FWH vent lines discharge non-condensable gases from the FWHs to the condenser.

The Steam and Power Conversion System is located in the turbine building. The system design configuration of the Steam and Power Conversion System is shown in Figure 17.1-1.

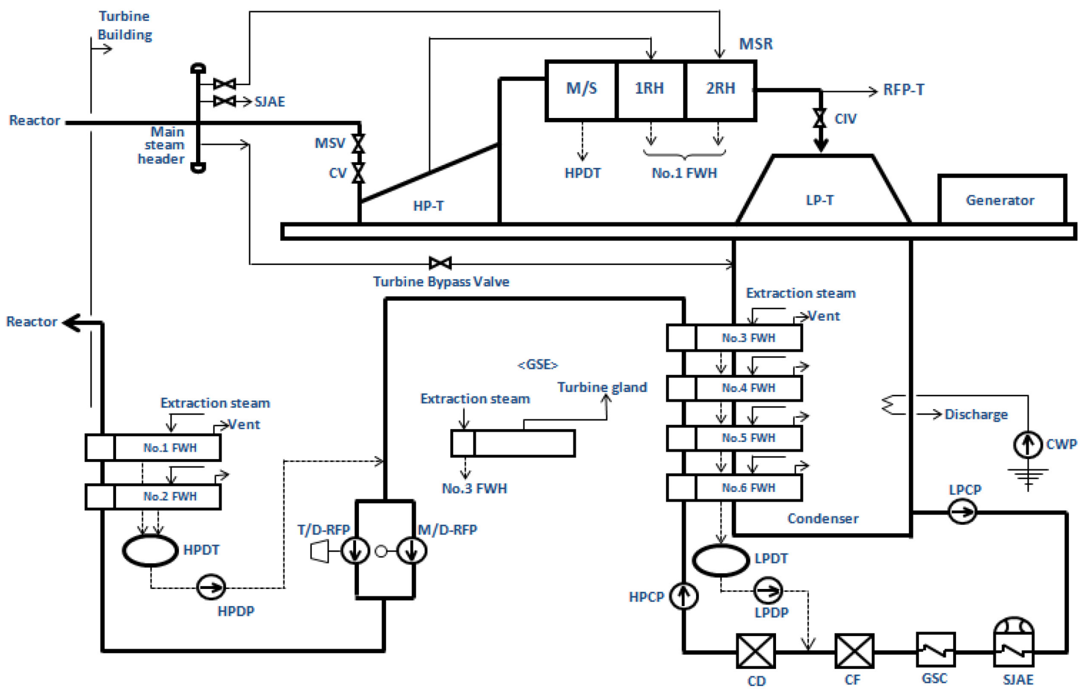

Figure 17.1-1: System Design Configuration of the Steam and Power Conversion System

17.1.2 Document Structure

This chapter includes the following sections:

Section 17.2 Purpose and Scope:
This section sets out the purpose of the chapter and identifies what is included in the scope of the chapter and what is excluded.

Section 17.3 to 17.11:
These sections describe the steam and power conversions systems and the safety function they deliver. The systems considered are:

- 17.3: Turbine Generator
  (including the Electro Hydraulic Control (EHC) and Excitation systems),
- 17.4: Turbine Main Steam, Turbine Auxiliary Steam and Turbine Bypass System,
- 17.5: Extraction Steam System,
- 17.6: Turbine Gland Steam System,

- 17.7: Feedwater Heater Drain and Vent System,
- 17.8: Condenser,
- 17.9: Circulating Water System,
- 17.10: Condensate and Feedwater System, and
- 17.11: Condensate Purification System.

Each of the sections has a standard set of sub-headings (where "X" is the relevant sub-heading from the above):

- X.1: System Summary Description,
- X.2: System Roles,
- X.3: Functions Delivered,
- X.4: Basic Configuration,
- X.5: Modes of Operation,
- X.6: Design Bases,
- X.7: System Design Description, and
- X.8: Claims and Link to High Level Safety Functions.

Section 17.12 Assumptions, Limits and Conditions for Operation:
This section summarises the limits and conditions for operation that are specified in greater detail in the Basis of Safety Case (BSC) documents for the SSCs in the scope of this chapter. Assumptions are not covered in this chapter because there are no fundamental assumptions.

Section 17.13 Summary of ALARP Justification:
This section presents a summary of how steam and power conversion systems contribute to reducing risks to As Low As Reasonably Practicable (ALARP).

Section 17.14 Conclusions:
This section provides a summary of the main aspects of this chapter.

Section 17.15 References:
This section lists all documents referenced within this chapter.

The chapter also includes three appendices.
Appendix A – Safety Functional Claims Tables:
The claim tree for the SSCs in this chapter shown in Appendix A is a simplified version of the detailed claim tree contained in the BSC or Topic Report (TR) of the related SSC.
Appendix B – Safety Property Claims Tables:
The nine generic SPCs for all Mechanical Engineering (ME) SSCs that define the design requirements applicable to the SSCs scope of this chapter are presented in Appendix B tables as ME SPCs. These tables of SPCs were derived for the ME SSCs based on the 'guide word' approach specified in Hitachi-GE's Safety Case Development Manual (SCDM) [Ref-17.1]. Having derived the SPCs, a mapping exercise was undertaken to ensure that the SPCs fully cover the relevant NSEDPs applicable to the ME area. More information on the development of SPCs, and the coverage, at the more detailed level in the safety case, to demonstrate full compliance with the relevant NSDEPs is presented in Chapter 5: General Design Aspects, Section 5.3 and the Topic Report on Safety Requirements for Mechanical SSCs [Ref-17.2]. Fulfilment of the requirements from the SPCs is justified in the BSC or Topic Report of the related SSC as well as the Topic Report on Mechanical SSCs Architecture [Ref-17.3].
Appendix C – Document Map:
The document map showing Level 2 documents that support this chapter is provided in Appendix C.

The main links of this chapter with other GDA PCSR chapters are as follows:

- For links to GEP and CSA documentation, please refer to Chapter 1: Introduction. For GEP, where specific references are required, for example in Radioactive Waste Management, Radiation Protection, Decommissioning, these are included in the specific sections within the Generic PCSR.
- The general principles for the identification of Assumptions, Limits and Conditions for Operation (LCOs) related to the systems within this chapter scope are described in Chapter 4: Safety Management throughout Plant Lifecycle.
- The categorisation of safety functions and safety classification of SSC in this chapter conform with the methodology described in Chapter 5. The general requirements for equipment qualification, Examination Inspection Maintenance and Testing (EIM&T) and codes and standards that come from this safety categorisation and classification are also described in Chapter 5. Further details can be found in the section related to EIM&T of the BSC document of the systems within scope of this chapter.
- Hazard assessments (e.g. flooding, fire, rotating equipment related hazards, etc.) to demonstrate adequate performance of systems within this chapter scope are included in Chapters 6 and 7.
- Additional requirements for the SSCs that are classified as Very High Integrity (VHI), beyond those required for standard Class 1 components, are described in Chapter 8: Structural Integrity.
- The design of the reactor fuel and its support structures is done in detail in Chapter 11: Reactor Core.
- The design of additional safety functions of some reactor coolant systems such as the reactor core cooling function as part of the Emergency Core Cooling System (ECCS) of the Nuclear Boiler System (NB) and the Residual Heat Removal System (RHR) , or the containment heat removal function of the RHR, etc. are described in Chapter 13: Engineered Safety Features.
- The design of the systems scope of this chapter from the Control and Instrumentation point of view is described in detail in Chapter 14: Control and Instrumentation.
- The design of the systems scope of this chapter from the Electrical point of view is described in detail in Chapter 15: Electrical Power Supplies.
- The design of the mechanical systems supporting operation of the systems scope of this chapter such as cooling water supply, Heating Ventilating and Air Conditioning (HVAC), compressed air supply, etc. is described in detail in Chapter 16: Auxiliary Systems.
- The design of the reactor coolant systems beyond the Reactor Building (Main Steam System and Condensate and Feedwater System on the turbine side, etc.) are described in Chapter 17.
- Demonstration, using transient analysis, of the adequate performance of systems within this chapter scope during design basis events and beyond design basis events is covered in Chapters 24 and Chapter 26: Beyond Design Basis and Severe Accident Analysis.
- Probabilistic analysis that demonstrates adequate reliability of systems within this chapter scope is in Chapter 25: Probabilistic Safety Assessment.
- Substantiation of Human Based Safety Claims related to human interactions with systems within this chapter scope is described in Chapter 27.
- An overview of how the UK ABWR design has evolved, and how this evolution contributes to the overall ALARP case is described in Chapter 28: ALARP Evaluation.
- General requirements for decommissioning of the systems within this chapter scope are described in Chapter 31: Decommissioning.

This chapter is supported by a set of reference documents, primarily BSCs (Level 2 documents) and their associated Level 3 documents, including System Design Descriptions (SDDs). Each BSC describes a specific system within the scope of Chapter 12: Reactor Coolant Systems, Reactivity Control Systems and Associated Systems, explaining where the arguments and evidence that substantiate the safety claims for those systems are presented. A full list of the Level 2 documents is provided within the document map in Appendix C.

17.2 Purpose and Scope

17.2.1 Purpose

The purpose of this chapter is to present a high level summary of the safety case for the UK ABWR steam and power conversion systems, and a route map for where the more detailed evidence can be found. The chapter supports the overall conclusion of the PCSR that risks associated with the UK ABWR are demonstrably ALARP.

The objective of this chapter is to provide a description of the systems (primarily located within the Turbine Building) that are used to generate electricity. The scope of the chapter therefore covers the following systems:

- Turbine Generator,
- Turbine Main Steam, Turbine Auxiliary Steam and Turbine Bypass System,
- Extraction Steam System,
- Turbine Gland Steam System,
- Feedwater Heater Drain and Vent System,
- Condenser,
- Circulating Water System,
- Condensate and Feedwater System,
- Condensate Purification System,
- The mechanical components of the turbine Electro-Hydraulic Control (EHC) system (Turbine Control Valve and Turbine Bypass Valve), and
- Excitation System.

The aim of the chapter is also to provide a link to the supporting documents that substantiate that all required safety functions can be delivered by the steam and power conversion systems, with an adequate level of confidence to support the Generic Design Assessment (GDA) process.

17.2.2 Scope

For each of the steam and power conversion systems (listed above), the chapter covers the following:

- Safety claim(s), safety function(s),
- System description,
- System configuration(s),
- System operating mode(s), and
- System design specification(s) (i.e. design codes and standards, environmental qualification, safety category and classification, seismic categorisation, safety functional (SFC) and property (SPC) claim(s) The table of SPCs, shown in Appendix B, were derived for the topic covered in this chapter based on the ‘guide word’ approach specified in Hitachi-GE’s Safety Case Development Manual [Ref-17.1]. Having derived the SPCs, a mapping exercise was undertaken to ensure that the SPCs fully cover the relevant NSEDPs applicable to the topic area. More information on the development of SPCs, and the coverage, at the more detailed level in the safety case, to demonstrate full compliance with the relevant NSDEPs is presented in Chapter 5, Section 5.3.),
- Support systems (i.e. power supply, Control and Instrumentation (C&I), etc), and

- A description of where the arguments and evidence that substantiate all relevant safety case claims are presented in supporting documents.

The following is out of scope of Chapter 17.

- Internal Hazards associated with the systems described in Chapter 17 (e.g. flooding, fires, dropped loads or missiles). These are covered in Chapter 7.
- Chapter 24 defines the performance requirements of systems in Chapter 17 in design basis faults. These requirements define the major claims on the safety systems that are substantiated in the supporting Level 2 Topic Reports and Basis of Safety Case Documents.
- The contribution of Chapter 17 systems to severe and beyond design basis accidents is assessed and the conclusions reported in Chapter 26, Severe Accident Analysis (SAA))
- Probabilistic analysis to demonstrate adequate performance of systems within Chapter 17 scope during accident conditions is included in Chapter 25.
- The supplies to provide electrical power to the SSCs in Chapter 17 are described in Chapter 15.
- Control and instrumentation functions including EHC to support the SSCs in Chapter 17 is described and justified in Chapter 14.
- The chemistry of the fluids of the Chapter 17 systems is described and justified in Chapter 23: Reactor Chemistry.
- Environmental and security aspects of the UK ABWR design. For links to GEP, and CSA documentation, please refer to Chapter 1. For GEP, where specific references is required, for example in Chapter 18: Radioactive Waste Management, Chapter 20: Radiation Protection, Chapter 31, these will be included in the specific sections within the Generic PCSR.

17.3 Turbine Generator

17.3.1 System Summary Description

This section is a general introduction to the Turbine Generator where the system roles, system functions, system configuration and modes of operation are briefly described.

17.3.2 System Roles

The main role of the Turbine Generator is to convert the thermal energy of the steam to electrical energy.

17.3.3 Functions Delivered

The Turbine Generator is designed to perform the following normal operation. Safety functions are discussed in 17.3.6 Design Bases.

(1) The turbine is a tandem-compound 6-flow exhaust condensing-type. It consists of a double-flow High Pressure Turbine (HP-T) and 3 double-flow Low Pressure Turbines (LP-Ts).
(2) The thermal energy of the steam entering the turbine is converted into mechanical energy by the turbine.
(3) The turbine drives the generator which is coupled with the turbine rotor.
(4) The generator is driven by the turbine and converts the mechanical energy into the electrical energy.

17.3.4 Basic Configuration

The Turbine Generator consists of the following main components. The Turbine Generator is located in the Turbine Building (T/B).

(1)	Steam Turbine	
	High Pressure Turbine (HP-T)	1 Set
	Low Pressure Turbine (LP-T)	3 Sets
(2)	Main Steam Stop Valve (MSV)	4 Sets
(3)	Steam Control Valve (CV)	4 Sets
(4)	Combined Intermediate Valve (CIV)*1	6 Sets
(5)	Generator	1 Set
(6)	Moisture Separator Reheater	2 Sets

*1: Combined Intermediate steam Stop Valve (ISV) and Intercept Valve (IV)

17.3.5 Modes of Operation

Modes of operation of the Turbine Generator are summarised as follows:

17.3.5.1 **Normal Operation**

The steam from the Reactor passes through 4 Main Steam Valves (MSVs) and is controlled by 4 Steam Control Valves (CVs). After leaving the CVs, the steam is taken by 4 steam pipes to 2 inlets in the lower casing and 2 inlets in the upper casing into the HP-T. The double-flow HP-T is controlled by the throttling governing method.

After the steam expands at the HP-T, it passes through 4 cold reheat pipes from the lower casing and is taken to 2 Moisture Separator Reheaters (MSRs). Within this reheater, the moisture of the steam at the LP-T inlet can be controlled to a superheated condition. Each MSR vessel contains a moisture separator and 2 heating stages. Each heating stage has a different heat source, heating steam for the first heating stage is supplied with extraction steam from the intermediate stage of the HP-T, and heating steam for the second heating stage is supplied from the main steam line.

Reheated steam leaves the 2 MSR vessels through 6 hot reheat pipes flowing through the 6 Combined Intermediate Valves (CIVs) then to the 6 LP-T inlets (2 inlets for each LP-T). Then the steam passes out through the exhaust outlets and is condensed into the condenser.

