Form10/00

UK ABWR

Document ID	:	GA91-9101-0101-16001
Document Number	:	SE-GD-0129
Revision Number	:	B

UK ABWR Generic Design Assessment

Generic PCSR Sub-chapter 16.1 : Water Systems

Hitachi-GE Nuclear Energy, Ltd.

DISCLAIMERS

Proprietary Information

This document contains proprietary information of Hitachi-GE Nuclear Energy, Ltd. (Hitachi-GE), its suppliers and subcontractors. This document and the information it contains shall not, in whole or in part, be used for any purpose other than for the Generic Design Assessment (GDA) of Hitachi-GE's UK ABWR. This notice shall be included on any complete or partial reproduction of this document or the information it contains.

Copyright

Table of Contents

16.1.1 Ultimate Heat Sink

16.1.1.1 System Summary Description

This section is a general introduction to the conceptual design of the Ultimate Heat Sink (UHS) since the actual design depends on the site and therefore is site specific.

16.1.1.1.1 System Roles

The main role of the UHS is to provide cooling water and act as a heat sink for the Reactor Building Service Water System (RSW) during normal operation and accident conditions. As well as the safety duties described in section 16.1.1.2.1 the UHS also provides cooling for plant auxiliaries required for power generation.

16.1.1.1.2 Functions Delivered

The UHS provides that an adequate source of cooling water is available at all times for reactor operation, shutdown cooling and accident mitigation. The RSW receives the cooling water from the UHS and returns the water to it. There are no other heat loads associated with the UHS in addition to the RSW.

16.1.1.1.3 Basic Configuration

The conceptual configuration of the SSCs related to the UHS is summarised as follows:

(1) UHS

(2) Water Intake Canal (refer to Generic PCSR Chapter 10 “Civil Works and Structures (GA91-9101-0101-10000))”

(3) Heat Exchanger Building (Hx/B)
The Hx/B is the structure housing the RSW Pumps, associated piping and valves. Refer to Generic PCSR chapter 10 “Civil Works and Structures (GA91-9101-0101-10000)” for the design description of the Hx/B.

(4) Reactor Building Service Water System (RSW)
The RSW is divided into 3 independent and separated divisions A, B and C each one provided with the following main components:
  (a) Two RSW Pumps per division
  (b) Piping and valves
  (c) Instruments and controllers

(5) Reactor Building Cooling Water System (RCW)
The RCW is divided into 3 independent and separated divisions A, B and C each one provided with the following main components :
  (a) Two RCW Pumps per division
  (b) Three RCW Heat Exchangers per division
  (c) Piping and valves
  (d) Instruments and controllers

16.1.1.1.4 Modes of Operation

The UHS is designed to operate in conjunction with the RSW and RCW for the following principal modes:

The UHS provides cooling water to the RSW and accepts the heatload sent from the RSW as a result of the heat removal from the R/B auxiliaries operating during the modes indicated below by the RCW, which transfers the heat to the RSW through the RCW Heat Exchangers:

(a) Normal Operation Mode
(b) Reactor Shutdown Mode
(c) Loss of Coolant Accident (LOCA) Mode
(d) Hot Stand-by Mode (Offsite Power and Main Condenser Available)
(e) Hot Stand-by Mode (Offsite Power and Main Condenser Unavailable)

16.1.1.2 Design Bases

This section describes the design basis for the UHS.

16.1.1.2.1 Safety Functions

The UHS has been designed to meet the following Safety Functional Claims (SFCs). The relation between the SFCs put on this system and the high level claims is shown in Appendix-1.

Normal Operations and Fault Conditions
The UHS is the principal means to provide sufficient cooling water to the RSW to dissipate the heat from the plant auxiliaries required for normal operation, normal reactor shutdown, hot stand-by with off-site power and main condenser available, hot stand-by under Loss of Off-site Power (LOOP) and main condenser unavailable, and LOCA accident conditions.
This function is categorised as Category A and the components to deliver it are designed to meet Class 1 requirements. [UHS_SFC_5-2.1]

16.1.1.2.2 Design Bases for Power Generation

From the power generation perspective, the UHS provides sufficient cooling water to the RSW to dissipate the heat from the plant auxiliaries required for power generation during plant operation, although no safety requirements are put on the system from this perspective.

16.1.2 Reactor Building Cooling Water Systems

16.1.2.1 System Summary Description

This section is a general introduction to the Reactor Building Cooling Water Systems (RCW and RSW) where the systems roles, systems functions, systems configuration and modes of operation are briefly described. The RCW/RSW safety case is justified in the Reactor Building Cooling Water System Basis of Safety Cases (BSC) [Ref-1]. The RCW/RSW is described in detail in the system specifications[Ref-3] [Ref-13] and the Piping and Instrumentation Diagrams[Ref-4] [Ref-5] [Ref-6] [Ref-7] [Ref-8] [Ref-9] [Ref-10] [Ref-11] [Ref-12] [Ref-14] [Ref-15] [Ref-16].

16.1.2.1.1 System Roles

The main role of the RCW is to supply cooling water to the plant auxiliaries in order to preserve the specified functions. Plant auxiliaries consist of the equipment of low safety significance (reactor auxiliaries, radioactive waste system auxiliaries, some turbine auxiliaries containing fluids with radioactive substances and etc.) and the equipment of high safety significance (reactor auxiliaries, the emergency heating ventilation and air conditioning auxiliaries and etc.).

The main role of the RSW is to cool and remove the heat from the RCW by supplying service water from the UHS.

16.1.2.1.2 Functions Delivered

The RCW is designed to perform the following normal operation and safety functions:

(1) The RCW recirculates cooling water through the closed loop comprising the RCW Heat Exchanger and the equipment of low safety significance by the RCW Pump to remove the heat from each piece of equipment during normal plant operation, shutdown or hot stand-by (offsite power available) and transfer it to the RSW.

(2) The RCW recirculates cooling water through the closed loop comprising the RCW Heat Exchanger and the equipment of high safety significance by the RCW Pump to remove the heat from each piece of equipment after automatic initiation during plant abnormal conditions such as Loss of Offsite Power (LOOP) or Loss of Coolant Accident (LOCA) and transfer it to the RSW.

(3) With regard to the Fuel Pool Cooling and Clean-up System (FPC), the RSW and the HVAC Emergency Cooling Water System (HECW) auxiliaries, the RCW recirculates cooling water through the closed loop comprising the RCW Heat Exchanger and their auxiliaries by the RCW Pump to remove the heat from each one of their auxiliaries regardless of the plant operation conditions and transfer it to the RSW.

The RSW is designed to perform the following normal operation and safety functions:

(4) The RSW provides service water to the RCW Heat Exchangers from the water intake pit in order to remove the heat from RCW and discharge it into the water discharge pit.

16.1.2.1.3 Basic Configuration

The RCW consists of three independent divisions for cooling of all safety auxiliaries (RCW (A), RCW (B) and RCW (C)) provided with two RCW Pumps and three RCW Heat Exchangers each. In addition, each division is provided with one RCW Surge Tank to ensure the RCW Pump intake pressure and time margin against leakage of cooling water from the system. The RCW is provided with two RCW Chemical Addition Tanks (one tank is shared by two divisions, and another tank is shared by the other division of RCW and the Turbine Building Cooling Water System (TCW)) to inject corrosion inhibitor into the cooling water when necessary.

The main components are summarised as follows:
(1) Two RCW Pumps per division (A, B, C)
(2) Three RCW Heat Exchangers per division (A, B, C)
(3) One RCW Surge Tank per division (A, B, C)
(4) Two RCW Chemical Addition Tanks in the system (Division A and C share the one tank, and division B of RCW and TCW share another tank)
(5) Piping and valves
(6) Instruments and controllers

The RSW consists of three independent divisions A, B and C corresponding to the RCW divisions. Each division consists of two RSW Pumps, three RSW Strainers, piping, etc.
The main components are summarised as follows:
(1) Two RSW Pumps per division (A, B, C)
(2) Three RSW Strainers per division (A, B, C)
(3) Piping and valves
(4) Instruments and controllers
Figure 16.1-1 shows an outline of the RCW/RSW basic configuration.

16.1.2.1.4 Modes of Operation

The RCW and RSW can deliver the following operation modes:
(1) Normal Operation Mode
The RCW and RSW remove the heat from auxiliaries of low safety significance and some auxiliaries of higher safety significance during plant normal operation. This mode is initiated and controlled by remote manual operation from the Main Control Room (MCR). Two RCW Pumps, two RSW Pumps and Three Heat Exchangers are in service at each division during this mode while the remaining components are on stand-by.
(2) Reactor Shutdown Mode
The RCW and RSW remove decay heat from the RHR Heat Exchanger as well as the heat load of auxiliaries of low safety significance and some of higher safety significance during reactor shutdown. This mode is initiated and controlled by remote manual operation from the MCR and, two RCW Pumps, two RSW Pumps and three RCW Heat Exchangers are in service in each division during this mode.
(3) LOCA Mode
This mode is initiated automatically upon LOCA signal to remove decay heat from the RHR Heat Exchangers as well as the heat load of auxiliaries of high safety significance (Emergency Diesel Generator Facility, etc.) and some of low safety significance. The two RCW Pumps, three RCW Heat Exchangers and two RSW Pumps of each division are operated for this mode.
(4) Hot Stand-by Mode (Offsite Power Available)
This mode is manually operated from the MCR in conjunction with the Hot Stand-by Mode of the Turbine System to remove the heat load of auxiliaries of low safety significance and some of higher safety significance. Two RCW Pumps, two RSW Pumps and three RCW Heat Exchangers per division are in service with the rest on stand-by.
(5) Hot Stand-by Mode (Offsite Power Unavailable)
This mode is initiated automatically upon LOOP signal to remove decay heat from the RHR Heat Exchangers as well as the heat load of auxiliaries of high safety significance (Emergency Diesel Generator Facility, etc.) and some of low safety significance by operating the two RCW pumps, the two RSW Pumps and the three RCW Heat Exchangers of each division. Power supply for this mode is supplied by the Emergency Diesel Generator System.
(6) Refuelling Outage Backup Mode

One of three divisions of RCW and RSW is shut off for maintenance while the other two divisions are in service during this mode. The cooling water for auxiliaries of high and low safety significance that are required to continuously operate in the division under maintenance is supplied by one of the operating divisions through the interconnecting tie lines. Two RCW Pumps, two RSW Pumps and three RCW Heat Exchangers are operating per available division. In this mode, remote manual operation is conducted from the MCR.

16.1.2.2 Design Bases

This section describes the design bases for the RCW/RSW. The claims put on the system come from the Reactor Building Cooling Water System BSC [Ref-1].

16.1.2.2.1 Safety Functions

The RCW and RSW have been designed to meet the following SFCs. The relation between the SFCs put on these systems and the high level claims is shown on Appendix-2.

Normal Operations and Fault Conditions

(1) The RCW and RSW are the principal means to remove heat from plant Class 1 auxiliaries required for normal operation, normal reactor shutdown, hot stand-by, hot stand-by under LOOP with main condenser unavailable and infrequent faults such as LOCA.
The RCW and RSW support the delivery of Category A safety functions and the components necessary to deliver heat removal are designed to meet Class 1 requirements. [RCW-RSW_SFC_5-2.1]

(2) The RCW and RSW are the principal means to remove heat from plant Class 2 auxiliaries required for normal operation, normal reactor shutdown, hot stand-by, hot stand-by under LOOP with main condenser unavailable and infrequent faults such as LOCA.
The RCW and RSW support the delivery of Category B safety functions and the components necessary to deliver heat removal are designed to meet Class 2 requirements. [RCW-RSW_SFC_5-2.2]

(3) The RCW and RSW are the principal means to remove heat from plant Class 3 auxiliaries required for normal operation, normal reactor shutdown, hot stand-by, hot stand-by under LOOP with main condenser unavailable and infrequent faults such as LOCA.
The RCW and RSW support the delivery of Category B and Category C safety functions and the components necessary to deliver heat removal are designed to meet Class 3 requirements. [RCW-RSW_SFC_5-12.1]

Fault Conditions

(4) The RCW components within the PCVB are completely isolated by the PCIS in order to form barrier to confine the radioactive material within the containment boundary and prevent its dispersion to the environment in the event of faults. [PCIS SFC 4-7.11]

16.1.2.2.2 Design Bases for Power Generation

From the power generation perspective, the RCW and RSW are the principal means to remove heat from plant auxiliaries required for power generation during plant operation, though it is emphasised that these functions are not safety related.