The generator is driven by the turbine and converts the mechanical energy into the electrical energy.

17.3.5.2 **Start-up and Shutdown Operation**

At start-up and after shutdown of turbine operation, the turbine and generator rotors are to be rotated at a low speed by a turning device while the rotor temperature is high to prevent deflection.

At start-up and after shutdown of turbine operation, excess steam flow from the Reactor is fed to a condenser through the Turbine bypass valves.

At start-up of turbine operation, steam to the turbine is fed and controlled by CVs, and the turbine is sped up to the rated speed by predetermined acceleration.

After the turbine reaches the rated speed, the turbine generator is synchronised to the grid.

17.3.5.3 **Transient Conditions**

If an emergency condition of the turbine generator or the plant occurs, the turbine generator is tripped quickly and automatically by closing the MSVs, CVs and CIVs rapidly.

In the case of excess load rejection, CVs and/or CIVs are closed rapidly and automatically in order to protect the turbine from excess over-speed.

17.3.6 Design Bases

This section describes the design bases for the Turbine Generator.

17.3.6.1 **Safety Functions**

The Turbine Generator has been designed to meet the following Safety Function. The relationship between the Safety Function put on this claim and the high level claims is shown in Appendix A.
The Turbine Generator converts the thermal energy of the steam to electrical energy [TG SFC 5-10.1]. The Turbine contains reactor coolant which is beyond the reactor coolant pressure boundary [TG SFC 4-3.1]. Radiation shield is installed around HP-T in order to reduce worker and public dose [TG SFC 4-7.1]. The Turbine Generator delivers a Safety Category B function, and the components necessary to deliver this function are classified as Safety Class 3 according to the safety categorisation and classification of UK ABWR [Ref-17.4].

17.3.6.2 **Design Bases for Power Generation**

From the power generation perspective, the Turbine Generator meets the following design bases:
The Turbine Generator continuously generates power by using steam generated in the Reactor, at the required flow rate, pressure and temperature.

17.3.7 System Design Description

This section describes the design of the Turbine Generator from the power generation perspective.

17.3.7.1 **Overall Design and Operation**

The steam from the Reactor passes through 4 MSVs and is controlled by 4 CVs. After leaving the CVs, the steam is taken by 4 steam leads to 2 inlets in the lower casing and 2 inlets in the upper casing into the HP-T. The double-flow HP-T is controlled by the throttling governing method.

After the steam expands at the HP-T, it passes through 4 cold reheat pipes from the lower casing and is taken to 2 MSRs. The steam is dried and reheated in MSRs.

Reheated steam leaves the 2 MSR vessels through 6 hot reheat pipes flowing through the 6 CIVs then to the 6 LP-T inlets (2 inlets for each LP-T). Then the steam passes out through the exhaust outlets and is condensed in the condenser. The generator is driven by the turbine and converts the mechanical energy into electrical energy.

17.3.7.2 **Equipment Design**

17.3.7.2.1 Steam Turbine

(1) Configuration

The turbine is a tandem-compound 6-flow exhaust condensing-type. It consists of a double-flow HP-T and 3 double-flow LP-Ts. Radiation shield is installed around HP-T in order to reduce worker and public dose.

The turbine is monitored and controlled by the turbine control system, and is operated at 1,500 min^{-1} in normal operation.

(2) Performance

The Steam Turbine is designed to perform as follows.

Steam Turbine	Number:	1 set
	Type:	tandem-compound 6-flow exhaust condensing-type
	Rated Power:	almost 1,350 MW (At Generator terminals)
	Rotational speed:	1,500 min^{-1}

17.3.7.2.2 MSV

(1) Configuration

4 MSVs are installed to pass the main steam from the reactor to the turbine.

Upon receipt of signals from the turbine control system, the hydraulically operated MSVs close rapidly by spring action to shut off the flow of steam.

Steam strainers are provided to prevent the intrusion of foreign matter.

Warming-up devices are provided to warm up the MSVs and the CVs casing.

MSVs are closed if the control system loses power or on loss of oil pressure.

(2) Performance

The MSVs are designed to perform as follows.

MSV	Number:	4 Sets
	Type:	Hydraulic-operated Poppet Type valve

17.3.7.2.3 CV

(1) Configuration

4 CVs are installed to pass the main steam from the reactor to the turbine.

Upon receipt of signals from the turbine control system, the hydraulically operated CVs close rapidly by spring action to shut off the flow of steam.

CVs are closed in case the control system loses power or loss of oil pressure.

(2) Performance

The CVs are designed to perform as follows.

CV	Number:	4 Sets
	Type:	Hydraulic-operated Poppet Type valve

17.3.7.2.4 Generator

(1) Configuration

The generator is a direct-driven, three-phase, 50 Hz, 1500 min^{-1}, four-pole synchronous generator with a water-cooled stator and a hydrogen cooled rotor. It converts the mechanical energy into electrical energy.

The generator is provided with a gas control system, shaft sealing oil system, and stator cooling water system in order to support the generator operation.

(2) Performance

The generator is designed to perform as follows.

Generator	Number:	1 set
	Type:	3 phase, 4 pole synchronous
	Rotational speed:	1,500 min^{-1}

17.3.7.2.5 Moisture Separator Reheater

(1) Configuration

MSRs (2×50 percent) are installed in the cross-around piping connecting the HP-T and the LP-Ts. Each MSR vessel contains a moisture separator and 2 heating stages.

The moisture in the steam is separated and removed in the moisture separator, and the steam is reheated in 2 heating stages in series.

The two MSRs are always operated at the same time in order to avoid heat imbalance of steam at the LP-Ts inlets.

(2) Performance

The MSRs are designed to perform as follows.

Moisture Separator Reheater	Number:	2 Sets
	Type:	Horizontal Type, 2 stages

17.3.7.3 **Support Systems**

The main systems supporting mechanical SSCs for the Turbine Generator are described as follows:

17.3.7.3.1 Instrumentation and Control Systems

(1) Turbine Measurement

The turbine operating conditions can be monitored through instrumentation. The primary measuring points of the turbine are as follows:

(a) Turbine speed,

(b) Steam pressure upstream of MSVs and CIVs,

(c) Steam pressure at turbine exhaust,

(d) Lubricant oil pressure at inlet of turbine bearings,

(e) Lubricant oil temperature at outlet of turbine bearings,

(f) Opening of CVs, and

(g) Vibration of turbine bearings.

(2) Generator Measurement

The generator operating conditions can be monitored through instrumentation. The primary measuring points of the generator are as follows:

(a) Stator windings temperature,

(b) Stator core temperature,

(c) Shaft vibration of the rotor,

(d) Bearing metals temperature,

(e) Exhaust air temperature for collectors,

(f) Hydrogen gas pressure and temperature in the generator,

(g) Differential pressure between sealing oil and gas in the generator, and

(h) Stator cooling water inlet pressure and outlet temperature.

(3) Control and Interlocks

(a) Turbine Electro-Hydraulic Control system (EHC)

The EHC detects the turbine rotating speed and the reactor pressure, and controls the CVs to keep the reactor pressure at a constant level during normal operation. In case of a rise in frequency, the CVs and CIVs are throttled to inhibit a rise in turbine speed. At the same time, the TBVs are opened to release excess steam directly into the condenser. The control function is sub-divided into the following functions:

(i) Speed control function,

(ii) Load control function,

(iii) Pressure control function,

(iv) TBVs control function, and

(v) Flow control function.

The following signals are used for reactor scram initiation, further detail is given in Generic PCSR Chapter 14.

(1) Main Steam Stop Valve Closure

(2) Steam Control Valve Rapid Closure

17.3.7.3.2 Power Supply System

The Turbine Generator components are mainly connected to the Safety Class 3 AC. Some of the important components receive power from a Motor Control Centre (MCC) which can be supplied from an Emergency Diesel Generator (ED/G).

17.3.7.3.3 Turbine Lubricating Oil System

The Turbine Lubricating Oil System supplies lubricating oil to each bearing of the main turbine and generator.

17.3.7.3.4 Turbine Control Oil System

The Turbine Control Oil System supplies control oil and emergency trip oil to the actuators of each of the turbine main valves (Main Stop Valves, Turbine Control Valves, Combined Intermediate Valves, Turbine Bypass Valves).

17.3.7.3.5 Generator Gas Control System

The Generator Gas Control System supplies the hydrogen gas to the generator.

In addition, hydrogen gas purging features are implemented by using carbon dioxide as an inert gas.

17.3.7.3.6 Generator Shaft Sealing Oil System

The Shaft Sealing Oil System supplies the sealing oil to the generator in order to seal the hydrogen in the generator.

17.3.7.3.7 Generator Stator Cooling Water System

The Generator Stator Cooling Water System supplies the cooling water to the stator windings at a constant pressure and temperature.

17.3.7.3.8 Excitation system

The excitation system supplies excitation current to the main generator field winding and to control the generator voltage.

17.3.8 Claims and Link to High Level Safety Functions

The list of claims in this chapter/section and the linkage to corresponding High Level Safety Functions are shown in Appendix A. A short description on the application of High Level Safety Functions in the development of the claims, arguments and evidence is provided in GDA PCSR Chapter 1.

17.4 Turbine Main Steam, Turbine Auxiliary Steam and Turbine Bypass System

17.4.1 System Summary Description

This section is a general introduction to the Turbine Main Steam (MS), Turbine Auxiliary Steam (AS) and Turbine Bypass System (TBP) where the system roles, system functions, system configuration and modes of operation are briefly described [Ref-17.5].

17.4.2 System Roles

(1) MS
The main roles of the MS are to supply steam generated from the reactor to drive the steam turbine, and also to supply steam to the AS and TBP.
(2) AS
The main roles of the AS are to supply driving steam to the Reactor Feedwater Pump Turbine (RFP-T) and the Steam Jet Air Ejector (SJAE), and to supply heating steam to the Moisture Separator Reheater (MSR) and the Gland Steam Evaporator (GSE).
(3) TBP
The main role of the TBP is to release steam from the reactor to the condenser for reactor pressure control during the Startup and System shutdown, or when the reactor steam production exceeds turbine steam demand.

The MS should be differentiated from the Nuclear Boiler System (NB), which is a continuation of the MS beyond the Turbine Building (T/B). The NB is addressed in PCSR Chapter 12 and Main Turbine is addressed in PCSR Chapter 17, Section 17.3.

17.4.3 Functions Delivered

The MS, AS and TBP are designed to perform the following operation. Safety functions are discussed in 17.4.6 Design Bases.
(1) The MS supplies required steam to the steam turbine, AS and TBP during Power operation and transient.
(2) The AS supplies steam to the RFP-T, SJAE, MSR 2nd Stage Reheater (MSR-2RH) and GSE.
(3) The TBP directly discharges steam from the MS header to the condenser.

17.4.4 Basic Configuration

The MS consists of 4 MS pipes to convey steam from the reactor to the High Pressure Turbine (HP-T) via the main steam header. The AS is branched from the MS header to supply MSR-2RH heating steam and SJAE driving steam. The TBP is also branched from the MS header to discharge steam to the condenser. The MS, AS and TBP consist of the following main components:

Turbine Bypass Valve (TBV)	3 units

17.4.5 Modes of Operation

The modes of operation of the MS, AS and TBP are summarised as follows:

17.4.5.1 Power Operation

The MS consists of 4 MS pipes to convey steam from the reactor to the High Pressure Turbine (HP-T) via the main steam header. The MS pipe size is selected to regulate pressure loss to an acceptable limit. MS pipe volume is determined to ensure adequate volumes to prevent an extreme rise in reactor pressure when load rejection occurs. The MS header is provided to equalise the pressure in the steam piping connected to the MSVs, in order to reduce pressure rises during periodic operational testing of the MSVs, minimise pressure fluctuations, and facilitate the auxiliary steam supply.

The AS is branched from the MS header to supply MSR-2RH heating steam and SJAE driving steam during Power operation.

17.4.5.2 Startup and System Shutdown

The AS supplies GSE heating steam and RFP-T driving steam at plant low load.

The TBV opens in response to a control signal from the turbine control system before the generator is synchronised, after the generator is desynchronised, and while the turbine load limiter is in operation. The main steam is depressurised and sent to the condenser lower shell.

17.4.5.3 Transient Conditions

The AS supplies RFP-T driving steam in the event of a main turbine trip and loss of LP steam supply.

The TBV opens in case of an emergency shutdown (due to turbine trip, load rejection, reactor scram, etc.) or a rapid load reduction, in response to a control signal from the turbine control system to partially depressurise and send the steam to the condenser shell .

17.4.6 Design Bases

This section describes the design bases for the MS, AS and TBP.

17.4.6.1 Safety Function

The MS, AS and TBP have been designed to meet the following Safety Functions. The relationship between the safety functions put on these claims and the high level claims is shown in Appendix A.
The MS contains reactor coolant which is beyond the reactor coolant pressure boundary [MSASTBP SFC 4-3.1]. The MS, AS and TBP transfer steam generated at the reactor to the turbine side for power generation [MSASTBP SFC 5-10.1]. The TBP mitigates reactor pressure increase [MSASTBP SFC 4-6.1]. The MS, AS and TBP deliver a Safety Category B function and the components necessary to deliver this function are classified as Safety Class 3 according to the safety categorisation and classification of UK ABWR [Ref-17.4].

17.4.6.2 **Design Bases for Power Generation**

From the power generation perspective, the MS, AS and TBP meets the following design bases:
(1) The MS supplies steam to the steam turbine and the AS for power generation.
(2) The AS supplies driving steam to the RFP-T and SJAE, and supplies heating steam to the MSR and GSE.
(3) The TBP releases excess steam from the reactor to the condenser during Startup and System shutdown.

17.4.7 System Design Description

This section describes the design of the MS, AS and TBP from the power generation perspective.

17.4.7.1 **Overall Design and Operation**

(1) The MS supplies required steam to the steam turbine, AS and TBP during Power operation and transient.
(2) The AS supplies steam to the RFP-T, SJAE, MSR-2RH and GSE.
(3) The TBP directly discharges steam from the MS header to the condenser.

17.4.7.2 **Equipment Design**

17.4.7.2.1 TBV
(1) Configuration
The TBV consists of three valves which are connected to the MS lines upstream of the MSVs.
(2) Performance
The TBV is designed to perform as follows.

TBV	Type:	Globe valve
	Actuator type:	Hydraulic drive
	Number:	3 units
	Capacity:	33 percent of reactor outlet steam flow rate

17.4.7.3 **Support Systems**

The main systems supporting mechanical SSCs for the delivery of steam supply are described as follows.

17.4.7.3.1 Control and Instrumentation Systems
The Pressure Control Valve (PCV) in the AS automatically controls the steam pressure for SJAE and GSE as required.
The details of the TBV control are indicated in Chapter 14.
For reference, the steam pressure is controlled with the TBV in case that;

(1) The reactor is pressurised to a rated pressure,
(2) The generator is synchronised,
(3) The quantity of steam generated by the reactor exceeds the turbine steam requirement, or
(4) The plant is in System shutdown.
The TBV is also utilised in Frequency Sensitive Mode (FSM) and Limited Frequency Sensitive Mode (LFSM).

17.4.7.3.2 Power Supply System

The MS, AS and TBP components are connected to Safety Class 3 AC.

17.4.7.3.3 Nuclear Boiler System (NB)

The NB is the continuation of the MS beyond the Turbine Building (T/B).

17.4.7.3.4 Main Turbine

The turbine is a tandem-compound 6-flow exhaust condensing-type. It consists of a double-flow HP turbine and 3 double-flow LP turbines. The main turbine is the continuation of the MS and includes the Main Stop Valve, Control Valve, Turbines and MSRs.

17.4.7.3.5 Reactor Feedwater Pump Turbine (RFP-T)

The RFP-T drives the Turbine-Driven Reactor Feedwater Pump (T/D-RFP) using steam. The AS supplies RFP-T driving steam at plant low load.

17.4.7.3.6 Turbine Gland Steam System (TGS)

The TGS supplies sealing steam to the turbine shaft seal parts and the major valve gland parts. The AS supplies heating steam to the GSE during Startup and System shutdown.

17.4.7.3.7 Air Off Take System (AO)

The AO extracts air and non-condensable gas (H2 and O2) from the Condenser by SJAE to achieve and maintain condenser vacuum. The AS supplies driving steam to SJAE during Power operation.

17.4.8 Claims and Link to High Level Safety Functions

The list of claims in this chapter/section and the linkage to corresponding High Level Safety Functions are shown in Appendix A. A short description on the application of High Level Safety Functions in the development of the claims, arguments and evidence is provided in GDA PCSR Chapter 1.

17.5 Extraction Steam System

17.5.1 System Summary Description

This section is a general introduction to the Extraction Steam System (ES) where the system roles, system functions, system configuration and modes of operation are briefly described.

17.5.2 System Roles

The main roles of the ES are to supply required steam to components in the Turbine building.

17.5.3 Functions Delivered

The ES is designed to perform the following operations. Safety functions are discussed in 17.5.6 Design Basis.

(1) The ES supplies High Pressure Turbine (HP-T) exhaust steam to the Low Pressure Turbine (LP-T) through Moisture Separator Reheaters (MSRs).
(2) The ES supplies required heating steam to the Feedwater Heaters (FWHs) and MSR 1st Stage Reheater (MSR-1RH) from the HP-T and LP-Ts, and processes drains separated in the turbine stage to increase the plant thermal efficiency.
(3) The ES supplies steam required to drive Reactor Feedwater Pump Turbine (RFP-T) from the cross-around pipe at the MSR outlet.
(4) The ES supplies Gland Steam Evaporator (GSE) heating steam at high load operation.

17.5.4 Basic Configuration

The ES consists of piping and valves. The ES should be differentiated from the Main Turbine, which is described in 17.3.

17.5.5 Modes of Operation

The modes of operation of the ES are summarised as follows:

17.5.5.1 **Power Operation**

(1) Four pipes are used to extract HP-T exhaust and send it to 2 horizontal MSRs. The exhaust is then sent to the LP-T through 6 pipes.
(2) No.1 extraction pipes extract steam from the HP-T through 2 pipes and sends it as heating steam to two No.1 FWHs. A balancing pipe is provided halfway between the 2 extraction pipes to balance HP-T exhaust rates in case one FWH is out of service.
    No.2 extraction pipes extract steam from 4 cross-around pipes. The 4 pipes are merged into 2 pipes and connected to two No.2 FWHs to provide heating steam.
    No.3 extraction pipes extract steam from the 3 LP-T casings through 2 pipes respectively. The 2 pipes merge into a header which sends heating steam to three No.3 FWHs.
    No.4 extraction pipes extract steam from the 3 LP-T casings through 2 pipes respectively. The 2 pipes merge into a header which sends heating steam to three No.4 FWHs.

No.5 extraction pipes extract steam from the 3 LP-T casings through 4 pipes respectively, and then sends it as heating steam to three No.5 FWHs.
No.6 extraction pipes extract steam from the 3 LP-T casings through 8 pipes respectively, and then sends it as heating steam to three No.6 FWHs.

(3) Two pipes from the HP-T are used to extract heating steam for the MSR-1RH. Each pipe branches into 2 pipes and is connected to two MSR-1RHs respectively.
(4) The RFP-T LP driving steam is extracted from the cross-around pipes at the MSR outlet. The exhaust is discharged to the condenser through the expansion joint and stop valve.
(5) GSE heating steam is supplied from the HP-T exhaust. At plant low load such as Startup and System shutdown, heating steam is supplied from the Turbine Auxiliary Steam System (AS).

17.5.5.2 **Startup and System Shutdown**

The cross-around pipe is equipped with a drain line to the condenser for drainage at plant low load such as Startup and System shutdown. This drain line is equipped with a motor-operated valve and interlock to fully open at plant low load.

17.5.5.3 **Transient Conditions**

(1) In case the water level in each FWH increases, the extraction check valve is fully closed to prevent turbine water induction. An air-operated extraction drain valve is provided on the upstream side of the extraction check valve to discharge any water remaining on the upstream side of the valve to the condenser when the extraction check valve closes. The No. 2 extraction pipe is not equipped with a drain line as this pipe extracts steam from the upper side of the cross-around pipe, and the MSR processes any remaining drain.
(2) One of two RFP-Ts can be isolated while the plant is service by the following:
    (a) Isolating the RFP-T from the condenser
        An exhaust pipe is equipped with a motor-operated butterfly valve to isolate the RFP-T from the condenser when inspecting a non-operating RFP-T.
    (b) Isolating the RFP-Ts from each other
        A line shared by the RFP-Ts is equipped with a stop valve to isolate the RFP-Ts from each other, and ensure that a non-operating RFP-T does not affect the operating RFP-T.
(3) During Power operation, the RFP-Ts are driven by LP steam. If the LP heating steam source is lost in a transient state such as load rejection, HP steam is automatically supplied to the RFP-Ts to continue operation.

17.5.6 Design Bases

This section describes the design bases for the ES.

17.5.6.1 **Safety Functions**

The ES has been designed to meet the following Safety Functions. The relation between the safety function put on this claim and the high level claims is shown in Appendix A.
The ES transfers steam to the turbine components for power generation through piping [ES SFC 5-10.1]. The ES contains reactor coolant which is beyond the reactor boundary [ES SFC 4-3.1]. Radiation shield is installed around the cross-around pipes at LP-T inlet in order to reduce worker and public dose [ES SFC 4-7.1]. The ES delivers a Safety Category B function, and the components necessary to deliver this function are classified as Safety Class 3 according to the safety categorisation and classification of UK ABWR [Ref-17.4].

17.5.6.2 **Design Bases for Power Generation**

From the power generation perspective, the ES meets the following design bases.

(1) The ES supplies High Pressure Turbine (HP-T) exhaust steam to the Low Pressure Turbine (LP-T) through Moisture Separator Reheaters (MSRs), heating steam to the Feedwater Heaters (FWHs) and MSR 1st Stage Reheater (MSR-1RH) from the HP-T and LP-Ts, and processes drains separated in the turbine stage to increase the plant thermal efficiency.
(2) The ES supplies steam required to drive Reactor Feedwater Pump Turbine (RFP-T) from the cross-around pipe at the MSR outlet.
(3) The ES supplies Gland Steam Evaporator (GSE) heating steam at plant high load.
(4) The pressure loss of the HP-T exhaust system and extraction pipes are designed to be within specified values as it affects turbine efficiency.

17.5.7 System Design Description

This section describes the design of the ES from the power generation perspective.

17.5.7.1 **Overall Design and Operation**

(1) HP-T exhaust system
The ES supplies HP-T exhaust steam to MSRs for removing moisture and heating the steam, and then sends it to the LP-T to prevent erosion in the LP-T and increase the plant thermal efficiency. Radiation shield is installed around the cross-around pipes at LP-T inlet in order to reduce worker and public dose.
(2) Extraction system to FWHs
The ES supplies heating steam from the HP-T and LP-Ts to FWHs to heat reactor feedwater to increase the plant thermal efficiency.
(3) MSR-1RH heating steam system
The ES supplies MSR-1RH heating steam extracted from the HP-T.
(4) RFP-T LP driving steam system
The ES supplies LP steam for driving the RFP-T from the cross-around pipe at the MSR outlet and sends RFP-T exhaust steam to the condenser.
(5) GSE heating steam system
The ES supplies GSE heating steam from the HP-T exhaust at plant high load.
(6) Protection of equipment and pipes
The Combined Intermediate Valve (CIV) rapidly closes in a transient state such as load rejection or turbine trip. Safety valves are provided to protect equipment against damage due to a possible rise in pressure greater than the transient pressure rise.
A total of 6 safety valves are required: 3 for each MSR. Steam discharged from the safety valves is sent to the condenser.
(7) Extraction check valve
Each extraction pipe is equipped with an air-operated extraction check valve in order to:
(a) Suppress turbine overspeed (down to the specified speed) due to steam backflow from the extraction pipe and FWH in a transient condition, such as load rejection or turbine trip, and
(b) Prevent condensate from turbine water induction in case a FWH tube leaks.
Similarly, the MSR-1RH heating steam pipe is also equipped with a stop valve and a check valve for isolation.
The No.5 and No.6 FWHs built in the neck of the condenser do not have check valves on their extraction pipes because:
(i) The small energy being held has little influence on turbine overspeed,

(ii) FWH tube leak flow amount is capable of being discharged to the condenser through the Feedwater Heater Drain System (HD).

(8) The GSE is heated by either AS or ES. In case of Pressure Control Valve (PCV) failure during AS operation, the system pressure will rise. Safety valves are therefore provided to protect equipment against damage due to such rises in pressure. Safety valves are provided on the heating steam PCV downstream. Steam is released to the condenser through the safety valves.

17.5.7.2 **Equipment Design**

The ES consists of piping and valves. The ES supplies steam to the MSRs, LP-Ts, FWHs, RFP-Ts, and GSE. Those equipment are in the scope of other systems.

17.5.7.3 **Support Systems**

The main systems supporting mechanical SSCs for the delivery of extraction steam supply are described as follows:

17.5.7.3.1 Control and Instrumentation Systems

(1) The extraction check valves are forcibly closed as follows:
  (a) In case a turbine trips (actuation of the extraction relay dump valve),
  (b) In case the FWH water level is "High High" (actuation of the level switch), or
  (c) In case remote operation is performed from the Main Control Room (MCR).
  When the extraction check valve is forcibly closed, the extraction drain valve is fully open.
  On loss of air pressure, the extraction check valve is closed and the extraction drain valve opened.
(2) During Power operation, the RFP-T is driven by LP steam extracted from the cross-around pipe at the MSR outlet. If this steam source is lost in a transient state (such as load rejection), the Low Pressure Control Valve (LP-CV) is fully open. A mechanism linked to the High Pressure Control Valve (HP-CV) automatically opens to use HP steam from the main steam pipe as RFP-T driving steam.
(3) The interlock for switching the GSE heating steam sources (between main steam and extraction steam) works to detect the extract pressure and open or close the heating steam stop valve.
  (a) Opens at high extraction pressure: (Main steam to Extraction steam)
  (b) Closes at low extraction pressure: (Extraction steam to Main steam)
  (c) The RFP-T is equipped with an interlock for tripping the turbine at "Low" exhaust vacuum.

17.5.7.3.2 Power Supply System

The ES components are connected to a Safety Class 3 AC.

17.5.7.3.3 Main Turbine

The turbine is a tandem-compound 6-flow exhaust condensing-type. It consists of a double-flow HP turbine and 3 double-flow LP turbines. The ES sends HP-T exhaust steam to MSRs for removing moisture and heating the steam, and then sends it to the LP-T to prevent erosion in the LP-T and increase the plant thermal efficiency.

17.5.7.3.4 Reactor Feedwater Pump Turbine (RFP-T)

The RFP-T drives the Turbine-Driven Reactor Feedwater Pump (T/D-RFP) by means of steam. The ES supplies RFP-T driving steam during Power operation.

17.5.7.3.5 Condensate and Feedwater System (CFDW)

The CFDW supplies feedwater from the condenser to the reactor. The ES sends heating steam from the HP-T and LP-Ts to FWHs to heat reactor feedwater to increase the plant thermal efficiency.

17.5.7.3.6 Feedwater Heater Drain & Vent System (HD and HV)
The HD drains the Feedwater Heater (FWH) and Moisture Separator Reheater (MSR) drain.

17.5.7.3.7 Turbine Gland Steam System (TGS)
The TGS supplies sealing steam to the turbine shaft seal parts and the major valve gland parts. The ES supplies GSE heating steam from the HP-T exhaust at plant high load.

17.5.8 Claims and Link to High Level Safety Functions

The list of claims in this chapter/section and the linkage to corresponding High Level Safety Functions are shown in Appendix A. A short description on the application of High Level Safety Functions in the development of the claims, arguments and evidence is provided in GDA PCSR Chapter 1.

17.6 Turbine Gland Steam System

17.6.1 System Summary Description

This section is a general introduction to the Turbine Gland Steam System (TGS) where the system roles, system functions, system configuration and modes of operation are briefly described.

17.6.2 System Roles

The main roles of the TGS are to supply sealing steam to the turbine shaft seal parts and the major valve gland parts, and to prevent leaking air into the condenser.

17.6.3 Functions Delivered

The TGS is designed to perform the following operation. Safety functions are discussed in 17.6.6 Design Basis.

(1) The TGS supplies sealing steam to the turbine shaft labyrinth packing parts and to the gland packing parts of major valve stems to prevent leaking air into the condensers.
(2) To reduce the leakage of radioactivity outside of the plant through the Gland Steam Exhauster (GSEXH), the sealed parts are constructed to prevent reactor generated steam from leaking into the Gland Steam Condenser (GSC). Clean steam produced in the Gland Steam Evaporator (GSE) is used as the sealing steam.
(3) Drain from the GSC is sent to the Seal Drain Collection Tank (SDCT).

17.6.4 Basic Configuration

The TGS consists of the following main components.

(1)	Gland Steam Evaporator (GSE)	1 unit
(2)	Gland Steam Evaporator Drain Tank (GSE-DT)	1 unit
(3)	Gland Steam Condenser (GSC)	1 unit
(4)	Gland Steam Exhauster (GSEXH)	2 units (1 unit as standby)

(5) The TGS seals the following parts.