16.1.2.3 System Design Description

This section describes the design of the RCW and RSW to support and justify the delivery of RCW-RSW_SFC_5-2.1, RCW-RSW_SFC_5-2.2 and RCW-RSW_SFC_5-12.1.Additional design description can be found in[Ref-1] [Ref-3] [Ref-4] [Ref-5] [Ref-6] [Ref-7] [Ref-8] [Ref-9] [Ref-10] [Ref-11] [Ref-12] [Ref-13] [Ref-14] [Ref-15] [Ref-16].

16.1.2.3.1 Overall System Design and Operation

The RCW and RSW are composed of three electrical and mechanical independent divisions designated A, B, and C. Each division contains the necessary piping, pumps, valves and heat exchangers.

The RCW distributes cooling water to remove heat from the plant auxiliaries during normal operation, normal reactor shutdown, hot stand-by conditions (with off-site power and main condenser available conditions, and under LOOP with main condenser unavailable conditions) and post-LOCA conditions and transfers it to the RSW through the heat exchangers, which removes heat from the RCW and transfers it to the UHS.

The auxiliaries to be supplied cooling water by RCW are assigned to the three divisions by considering equipment arrangement, heat loads, flow balance and the distribution of power supply to the loads.

During all plant operating modes, two RCW Pumps and three heat exchangers are normally operating in each division.

The RCW is provided with isolation valves to automatically separate the essential auxiliaries required during LOOP and LOCA from those non-essential, in order to assure the integrity and safety functions of the system during LOOP and LOCA.

The RCW is configured as a closed loop and designed such that it automatically fills up cooling water to prevent cooling water insufficiency through the surge tanks. Makeup water is automatically added to the surge tanks from the MUWP.

There are interconnecting tie lines between the divisions, which will be used to supply cooling water to auxiliaries of the RCW division isolated for maintenance during refuelling outages. During refuelling outage backup mode, the auxiliaries supplied cooling water are limited so that the capacities of the RCW Pumps and heat exchangers in the supplying divisions are not exceeded. The tie lines are closed during the rest of operating modes.

16.1.2.3.2 Equipment Design and Operation

(1) RCW Pump
  (a) Purpose
  The purpose of the RCW pump is to send cooling water to the plant auxiliaries and remove the heat from them in order to deliver RCW-RSW_SFC_5-2.1, RCW-RSW_SFC_5-2.2 and RCW-RSW_SFC_5-12.1.
  (b) Configuration and Operation
  Divisions A and B of the RCW are designed to supply approximately 4,500m^3/h of cooling water and division C of the RCW is designed to supply approximately 3,900m^3/h of cooling water to satisfy the required flow of cooling water for all operating modes. Based on this, divisions A and B are provided with two 50%-capacity pumps of approx.

2,250m^3/h of design flow rate per pump for each devision, and division C is provided with two 50%-capacity pumps of approx. 1,950m^3/h of design flow rate per pump.

(c) Performance
The RCW Pump is designed to perform as follows in order to ensure the delivery of RCW-RSW_SFC_5-2.1, RCW-RSW_SFC_5-2.2 and RCW-RSW_SFC_5-12.1:

Table 16.1-1 : RCW Pump Capacity

	RCW (A/B)	RCW(C)
Number	2 units/division (2 divisions)	2 units/division (1 division)
Rated Flow	Approx. 2,250m^3/h (per unit)	Approx.1,950m^3/h (per unit)

(2) RCW Heat Exchanger
(d) Purpose
The RCW heat exchangers cool the plant auxiliaries in order to preserve the specified functions by transferring heat energy from the RCW circulating water to the RSW service water supplied from the Ultimate Heat Sink in order to deliver RCW-RSW_SFC_5-2.1, RCW-RSW_SFC_5-2.2 and RCW-RSW_SFC_5-12.1.
(e) Configuration and Operation
The RCW is provided with three plate type heat exchangers per division for heat removal from the RCW during all operating modes per division. Divisions A and B are provided with three heat exchangers of approximately 9.7MW/unit each and division C is provided with three heat exchangers of approximately 8.0MW/unit. One side water is service water circulated by the RSW, whereas the other side (RCW) is fresh cooling water.
(f) Performance
The RCW Heat Exchanger is designed to perform as follows in order to ensure the delivery of RCW-RSW_SFC_5-2.1, RCW-RSW_SFC_5-2.2 and RCW-RSW_SFC_5-12.1:

Table 16.1-2 : RCW Heat Exchanger Capacity (Divisions A and B)

RCW Heat Exchanger (A)/(B)		
	Fresh water side	Service water side
Fluid	Fresh water	Service water
Flow rate (m^3/h per unit)	Approx.1,500	Approx.1,800
Capacity (MW/unit)	Approx.9.7	

Table 16.1-3 : RCW Heat Exchanger Capacity (Division C)

RCW Heat Exchanger (C)		
	Fresh water side	Service water side
Fluid	Fresh water	Service water
Flow rate (m^3/h per unit)	Approx.1,300	Approx.1,800
Capacity (MW/unit)	Approx.8.0	

(3) RSW Pump
(g) Purpose
The main purpose of the RSW Pump is to supply service water to the RCW Heat Exchanger in order to remove the heat from the RCW cooling water by heat transfer in order to deliver RCW-RSW_SFC_5-2.1, RCW-RSW_SFC_5-2.2 and RCW-RSW_SFC_5-12.1.
(h) Configuration and Operation

Each division of the RSW is designed to supply approximately 5,400m^3/h of service water to satisfy the required flow of cooling water for all operating modes. Based on this, each division is provided with two 50%-capacity pumps of approx. 2,700m^3/h of design flow rate per pump with a total of six pumps.

(i) Performance
The RSW Pump is designed to perform as follows in order to ensure the delivery of RCW-RSW_SFC_5-2.1, RCW-RSW_SFC_5-2.2 and RCW-RSW_SFC_5-12.1:

Table 16.1-4 : RSW Pump Capacity

RCW (A/B/C)	
Number	2 units/division (3 divisions)
Rated Flow	Approx. 2,700m^3/h (per unit)

16.1.2.3.3 Main Support Systems

16.1.2.3.3.1 Instrumentation and Control System

(1) Instrumentation
Instrumentation is provided to measure and monitor the operating conditions of the RCW and RSW components necessary for the delivery of the safety functions. The main provisions for instrumentation are described as follows:
- (a) General Provisions
  - (i) As a general rule, all instruments are arranged so that monitoring and control of process variables (flow rate, pressure, etc.) as well as operation are performed from the Main Control Room (MCR).
  - (ii) Sampling points for determining cooling water quality and detecting any leakage of radioactive fluids from the auxiliaries (such as the RHR Heat Exchangers, the CUW Heat Exchangers, etc.) are provided.
  - (iii) The position of all motor-operated and pneumatic valves is indicated on the MCR.

(2) Control
The main control provisions related to the delivery of the safety functions by the RCW and RSW are summarised as follows:
- (b) General Provisions
  - (i) The isolation valves separating non-essential low safety significance loads from those essential during LOOP and LOCA are designed to close automatically upon the LOOP or the LOCA signal. These valves fully close if the control source of the valve is lost.
  - (ii) The RCW is designed to supply cooling water automatically to the RHR Heat Exchanger upon the LOOP or the LOCA signals.
  - (iii) All the RCW Pumps, the RCW Heat Exchangers and the RSW Pumps are designed to start automatically upon the LOOP or the LOCA signals.

16.1.2.3.3.2 Power Supply System

(1) The normal AC power supply to the RCW and RSW electrical components is provided by an independent and off-site source (external grid). In addition, RCW and RSW Class 1 components, valves, instruments and controllers are provided with emergency AC power supply and DC power supply.

(2) Each of the RCW and RSW divisions A, B and C is supplied power by independent divisions 1, 2 and 3 of the emergency power supply system respectively.

16.1.2.3.4 System Architecture

(1) Redundancy
The RCW and RSW consist of three redundant divisions A, B, and C with their respective pumps, heat exchangers, strainers, piping, valves, and instrumentation such that, single failure of any dynamic component does not prevent the delivery of the safety functions.

(2) Independence
The components forming the three divisions of the RCW and the RSW are independent and separately arranged in different locations within the Heat Exchanger Building (Hx/B) to prevent failure of a component in one of the divisions from leading to a common cause failure of all divisions.

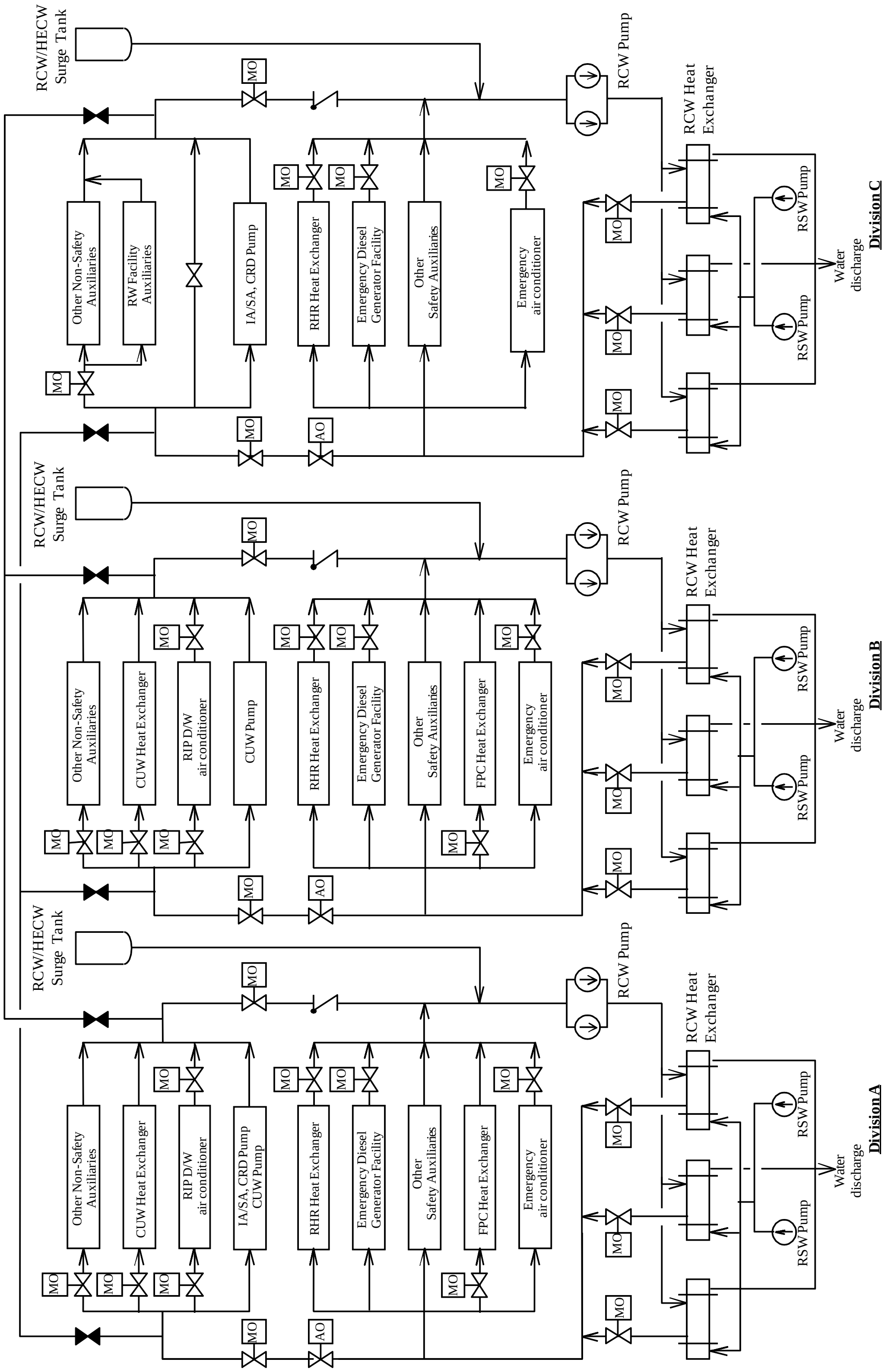


Figure 16.1-1 : Outline of the Reactor Building Cooling and Service Water System

16.1.3 Turbine Building Cooling Water Systems

16.1.3.1 Turbine Building Cooling Water System

16.1.3.1.1 System Summary Description

This section is a general introduction to the Turbine Building Cooling Water System (TCW) where the system roles, system functions, system configuration and modes of operation are briefly described [Ref-2].

16.1.3.1.2 System Roles

The purpose of The TCW is to supply cooling water to turbine auxiliary equipment to assure their functions.

16.1.3.1.3 Functions Delivered

The TCW supplies cooling water to turbine auxiliary equipment, such as oil coolers, motor coolers, shaft bearings, and HVAC Normal Cooling Water System (HNCW) refrigerators.

16.1.3.1.4 Basic Configuration

The TCW consists of the following main components:

(1)	Turbine Building Cooling Water Pump	3 units (1 unit as stand-by)
(2)	Turbine Building Cooling Water Heat Exchanger	3 units (1 unit as stand-by)
(3)	TCW surge tank	1 unit

16.1.3.1.5 Modes of Operation

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

16.1.3.1.5.1 Normal Operation

(1) During normal operation, the TCW Pumps circulate the cooling water through the TCW Heat Exchangers. The TCW Pump and TCW Heat Exchanger are composed of 3 × 50 % capacity with 1 unit as stand-by respectively.

(2) The TCW Pump suction is connected to the TCW surge tank to assure the required Net Positive Suction Head (NPSH).

(3) The TCW surge tank is provided as a reservoir for small amounts of leakage from the TCW and for the expansion and contraction of the cooling water when the system temperature changes.

(4) When the nitrite concentration or pH in the cooling water drops below a low limit, an anti-corrosion chemical is injected to the TCW Pump suction from the RCW chemical addition tank where the anti-corrosion chemical is added manually.
In this injection system, the cooling water circulates from TCW Pump discharge header to TCW Pump suction header via RCW chemical addition tank by the TCW Pump head.

(5) The Temperature Control Valve (TCV) is located at the oil cooler inlet to reduce the cooling water pressure in the oil cooler and minimise the possibility of cooling water leaking into oil in case of tube leak.
In addition, regarding the Turbine Electro Hydraulic Control System (EHC) oil cooler, titanium tube and double tube plate are adopted to prevent leakage.

(6) To protect the TCW surge tank downcomer against corrosion, a recirculation line is connected

between the TCW Heat Exchanger outlet and the TCW surge tank to supply anti-corrosion chemical.

16.1.3.1.5.2 Refuelling Outage

(1) A small bypass valve is provided at the TCW Heat Exchanger outlet to fill it with cooling water for recovery after cleaning the unit.
(2) Basically, the cooling water drain is discharged to the Miscellaneous Non-radioactive Drain Transfer System (MSC).

16.1.3.1.5.3 Transient Conditions

The TCW surge tank hydrostatic head provides suction pressure for the TCW Pump. In case the TCW surge tank water level drops below the preset level, all TCW Pumps are stopped to prevent pump cavitation.

16.1.3.1.6 Design Bases

This section describes the design bases for the TCW.

16.1.3.1.6.1 Safety Functions

Normal Operations
The TCW 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-3.
The TCW supplies cooling water to turbine auxiliary equipments. The TCW 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.
[TCW SFC 5-11.1]

16.1.3.1.6.2 Design Bases for Power Generation

From the power generation perspective, the TCW meets the following design bases:
The TCW supplies cooling water to turbine auxiliary equipment, such as oil coolers, motor coolers, shaft bearings, and HVAC Normal Cooling Water System (HNCW) refrigerators.

16.1.3.1.7 System Design

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

16.1.3.1.7.1 Overall Design and Operation

(1) The TCW is a closed system that circulates cooling water with chemical additives by TCW Pump to cool turbine auxiliary equipment.
(2) In case of cooling water insufficiency, it is supplied from MUWP to the TCW surge tank.
(3) An anti-corrosion chemical is injected to the TCW Pump suction via the RCW chemical addition tank to protect piping and equipment in the system against corrosion.
(4) The TCW supplies cooling water to turbine auxiliary equipments, such as oil coolers, motor coolers, shaft bearings, refrigerators.
(5) The TCW supplies cooling water to only non-radioactive equipment to prevent radioactive pollution.

16.1.3.1.7.2 Equipment Design

16.1.3.1.7.2.1 TCW Pump

(1) Configuration
- (a) 3 TCW Pumps (50 % × 3) are installed (1 unit as stand-by).
- (b) The shaft sealing is of a mechanical seal type to reduce the quantity of leakage.

(2) Performance
The TCW Pump is designed to perform as follows:

TCW Pump	Number:	3 units (1 unit as stand-by)
	Capacity:	to 3,700 m^3/h/unit

16.1.3.1.7.2.2 TCW Heat Exchanger

(1) Configuration
- (a) 3 TCW Heat Exchangers (50 % × 3) are installed (1 unit as stand-by).
- (b) If 1 of the active TCW Heat Exchangers fails to operate, the stand-by unit is placed in service manually.

(2) Performance
The TCW Heat Exchanger is designed to perform as follows:

TCW Heat Exchanger	Number:	3 units (1 unit as stand-by)
	Design heat duty:	to 22 MW/unit

16.1.3.1.7.3 Support Systems

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

16.1.3.1.7.3.1 Control and Instrumentation Systems

(1) Control
- (a) The air-operated TCV is locked at the current position (Fail As Is) in case of a loss of air supply, to prevent an extreme rise or drop in the temperature of the fluid being cooled (such as water, oil, air and hydrogen gas), except that the air-operated valve for supplying water to the TCW surge tank is fully open (Fail Open).
- (b) The cooling water temperature at the TCW Heat Exchanger outlet is maintained constant by controlling the TCW Heat Exchanger water flow rate and the bypass flow rate by using the air-operated TCW-TCV at its outlet.
- (c) The performance of the main turbine and the RFP-T are affected by the oil temperature variation, therefore, the TCVs are installed at the main turbine oil cooler and the RFP-T oil cooler supply lines respectively to regulate the cooling water flow rate in order to keep the oil temperature at the required value. The preset turbine oil temperature is changed in accordance with the turbine operation condition.
- (d) The cooling water flow rate to the EHC fluid cooler and the hydrogen coolers is regulated by TCV to keep the oil or hydrogen temperature at cooler outlet constant.
- (e) The cooling water flow rate to all of the other coolers is manually regulated by individual throttling valves located at cooler outlet.

(2) Interlocks
The TCW Pump has the following interlocks:
- (a) In case of a drop in the TCW Pump discharge pressure, the alarms are transmitted to the Main Control Room (MCR) and the stand-by pump starts automatically. After TCW Pump flow rate decreases and its discharge pressure is recovered, 1 TCW Pump is shutdown

manually from the MCR.

(b) In case of the TCW surge tank water level "Low Low Low", all TCW Pumps trip automatically.

16.1.3.1.7.3.2 Power Supply System

The TCW components are basically connected to a safety class 3 AC.

16.1.3.1.7.3.3 Turbine Building Service Water System (TSW)

The TSW supplies service water to the TCW Heat Exchanger to cool the TCW water.

16.1.3.1.7.3.4 Makeup Water Purified System (MUWP)

The MUWP supplies makeup water to the TCW surge tank.

16.1.3.2 Turbine Building Service Water System

16.1.3.2.1 System Summary Description

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

16.1.3.2.2 System Roles

The purpose of the TSW is to supply sea water (site dependent) as cooling water to the Turbine Building Cooling Water Heat Exchanger and remove heat from the Turbine Building Cooling Water System (TCW).

16.1.3.2.3 Basic Configuration

The TSW consists of the following main components:

(1) TSW Pump 3 units (1 unit as stand-by)
(2) TSW strainer 3 units (1 unit as stand-by)

16.1.3.2.4 Modes of Operation

Modes of operation of the TSW are summarised as follows:

16.1.3.2.4.1 Commercial Operation

(1) The TSW is equipped with 3 TSW Pumps of 50 % capacity (1 unit as stand-by) to assure normal plant operation and startup/shutdown operations.

(2) A TSW strainer is provided on each TCW Heat Exchanger inlet to protect the TCW Heat Exchanger and TSW piping by removing debris and aquatic organisms from the sea water.
The TSW strainer is able to perform self cleaning, changeover to the stand-by strainer and overhaul while the TSW is in service.
The TSW strainer self-cleaning starts automatically and periodically, or in the event of high differential pressure.

16.1.3.2.4.2 Refuelling Outage

The residual air in the piping and the TCW Heat Exchanger during the TSW water filling is discharged by the discharge pressure of TSW Pump.

16.1.3.2.4.3 Transient Conditions

The stand-by TSW Pump starts automatically in the event that a normally operating pump trips or the discharge pressure drops below a preset limit.

16.1.3.2.5 Design Bases

This section describes the design bases for the TSW.

16.1.3.2.5.1 Safety Functions

Normal Operations
The TSW 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-3.
The TSW supplies service water to the TCW Heat Exchanger and removes heat from the TCW. The TSW 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.[TSW SFC 5-11.1]

16.1.3.2.5.2 Design Bases for Power Generation

From the power generation perspective, the TSW meets the following design bases:
The TSW supplies the sea water (site dependent) from intake pool to the TCW Heat Exchanger via the TSW strainer and draws off the water to the discharge pool by Turbine Building Service Water pump.

16.1.3.2.6 System Design

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

16.1.3.2.6.1 Overall Design and Operation

The TSW supplies the sea water (site dependent) from intake pool to the TCW Heat Exchanger via the TSW strainer and draws off the water to the discharge pool by TSW Pump.
The TSW operating pressure is lower than the TCW to prevent sea water (site dependent) from leaking into the TCW.

16.1.3.2.6.2 Equipment Design

16.1.3.2.6.2.1 TSW Pump

(1) Configuration
  (a) 3 TSW Pumps (50 % × 3) are installed (1unit as stand-by).
  (b) The TSW Pump is a vertical type.
(2) Performance
  The TSW Pump is designed to perform as follows.

TSW Pump	Number:	3 units (1 unit as stand-by)
	Capacity:	to 3,800 m^3/h/unit

16.1.3.2.6.3 Support Systems

The main systems supporting mechanical SSCs for the delivery of service water supply to TCW Heat Exchangers are described as follows:

16.1.3.2.6.3.1 Control and Instrumentation Systems

When 2 TSW Pumps are in operation, a low outlet pressure signal or a pump trip makes stand-by pump start automatically.
The TSW strainer self-cleaning starts automatically and periodically, or in the event of high differential pressure.

16.1.3.2.6.3.2 Power Supply System

The TSW components are connected to a safety class 3 AC.

16.1.3.2.6.3.3 Turbine Building Cooling Water System (TCW)

The TSW supplies sea water (site dependent) as service water to the TCW Heat Exchanger and removes heat from the TCW.

16.1.4Makeup Water Systems

16.1.4.1 Makeup Water Condensate System

16.1.4.1.1 System Summary Description

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

16.1.4.1.2 System Roles

The purpose of the MUWC is to supply condensate required for each component.

16.1.4.1.3 Functions Delivered

The MUWC supplies required water such as filling water and water for washing purpose during the Refuelling outage.

16.1.4.1.4 Basic Configuration

The MUWC consists of the following main components:

(1)	Condensate Storage Tank (CST)	1 unit
(2)	Makeup Water Condensate Pump	3 units

16.1.4.1.5 Modes of Operation

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

16.1.4.1.5.1 Normal Operation

(1) At least 1 of 3 MUWC Pumps is in operation. A minimum flow pipe is provided to continuously supply even when the makeup water flow rate is very low.
A pressure transmitter is provided at the pump discharge header to detect drops in pressure and automatically start the stand-by pump.