Main turbine (1 unit)	HP shaft packing part
	LP shaft packing part
	MSV stem gland part
	CV stem gland part
	ISV stem gland part
	IV stem gland part
	TBV stem gland part
RFP-T (2 units)	HP side shaft packing part
	LP side shaft packing part
	RFP-T HP steam stop valve stem gland part
	RFP-T HP steam control valve stem gland part
	RFP-T LP steam stop valve stem gland part
	RFP-T LP steam control valve stem gland part

17.6.5 Modes of Operation

The modes of operation of the TGS are summarised as follows:

17.6.5.1 **Power Operation**

(1) The GSE generates clean sealing steam for gland steam supply to the steam seal header.
(2) The Makeup Water Condensate System (MUWC) supplies makeup water for steam generation in the GSE.
(3) The GSC cools steam that leaks from the shaft seal closer to the outside side of the main turbine, RFP-T, RFP-T high pressure /low pressure stop valves and steam control valve, then the GSEXH discharges air which is in-leaked at each shaft to the exhaust stack.
(4) The GSC drains to the Seal Drain Collection Tank (SDCT).
(5) The High Pressure Turbine (HP-T) shaft packing parts are equipped with 2 stage leak-off return lines to the Extraction Steam System (ES) (Feedwater heater) and to the condenser respectively. The leak-off line to the condenser is equipped with a flow limiting orifice just before the condenser inlet to prevent extreme drops in pressure of the shaft packing and rapid rises in flow velocity in its leak-off pipe.
(6) Leak-off from the Turbine Control Valve (CV) and Turbine Bypass Valve (TBV) are collected into the cross-around pipe. Sealing steam leaking from the valve gland parts is recovered to the condenser.
(7) Sealing steam leaking from gland parts of Main Stop Valve (MSV), Intermediate Steam Stop Valve (ISV), and Intercept Valve (IV) is recovered to the condenser.
(8) Leak-off from the Reactor Feedwater Pump Turbine (RFP-T) high pressure /low pressure stop valves and steam control valves are recovered to the condenser. Sealing steam leaking from the valve gland parts is also recovered to the GSC.

17.6.5.2 **Startup and System Shutdown**

(1) In case the GSE is not available when the heating steam pressure is lower at Startup and System shutdown, pressure-reduced steam from the Heating Steam System (HS) is used as the sealing steam.
(2) A warming line is attached to the GSE generated steam line for GSE warming up.

17.6.5.3 **Transient Conditions**

(1) If the GSE fails, the pressure reduced HS steam is used as sealing steam.
(2) Motor-operated bypass valves are provided to back up the gland steam Pressure Control Valve (PCV) and a startup gland steam PCV.
(3) When the Main Steam Isolation Valve (MSIV) is closed, the heat source for the GSE is lost. Sealing steam is thus supplied to the turbine by heat retained in the GSE shell, in order to prevent a rapid drop in the condenser vacuum until the specified turbine speed is reached.

17.6.6 Design Bases

This section describes the design bases for the TGS.

17.6.6.1 **Safety Functions**

The TGS has been designed to meet the following Safety Function. The relation between the safety function put on this claim and the high level claims is shown in Appendix A.

The TGS supplies sealing steam to the turbine shaft seal parts and the major valve gland parts [TGS SFC 5-10.1]. The TGS contains reactor coolant which is beyond the reactor coolant pressure boundary [TGS SFC 4-3.1]. The TGS delivers a Safety Category B function, and the components necessary to deliver this function are classified as Safety Class 3 according to the safety categorisation and classification of UK ABWR [Ref-17.4].

17.6.6.2 **Design Bases for Power Generation**

From the power generation perspective, the TGS meets the following design bases.
(1) The TGS supplies sealing steam to the turbine shaft labyrinth packing and to the gland packing of major valve stems to prevent leaking air into the condensers.
(2) To reduce the leakage of radioactivity outside of the plant through the Gland Steam Exhauster (GSEXH), the sealed parts are constructed to prevent reactor generated steam from leaking into the Gland Steam Condenser (GSC). Clean steam produced in the Gland Steam Evaporator (GSE) is used as the sealing steam.
(3) Drain from the GSC is sent to the Seal Drain Collection Tank (SDCT).

17.6.7 System Design Description

This section describes the design of the TGS from the power generation perspective.

17.6.7.1 **Overall Design and Operation**

(1) The TGS supplies sealing steam to the turbine shaft labyrinth packing and to the gland packing of major valve stems to prevent leaking air into the condensers.
(2) The sealed parts are constructed to prevent reactor generated steam from leaking into the GSC. Clean steam produced in the GSE is used as the sealing steam.
(3) The capacities of TGS equipment are designed at the maximum flow rate (based on the Double Packing Clearance (DPC)).
(4) The heating source of the GSE is the AS in case required heating pressure cannot be assured (e.g. at plant low load such as Startup and System shutdown) or the ES when operating at the plant high load.
(5) The TGS is able to seal the turbine gland parts with the HS steam for back-up of the GSE, or for the Startup and System shutdown.
(6) Air from the GSEXH is discharged directly to the exhaust stack. A radiation monitor capable of continuously monitoring and recording radioactivity is installed in the Off-Gas System (OG) at the GSC outlet for radiological control and to detect any tube leaks in the GSE.
(7) The sealing steam supply line from HS is equipped with a check valve to prevent radioactivity escape due to a backflow of steam generated in the GSE. A connection pipe is provided from the upstream part of the check valve to the condenser.
(8) The turbine gland steam supply line is equipped with safety valves to protect the equipment against damage due to a pressure rise in case of PCV failure.

17.6.7.2 Equipment Design

17.6.7.2.1 GSE

(1) Configuration
One 100 percent capacity GSE is provided. Moisture is removed by the separator installed in the GSE shell to prevent carry-over. A continuous blowpipe extending from the GSE shell to the condenser is provided to maintain cleanliness inside of the shell. Gases (e.g., air, oxygen) are separated when makeup water is sprayed on the shell. Therefore, a vent pipe is provided on the shell side to discharge the gases to the condenser.

(2) Performance
The GSE is designed to perform as follows.

GSE	Number:	1 unit
	Generated steam:	almost 27,000 kg/h/unit (at DPC)

17.6.7.2.2 GSC

(1) Configuration
The GSC receives and cools steam and air leaking from the main turbine and RFP-T.

(2) Performance
The GSC is designed to perform as follows.

GSC	Number:	1 unit
	Processed steam flow rate:	almost 10,000 kg/h/unit (at DPC)
	Processed air flow rate:	almost 3,000 kg/h/unit (at DPC)

17.6.7.3 Support Systems

The main systems supporting mechanical SSCs for the delivery of gland seal supply are described as follows:

17.6.7.3.1 Control and Instrumentation Systems

(1) Control and Interlocks

(a) The GSE heating steam source is the ES at plant high load.
The GSE shell pressure controller (on the ES side) regulates the GSE heating steam PCV (on ES side) to attain constant shell pressure.

(b) The GSE heating steam source is the Turbine Auxiliary Steam System (AS) at plant low load.
The GSE shell pressure controller regulates the GSE heating steam PCV (AS side) to attain constant shell pressure.
The GSE heating steam pressure controller regulates the GSE heating steam PCV (on AS side) to attain constant heating steam pressure.
The higher pressure selector provided inside the GSE shell pressure controller (AS side) selects the higher of 2 control signals, and controls the opening of the GSE heating steam PCV (on AS side).
The GSE heating steam PCV (on AS side) is thus controlled by the shell pressure controller, but its opening is limited by the heating steam pressure controller in the transient state. This minimises the peak pressure and prevents the untimely opening of safety valve on the heating steam side.

(c) Two GSE heating steam PCVs (small PCV and large PCV) are installed on the AS side. Both PCVs are automatically controlled when the MS pressure is low. When the MS pressure increases, the large PCV automatically closes and the small PCV is controlled.

(d) The GSE heating steam PCV automatically switches from the AS side to the ES side when the plant load increases, and vice versa when the plant load decreases.
(e) When steam generated by the GSE is used in the normal operation, the gland steam pressure regulator controls the gland steam PCV to maintain constant gland steam header pressure.
(f) When HS steam is used at Startup or System shutdown, the gland steam pressure regulator controls the startup gland steam PCV to maintain constant gland steam header pressure.
(g) At Startup, the startup gland steam PCV is automatically switched to the gland steam PCV. At System shutdown, these valves operate in reverse automatically.

(2) Water level control

The GSE shell water level is controlled at a constant level by the control valve on the makeup water side.

To prevent water induction to the turbine gland in case the water level rises abnormally, the LCV outlet valve is fully closed when the shell water level is “High High”.

The GSE shell LCV outlet valve and its bypass valve receive power from a Motor Control Centre (MCC) which can be supplied from an Emergency Diesel Generator (ED/G) to ensure makeup water, even in case of Loss of Off-site Power (LOOP).

In case of degraded GSEXH performance, an interlock is provided to detect GSC shell pressure, and alarm the MCR and automatically start the standby GSEXH in case the operating GSEXH trips.

17.6.7.3.2 Power Supply System

The TGS components are connected to a Safety Class 3 AC. The motor-operated valves of this system receive power from a Motor Control Centre (MCC) which can be supplied from an Emergency Diesel Generator (ED/ G) for enabling operations to shut down the supply of sealing steam to the turbine gland and to prevent condensate from being in contact with the turbine gland parts, even in the case of LOOP.

17.6.7.3.3 Turbine Auxiliary Steam System (AS)

The AS supplies heating steam to the GSE at plant low load.

17.6.7.3.4 Extraction Steam System (ES)

The ES supplies heating steam to the GSE at plant high load.

17.6.7.3.5 Feedwater Heater Drain System (HD)

The HD recovers the GSE drain to the No.3 Feedwater heater to heat feedwater with extraction steam.

17.6.7.3.6 Heating Steam System (HS)

The HS supplies sealing steam when the GSE is not available and when heating steam pressure is lower at Startup and System shutdown.

17.6.7.3.7 Makeup Water Condensate System (MUWC)

The MUWC supplies the makeup water for steam generation in the GSE.

17.6.7.3.8 Off-Gas System (OG)

The OG extracts the GSEXH discharge air to the exhaust stack.

17.6.8 Claims and Link to High Level Safety Functions

The list of claims in this chapter/section and the linkage to corresponding High Level Safety Functions are shown in Appendix A. A short description on the application of High Level Safety Functions in the development of the claims, arguments and evidence is provided in GDA PCSR Chapter 1.

17.7 Feedwater Heater Drain and Vent System

17.7.1 System Summary Description

This section is a general introduction to the Feedwater Heater Drain and Vent System (HD and HV) where the system roles, system functions, system configuration and modes of operation are briefly described.

17.7.2 System Roles

The main roles of the HD are to drain the Feedwater Heater (FWH) and Moisture Separator Reheater (MSR) drain and utilise the drain for feedwater heating.
The main roles of the HV are to discharge non-condensable gases from the FWHs to prevent a reduction in their heat transfer performance.

17.7.3 Functions Delivered

The HD and HV are designed to perform the following operation. Safety functions are discussed in 17.7.6 Design Basis.

(1) HD

The HD drains the FWH and MSR drain to heat feedwater to improve plant thermal efficiency.
The High Pressure (HP) FWH drain is directly recovered on the Reactor Feedwater Pump (RFP) suction side, and the Low Pressure (LP) FWH drain is directly recovered on the High Pressure Condensate Pump (HPCP) suction side respectively, to further improve plant thermal efficiency and reduce the capacity of the Condensate and Feedwater System (CFDW).

(2) HV

The HV discharges non-condensable gases from the FWHs to prevent a reduction in their heat transfer performance. Non-condensable gases from the MSR 1st and 2nd Stage Reheaters (MSR-1/2RHs) are discharged through their outlet header with steam to prevent overcooling of the heat transfer tubes.
The HV is also equipped with FWH shell relief valves to protect the FWHs against damage due to excessive pressure in case of tube leak.

17.7.4 Basic Configuration

The HD and HV consist of the following main components.

(1)	HPDP	3 units (1 unit as standby)
(2)	LPDP	3 units (1 unit as standby)
(3)	HPDT	1 unit
(4)	LPDT	1 unit
(5)	MSR-MDT	2 units
(6)	MSR-1DT	2 units
(7)	MSR-2DT	2 units

17.7.5 Modes of Operation

The modes of operation of the HD and HV are summarised as follows:

17.7.5.1 Power Operation

(1) HD
  (a) The MSR-1/2RHs drain is sent to the drain tanks, and then recovered to the No. 1 FWH through the low Level Control Valves (LCVs).
  (b) Separated drain in the MSR-MSs is sent to the MSR Moisture Separator Drain Tank (MSR-MDT), and then recovered in the HPDT through the low LCVs.
  (c) The No. 1 FWH drain is recovered to the HPDT through the low LCV. The No. 2 FWH drain flows into the HPDT under gravity.
  (d) High Pressure Pumped Drain System (HPPD) and Low Pressure Pumped Drain System (LPPD) is operated at 50 percent plant load or more.
  (e) The GSE drain is sent to Gland Steam Evaporator Drain Tank (GSE-DT), and then recovered to the No. 3 FWH through the low LCV.
  (f) The RFP bleed off water is sent to the No. 3 FWH through an orifice.
  (g) The No. 3 FWH drain is sequentially sent to the No. 4, No. 5 and No. 6 FWH through the low LCVs. No. 6 FWH drain is then recovered to the LPDT by gravity.
  (h) The drain water level of each FWH with drain cooler is controlled by the low LCV which is provided along the drainpipe, and the high LCV which is provided on the dump line to the condenser.
  (i) The No. 2 and No. 6 FWHs need not be equipped with LCVs since they have no drain cooler.

(2) HV
  (a) The MSR-1/2RHs vent system extracts the non-condensable gas and the scavenging steam from its outlet header, and then sends both to the No. 1 FWH.
  The vent pipe is equipped with an orifice to regulate the MSR-1/2RHs vent rate during Power operation.
  (b) The MSR-1/2DT vent is connected to the MSR-1/2RHs to equalise vent pressures and improve drain discharge performance.
  (c) Non-condensable gas from the FWH is continuously sent to the condenser, and then discharged from the condenser to the Air Off Take System (AO) through the Steam Jet Air Ejector (SJAE). An orifice is provided on the vent pipe connected to each FWH to limit the vent rate.
  (d) The HPDT vent pipe is provided to send the steam flashed in the HPDT to the No. 2 FWH, and the LPDT vent pipe is provided to send the steam flashed in the LPDT to the No. 6 FWH respectively, for pressure-equalising and heat recovery.
  (e) The non-condensable gas separated in the GSE is recovered to the condenser through an orifice.

17.7.5.2 Startup and System Shutdown

(1) Drains sent to the HPDT are recovered to the condenser through the dump line before the HPPD starts. Drains sent to the LPDT are recovered to the condenser through the dump line before the LPPD starts.
(2) The MSR-1RH drain, MSR-2RH drain, and MSR-MS drain are recovered to the condenser through the dump line at partial plant loads.
(3) Drain of the MSR-1RH heating steam header and drain of the MSR-2RH heating steam header are recovered to the condenser at partial plant loads to prevent the retention of drain. Each drain line is equipped with a flow rate limiting orifice.

(4) The MSR-1/2RHs vent is recovered to the condenser at partial plant load.

17.7.5.3 Transient Conditions

(1) In the case that the water levels of the drain tanks and FWHs, excluding the No. 2 and No. 6 FWHs, go up abnormally by a low LCV failure or heating tube leakage, etc., the drains are recovered to the condenser through the dump lines.
(2) The dump line having a high LCV branches from each normal drain line LCV upstream. The LP FWH dump line is connected directly from the upstream of FWH drain cooler in order to deal with any effects of low-pressure differences during plant partial load.

17.7.6 Design Bases

This section describes the design bases for the HD and HV.