(2) The MUWC supplies purging, scramming and filling water to the CRD from the condensate spillover line at the normal operation, and the excess water is recovered to the CST. When the condensate spillover line is not available, the makeup water for CRD is supplied from the CST.

(3) The Makeup Water Purified System (MUWP) supplied purified makeup water to the CST, and the makeup water valve is remotely operated in the Main Control Room (MCR).

16.1.4.1.5.2 Startup and System shutdown

The returned water to the condenser at System shutdown is recovered to the CST via the condensate spillover line.

16.1.4.1.5.3 Refuelling Outage

The water stored for emergency in the Power operation is able to be used as a part of the water required for such as the fuel pool filling in the reactor building during the Refuelling outage.

16.1.4.1.6 Design Bases

This section describes the design bases for the MUWC.

16.1.4.1.6.1 Safety Functions

The MUWC 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-4.

Normal Operations

(1) The MUWC supplies required condensate to each component. [MUWC SFC 5-10.1]
The MUWC 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.

Fault Conditions

(2) The CST is used as a water source for the Reactor Core Isolation Cooling System (RCIC) and High Pressure Core Flooding System (HPCF) in the event of frequent and infrequent faults such as LOCA. [MUWC SFC 2-1.1]
The MUWC delivers a Safety Category A function, and the components necessary to deliver this function are classified as Safety Class 2 according to the safety categorisation and classification of UK ABWR.

(3) The MUWC components within the PCVB are completely isolated by the PCIS in order to form barrier to confine the radioactive material within the containment boundary and prevent its dispersion to the environment in the event of faults. [PCIS SFC 4-7.21]
(This function is categorized as Category A and the components to deliver it are designed to meet Class 1 requirements.This safety function is developed and justified in Generic PCSR Chapter 13 “Engineered Safety Features” section 13.2.3.1.2 related to the Primary Containment Facility)

Normal Operations and Fault Conditions

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

16.1.4.1.6.2 Design Bases for Power Generation

From the power generation perspective, the MUWC meets the following design bases:
The MUWC supplies required water such as filling water and water for washing purpose during the Refuelling outage.

16.1.4.1.7 System Design

This section describes the design of the MUWC.

16.1.4.1.7.1 Overall Design and Operation

(1) The MUWC supplies required condensate at Startup, System shutdown and Power operation to each component which may potentially have radioactive contamination.

(2) The MUWC is used as a water source for the Reactor core isolation cooling system (RCIC), High Pressure Core Flooder System (HPCF), Suppression Pool Clean-up System (SPCU) and Control Rod Drive System (CRD), and also receives cleaned water from the LCW.
(3) The CST retains the quantity of condensate required by the HPCF or RCIC to deliver the safety functions required of these systems following faults during plant operation. Accordingly, the suction nozzles for the HPCF and RCIC are installed lower in the tank than the nozzles for the other systems to assure supply to these systems.
(4) The CST is equipped with a level switch to use the suppression pool water for supplying to the HPCF and RCIC in case the CST water level drops below a preset level.

16.1.4.1.7.2 Equipment Design

16.1.4.1.7.2.1 CST

(1) Configuration
  (a) The CST stores condensate as a water source for the HPCF, RCIC, SPCU and CRD. The CST usually stores the water from the LCW.
  (b) The CST stores the water for the Emergency Core Cooling System (ECCS) and the water used for makeup, filling, sealing, wash of equipment and decontamination. Since a water source for the ECCS must always be reserved, its suction nozzle is installed lower than the nozzles for the other systems to assure supply to these systems.
  (c) A vacuum relief valve and a pressure relief valve are provided on the CST.
  (d) To detect leaks from the CST as early as possible, leaking water is collected into a pit equipped with a leak detector.
  (e) The drain pipes and overflow pipes of the CST are connected to the LCW collection tank. To prevent the air in the LCW collection tank from flowing into the MUWC through the overflow pipe, the pipe end will be below the level of water in the LCW collection tank, or a similar countermeasure, such as a U-seal will be installed.

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

CST	Number:	1 unit
	Nominal Capacity:	to 2,400 m^3

16.1.4.1.7.2.2 MUWC Pump

(1) Configuration
  (a) This pump transfers condensate water from the CST to equipment.
  (b) The MUWC Pumps receive power from a Motor Control Centre (MCC) which can be supplied from an Emergency Diesel Generator (ED/G) to ensure the water supply even during a loss of power incident.
  (c) 3 MUWC Pumps are installed, however during Power operation, a single pump is sufficient to supply usual requirements.
  (d) All 3 pumps are used to supply a large amount of condensate water, such as for filling of the reactor well during a Refuelling outage.
(2) Performance
The MUWC Pump is designed to perform as follows:

MUWC Pump	Number:	3 units
	Capacity:	to 130 m^3/h/unit

16.1.4.1.7.3 Support Systems

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

16.1.4.1.7.3.1 Control and Instrumentation Systems

(1) The purified water is automatically supplied to the CST by an automatic interlock which controls the makeup valve acccording to the CST water level High/Low switch. Water level High/Low alarms are set alert operators to CST abnormal water levels.
(2) The CST makeup can also be manually opened/closed from the MCR.
(3) In case of a MUWC Pump discharge pressure “Low”, 1 stand-by pump starts automatically.
(4) The stand-by MUWC Pump is stopped manually when pump discharge pressure and system flow rate conditions allow.
(5) The CST is equipped with a water level transmitter to detect water levels, to run and stop the MUWC Pump and to control the Level Control Valve (LCV) for the purified water makeup. These operations are able to be controlled also by manual.
(6) To prevent the MUWC Pump cavitation due to lower water level of the CST, interlocks are provided to automatically trip the pump at a preset level for normal operation and for outage respectively.
To prevent the MUWC Pump from frequent start and stop, interlocks are provided to prevent stand-by pump startup in case the CST water level is below preset levels for normal operation and for outage respectively.

16.1.4.1.7.3.2 Power Supply System

The MUWC Pump components are not required to be connected to the emergency power from a nuclear safety perspective.

16.1.4.1.7.3.3 Reactor Core Isolation Cooling System (RCIC)

The MUWC is one of the water source for makeup water through the RCIC to the Reactor Pressure Vessel (RPV).

16.1.4.1.7.3.4 High Pressure Core Flooder System (HPCF)

The MUWC is one of the water source for makeup water through the HPCF to the Reactor Pressure Vessel (RPV).

16.1.4.1.7.3.5 Suppression Pool Clean-up System (SPCU)

The MUWC is one of the water source for makeup water through the SPCU to the spent fuel storage pool.

16.1.4.1.7.3.6 Control Rod Drive System (CRD)

The MUWC supplies purge water through the CRD to the Fine Motion Control Rod Drive (FMCRD), Reactor Internal Pumps (RIPs) and the Reactor Water Clean-up System (CUW) when the condensate spillover line is not available.

16.1.4.1.7.3.7 Low Conductivity Waste System (LCW)

The MUWC receives water from LCW. The drain pipes and overflow pipes of the CST are connected to the LCW collection tank.

16.1.4.1.7.3.8 Turbine Gland Steam System (TGS)

The MUWC supplies the makeup water for steam generation in the Gland steam evaporator (GSE).

16.1.4.1.7.3.9 Condenser

The MUWC supplies makeup water to the condenser to control the condenser hotwell water level.

16.1.4.1.7.3.10 Makeup Water Purified System (MUWP)

The MUWP supplies purified makeup water to the CST.

16.1.5 HVAC Cooling Water System

16.1.5.1 HVAC Emergency Cooling Water System (HECW)

16.1.5.1.1 System Summary Description

This section is a general introduction to the HECW where the system roles, system functions, system configuration and modes of operation are briefly described. The HECW is described in detail in the system specifications [Ref-17] and the Piping and Instrumentation Diagrams [Ref-18] [Ref-19] [Ref-20].

16.1.5.1.1.1 System Roles

The HECW is designed for achieving the following purpose.

Providing chilled water as a cooling medium to the following cooling coils of the Normal/Emergency Heating Ventilating Air Conditioning System (HVAC) Supply Air Treatment Facilities and Local Cooling Units during normal operation, shutdown, refuelling outage and fault conditions such as LOCA and LOOP.

Table 16.1.5-1: HVAC Sub-system associated with HECW

No.	Bldg.	HVAC Sub-system	Safety Division
1	R/B	Reactor Building Emergency Electrical Equipment Zone [RBEEE (A), (B) and (C)/Z] HVAC	Normal/Emergency
2	EDG/B	Emergency Diesel Generator Electrical Equipment Zone [DGEE (A), (B) and (C)/Z] HVAC	Normal/Emergency
		Emergency Diesel Generator Room [EDG (A), (B) and (C)] Local Cooling Units	Emergency
3	C/B	Control Building Emergency Electrical Equipment Zone [CBEEE (A), (B) and (C)/Z] HVAC	Normal/Emergency
4	C/B	Main Control Room [MCR (A) and (B)] HVAC	Normal/Emergency
5	Hx/B	Heat Exchanger Building Emergency [Hx/B-E (A), (B) and (C)] Local Cooling Units	Emergency

16.1.5.1.1.2 Function Delivered

The HECW is designed to provide the cooling function for the Normal/Emergency HVAC during normal operation, shutdown, refuelling outage and fault conditions to ensure equipment operation in these areas are maintained.

16.1.5.1.1.3 Basic Configuration

The HECW consists of three separate but non-identical divisions A, B and C. The system main components are summarised as follows:

(1) HECW Chillers (hereinafter Chiller)
  - (a) Divisions A and B of Normal/Emergency
    3 units [per division] (divisions A and B shares one stand-by unit)
  - (b) Divisions A and B of Emergency
    1 unit [per division]
  - (c) Division C of Normal/Emergency
    3 units (one stand-by unit)

(d) Division C of Emergency
1 unit

(2) HECW Chilled Water Pumps (hereinafter Chilled Water Pump)
(a) Divisions A and B of Normal/Emergency
3 units [per division] (divisions A and B shares single stand-by unit)
(b) Divisions A and B of Emergency
1 unit [per division]
(c) Division C of Normal/Emergency
3 units (one stand-by unit)
(d) Division C of Emergency
1 unit

(3) HECW Chemical Addition Tank (hereinafter Chemical Addition Tank)
1 unit [per division A, B and C each]

(4) Surge Tank [Sharing with Reactor Building Cooling Water System (RCW)]

(5) Piping and Valves
1 set with divisional segregation.

(6) Instrumentation and Control Devices
1 set with divisional segrergation.

Figure 16.1-2 to 16.1-4 show an outline of the HECW.

16.1.5.1.1.4 Modes of Operation

16.1.5.1.1.4.1 Normal Operations

(1) Divisions A and B
During normal operation, shutdown and refuelling outage, the HECW of normal/emergency supplies chilled water to the cooling coils of the RBEEE (A), (B)/Z HVAC, DGEE (A), (B)/Z HVAC , CBEEE(A), (B)/Z HVAC Supply Air Treatment Facilities. Twin Chiller / Chilled Water Pump set per division can achieve this, but triple Chiller / Chilled Water Pump set per division is required if the MCR (A) or (B) HVAC Supply Air Treatment Facilities are also required.

(2) Division C
Division C of the HECW of normal/emergency supplies chilled water to the cooling coils of the RBEEE (C)/Z HVAC, DGEE (C)/Z HVAC, CBEEE (C)/Z HVAC Supply Air Treatment Facilities. Twin Chiller / Chilled Water Pump set is operated during normal operation, shutdown and refuelling outage. All Chiller / Chilled Water Pump set not in operation is available in stand-by availability determined by lowest run time or manually as determined by plant operator.

16.1.5.1.1.4.2 Emergency Operations

In the event of faults such as LOCA and LOOP, the HECW of normal/emergency is operated in the same manner as Normal Operation. The HECW of emergency supplies chilled water to the cooling coils of the Hx/B-E (A), (B) and (C) Local Cooling Units, the EDG (A), (B) and (C) Local Cooling Units. The HECW of emergency is only operated during fault conditions such as LOCA and LOOP.