17.7.6.1 Safety Functions

The HD and HV have been designed to meet the following Safety Function. The relation between the safety function put on this claim and the high level claims is shown in Appendix A.
The HD drainages the Feedwater Heater (FWH) and Moisture Separator Reheater (MSR) drain to the CFDW. The HV discharges non-condensable gases from the FWH and FWH shell relief valves discharges to the condenser [HDHV SFC 5-10.1]. The HD and HV contain reactor coolant which is beyond the reactor coolant pressure boundary [HDHV SFC 4-3.1]. The HD and HV deliver a Safety Category B function and the components necessary to deliver this function are classified as Safety Class 3 according to the safety categorisation and classification of UK ABWR [Ref-17.4].

17.7.6.2 Design Bases for Power Generation

From the power generation perspective, the HD and HV meet the following design bases:
(1) The HD drains the FWH and MSR drain, and utilises the drain for feedwater heating to improve plant thermal efficiency. The HP FWH drain is directly recovered on the RFP suction side, and the LP FWH drain is directly recovered on the HPCP suction side respectively, to further improve plant thermal efficiency and reduce the capacity of the CFDW facility.
(2) The HV discharges non-condensable gases from the FWHs to prevent a reduction in their heat transfer performance. Non-condensable gases from the MSR-1/2RHs are discharged through their outlet header with the steam to prevent overcooling of the heat transfer tubes.

17.7.7 System Design Description

This section describes the design of the HD and HV from the power generation perspective.

17.7.7.1 Overall Design and Operation

(1) HD
   (a) The MSR-1/2RHs drain is sent to the No. 1 FWH to heat feedwater with extraction steam.
   (b) The HP FWH and MSR-MS drain is sent to the HPDT and pumped up by the HPDP directly to the RFP suction side to heat feedwater.
   (c) The GSE drain and the RFP shaft seal bleed off water is sent to the No. 3 FWH to heat feedwater with extraction steam.

(d) The LP FWHs drain is cascaded to the next lower pressure FWHs to heat feedwater with extraction steam.
(e) The No. 6 FWH drain is sent to the LPDT and pumped up by the LPDP directly to the HPCP suction side to heat feedwater.
(f) An air operated valve is provided for the water level control of the FWH or MSR's drain tanks. It is designed to fail safe on loss of its air source or instrumentation. (Normal drain line: Fail Close, Dump line: Fail Open). The air operated valve for the HPDT (LPDT) water level control are "Fail As Is" in consideration of the effects on the CFDW.
(g) Condensate from the No. 3 FWH outlet condensate line is partly injected as cooling water into the HPDT downcomer and its dump line to assure the HPDP Net Positive Suction Head (NPSH), and to prevent pump cavitation in case the plant load is rapidly reduced.

(2) HV
(a) The MSR-1/2RHs vent is discharged into the No. 1 FWH to prevent the retention of non-condensable gas and to heat feedwater. A specified vent rate makes it possible to stabilise the flow of drain condensed in the heat transfer tube and to prevent the overcooling of the drain.
(b) The HPDT (LPDT) vent is discharged into the No. 2 (No. 6) FWH to prevent the retention of non-condensable gas, to heat feedwater, and to equalise these pressures.
(c) The FWHs vent is discharged into the condenser to prevent a reduction of the FWH heat transfer performance.
(d) The FWH shell relief valves are provided to protect the FWHs shell against damage due to excessive pressure except No. 5 and No. 6 FWHs which need not be equipped with relief valves since their extraction pipes have no check valve.

17.7.7.2 **Equipment Design**

17.7.7.2.1 HPDP / LPDP

(1) Configuration
(a) Three HPDPs (50 percent × 3) are installed (1 unit as standby).
(b) Three LPDPs (50 percent × 3) are installed (1 unit as standby).
(c) The HPDP and LPDP pump up drain at more than 50 percent plant load. Drain is recovered to the condenser through the dump lines at less than 50 percent plant load.
(d) The HPDP and LPDP are provided with a minimum flow line to recirculate condensate to the drain tank when the pump flow rate is less than the minimum flow rate.
(e) HPDP shaft sealing is of the fixed bushing sealing type. The sealing water is supplied from the condensate system and equipped with a seal-water Temperature Control Valve (TCV).

(2) Performance
The HPDP and LPDP are designed to perform as follows.

(a)	HPDP	Number:	3 units (1 unit as standby)
		Capacity:	almost 1,800 m^3/h/unit
(b)	LPDP	Number:	3 units (1 unit as standby)
		Capacity:	almost 660 m^3/h/unit

17.7.7.3 **Support Systems**

The main systems supporting mechanical SSCs for the delivery of heater drainage and venting are described as follows:

17.7.7.3.1 Control and Instrumentation Systems

(1) Control

Water levels of the FWH shells and drain tanks are controlled to preset levels by low LCVs provided on their outlets. A high LCV is provided to discharge drain directly to the condenser and assure plant functions even in the case that the water level rises abnormally.

Each of these LCVs is controlled by an independent water level transmitter and redundant controllers. 3 parallel and independent water level transmitters for the HPDT (LPDT) are provided to prevent all HPDPs (LPDPs) from stopping simultaneously in case a system malfunction occurs.

A minimum flow line is provided to prevent the HPDP (LPDP) from overheating. The minimum flow valve is automatically controlled by detecting the pump discharge flow rate. (i.e., ON at less than the specified flow rate, OFF at greater than the specified flow rate)

(2) Interlocks

(a) Each FWH is equipped with a level switch at “High High” water level, and the following interlocks are installed.
  (i) No. 1, No. 3, and No. 4 FWHs: This interlock forcibly closes the low LCV connected to these FWHs and the air-operated extraction check valve, and forcibly opens the extraction drain valve.
  (ii) No. 2 FWH: This interlock forcibly closes the air-operated extraction check valve.
  (iii) No. 5 FWH: This interlock forcibly closes the low LCV connected to these FWHs.

(b) The signal of MSR-MS water level “High High” makes the turbine trip. This interlock is redundant, 2 out of 3, to prevent turbine trip due to a detector failure.

(c) The signal of HPDT (LPDT) water level “Low Low” makes the HPDP (LPDP) trip.

(d) The HPDP (LPDP) run-out protection is provided against an excessive flow in case the standby pump does not start when 1 HPDP (LPDP) trips, or when the LPCP or HPCP trip.

(e) The standby HPDP (LPDP) is started when 1 of 2 running HPDP (LPDP) trips.

(f) The HPDT (LPDT) is equipped with a level switch at “High High” water level, and a protective interlock to forcibly close the low LCV connected to the tank.

(g) When each train of the LP FWH stops, a signal “not fully open” from a related feedwater inlet or outlet valve causes an interlock to shut off drain from the GSE and RFP bleed-off. When each train of the HP FWH stops running, a signal “not fully open” from a related feedwater inlet or outlet valve causes an interlock to shut off drain from the MSR-1/2DTs.

(h) At plant runback or load rejection, level switches for the MSR-MS, whose pressure rapidly drops, is designed to prevent a malfunction due to drain flashing in consideration of the following:
  (i) To prevent the drain retention in the detection pipe and its connecting point, and
  (ii) To reduce flashing steam action on the level switch float.

17.7.7.3.2 Power Supply System

The HD and HV components are connected to a Safety Class 3 AC.

17.7.7.3.3 Extraction Steam System (ES)

The ES supplies steam to the HD to heat the feedwater.

17.7.7.3.4 Turbine Gland Steam System (TGS)

The HD recovers the GSE drain to the No. 3 FWH to heat feedwater with extraction steam.

17.7.7.3.5 Air Off Take System (AO)
The HV sends non-condensable gas from the FWH to the condenser, and then the gas is discharged from the condenser to the AO through the SJAE.

17.7.7.3.6 Condensate and Feedwater System (CFDW)
The HD recovers the HP FWH drain to the CFDW on the RFP suction side. The HD recovers LP FWH drain to the CFDW on the HPCP suction side. The HD recovers RFP shaft seal bleed off water from the CFDW to the No. 3 FWH to heat feedwater with extraction steam.

17.7.7.3.7 Condenser
The HV discharges FWHs vent to the condenser to prevent a reduction of the FWH heat transfer performance. The HV connects the No. 1 to No. 4 FWH shell relief valves discharges to the condenser to protect the FWHs shell against damage due to excessive pressure.

17.7.8 Claims and Link to High Level Safety Functions

The list of claims in this chapter/section and the linkage to corresponding High Level Safety Functions are shown in Appendix A. A short description on the application of High Level Safety Functions in the development of the claims, arguments and evidence is provided in GDA PCSR Chapter 1.

17.8 Condenser

17.8.1 System Summary Description

This section is a general introduction to the Condenser where the system roles, system functions, system configuration and modes of operation are briefly described.

17.8.2 System Roles

The main role of the Condenser is to condense steam to reuse as feedwater to the reactor.

17.8.3 Functions Delivered

The Condenser is designed to perform the following operation. Safety functions are discussed in 17.8.6 Design Basis.

(1) The Condenser secures a vacuum to assure the performance of the Low Pressure Turbine (LP-T) and RFP Turbine (RFP-T).
(2) The Condenser is able to be operated even if the water supply to one shell or the tube bundle is shut down based on the partial plant operation condition.

17.8.4 Basic Configuration

The Condenser consists of the following main component.
Condenser 1 unit

17.8.5 Modes of Operation

The modes of operation of the Condenser are summarised as follows:

17.8.5.1 **Power Operation**

During Power operation, the Condenser cools the turbine exhaust steam, drain and steam from respective systems, and stores it as feedwater for the reactor. The Condenser secures a vacuum for assuring the performance of Low Pressure Turbine (LP-T) and RFP Turbine (RFP-T). The Condenser collects non-condensable gases in steam and drain, cools those gases, and then discharges the gases by the Air Off Take System (AO). The hotwell works to ensure a stable Low Pressure Condensate Pump (LPCP) suction condition to pump up condensate and a sufficiently long condensate retention time to reduce the radioactivity of the condensate.

17.8.5.2 **Startup, System Shutdown and Transient Condition**

During transient conditions, the Condenser is designed to receive turbine bypass steam, relief valve discharges, feedwater heater drain dumps through high level control valves.
The vacuum break valve is provided on the upper part of the condenser shell to break the condenser vacuum at System shutdown.

The Condenser is able to be operated even if the water supply to one shell or the tube bundle is shut down based on the partial plant load condition.

17.8.6 Design Bases

This section describes the design bases for the Condenser.

17.8.6.1 **Safety Functions**

The Condenser has been designed to meet the following Safety Function. The relationship between the safety function put on this claim and the high level claims is shown in Appendix A.
The Condenser cools steams to reuse as feedwater to the reactor [COND SFC 5-10.1]. The Condenser contains reactor coolant which is beyond the reactor coolant pressure boundary [COND SFC 4-3.1]. The Condenser delivers a Safety Category B function, and the components necessary to deliver this function are classified as Safety Class 3 according to the safety categorisation and classification of UK ABWR [Ref-17.4].

17.8.6.2 **Design Bases for Power Generation**

From the power generation perspective, the Condenser meets the following design bases.
(1) The Condenser secures a vacuum to assure the performance of Low Pressure Turbine (LP-T) and RFP Turbine (RFP-T).
(2) The Condenser is able to be operated even if the water supply to one shell or the tube bundle is shut down based on the partial plant operation condition.
(3) Protective measures are taken according to the condenser running state i.e. abnormal rise in pressure or temperature. For a rise in Condenser pressure (loss of vacuum), there is a hierarchy of protection measures: first an alarm, then a turbine trip, then MSIV close, then TBV close, then opening of rupture discs on the turbine exhaust hood.

17.8.7 System Design Description

This section describes the design of the Condenser from the power generation perspective.

17.8.7.1 **Overall Design and Operation**

(1) The Condenser cools the turbine exhaust steam, the turbine bypass steam and other steam into condensate, and stores it as feedwater for the reactor.
(2) The Condenser secures a vacuum to assure the performance of LP-T and RFP-T.
(3) The Condenser collects non-condensable gases in steam and drain, cools those gases, and then discharges the gases by the AO.
(4) The hotwell works to ensure a stable LPCP suction condition to pump up condensate and a sufficiently long condensate retention time to reduce radioactivity of the condensate.
(5) The Condenser recovers drain and steam from respective systems.

17.8.7.2 **Equipment Design**

17.8.7.2.1 Condenser

(1) Configuration
The Condenser is constructed so that each shell is provided perpendicularly to the turbine axle below 3 LP-T exhaust rooms, and that the No.3 to No. 6 Feedwater Heaters (FWHs) are mounted on the upper shell in consideration of exhaust flow resistance minimisation.

A water-sealed rubber expansion joint is mounted between the turbine and Condenser to absorb thermal expansion. A pressure-equalising shell is provided to equalise shell pressures.

Steam generated from the reactor contains radioactive gases. To reduce radioactivity, the hotwell is equipped with a retention channel to hold condensate in the Condenser for a required time.

The hotwell is divided into 6 sections (2 parts per shell), each of which is equipped with a conductivity measurement to identify which tube bundle caused a cooling water leak.

The Condenser hotwell reserves a required water level by a water level controller. Hotwell parts of each shell are equipped with a connecting pipe and a single section condensate outlet box to eliminate hotwell level difference.

Condensate immediately after condensation is well mixed with turbine exhaust steam discharged from the lower part of the tube bundle for deaeration, and to help maintain the saturation temperature of the condensate at the condenser pressure, before dropping into the hotwell.

The Condenser receives sea water as cooling water in the water box side and recovers the turbine exhaust steam and drain/steam from respective systems in the shell side.

Air and non-condensable gas mixed with steam are sent to an air cooler zone which is at a higher vacuum in Condenser, and then discharged via the AO.

The Condenser is designed to suppress tube vibration and erosion caused by turbine exhaust steam, turbine bypass steam or other incoming fluid.

12 LP FWHs (3 train by 4 stage) are installed on the Condenser upper shell. These heaters are located in the centre to reduce the flow resistance for the turbine exhaust.

The Condenser is located to satisfy the siphon height relative to the discharge pool water level when the CWP stops or operates.

(2) Performance

The Condenser is designed to perform as follows.

Condenser	Number:	1 unit
	Shell pressure:	5.07 kPa[abs]
	Design heat duty:	almost 2.5×106 kW
	Cooling water flow rate:	almost 180,000 m^3/h

17.8.7.3 **Support Systems**

The main systems supporting mechanical SSCs for the Condenser are described as follows:

17.8.7.3.1 Control and Instrumentation Systems

(1) Makeup water is supplied from the MUWC to the Condenser to control the condenser hotwell water level.
(2) The condenser hotwell is equipped with a “Low” level alarm and a “Low Low” level detecting switch for tripping the LPCP.
(3) The condenser water box air vent valve automatically closes in case the condenser water box water level reaches “High” level when the Circulating Water System (CW) and condenser water box are being filled with water.
(4) A full level lamp is provided to check whether the condenser water box is full.

17.8.7.3.2 Power Supply System

The Condenser components are basically connected to a Safety Class 3 AC.

17.8.7.3.3 Circulating Water System (CW)

The CW supplies cooling water to the Condenser to achieve condenser vacuum.