16.1.5.1.2 Safety Design Basis

This section describes the design bases for the HECW[Ref-17].

16.1.5.1.2.1 Safety Functions

The HECW has been designed to meet the following SFC. The relation between the SFCs put on this system and the high level claims is shown in Appendix-5.

<u>Normal Operations</u>

(1) The HECW provides chilled water for the Normal/Emergency HVAC during normal operation, shutdown and refuelling outage. This function is classified as Category A and the components to deliver it are designed to meet Class 1 requirements. [HECW_SFC_5-2.1]

<u>Fault Conditions</u>

(2) The HECW provides chilled water for Normal/Emergency and Emergency HVAC during fault conditions such as LOCA and LOOP. This function is classified as Category A and the components to deliver it are designed to meet Class 1 requirements. [HECW_SFC_5-2.2]

16.1.5.1.3 System Design Description

This section describes the design of the HECW to support and justify the delivery of HECW_SFC_5-2.1 and HECW_SFC_5-2.2. Additional design description can be found in [Ref-17] [Ref-18] [Ref-19] [Ref-20].

16.1.5.1.3.1 System Design and Operation

The HECW is a closed loop chilled water system. The system comprises three electrical and mechanical independent divisions designated A, B and C in accordance with three divisions of the Normal/Emergency and Emergency HVAC. Each HECW division contains chillers, chilled water pumps, valves, piping, chemical addition tanks, instrumentation and controls. Cooling water for the chiller condensers is supplied by the RCW.

During normal operation, shutdown, refuelling outage and fault conditions, the HECW is provided for keeping each Normal/Emergency and Emergency HVAC cooling function to specified capacity by supplying chilled water to the cooling coils of the MCR HVAC, RBEEE/Z HVAC, DGEE/Z HVAC, CBEEE/Z HVAC Supply Air Treatment Facilities and Hx/B-E Local Cooling Units , EDG Local Cooling Units.
The HECW continuous operation is assured by receiving the power supply provided by ED/G in the event of LOOP.

16.1.5.1.3.2 Equipment Design and Operation

16.1.5.1.3.2.1 Chiller

(1) Purpose
The purpose of the Chiller is to provide chilled water for the cooling coils of the Normal/Emergency HVAC Supply Air Treatment Facilities and Emergency Local Cooling Units.

(2) Configuration and Operation
Divisions A and B of the HECW of normal/emergency each contains three partial capacity chillers which provide chilled water to respective cooling coils serving the MCR (A) or (B)

HVAC, RBEEE (A), (B)/Z HVAC, DGEE (A), (B)/Z HVAC, CBEEE (A), (B)/Z HVAC and Supply Air Treatment Facilities.
Divisions A and B of the HECW of emergency each contain a single capacity chiller which provide chilled water to respective cooling coils serving the Hx/B-E (A), (B), the EDG (A), (B) Local Cooling Units.
During normal operation, shutdown, refuelling outage and fault conditions, the HECW supplies chilled water to the cooling coils of the RBEEE (A), (B)/Z HVAC, DGEE (A), (B)/Z HVAC, CBEEE (A), (B)/Z HVAC and the Hx/B-E (A), (B) Local Cooling Units, the EDG (A), (B) Local Cooling Units. Twin Chiller / Chilled Water Pump set per division can achieve this, but triple Chiller / Chilled Water Pump set per division is required if the MCR (A) or (B) HVAC Supply Air Treatment Facilities are also required.
Division C of the HECW of normal/emergency contains three 50 % capacity chillers which provide chilled water to respective cooling coils serving the RBEEE (C)/Z HVAC, DGEE (C)/Z HVAC, CBEEE (C)/Z HVAC Supply Air Treatment Facilities.
Divisions C of the HECW of emergency contain a single capacity chiller which provide chilled water to respective cooling coils serving the Hx/B-E (C) Local Cooling Unit, the EDG (C) Local Cooling Units. (HECW_SFC_5-2.1 and HECW_SFC_5-2.2)

(3) Performance
The Chiller is designed to perform as follows in order to deliver cooling function for the Normal/Emergency and Emergency HVAC. (HECW_SFC_5-2.1 and HECW_SFC_5-2.2)

Divisions A and B Chiller of normal/emergency
(a) Number: 6 units [3 units per division] (divisions A and B shares one stand-by unit)
(b) Cooling Capacity: 606 kW [per unit]
(c) Chilled Water Flow: 53 m^3/h [per unit]

Divisions A and B Chiller of emergency
(a) Number: 2 units [1 unit per division] (divisions A and B shares one stand-by unit)
(b) Cooling Capacity: 812 kW [per unit]
(c) Chilled Water Flow: 70 m^3/h [per unit]

Division C Chiller of normal/emergency
(d) Number: 3 units (one stand-by unit)
(e) Cooling Capacity: 518 kW [per unit]
(f) Chilled Water Flow: 45 m^3/h [per unit]

Division C Chiller of emergency
(g) Number: 1 unit
(h) Cooling Capacity: 797 kW
(i) Chilled Water Flow: 69 m^3/h

16.1.5.1.3.2.2 Chilled Water Pump

(1) Purpose
The purpose of the Chilled Water Pump is to supply chilled water for the cooling coils of the Normal/Emergency and Emergency HVAC Supply Air Treatment Facilities.

(2) Configuration and Operation
Divisions A and B of the HECW of normal/emergency each contain three partial capacity

pumps which supply chilled water to respective cooling coils serving the MCR (A) or (B) HVAC, RBEEE (A), (B)/Z HVAC, DGEE (A), (B)/Z HVAC, CBEEE (A), (B)/Z HVAC and Supply Air Treatment Facilities.
Divisions A and B of the HECW of emergency each contain a single capacity pump which supply chilled water to respective cooling coils serving the Hx/B-E (A), (B) Local Cooling Units, the EDG (A), (B) Local Cooling Units.
During normal operation, shutdown, refuelling outage and fault conditions, the HECW supplies chilled water to the cooling coils of the RBEEE (A), (B)/Z HVAC, DGEE (A), (B)/Z HVAC, CBEEE (A), (B)/Z HVAC and the Hx/B-E (A), (B) Local Cooling Units, the EDG (A), (B) Local Cooling Units. Twin Chiller / Chilled Water Pump set per division can achieve this, but triple Chiller / Chilled Water Pump set per division is required if the MCR (A) or (B) HVAC Supply Air Treatment Facilities are also required.
Division C of the HECW of normal/emergency contains three 50 % capacity pumps which supply chilled water to respective cooling coils serving the RBEEE (C)/Z HVAC, DGEE (C)/Z HVAC, CBEEE (C)/Z HVAC Supply Air Treatment Facilities.
Divisions C of the HECW of emergency contain a single capacity pump which supply chilled water to respective cooling coils serving the Hx/B-E (C) Local Cooling Unit, the EDG (C) Local Cooling Units. (HECW_SFC_5-2.1 and HECW_SFC_5-2.2)

(3) Performance
The Chilled Water Pump is designed to perform as follows in order to deliver cooling function for the Normal/Emergency and Emergency HVAC (HECW_SFC_5-2.1 and HECW_SFC_5-2.2).

Divisions A and B Pump of normal/emergency
(a) Number: 6 units [3 units per division] (divisions A and B shares one stand-by unit)
(b) Rated Flow: 53 m^3/h [per unit]

Divisions A and B Pump of emergency
(c) Number: 2 units [1 unit per division] (divisions A and B shares one stand-by unit)
(d) Rated Flow: 70 m^3/h [per unit]

Division C Pump of normal/emergency
(e) Number: 3 units (one stand-by unit)
(f) Rated Flow: 45 m^3/h [per unit]

Division C Pump of emergency
(g) Number: 1 unit
(h) Rated Flow: 69 m^3/h

16.1.5.1.3.3 Main Support Systems

The major support system related to delivery of the HECW safety functions are briefly described as follows.

16.1.5.1.3.3.1 Instrumentation and Control Systems

The C&I system is designed to achieve the required performance and reliability of the HECW necessary for the safety functions delivered by this system. Refer to Generic PCSR Chapter 14 “Control and Instrumentation (GA91-9101-0101-14000)” for further details.

16.1.5.1.3.3.2 Power Supply Systems

A summary of the main power supply systems are given as below and they are needed for ensuring HECW safety functions. Refer to Generic PCSR Chapter 15 "Electrical Power Supplies " for further details.

The normal AC power supply to the HECW electrical components are provided by an independent and off-site source (external grid). In addition, the HECW components, instruments and controllers are provided with emergency AC power supply and DC power supply.

The HECW is supplied power by emergency bus from the divisions A, B and C, which are backed up by ED/G for those divisions in the event of LOOP.

16.1.5.1.3.3.3 Reactor Building Cooling Water System (RCW)

The RCW supplies cooling water to the chiller condensers. The RCW is also divisionalised (A, B, C divisions) to ensure delivery of required safety functions.

Division A

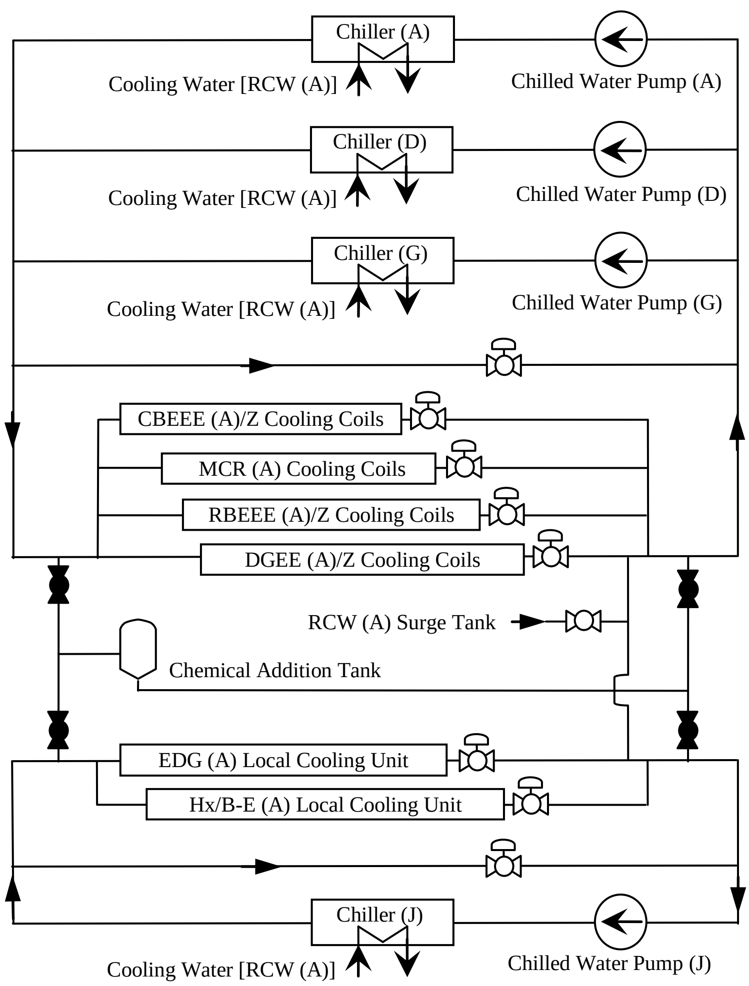
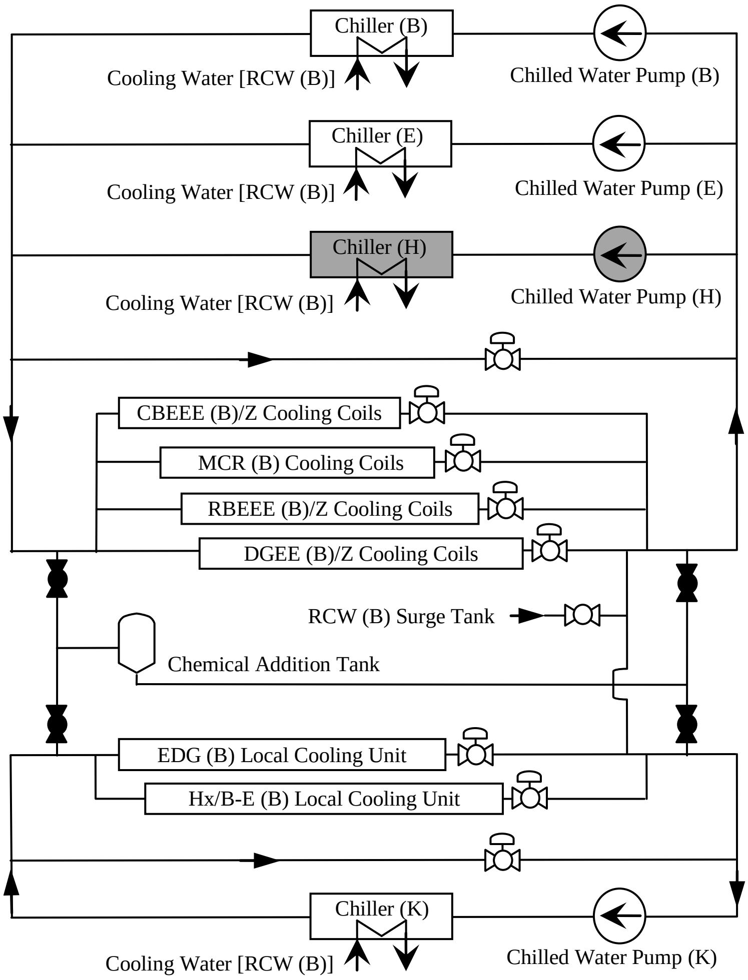


Figure 16.1-2 : Outline of the HECW (Division A)

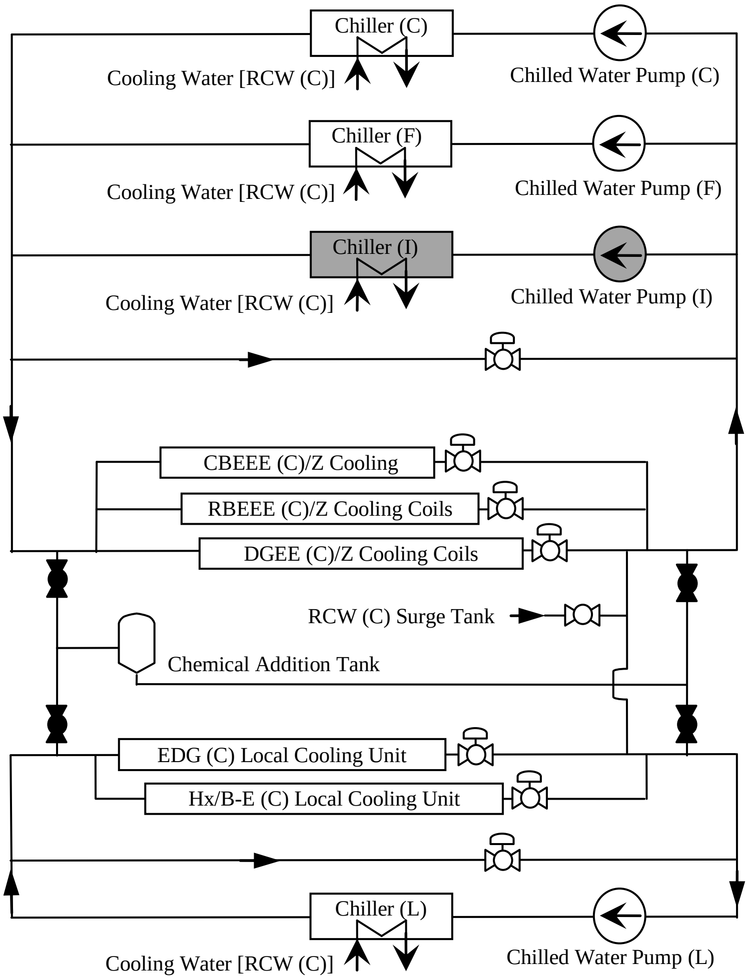
Division B



Note: This drawing shows a condition that Chiller (H) and Chilled Water Pump (H) are in standby.

Figure 16.1-3 : Outline of the HECW (Division B)

Division C



Note: This drawing shows a condition that Chiller (I) and Chilled Water Pump (I) are in standby.

Figure 16.1-4 : Outline of the HECW (Division C)

16.1.5.2 HVAC Normal Cooling Water System (HNCW)

16.1.5.2.1 System Summary Description

This section is a general introduction to the HNCW where the system roles, system functions, system configuration and modes of operation are briefly described. The HNCW is described in detail in the system specifications [Ref-21] and the Piping and Instrumentation Diagrams [Ref-22] [Ref-23] and [Ref-24].

16.1.5.2.1.1 System Roles

HNCW is designed to provide chilled water as a cooling medium to each cooling coil of the Drywell Cooling System (DWC) Dehumidifiers, the various Normal HVAC Supply Air Treatment Facilities and the Normal Local Cooling Units in the Reactor Building (R/B), Control Building (C/B), Turbine Building (T/B), Radwaste Building (Rw/B) and Service Building (S/B). The HNCW is operated during normal operation, shutdown and refuelling outage.

16.1.5.2.1.2 Function Delivered

The HNCW is designed to achieve the following function:

The HNCW supports the cooling function for the DWC Dehumidifiers, the various Normal HVAC Supply Air Treatment Facilities and the Normal Local Cooling Units during normal operation, shutdown and refuelling outage, by removing heat from these systems.

16.1.5.2.1.3 Basic Configuration

The HNCW main components are summarised as follows:
(1) HNCW Chiller (hereinafter Chiller)
5 units - 25 % each (1 unit stand-by)
(2) HNCW Chilled Water Pump (hereinafter Chilled Water Pump)
5 units - 25 % each (1 unit stand-by)
(3) HNCW Chemical Addition Tank (hereinafter Chemical Addition Tank)
1 set
(4) Surge Tank [Sharing with Turbine Building Cooling Water System (TCW)]
(5) Piping and Valves
1 set
(6) Instrumentation and Control Devices
1 set

Figure 16.1-3 shows an outline of the HNCW.

16.1.5.2.1.4 Modes of Operation

The HNCW can deliver the following operation modes.

16.1.5.2.1.4.1 Normal Operations

Up to four of the five Chiller / Chilled Water Pump sets are oprerated in plant normal operation, shutdown and refuelling outage based on the cooling load demand. One Chiller / Chilled Water Pump set is always available in stand-by.

16.1.5.2.1.4.2 Emergency Operations

In the event of faults such as LOCA and LOOP, the HNCW is inoperable. Supply and return chilled water pipelines which penetrate the Primary Containment Vessel (PCV) incorporate isolation valves which are automatically closed by LOCA signal to achieve Containment isolation.

16.1.5.2.2 Safety Design Basis

This section describes the design bases for the HNCW.

16.1.5.2.2.1 Safety Functions

The HNCW has been designed to meet the following SFCs. The relation between the SFCs put on this system and the high level claims is shown in Appendix-6.

Normal Operations and Fault Conditions

(1) HNCW provides chilled water for the DWC Dehumidifiers and the cooling coils of the various Normal HVAC Supply Air Treatment Facilities and the Normal Local Cooling Units. This function is classified as Category C and the components to deliver it are designed to meet Class 3 requirements. [HNCW_SFC_5-3.1]

(2) In the event of faults such as LOCA and LOOP, the HNCW is inoperable.

Fault Conditions

(3) The HNCW components within the PCVB are completely isolated by the PCIS in order to form barrier to confine the radioactive material within the containment boundary and prevent its dispersion to the environment in the event of faults.This safety function is developed and justified in the section related to the Primary Containment Facility in chapter 13.2. [PCIS_SFC_4-7.20]

16.1.5.2.3 System Design Description

This section describes the design of the HNCW to support and justify the delivery of HNCW_SFC_5-3.1 and HNCW_SFC_4-7.1. Additional design description can be found in [Ref-21] [Ref-22] [Ref-23] [Ref-24].

16.1.5.2.3.1 System Design and Operation

The HNCW is a closed loop chilled water system. The system is comprised of five chillers, five pumps, valves, piping, chemical addition tank, instrumentation and controls. Cooling water for the chiller condensers is supplied by the TCW.
During the plant normal operation, shutdown and refuelling outage, the HNCW supports the delivery of cooling and dehumidification within the drywell (via DWC) and to other parts of the plant by the Normal HVACs cooling function. The HNCW is designed to achieve the specified capacity of cooling by supplying chilled water to the DWC Cooling Dehumidifiers, the cooling coils of the various Normal HVAC Air Supply Treatment Facilities and the Normal Local Cooling Units.

In the event of faults such as LOCA and LOOP, the HNCW components are inoperable. Supply and return chilled water pipelines which penetrate the Primary Containment Vessel (PCV) incorporate isolation valves which are automatically closed by LOCA signal to isolate Containment.

16.1.5.2.3.2 Equipment Design and Operation

16.1.5.2.3.2.1 Chiller

(1) Purpose
The purpose of the Chiller is to provide chilled water for the DWC Dehumidifiers, the cooling coils of the Normal HVAC Supply Air Treatment Facilities and the Normal Local Cooling Units.

(2) Configuration and Operation
The HNCW contains five 25% capacity chillers which provide chilled water to respective cooling coils serving the Normal HVACs and the DWC Dehumidifiers. (HNCW_SFC_5-3.1)

(3) Performance
The Chiller is designed to perform as follows in order to deliver cooling and dehumidification within the drywell and the cooling function for the Normal HVACs. (HNCW_SFC_5-3.1)
(a) Number: 5 units [1 unit stand-by]
(b) Cooling Capacity: 2390 kW [per unit]
(c) Chilled Water Flow: 411 m^3/h [per unit]

16.1.5.2.3.2.2 Chilled Water Pump

(1) Purpose
The purpose of the Chilled Water Pump is to supply chilled water for the DWC Dehumidifiers, the cooling coils of the Normal HVAC Supply Air Treatment Facilities and the Normal Local Cooling Units.

(2) Configuration and Operation
The HNCW contains five 25% capacity Chilled Water Pumps which supply chilled water to respective cooling coils serving the Normal HVACs and the DWC Dehumidifiers. (HNCW_SFC_5-3.1)

(3) Performance
The Chilled Water Pump is designed to perform as follows in order to deliver cooling and dehumidification within the drywell and the cooling function for the Normal HVACs. (HNCW_SFC_5-3.1)

(a) Number: 5 units [1 unit stand-by]
(b) Rated Flow: 411 m^3/h [per unit]

16.1.5.2.3.3 Main Support Systems

The major support systems related to delivery of the HNCW safety functions are briefly described as follows.