17.8.7.3.4 Condensate and Feedwater System (CFDW)
The Condenser hotwell water is extracted by LPCPs to pump up to the reactor.

17.8.7.3.5 Air Off Take System (AO)
The AO extracts non-condensable gases from the Condenser.

17.8.7.3.6 Makeup Water Condensate System (MUWC)
The MUWC supplies makeup water to the Condenser to control the condenser hotwell water level.

17.8.8 Claims and Link to High Level Safety Functions

The list of claims in this chapter/section and the linkage to corresponding High Level Safety Functions are shown in Appendix A. A short description on the application of High Level Safety Functions in the development of the claims, arguments and evidence is provided in GDA PCSR Chapter 1.

17.9 Circulating Water System

17.9.1 System Summary Description

This section is a general introduction to the Circulating Water System (CW) where the system roles, system functions, system configuration and modes of operation are briefly described.

17.9.2 System Roles

The purpose of the CW is to supply cooling water to the condenser and cool the turbine exhaust and drain.

17.9.3 Functions Delivered

The CW is designed to perform the following operation. Safety functions are discussed in 17.9.6 Design Basis.

(1) The CW continuously supplies cooling water to cool the turbine exhaust and drain that flow into the condenser.
(2) Air in the condenser water boxes can be released to the discharge pool through the water box vent pipe.
(3) Cooling water in the condenser water box can be collected to the condenser water box drain sump and sent to the discharge pool by the condenser water box drain sump pump.

17.9.4 Basic Configuration

The CW consists of the following main components:

(1) Circulating Water Pump (CWP) 3 units

(2) Condenser water box drain sump pump 1 unit

17.9.5 Modes of Operation

The modes of operation of the CW are summarised as follows:

17.9.5.1 Power Operation

In normal operation, CW sends cooling water to respective sections of the condenser by 3 CWPs. A connection pipe with isolation valves is provided to ensure that all condensers can be supplied following a single pump failure.

17.9.5.2 Startup and System Shutdown

(1) Air in the condenser water boxes is released to the discharge pool through the water box vent pipe provided on the top of each water box by the CWP discharge pressure.
(2) Cooling water in the condenser water box can be collected to the condenser water box drain sump and sent to the discharge pool by the condenser water box drain sump pump.

17.9.5.3 **Transient Conditions**

(1) The CW is designed so that the CWPs continue supplying cooling water to the condenser, even in transient states such as load rejection and turbine trip.
(2) During plant operation, the CW is designed so that any CWP can be stopped, inspected and maintained individually.

17.9.6 Design Bases

This section describes the design bases for the CW.

17.9.6.1 **Safety Functions**

The CW has been designed to meet the following Safety Function. The relation between the safety function put on this claim and the high level claims is shown in Appendix A.
The CW supplies cooling water to the condenser. The CW delivers a Safety Category B function and the components necessary to deliver this function are classified as Safety Class 3 according to the safety categorisation and classification of UK ABWR [Ref-17.4]. [CW SFC 5-10.1]

17.9.6.2 **Design Bases for Power Generation**

From the power generation perspective, the CW meets the following design bases:
(1) The CW continuously supplies cooling water to cool the turbine exhaust and drain that flow into the condenser.
(2) Cooling water in the condenser water box can be collected to the condenser water box drain sump and sent to the discharge pool by the condenser water box drain sump pump.

17.9.7 System Design Description

This section describes the design of the CW from the power generation perspective.

17.9.7.1 **Overall Design and Operation**

The CW continuously supplies cooling water to cool the turbine exhaust and drain that flow into the condenser.
Sea water is used as the condenser cooling water.

17.9.7.2 **Equipment Design**

17.9.7.2.1 CWP

(1) Configuration
  (a) The CWP is capable of supplying the required condenser cooling water flow rate.
  (b) The CW is equipped with 3 CWPs of 33 percent capacity (without standby).
  (c) The CWPs is located in the circulating water structure.
  (d) The CWP shaft bearings are lubricated with water.
  (e) The cooling water for the motor and/or the shaft bearings is continuously supplied from the Turbine Building Cooling Water system (TCW).
  (f) The CWP design point is an intake pool water level at the low tide level. The pump is able to be operated continuously even at the lowest intake pool water level designed by a specified pressure difference of the intake screen.

(2) Performance
The CWP is designed to perform as follows.

CWP	Number:	3 units
	Capacity:	almost 62,000 m^3/h/unit

17.9.7.3 **Support Systems**

The main systems supporting mechanical SSCs for the delivery of cooling water supply are described as follows:

17.9.7.3.1 Control and Instrumentation Systems

(1) Control
  (a) The CW is operated in the Main Control Room (MCR) in normal operation.
  (b) The opening of the condenser water box outlet valve and the CWP discharge valve are indicated in the MCR. The valves' opening is controlled by a switch.
  (c) The condenser water box drain sump water level is controlled by the sump inlet drain valve.

(2) Interlocks
  (a) The CWP starts to run with partial opening of the discharge valve when the operation switch is "ON" and stops at the same discharge valve opening when the operation switch is "OFF".
  (b) The CWP discharge valves work by interlocks with the CWP, as follows:
    (i). When the CWP operation is switched to startup mode, the discharge valve opens in conjunction with the pump.
    (ii). When the CWP operation is switched to stop mode, the discharge valve starts to close. After the discharge valve is fully closed, the CWP stops.
  (c) In water filling operation, the condenser water box air vent valve automatically closes when the condenser water box water level is "High".
  (d) The cooling water temperature is measured at each inlet and outlet of the respective condensers. In this case, the outlet temperature is measured in the outlet pipe to obtain constant data of the temperatures.
  (e) Indicators are provided to indicate whether the condenser water box is full.
  (f) The condenser water box drain sump pump starts or stops based on the sump water level.
  (g) To prevent water from the CW pipeline leaking into the T/B, leak detectors are installed in the condenser water box area, with their alarm signals indicated in the MCR.

17.9.7.3.2 Power Supply System

The CW components are basically connected to a Safety Class 3 AC.

17.9.7.3.3 Condenser

The CW supplies cooling water to the condenser and cool turbine exhaust and drain.

17.9.7.3.4 Turbine Building Cooling Water System (TCW)

The TCW supplies cooling water to the CWP motor and/or the motor shaft bearing.

17.9.8 Claims and Link to High Level Safety Functions

The list of claims in this chapter/section and the linkage to corresponding High Level Safety Functions are shown in Appendix A. A short description on the application of High Level Safety Functions in the development of the claims, arguments and evidence is provided in GDA PCSR Chapter 1.

17.10 Condensate and Feedwater System

17.10.1 System Summary Description

This section is a general introduction to the Condensate and Feedwater System (CFDW) where the system roles, system functions, system configuration and modes of operation are briefly described [Ref-17.6].

17.10.2 System Roles

The main roles of the CFDW are to supply feedwater from the condenser to the reactor, at the required flow rate, pressure and temperature.
The CFDW should be differentiated from the Feedwater piping at the reactor building, which is a continuation of the CFDW beyond the Turbine Building (T/B). The Feedwater piping at the reactor building is addressed in PCSR chapter 12.

17.10.3 Functions Delivered

The CFDW is designed to perform the following operations. Safety functions are discussed in 17.10.6 Design Basis.
The CFDW pumps the condensed water from the condenser hotwell by Low Pressure Condensate Pumps (LPCPs), then increases the pressure by High Pressure Condensate Pumps (HPCPs), Turbine-Driven Reactor Feedwater Pumps (T/D-RFPs) and Motor-Driven Reactor Feedwater Pumps (M/D-RFPs) supply the feedwater at the flow rate required by the reactor in such plant operation modes as Startup, System shutdown, Power operation and transient.

(1) The condensate is cleansed by the Condensate Filter (CF) and Condensate Demineralizer (CD).
(2) The steam of the SJAE and gland seal are condensed at the SJAE condenser and GSC and then the heat is recovered to the condensate.
(3) The CFDW heats feedwater with turbine extraction steam to increase the plant heat efficiency during normal plant operation.
(4) The CFDW supplies condensate for the following:
    (a) Low Pressure Turbine (LP-T) exhaust hood spray water for prevention of overheating due to windage loss under a low plant load,
    (b) Attemperator spray water to protect the turbine and condenser when the TBV is opened,
    (c) RFP and High Pressure Drain Pump (HPDP) shaft seal water,
    (d) Control rod driving water, and
    (e) High Pressure Drain Tank (HPDT) downcomer injection water.

17.10.4 Basic Configuration

The CFDW consists of the following main components.

(1)	Low pressure Condensate Pump (LPCP)	3 units (1 unit as standby)
(2)	High pressure Condensate Pump (HPCP)	3 units (1 unit as standby)
(3)	Reactor Feedwater Pump (RFP)	
	(a) T/D-RFP	2 units
	(b) M/D-RFP	2 units (Standby)
(4)	Feedwater Heater (FWH)	
	(a) No.1 FWH	2 units
	(b) No.2 FWH	2 units
	(c) No.3 FWH	3 units
	(d) No.4 FWH	3 units
	(e) No.5 FWH	3 units
	(f) No. 6 FWH	3 units
(5)	Condensate Transfer Pump (CTP)	1 unit
(6)	Seal Drain Collector Pump (SDCP)	2 units
(7)	Seal Drain Collection Tank (SDCT)	1 unit

17.10.5 Modes of Operation

The modes of operation of the CFDW are summarised as follows:

17.10.5.1 **Power Operation**

(1) The condensate pumped by 2 LPCPs from the condenser hotwell is cleansed by the CF and CD, cools the process gas in the Steam Jet Air Ejector (SJAE) condenser and Gland Steam Condenser (GSC) and then recovers heat to the condensate.
(2) The heat-recovered condensate is pressurised by 2 HPCPs, heated by LP FWHs (4 stages × 3 trains), and then fed to RFPs.
(3) The HP FWH drain, pressurised by the HPDP, is recovered to the RFP suction from the Feedwater Heater Drain System (HD).
(4) The LP FWH drain, pressurised by the Low Pressure Drain Pump (LPDP), is recovered to the CD inlet from the HD.
(5) After being fed to the RFPs, the condensate is pressurised by 2 T/D-RFPs, heated by HP FWHs (2 stages × 2 trains), merged to a header to equalise their temperatures, and then sent to the reactor via 2 feedwater pipes.
(6) The reactor feedwater flow rate is controlled by rotational speed of the Reactor Feedwater Pump Turbine (RFP-T).
(7) The RFP bleed off water is recovered to the No.3 FWH for heat efficiency.
(8) The condenser hotwell water level is maintained by an overflow line connected out from the CD downstream side.
(9) Oxygen is injected in order to improve the anti-corrosion effect on pipelines, into the main condensate pipeline to form stable protective iron oxide films on the inner wall surfaces of equipment and pipes that constitute the CFDW.
(10) The seal water drain of the RFPs is recovered into the SDCT, and then continuously pumped to the condenser by the 1 of 2 SDCPs mounted on the upper part of the SDCT. The seal water drain of the HPDPs is also recovered into the SDCT.
(11) Hydrogen gas is injected into the Condensate and Feedwater system during normal plant operation to make the dissolved oxygen concentration and the Electrochemical Corrosion Potential (ECP) of the reactor coolant decrease. Platinum (Pt) solution is injected to improve

the effect of the hydrogen by catalysing the reaction of recombination between H_2 and O_2. Zinc is also injected in order to mitigate an increase of dose rate from deposited ^{60}Co due to the hydrogen injection.

17.10.5.2 **Startup and System Shutdown**

(1) The feedwater is recirculated to the condenser through a feedwater recirculation line, which is branched from the upstream of the feedwater flow element at the final FWH (No.1 FWH) outlet to reduce the entry of impurities into the reactor and to ensure feedwater quality before Startup.
(2) The condensate is recirculated to the condenser through a condensate recirculation line, which is connected to the condenser, to ensure the minimum required flow rate of cooling water for the SJAE condenser and the GSC, and the minimum flow rate of the LPCP.
(3) The CF and CD are bypassed for recirculating and flushing operation before Startup.

17.10.5.3 **Transient Conditions**

(1) LPCP, High Pressure Condensate Pump (HPCP), and RFPs are connected in series for operation. In case that 1 of the 2 operating pumps trips, a stand-by pump starts automatically to continue supplying water to the reactor and prevent a large drop in reactor water level and a reactor scram.
(2) The stop valves at the suction and discharge of each standby pump are fully open in operation for quick startup required by the reactor system.
(3) In case that 1 of 2 T/D-RFPs trips and the standby M/D-RFPs fail an automatic start, the reactor recirculation flow control system runs back the Reactor Internal Pump (RIP) to avoid reactor scram caused by a drop in reactor water level, and to prevent long-time run-out of the currently running T/D-RFP.
(4) When a pump trips, one of the downstream pumps automatically trips after detecting the change in the number of operating upstream pumps except for RFP, since it does not have downstream pumps. (In the case of one LPCP trip, one HPCP trips which also causes one RFP to trip.) Consequently, when the upstream standby pump starts, standby pumps of the downstream pumps also start. This is to reduce a drop in pump suction pressure.
(5) In case that FWH tube-leak occurs, one FWHs train is isolated from the operating line and the plant output is limited.
(6) The condensate is continuously injected to the HPDT downcomer from the No.3 FWH outlet as cooling water for the purpose of securing the HPDP Net Positive Suction Head (NPSH) and to prevent pump cavitation at a rapid drop of the plant load.

17.10.6 Design Bases

This section describes the design bases for the CFDW.

17.10.6.1 **Safety Functions**

The CFDW has been designed to meet the following Safety Function. The relation between the safety function put on this claim and the high level claims is shown in Appendix A.
The FDW supplies feedwater to the reactor [CFDW SFC 5-10.1]. The CFDW contains reactor coolant which is beyond the reactor coolant pressure boundary [CFDW SFC 4-3.1]. The CFDW delivers a Safety Category B function, and the components necessary to deliver this function are classified as Safety Class 3 according to the safety categorisation and classification of UK ABWR [Ref-17.4].

17.10.6.2 **Design Bases for Power Generation**

From the power generation perspective, the CFDW meets the following design bases.
(1) The CFDW continuously supplies feedwater from the condenser to the reactor, at the required flow rate, pressure and temperature.
(2) The CFDW continuously supplies feedwater even one of the FWHs train is isolated from the operating line.

17.10.7 System Design Description

This section describes the design of the CFDW from the power generation perspective.

17.10.7.1 **Overall Design and Operation**

The condensate is pumped by 2 LPCPs from the condenser hotwell and is cleansed by the CF and CD, cools the process gas in the SJAE condenser and GSC and then recovers heat to the condensate. The heat-recovered condensate is pressurised by 2 HPCPs, heated by LP FWHs (4 stages × 3 trains), and then fed to RFPs. The HP FWH drain is pressurised by the HPDP and is recovered to the RFP suction from the Feedwater Heater Drain System (HD). The LP FWH drain is pressurised by the LPDP and is recovered to the CD inlet from the HD. After being fed to the RFPs, the condensate is pressurised by 2 T/D-RFPs and is heated by HP FWHs (2 stages × 2 trains), merged to a header to equalise their temperatures, and then sent to the reactor via 2 feedwater pipes.