16.1.5.2.3.3.1 Instrumentation and Control Systems

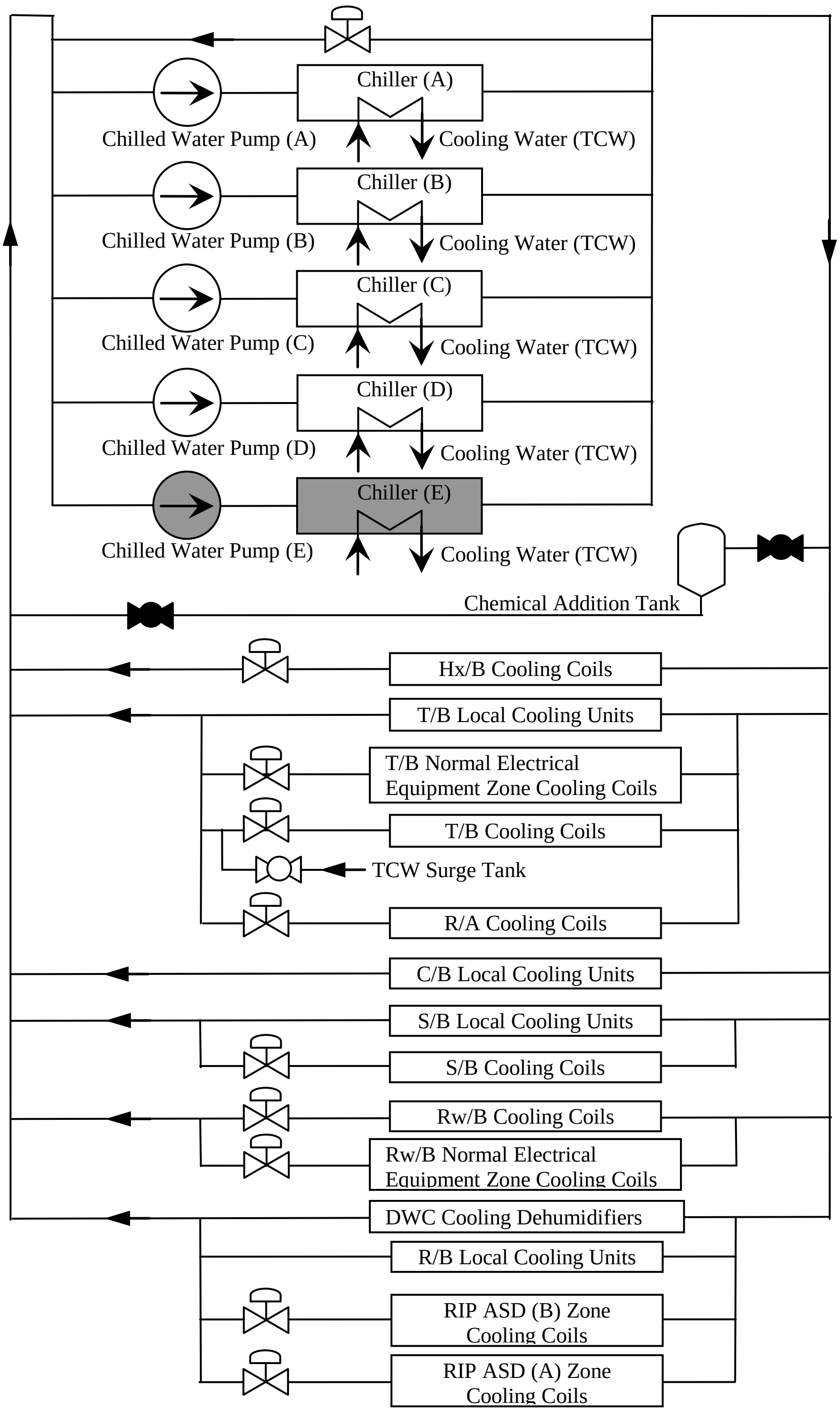
The C&I system is designed to achieve the required performance and reliability of the HNCW necessary for the safety functions delivered by this system.
Refer to Generic PCSR Chapter 14 "Control and Instrumentation (GA91-9101-0101-14000)" for further details.

16.1.5.2.3.3.2 Power Supply Systems

A summary of the main power supply systems are given as below and they are needed for ensuring HNCW safety functions. Refer to Generic PCSR Chapter 15 "Electrical Power Supplies" for further details.
Power supply for the Chillers and Chilled Water Pumps are supplied via the normal bus.

16.1.5.2.3.3.3 Turbine Building Cooling Water System (TCW)

The TCW supplies cooling water to the chiller condensers.



Note: This drawing shows a condition that Chiller (E) and Chilled Water Pump (E) are in standby.

Figure 16.1-5 : Outline of the HNCW

16.1.6 Emergency Equipment Cooling Water System

16.1.6.1 System Summary Description

This section is a general introduction to the Emergency Equipment Cooling Water System (EECW) where the systems roles, systems functions, systems configuration and modes of operation are briefly described. The EECW is described in detail in the system specifications [Ref-25] and the Piping and Instrumentation Diagrams[Ref-26] [Ref-27].

16.1.6.1.1 System Role

The main role of the EECW is to supply recirculation cooling water to the Backup Building Generators (BBG) in order to ensure power supply to the BBG loads in the event of frequent design basis faults with failure of the Class 1 core cooling systems, and in the event of beyond design basis faults and severe accidents.

16.1.6.1.2 Functions Delivered

The EECW is designed to perform the following functions:
(1) The EECW recirculates cooling water through a closed loop to remove heat from the BBG auxiliaries and transfers it to the Air Fin Coolers (AFCs)
(2) The EECW is provided with a heater and recirculates heated water during stand-by operation in winter time to prevent the cooling water in the outdoor and AFC piping from freezing.
(3) The EECW is provided with a surge tank to absorb the thermal expansion of cooling water accompanied by temperature fluctuation in the water and piping, to makeup cooling water in case of water leakage in the system and to maintain the EECW Pump intake pressure and ensure a time margin in the occurence of a cooling water leakage from the system.
(4) The EECW is provided with the EECW Chemical Addition Tank to inject corrosion inhibitor into the cooling water as necessary.

16.1.6.1.3 Basic Configuration

The EECW consists of the following components:

(1)	EECW Pump	2 units/division	x 2 divisions
(2)	AFC	1 units/division	x 2 divisions
(3)	Heater	1 units/division	x 2 divisions
(4)	Surge Tank	1 units/division	x 2 divisions
(5)	Chemical Addition Tank	1 unit for the system	
(6)	Piping and Valves		
(7)	Instrumentation and Controls		

16.1.6.1.4 Modes of Operation

The EECW can deliver the following operation modes:
(1) Stand-by Mode, Freezing Prevention Operation
The EECW is in stand-by during plant normal operation. In winter time, one EECW pump is continuously operated to recirculate cooling water heated by the EECW heater in order to prevent freezing of the water in the outdoor piping and the AFC.

(2) BBG Cooling Mode
When a BBG division is operating, the corresponding division of the EECW recirculates cooling water through a closed loop to remove heat from the BBG auxiliaries and transfer it to outside air through the AFCs. The EECW is automatically initiated upon BBG initiation.

16.1.6.2 Design Bases

This section describes the design bases for the EECW. [Ref-25]

16.1.6.2.1 Safety Functions

The EECW has been designed to meet the following SFCs. The relation between the SFCs put on this systems and the high level claims is shown in Appendix-7.

Fault Conditions
(1) The EECW is the principal means to remove heat from the Backup Building Generator (BBG) auxiliaries so that power can be supplied to the BBG loads in the event of frequent design basis faults with failure of the Class 1 core cooling system. [EECW_SFC_5-3.1]
(The EECW supports the delivery of a Category A safety function and the components necessary to deliver heat removal are designed to meet Class 2 requirements.)

Beyond Design Basis Fault Conditions
(2) The EECW is the principal means to remove heat from the Backup Building Generator (BBG) auxiliaries so that power can be supplied to the BBG loads in the event of beyond design basis faults and severe accidents. [EECW_SFC_5-3.2]
(The EECW supports the delivery of a Category B safety function and the components necessary to deliver heat removal are designed to meet Class 2 requirements.)

16.1.6.3 System Design Description

This section describes the design of the EECW to support and justify the delivery of EECW_SFC_5-3.1 and EECW_SFC_5-3.2. [Ref-25][Ref-26][Ref-27]

16.1.6.3.1 Overall System Design and Operation

16.1.6.3.1.1 Stand-by Mode, Freezing Prevention Operation

The EECW is in stand-by during plant normal operation.

In winter time, one EECW pump is continuously operated to recirculate cooling water heated by the EECW heater in order to prevent freezing of the water in the outdoor piping and the AFC. If the operating pump trips, the stand-by pump is started.

Also, a corrosion inhibitor is injected from the Chemical Addition Tank into the cooling water in order to prevent corrosion of the components, piping and valves as necessary.

16.1.6.3.1.2 BBG Cooling Mode

When a BBG division is operating, both pumps of the corresponding division of the EECW are activated to recirculate cooling water through the closed loop to remove heat from the BBG auxiliaries and transfer it to outside air through the AFCs. The EECW is automatically initiated upon BBG initiation.

16.1.6.3.2 Equipment Design and Operation

(1) EECW Pump
  (a) Purpose
  The EECW pumps send cooling water to the BBG auxiliaries and remove heat from them in order to deliver EECW_SFC_5-3.1 and EECW_SFC_5-3.2.
  (b) Configuration and Operation
  Each division of the EECW is provided with two 50 %-capacity pumps. One division of the EECW provides sufficient cooling water flowrate to cool one BBG division when the BBG is in Emergency Operation Mode.
  In stand-by operation in winter, one pump is continuously running together with the EECW Heater in order to prevent the water in the outside piping from freezing.
  (c) Performance
  The EECW Pump is designed to perform as follows in order to ensure the delivery of the safety functions:
    (i) Number: 2 units/division x 2 divisions
    (ii) Flow Rate: 150m^3/h/unit

(2) Air Fin Cooler
  (a) Purpose
  The AFCs cool the BBGs in order to preserve their power supply function by transferring heat energy from the EECW circulating water to the atmosphere in order to deliver EECW_SFC_5-3.1 and EECW_SFC_5-3.2.
  (b) Configuration and Operation
    (i) One AFC unit is provided for each division.
    (ii) One AFC unit is capable of cooling BBG auxiliaries under the condition of the design temperature of the air.
  (c) Performance
  The AFC is designed to perform as follows in order to ensure the delivery of the safety functions:
    (i) Number: 1 unit/division x 2 divisions
    (ii) Flow Rate: 300m^3/unit

16.1.6.3.3 Main Support Systems

16.1.6.3.3.1 Instrumentation and Control System

The main instrumentation and control provisions related to EECW operation from the performance and reliability points of view are summarised as follows.

(1) Instrumentation
  Instrumentation is provided to measure and monitor the operating conditions of the EECW components necessary for the delivery of the safety functions and thus ensure their performance and reliability. The status, measurements and alarms of the components and valves to be remotely operated are displayed in both the B/B and the MCR, and can be operated from one of them at a time.

(a) A pressure gauge is provided at the discharge of the EECW pump. An alarm is activated upon low discharge pressure.
(b) Temperature is locally indicated at the downstream of the AFC for monitoring.

(2) Control
The main control provisions related to the delivery of the safety functions by the EECW are summarised as follows.
(a) The EECW is capable of manual initiation by remote operation from the B/B or from the MCR. It cannot be operated from more than one of them at a time.
(b) The EECW Pumps and the AFC are initiated automatically upon startup of the BBG.

16.1.6.3.3.2 Power Supply System

(1) The normal AC power supply to the EECW electrical components is provided by an independent and off-site source (external grid).
(2) In the event of LOOP and startup of the BBGs, power is supplied by the BBGs installed in the B/B. The BBGs are designed to operate without cooling from the EECW until startup of the EECW pumps and full opening of the valves. The BBG is a source distinct from the Emergency Diesel Generators which provide power to the emergency systems installed in the R/B.