17.10.7.2 **Equipment Design**

17.10.7.2.1 LPCP, HPCP, RFPs
(1) Configuration
LPCP, HPCP, and RFPs are installed in series to supply feedwater from the condenser to the reactor. 50 percent × 3 LPCPs are installed (1 unit as standby) at the condenser outlet. 50 percent × 3 HPCPs are installed (1 unit as standby) at CF and CD discharge. 2 T/D-RFPs (50 percent × 2) and 2 M/D-RFPs (25 percent × 2) are installed at LP FWH discharge. M/D-RFP is used to supply feedwater to the reactor during Startup and System shutdown, and is the stand-by pump of T/D-RFP during Power operation.
(2) Performance
The LPCP, HPCP, RFPs are designed to perform as follows.

(a)	LPCP	Number:	3 units (1 unit as standby)
		Capacity:	almost 2,700 m^3/h/unit
(b)	HPCP	Number:	3 units (1 unit as standby)
		Capacity:	almost 3,300 m^3/h/unit
(c)	T/D-RFP	Number:	2 units
		Capacity:	almost 4,700 m^3/h/unit
(d)	M/D-RFP	Number:	2 units (Standby)
		Capacity:	almost 2,300 m^3/h/unit

17.10.7.2.2 FWH

(1) Configuration

HP FWHs (2 stages) are provided in 2 trains. The extraction steam for the top FWHs (No.1 FWHs) is supplied from the High Pressure Turbine (HP-T), and from HP-T exhaust line for No.2 FWHs. LP FWHs (4 stages) are provided in 3 trains. The extraction steam for the LP FWHs is supplied from LP-T.

Even in the case of HP/LP FWH tube leak, it is capable of operating the plant by closing inlet and outlet valves of HP/LP FWHs.

(2) Performance

The FWHs are designed to perform as follows.

(a)	No.1 FWH	Number:	2 units
		Design heat duty:	almost 140 MW/unit
(b)	No.2 FWH	Number:	2 units
		Design heat duty:	almost 160 MW/unit
(c)	No.3 FWH	Number:	3 units
		Design heat duty:	almost 51 MW/unit
(d)	No.4 FWH	Number:	3 units
		Design heat duty:	almost 47 MW/unit
(e)	No.5 FWH	Number:	3 units
		Design heat duty:	almost 30 MW/unit
(f)	No.6 FWH	Number:	3 units
		Design heat duty:	almost 55 MW/unit

17.10.7.3 **Support Systems**

The main systems supporting mechanical SSCs for the delivery of feedwater supply are described as follows:

17.10.7.3.1 Control and Instrumentation Systems

(1) Measurement

The reactor feedwater flow elements are installed for reactor operational control and turbine performance control. The condensate flow element and drain flow element at the HPDP discharge header and the other flow rate measurements listed below are installed to measure each flow rate.

(a) RFP bleed off water and seal water drain
(b) Condenser spillover water
(c) HPDP seal water
(d) HPDT downcomer injection water

(2) Control and Interlocks

(a) Pumps

Pumps are able to be operated from MCR during normal operation, including reactor startup/ shutdown operation. Standby pumps are able to be started automatically.

The LPCP, HPCP, and RFPs are connected in series. When one of two pumps trips, the standby pump starts automatically and continues supplying water to the reactor, preventing a large drop in reactor water level and a reactor scram.

When a pump trips, a downstream pump automatically trips by detecting the difference in number between upstream and downstream pumps, and after an upstream standby pump starts, the downstream pump starts, in order to reduce a drop in pump suction pressure.

Suction and discharge stop valves of each standby pump are fully open in the standby state for quick startup required by the reactor system.

The T/D-RFP controls its rotational speed and the M/D-RFP controls the opening of its discharge Flowrate Control Valve (FCV) to control the feedwater flow rate of the reactor.
The auxiliary oil pumps of the M/D-RFP and HPCP run continuously to quickly start the standby pump at a pump trip, and to prevent scram due to a drop in reactor water level.
All LPCPs are stopped if the condenser hotwell water level becomes “LL”, to prevent air from being involved.
In case one of two running HPDPs trips, the following interlocks are provided to reduce RFP suction pressure drop:
One HPDP or one LPDP trips and standby fails to start: Trip one T/D-RFP and start one M/D-RFP.
Two HPDPs or two LPDPs trip and standby fail to start: Trip one T/D-RFP and inhibit the startup of M/D-RFPs.
The HPCP automatically trips as well as condenser spillover line auto isolation in the unlikely event of a large amount of chloride ingress to the condensate and feedwater system to keep specified water conductivity to the reactor.

(b) FWHs
The FWH tube leaks are able to be visually checked by the FWH water level or the drain water Level Control Valve (LCV) opening. The trains containing the leaking FWH are able to be manually isolated from the MCR. No interlock is provided here to eliminate the potential for Loss of Coolant Accident (LOCA).

17.10.7.3.2 Power Supply System
The CFDW components are connected to the Safety Class 3 AC.

17.10.7.3.3 Feedwater Heater Drain System (HD)
The HD returns heater drains via LPDPs and HPDPs to the CFDW. The RFP bleed off water is recovered from the CFDW to the HD through the No.3 FWH.

17.10.7.3.4 Extraction Steam System (ES)
The ES supplies steam to each FWH to heat the condensate and feedwater. The ES also supplies driving steam to RFP-T.

17.10.7.3.5 Turbine Building Cooling Water System (TCW)
The TCW supplies cooling water to the LPCP motor cooler, LPCP motor shaft bearing, HPCP oil cooler, HPCP motor cooler, M/D-RFP oil cooler, M/D-RFP motor cooler and RFP-T oil cooler.

17.10.7.3.6 Condenser
The condenser ensures condensate can be extracted by LPCP.

17.10.8 Claims and Link to High Level Safety Functions

The list of claims in this chapter/section and the linkage to corresponding High Level Safety Functions are shown in Appendix A. A short description on the application of High Level Safety Functions in the development of the claims, arguments and evidence is provided in GDA PCSR Chapter 1.

17.11 Condensate Purification System

17.11.1 Design Basis

This section describes the design basis for the Condensate Purification System (hereinafter referred to as CP) [Ref-17.7].

17.11.1.1 **Safety Functions**

The CP has been designed to meet the following Safety Function. The relation between the safety function put on this claim and the high level claims is shown on Appendix A.
The CP removes impurities (soluble and insoluble) in the condensate. The failure of the CP would lead to a deterioration of the water quality in the plant. To deliver its function, the components of the CP are designed in accordance with Safety Class 3 Safety Category B and the classification of UK ABWR [Ref-17.4] [CFCD*1 SFC 1].
(*1:CF is abbreviation of Condensate Filter system. CD is abbreviation of Condensate Demineralizer system.)

The CFCD contains reactor coolant which is beyond the reactor coolant pressure boundary [CFCD SFC 4-3.1].

The following parts of the CFCD are classified as non-class with safety category.

- CF :
  Back wash Air Surge Tank, Air Filter, Makeup Water and Station Service Air Supply Piping, and Backwash Waste Piping.
- CD :
  Resin Backwash Tank, Recycle Pump, Drain Strainer, Makeup Water and Station Service Air Supply Piping, and Backwash Waste Piping.

17.11.1.2 **Design Bases for Power Generation**

(1) The CP purifies condensate continuously.
(2) Purification continues even when backwash for the CF and resin cleaning for the CD are required.

17.11.2 System Design Description

This section describes the design of the CFCD from the power generation perspective.

17.11.2.1 **Overall Design and Operation**

The CP is installed as the CF on upstream side and the CD on downstream side in series between Gland Steam Condenser and High Pressure Condensate Pump. The condensate is purified by the CF which removes insoluble substances and the CD which removes soluble substances and then it is transferred to the downstream feed water system.

17.11.2.2 **Equipment Design**

17.11.2.2.1 Condensate Filter

(1) Configuration
Three CF vessels operate in parallel to purify the condensate. When a CF vessel requires backwash, the relevant CF vessel is stopped after opening the bypass valve and the vessel isolated from the purification operation then the backwash performed. After the backwash, the CF is returned to the purification operation.

(2) Performance
The capacity of the CF vessel is determined considering that total condensate is purified with three CF vessels. Also, the outlet water quality is retained as follows.

CF vessel capacity: 1,500 m^3/h/unit (rated)

17.11.2.2.2 Condensate Demineralizer

(1) Configuration
Six CD vessels operate in parallel and purify the total condensate. When CD vessel requires resin cleaning, the relevant CD vessel is stopped and cleaned while the other five vessels are in operation. After the resin cleaning is completed, the CD is returned to the purification operation.

(2) Performance
The capacity of the CD vessel is determined considering that the total condensate is purified by six vessels. Also, the outlet water quality is retained as follows.
   (a) CD vessel capacity: 930m^3/h/ unit (rated)
   (b) CD outlet water quality
   - Conductivity (25°C) : 10 μ S/m or less
   - Silica (as SiO22-) : 10ppb or less
   - Chloride (as Cl-) : 2ppb or less

17.11.2.3 **Support Systems**

17.11.2.3.1 Measurement

(1) CF flow rate
The flow indicator is installed at each outlet of the CF vessel to measure the integrated flow rate of the vessel and flow unbalance of each vessel and determine the CF backwash period.

(2) CD outlet conductivity
The conductivity meter is installed at each outlet of the CD vessel to measure purification performance of each vessel.

(3) Differential pressure of the CF and the CD inlet/outlet header piping
The differential pressure gauge is installed at the CF and the CD inlet/outlet of the header piping to measure their operation.

17.11.2.3.2 Backwash System for the CF

The following components are installed to perform the backwash:

(1) Back Wash Air Surge Tank: To ensure enough air and pressure required for one CF backwash process,
(2) Air Filter: To remove impurities in the backwash air,
(3) Makeup Water and Station Service Air Supply Piping: To provide water and air required for the backwash, and
(4) Backwash Waste Piping: To transfer the backwash waste to Radioactive Waste System.

17.11.2.3.3 Backwash System for the CD

Following components are installed to perform the resin backwash:
(1) Resin Backwash Tank: To clean the ion exchange resin which is transferred from the CD vessel and return it after the cleaning,
(2) Drain Strainer: Placed at the waste fluid line to trap resin if it flows into the waste line,
(3) Makeup Water and Station Service Air Supply Piping: To provide water and air required for the resin backwash and transfer, and
(4) Backwash Waste Piping: To transfer the backwash waste to the Radioactive Waste System.

17.11.2.3.4 Makeup Water Condensate System (MUWC)
The MUWC provides water for the backwash for the CF and for the resin transfer and the backwash for the CD.

17.11.2.3.5 Station Service Air System (SA)
The SA provides air for the backwash for the CF and for the resin transfer and the backwash for the CD.

17.11.2.3.6 Instrument Air System (IA)
The IA provides air to operate the air valve and control equipment for the CF and the CD.

17.11.2.3.7 Radioactive Waste System
Process the backwash waste from the CF and backwash waste and spent resin from the CD.

17.11.3 Claims and Link to High Level Safety Functions

The list of claims in this chapter/section and the linkage to corresponding High Level Safety Functions is shown in Appendix A. A short description on the application of High Level Safety Functions in the development of the claims, arguments and evidence is provided in GDA PCSR Chapter1.

17.12 Assumptions, Limits and Conditions for Operation

Based on the general principles for the identification of Assumptions and LCOs described in Standard Control Procedure for Identification and Registration of Assumptions, Limits and Conditions for Operation [Ref-17.8], limits directly related to operational systems, ex. Operation Control, will be determined in the site specific phase and the details will commensurate with the maturity of the design. For this reason there are no applicable LCOs on the systems described in this chapter within the scope of the GDA.

17.13 Summary of ALARP Justification

This section presents a high level overview of how the ALARP principle has been applied to steam and power conversion systems, and how this contributes to the overall ALARP argument for the UK ABWR.

PCSR Chapter 28 presents an overview of how the UK ABWR design has evolved, and how this evolution contributes to the overall ALARP case. The approach to ALARP during GDA is further described in the GDA ALARP Methodology [Ref-17.9] and the Safety Case Development Manual [Ref-17.1].

For the mechanical systems covered by this chapter, this ALARP methodology has also been embedded within the design process [Ref-17.10]. This places requirements on designers to consider ALARP through a comprehensive checklist which includes such elements as optioneering, risk assessment and the identification of Relevant Good Practice (RGP) and OPEX.

For the steam and power conversion systems, specific areas where RGP has been identified and applied include:

- Failure of a condenser tube in the Main Condenser can lead to sea water entering the primary circuit. Sea water and hence chloride ingress could lead to corrosion and degradation of SSCs that are important to safety. In line with good practice for similar systems in the UK and internationally, a design is to include an interlock to limit water conductivity in the reactor side. On detection of high conductivity, this interlock stops water flow to the reactor by tripping the high pressure condensate pumps. This provides an additional layer of protection against chloride ingress, in addition to the Condensate Demineralizer system described in the Chapter 17, Section 17.11. Further detail can be found in [Ref-17.11] and [Ref-17.12].

Examples of where ALARP assessments have been used to inform the design include:

- The Turbine Gland Steam (TGS) System supports the turbine gland seal to prevent reactor steam leaking into the Turbine Building, and prevent air ingress into the main condenser. The TGS system uses water from the Condensate Storage Tank (CST) to generate steam, and then delivers this steam to the gap between the rotating shaft and the turbine casing. This is an improvement over earlier designs which used reactor water/ steam, and because the CST potentially has low levels of radioactive contamination, the TGS design results in small quantities of gaseous radioactive waste being discharged via the stack.

The material of the SSCs for the steam and power conversion systems are also demonstrated to be adequate to achieve the necessary structural integrity. Further detail can ben found in Chapter 8.

This prompted a search for potential risk reduction measures and an optioneering exercise by a multi-disciplinary team of engineers. This optioneering exercise considered numerous options including additional abatement systems, use of House Steam in preference to steam produced from CST water and the use of purified water in preference to CST water. The optioneering considered a range of factors including doses to workers, discharges, operability and maintainability. The study concluded that implementing any of the identified alternatives would be grossly disproportionate to the safety benefit that would be achieved, and that the system was already well optimised. Further details can be found in [Ref-17.13] and [Ref-17.14].

Further discussion on ALARP is included within each of the Basis of Safety Case (BSC) documents that support this chapter. Each BSC also contains a section which discusses RGP and OPEX.

In summary, it is concluded that all reasonably practicable risk reduction measures have been implemented, through the application UK and international good practice and a systematic and comprehensive ALARP evaluation process. The risks due to steam and power conversion systems are therefore considered to be ALARP.

17.14 Conclusions

This chapter has provided an overview of the design of the steam and power conversion systems. It has shown that the UK ABWR will use modern and highly reliable technology for these important normally operational systems. Although the primary functional roles of the steam and power conversion systems are either for the commercial production of electricity or to support that commercial function, safety analysis has been a central consideration in their design. This chapter has shown that the UK ABWR will use highly reliable and well-proven technology for the steam and power conversion functions whose high reliability will reduce the risk of their failure placing demands on Category A Safety Functions. Although considerable effort has and will continue to be placed by the future licensee on making these systems highly reliable, conservative assumptions have been used in their safety analysis to ensure that the safety systems designed to protect against the failure of the steam and power conversion systems have sufficient defence-in-depth to ensure that the risks to safety are as low as reasonably practicable.

This chapter has:

- Identified and describe the systems within the scope of the Steam and Power Conversion Systems,
- Described the various modes of operation of the systems within the chapter scope,
- Specified all relevant Safety Case Claims - Safety Functional Claims (SFCs) and provide links to the relevant BSCs/TRs which identify corresponding Safety Property Claims (SPCs),
- Identified and described the safety functions of the Systems, Structures and Components (SSCs) within the scope of the chapter, and to specify the safety categorisation of those functions, and specify the safety classification of the SSCs within the scope of the chapter,
- Identified the support systems required for all systems within the chapter scope, and describe where the arguments and evidence that substantiate all relevant safety claims on these are presented in supporting documents,
- Described or provided pointers to where the detailed arguments and evidence can be found in the supporting BSCs, TRs,
- Provided information or provided pointers to relevant information that can be used to demonstrate compliance of the SSCs within the scope of the chapter with the relevant sections of the Nuclear Safety and Environmental Design Principles (NSEDPs), and
- Provided or identified references to the relevant evidence required to demonstrate that the risks associated with the SSCs within the scope of the chapter are As Low As Reasonably Practicable (ALARP).

17.15 References

[Ref-17.1] Hitachi-GE Nuclear Energy, Ltd. “GDA Safety Case Development Manual”, GA10-0511-0006-00001 (XD-GD-0036) Rev.3, June 2017.
[Ref-17.2] Hitachi-GE Nuclear Energy, Ltd., “Topic Report on Safety Requirements for Mechanical SSCs”, GA91-9201-0001-00117 (SE-GD-0308), Rev. 1, July 2016.
[Ref-17.3] Hitachi-GE Nuclear Energy, Ltd., “Topic Report on Mechanical SSCs Architecture”, GA91-9201-0001-00210 (SE-GD-0425), Rev. 0, October 2016.
[Ref-17.4] Hitachi-GE Nuclear Energy, Ltd., “List of Safety Category and Class for UK ABWR”, GA91-9201-0003-00266 (AE-GD-0224), Rev. 4, August 2017.
[Ref-17.5] Hitachi-GE Nuclear Energy, Ltd., “Basis of Safety Cases on Turbine Main Steam System”, GA91-9201-0002-00047 (SBE-GD-0013), Rev. 1, June 2016.
[Ref-17.6] Hitachi-GE Nuclear Energy, Ltd., “Condensate & Feedwater System Basis of Safety Case”, GA91-9201-0002-00050 (SBE-GD-0011), Rev. 2, June 2016.
[Ref-17.7] Hitachi-GE Nuclear Energy, Ltd., “Basis of Safety Cases on Condensate Purification System”, GA91-9201-0002-00051 (VPE-GD-0001), Rev.1, January 2017.
[Ref-17.8] Hiatchi-GE Nuclear Energy, Ltd., “Standard Control Procedure for Identification and Registration of Assumptions, Limits and Conditions fir Operation”, GA91-0512-0010-00001 (XD-GD-0042), Rev 2, march 2017.
[Ref-17.9] Hitachi-GE Nuclear Energy, Ltd., “GDA ALARP Methodology”, GA10-0511-0004-00001 (XD-GD-0037), Rev.1, November 2015.
[Ref-17.10] Hitachi-GE Nuclear Energy, Ltd., “General Design Process Approach for Mechanical Engineering SSCs”, GA91-9201-0003-00854 (SE-GD-0297), Rev 1, September 2016.
[Ref-17.11] Hitachi-GE Nuclear Energy, Ltd., “Topic Report on Impurity Ingress”, GA91-9201-0001-00171 (WPE-GD-0219), Rev. 0, March 2016.
[Ref-17.12] Hitachi-GE Nuclear Energy, Ltd., “Topic Report on Design Justification in Chemistry Aspect for Primary Water Systems”, GA91-9201-0001-00199 (WPE-GD-0232), Rev. 1, August 2016.
[Ref-17.13] Hitachi-GE Nuclear Energy, Ltd., “Turbine Gland Steam System: Demonstration of BAT”, GA91-9201-0003-01362 (SBE-GD-0049), Rev. 0, July 2016.
[Ref-17.14] Hitachi-GE Nuclear Energy, Ltd., “ALARP Assessment Report for Turbine Gland Steam System”, GA91-9201-0003-01418 (SBE-GD-0050), Rev. 0, August 2016.
[Ref-17.15] Hitachi-GE Nuclear Energy, Ltd., “Topic Report on Fault Assessment”, GA91-9201-0001-00022 (UE-GD-0071), Rev. 5, December 2016.

Appendix A: Safety Functional Claims Table

	Top Claim for Mechanical System						Safety Functional Claims for Mechanical System and Components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Section 6 Table 5.6-1: High Level Safety Functions in UK ABWR		PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	Claim Contents	Cat.	Class
1	4	Confinement / Containment of radioactive materials	4-3	Functions to contain reactor coolant	-	No claim	Commercial Operations	TG SFC 4-3.1	The Turbine contains reactor coolant which is beyond the reactor coolant pressure boundary.	B	3
2	5	Others	5-10	Functions to supply electric power (except for emergency supply)	-	No claim	Commercial Operations	TG SFC 5-10.1	The Turbine Generator converts the thermal energy of the steam to the electrical energy.	B	3

	Top Claim for Mechanical System						Safety Functional Claims for Mechanical System and Components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Section 6 Table 5.6-1: High Level Safety Functions in UK ABWR		PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	Claim Contents	Cat.	Class
1	4	Confinement / Containment of radioactive materials	4-3	Functions to contain reactor coolant	-	No claim	Commercial Operations	MSASTBP SFC 4-3.1	The MS contains reactor coolant which is beyond the reactor coolant pressure boundary.	B	3
2	4	Confinement / Containment of radioactive materials	4-6	Functions to mitigate reactor pressure increase with other system	-	No claim	Transient Conditions	MSASTBP SFC 4-6.1	The TBP mitigates reactor pressure increase.	C	3
3	5	Others	5-10	Functions to supply electric power (except for emergency supply)	-	No claim	Commercial Operations	MSASTBP SFC 5-10.1	The MS, AS and TBP transfer steam generated at the reactor to the turbine side for power generation.	B	3

	Top Claim for Mechanical System						Safety Functional Claims for Mechanical System and Components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Section 6 Table 5.6-1: High Level Safety Functions in UK ABWR		PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	Claim Contents	Cat.	Class
1	4	Confinement / Containment of radioactive materials	4-3	Functions to contain reactor coolant	-	No claim	Commercial Operations	ES SFC 4-3.1	The ES contains reactor coolant which is beyond the reactor boundary.	B	3
2	5	Others	5-10	Functions to supply electric power (except for emergency supply)	-	No claim	Commercial Operations	ES SFC 5-10.1	The ES transfers steam to the turbine components for power generation through piping.	B	3

	Top Claim for Mechanical System						Safety Functional Claims for Mechanical System and Components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Section 6 Table 5.6-1: High Level Safety Functions in UK ABWR		PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	Claim Contents	Cat.	Class
1	4	Confinement / Containment of radioactive materials	4-3	Functions to contain reactor coolant	-	No claim	Commercial Operations	TGS SFC 4-3.1	The TGS contains reactor coolant which is beyond the reactor coolant pressure boundary.	B	3
2	5	Others	5-10	Functions to supply electric power (except for emergency supply)	-	No claim	Commercial Operations	TGS SFC 5-10.1	The TGS supplies sealing steam to the turbine shaft seal parts and the major valve gland parts.	B	3

	Top Claim for Mechanical System						Safety Functional Claims for Mechanical System and Components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Section 6 Table 5.6-1: High Level Safety Functions in UK ABWR		PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	Claim Contents	Cat.	Class
1	4	Confinement / Containment of radioactive materials	4-3	Functions to contain reactor coolant	-	No claim	Commercial Operations	HDHV SFC 4-3.1	The HD and HV contain reactor coolant which is beyond the reactor coolant pressure boundary.	B	3
2	5	Others	5-10	Functions to supply electric power (except for emergency supply)	-	No claim	Commercial Operations	HDHV SFC 5-10.1	The HD drains the Feedwater heater (FWH) and Moisture separator reheater (MSR) drain to the CFDW. The HV discharges non-condensable gases from the FWH and FWH shell relief valves discharges to the condenser.	B	3

	Top Claim for Mechanical System						Safety Functional Claims for Mechanical System and Components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Section 6 Table 5.6-1: High Level Safety Functions in UK ABWR		PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	Claim Contents	Cat.	Class
1	4	Confinement / Containment of radioactive materials	4-3	Functions to contain reactor coolant	-	No claim	Commercial Operations	COND SFC 4-3.1	The Condenser contains reactor coolant which is beyond the reactor coolant pressure boundary.	B	3
2	5	Others	5-10	Functions to supply electric power (except for emergency supply)	-	No claim	Commercial Operations	COND SFC 5-10.1	The Condenser cools steams to reuse as feedwater to the reactor.	B	3

	Top Claim for Mechanical System						Safety Functional Claims for Mechanical System and Components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Section 6 Table 5.6-1: High Level Safety Functions in UK ABWR		PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	Claim Contents	Cat.	Class
1	5	Others	5-10	Functions to supply electric power (except for emergency supply)	-	No claim	Commercial Operations	CW SFC 5-10.1	The CW supplies cooling water to the condenser.	B	3

	Top Claim for Mechanical System						Safety Functional Claims for Mechanical System and Components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Section 6 Table 5.6-1: High Level Safety Functions in UK ABWR		PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	Claim Contents	Cat.	Class
1	4	Confinement / Containment of radioactive materials	4-3	Functions to contain reactor coolant	-	No claim	Commercial Operations	CFDW SFC 4-3.1	The CFDW contains reactor coolant which is beyond the reactor coolant pressure boundary.	B	3
2	5	Others	5-10	Functions to supply electric power (except for emergency supply)	-	No claim	Commercial Operations	CFDW SFC 5-10.1	The FDW supplies feedwater to the reactor.	B	3

	Top Claim for Mechanical System						Safety Functional Claims for Mechanical System and Components (SFC)				
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)						
	PCSR Ch.5 Section 6 Table 5.6-1: High Level Safety Functions in UK ABWR		PCSR Ch.5 Section 6 Table 5.6-1: High level Safety Functions in UK ABWR		Topic Report on Fault Assessment Table.4.2-1 Fault Schedule (UE-GD-0071)		State	Claim ID	Claim Contents	Cat.	Class
1	4	Confinement / Containment of radioactive materials	4-3	Functions to contain reactor coolant	-	No claim	Commercial Operations	CFCD SFC 4-3.1	The CFCD contains reactor coolant which is beyond the reactor coolant pressure boundary.	B	3
2	5	Others	5-8	Functions to clean up reactor coolant	-	No claim	Commercial Operations	CFCD SFC 5-8.1	The CP removes impurities (soluble and insoluble) in the condensate.	C	3

Appendix B: Safety Properties Claims Table

The safety properties claims defined for mechanical systems are shown in the following table.

	SPC	Safety Properties Claims (SPC) Contents	SCDM SPC Guide word [Ref-17.14]
1	ME SPC1	Design provision against Single Failure Mechanical systems and their support systems are designed with redundancy against single failure of any dynamic component under the worst permissible system availability state so that single failure does not prevent the delivery of the corresponding safety functions.	Fault Tolerance Reliability
2	ME SPC2	Design provision against Common Cause Failure Mechanical systems are designed with independency between redundant components so that the failure of one dynamic component does not lead to a common cause failure that could prevent the delivery of the corresponding safety functions.	Defence in Depth Reliability
3	ME SPC3	Design provision against System Interfaces The mechanical interfaces between SSCs of different safety classes inside a mechanical system or between several systems are designed such that failure in a lower class item will not propagate to higher safety class items and jeopardise the delivery of the corresponding safety functions.	Defence in Depth Reliability
4	ME SPC4	Internal Hazards Protection Mechanical SSCs are protected or designed to withstand the effects of the following internal hazards so that they do not affect the delivery of the corresponding safety functions: (1) Internal flooding (2)Internal fire and explosion (3) Internal missiles(4)Dropped and collapsed loads (5) Pipe whip and jet impact (6)Internal blast (7) Electromagnetic Interference (EMI) (8)Miscellaneous hazards	Fault Tolerance Reliability
5	ME SPC5	External Hazards protection Mechanical SSCs are protected or designed to withstand the effects of the external hazards (Earthquakes, Loss of Offsite Power (LOOP)) so that they do not affect the delivery of the corresponding safety functions.	Fault Tolerance Reliability
6	ME SPC6	Automation Mechanical systems are designed so that no human intervention is necessary for approximately 30 minutes following the start of the requirement for the safety function.	Human Factors Reliability
7	ME SPC7	Qualification Provision Mechanical SSCs are capable to deliver their safety functions under the associated operational and environmental conditions throughout their operational life.	Qualification Life Cycle Reliability
8	ME SPC8	EMIT(Examination, Maintenance, Inspection and Test) Mechanical SSCs are designed with the capability for being tested, maintained and monitored during power operation and/or refuelling outages in order to ensure the capability to deliver the safety functions claimed without compromising their availability throughout their operational life.	Life Cycle Reliability Layout and Accessibility Radiation Protection
9	ME SPC9	Codes and Standards Mechanical components are designed manufactured, constructed, installed, commissioned, quality assured, maintained, tested and inspected according to codes and standards commensurate to their Safety Class.	Relevant Good Practice Reliability

Note: the ME SPCs come from the NSEDPs as described in Generic PCSR Chapter 5, Section 5.3 General Safety Design Bases.

The safety properties claims table of each system is provided in the following tables.

Ch.17 Steam and Power Conversion Systems

	Safety Cat. & Class	ME SPC1	ME SPC2	ME SPC3	ME SPC4	ME SPC5	ME SPC6	ME SPC7	ME SPC8	ME SPC9
		Design provision against Single Failure	Design provision against Common Cause Failure	Design provision against System Interfaces	Internal Hazards Protection	External Hazards protection	Automation	Qualification Provision	EMIT	Codes and Standards
Steam and Power Conversion Systems										
Turbine Generator	B-3	-	-	X	-	X	-	X	X	X
MS, AS, TBP	B-3	-	-	X	-	X	-	X	X	X
ES	B-3	-	-	X	-	X	-	X	X	X
TGS	B-3	-	-	X	-	X	-	X	X	X
HDHV	B-3	-	-	X	-	X	-	X	X	X
Condenser	B-3	-	-	X	-	X	-	X	X	X
CW	B-3	-	-	X	-	X	-	X	X	X
CFDW	B-3	-	-	X	-	X	-	X	X	X
CP	B-3	-	-	X	-	X	-	X	X	X

Remarks:

"X" → Applicable

"-" → Not Applicable

Appendix C: Document Map