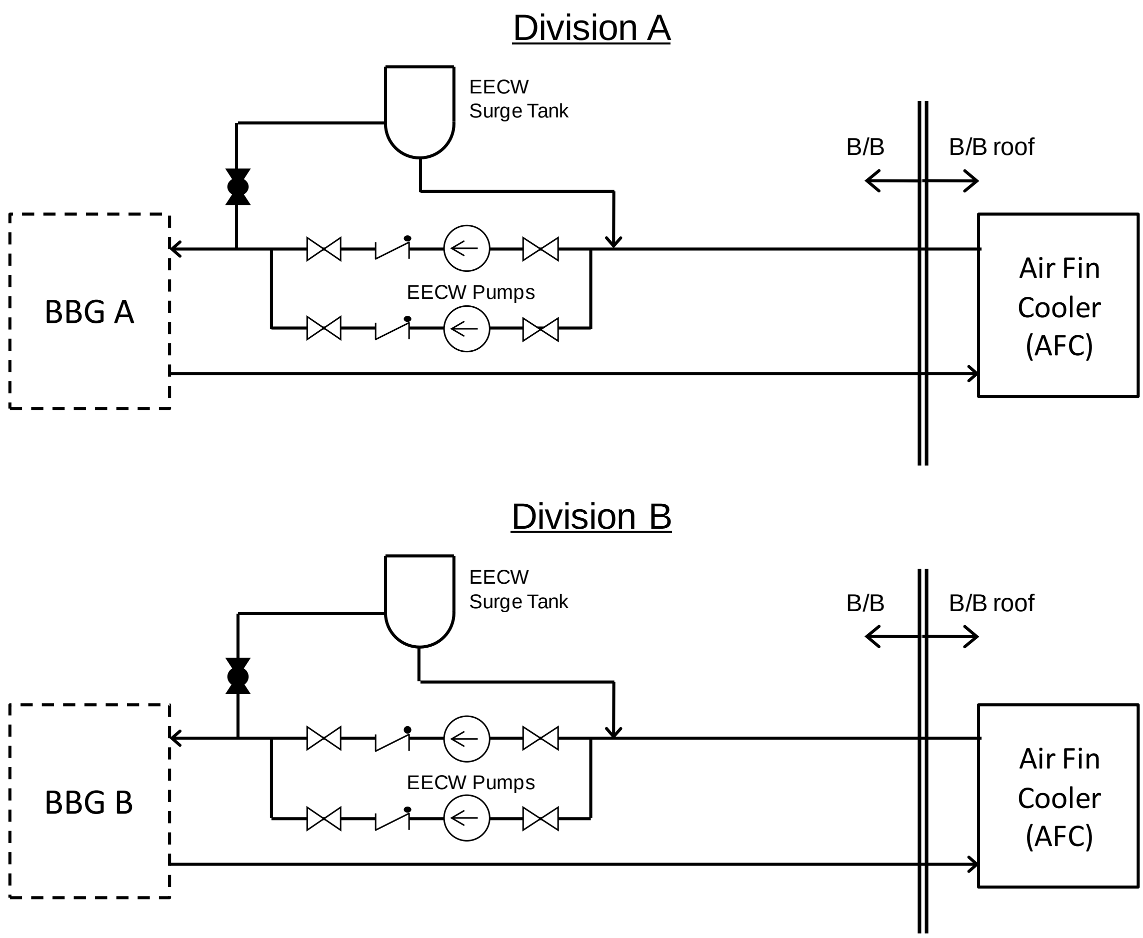


Figure 16.1-6 Outline of the EECW

16.1.7 Claims and Link to High Level Safety Functions

The list of claims in this sub chapter and the linkage to corresponding High Level Safety Functions is shown in Appendixes 1 to 7. A short description on the application of High Level Safety Fucntions in the development of the claims, arguments and evidence is provided in Generic PCSR Chapter 1 “Introduction (GA91-9101-0101-01000 (XE-GD-0214))”.

16.1.8 References

[Ref-1] Hitachi-GE Nuclear Energy, Ltd., "*Basis of Safety Cases on Reactor Building Cooling Water Systems*", GA91-9201-0002-00035 (SE-GD-0059) Rev.1, September 2014

[Ref-2] Hitachi-GE Nuclear Energy, Ltd., "*Basis of Safety Cases on Turbine Building Cooling Water Systems*", GA91-9201-0002-00036 (SBE-GD-0014), Rev.0, November 2014

[Ref-3] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System System Design Description*", GP25-1001-0001-00001 (SD-GD-0016) Rev.0, Octorber 2013

[Ref-4] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System P&ID (1/9)*", GP25-1001-0001-00001 (310QC98-333) Rev.0, March 2014

[Ref-5] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System P&ID (2/9)*", GP25-1001-0001-00002 (310QC98-334) Rev.0, March 2014

[Ref-6] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System P&ID (3/9)*", GP25-1001-0001-00003 (310QC98-335) Rev.0, March 2014

[Ref-7] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System P&ID (4/9)*", GP25-1001-0001-00004 (310QC98-336) Rev.0, March 2014

[Ref-8] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System P&ID (5/9)*", GP25-1001-0001-00005 (310QC98-337) Rev.0, March 2014

[Ref-9] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System P&ID (6/9)*", GP25-1001-0001-00006 (310QC98-338) Rev.0, March 2014

[Ref-10] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System P&ID (7/9)*", GP25-1001-0001-00007 (310QC98-339) Rev.0, March 2014

[Ref-11] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System P&ID (8/9)*", GP25-1001-0001-00008 (310QC98-340) Rev.0, March 2014

[Ref-12] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Cooling Water System P&ID (9/9)*", GP25-1001-0001-00009 (310QC98-341) Rev.0, March 2014

[Ref-13] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Service Water System System Design Description*", GP25-1001-0001-00001 (SD-GD-0017) Rev.0, May 2013

[Ref-14] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Service Water System P&ID (1/3)*", GP25-1001-0001-00001 (310QC98-343) Rev.0, March 2014

[Ref-15] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Service Water System P&ID (2/3)*", GP25-1001-0001-00002 (310QC98-344) Rev.0, March 2014

[Ref-16] Hitachi-GE Nuclear Energy, Ltd., "*Reactor Building Service Water System P&ID (3/3)*", GP25-1001-0001-00003 (310QC98-345) Rev.0, March 2014

[Ref-17] Hitachi-GE Nuclear Energy, Ltd., "*HVAC Emergency Cooling Water System System Design Description*", GP25-1001-0001-00001 (HPD-GD-H002) Rev.1, September 2014

[Ref-18] Hitachi-GE Nuclear Energy, Ltd., "*HVAC Emergency Cooling Water System P&ID (1/3)*", GP25-2101-0001-00001 (310QC67-568) Rev.0

[Ref-19] Hitachi-GE Nuclear Energy, Ltd., "*HVAC Emergency Cooling Water System P&ID (2/3)",* GP25-2101-0001-00002 (310QC67-569) Rev.0

[Ref-20] Hitachi-GE Nuclear Energy, Ltd., "*HVAC Emergency Cooling Water System P&ID (3/3)",* GP25-2101-0001-00003 (310QC67-585) Rev.0

[Ref-21] Hitachi-GE Nuclear Energy, Ltd., "*HVAC Normal Cooling Water System System Design Description*", GP24-1001-0001-00001 (HPD-GD-H003) Rev.0, Octorber 2014

[Ref-22] Hitachi-GE Nuclear Energy, Ltd., "*HVAC Normal Cooling Water Stystem P&ID (1/3)*", GP24-2101-0001-00001 (310QC67-570) Rev.1, November 2014

[Ref-23] Hitachi-GE Nuclear Energy, Ltd., "*HVAC Normal Cooling Water Stystem P&ID (2/3)*", GP24-2101-0001-00002 (310PB50-272) Rev.1, November 2014

[Ref-24] Hitachi-GE Nuclear Energy, Ltd., "*HVAC Normal Cooling Water Stystem P&ID (3/3)*", GP24-2101-0001-00003 (310QC67-572) Rev.1, November 2014

[Ref-25] Hitachi-GE Nuclear Energy, Ltd., "*Emergency Equipment Cooling Water System System Design Description*", GP27-1001-0001-00001 (SD-GD-0040) Rev.0, Octorber 2013

[Ref-26] Hitachi-GE Nuclear Energy, Ltd., "*Emergency Equipment Cooling Water System P&ID (1/2)*", GP27-2101-0001-00001 (310QC98-342) Rev.0, March 2014

[Ref-27] Hitachi-GE Nuclear Energy, Ltd., "*Emergency Equipment Cooling Water System P&ID (2/2)*", GP27-2101-0001-00002 (310QC98-361) Rev.0, March 2014

[Ref-28] Hitachi-GE Nuclear Energy, Ltd. *"Topic Report on Fault Assessment"*, GA91-9201-0001-00022 (UE-GD-0071) Rev. 2, May 2015

[Ref-29] Hitachi-GE Nuclear Energy, Ltd. *"List of Safety Category and Class for UK ABWR"* GA91-9201-0003-00266 (AE-GD-0224) Rev. 1, June 2015

16.1.9 Appendixes

Appendix-1: Claim tree for Ch. 16.1.1 (UHS)
Appendix-2: Claim tree for Ch. 16.1.2 (RCW/RSW)
Appendix-3: Claim tree for Ch. 16.1.3 (TCW/TSW)
Appendix-4: Claim tree for Ch. 16.1.4.1 (MUWC)
Appendix-5: Claim tree for Ch. 16.1.5.1 (HECW)
Appendix-6: Claim tree for Ch. 16.1.5.2 (HNCW)
Appendix-7: Claim tree for Ch. 16.1.6.2 (EECW)

16.1.9.1 Appendix-1: Claim tree for Ch. 16.1.1 (UHS)

	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)		PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
1	5	Others	5-2	Supporting functions especially important to safety	FS7	Reactor Core Cooling	Normal Operations and Fault Conditions	UHS_SFC_5-2.1	The UHS is the principal means to provide sufficient cooling water to the RSW to dissipate the heat from the plant auxiliaries required for normal operation, normal reactor shutdown, hot stand-by with off-site power and main condenser available, hot stand-by under LOOP and main condenser unavailable, and Loss of Coolant Accident (LOCA) accident conditions.
					FS10	Reactor Core Cooling			
					FS14	Long-term Heat Removal			

16.1.9.2 Appendix-2: Claim tree for Ch. 16.1.2 (RCW/RSW)

	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)		PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
1	5	Others	5-2	Supporting functions especially important to safety	FS7 FS10 FS14	Reactor Core Cooling Reactor Core Cooling Long-term Heat Removal	Normal Operations and Fault Conditions	RCW-RSW_SFC_5-2.1	The RCW and RSW are the principal means to remove heat from plant Class 1 auxiliaries required for normal operation, normal reactor shutdown, hot stand-by, hot stand-by under LOOP with main condenser unavailable and infrequent faults such as LOCA.
2	5	Others	5-2	Supporting functions especially important to safety	-	No claim	Normal Operations and Fault Conditions	RCW-RSW_SFC_5-2.2	The RCW and RSW are the principal means to remove heat from plant Class 2 auxiliaries required for normal operation, normal reactor shutdown, hot stand-by, hot stand-by under LOOP with main condenser unavailable and infrequent faults such as LOCA.
3	5	Others	5-12	Supporting functions to supply power (except for emergency supply)	-	No claim	Normal Operations and Fault Conditions	RCW-RSW_SFC_5-12.1	The RCW and RSW are the principal means to remove heat from plant Class 3 auxiliaries required for normal operation, normal reactor shutdown, hot stand-by, hot stand-by under LOOP with main condenser unavailable and infrequent faults such as LOCA.
4	4	Confinment/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	No claim	Fault Conditions	PCIS SFC 4-7.11	The RCW components within the PCVB are completely isolated by the PCIS in order to form barrier to confine the radioactive material within the containment boundary and prevent its dispersion to the environment in the event of faults.

16.1.9.3 Appendix-3: Claim tree for Ch. 16.1.3 (TCW/TSW)

	Top Claim for mechanical system						Safety Functional Claim (SFC) for the mechanical system and components		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (GA91-9201-0003-00266) Table 3-1 High Level Key Safety Functions and Safety Classification for UK ABWR)		PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (GA91-9201-0003-00266) Table 3-1 High Level Key Safety Functions and Safety Classification for UK ABWR)		Topic Report on Fault Assessment (GA91-9201-0001-00022) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
1	5	Others	5-11	Supporting functions to supply power (except for emergency supply)	-	No claim	Normal Operations	TCW SFC 5-11.1	The TCW supplies cooling water to turbine auxiliary equipments.
2	5	Others	5-11	Supporting functions to supply power (except for emergency supply)	-	No claim	Normal Operations	TSW SFC 5-11.2	The TSW supplies service water to the TCW Heat Exchanger and removes heat from the TCW.

16.1.9.4 Appendix-4: Claim tree for Ch. 16.1.4.1 (MUWC)

	Top Claim for mechanical system						Safety Functional Claim (SFC) for the mechanical system and components		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (GA91-9201-0003-00266) Table 3-1 High Level Key Safety Functions and Safety Classification for UK ABWR)		PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (GA91-9201-0003-00266) Table 3-1 High Level Key Safety Functions and Safety Classification for UK ABWR)		Topic Report on Fault Assessment (GA91-9201-0001-00022) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
1	5	Others	5-10	Supporting functions to supply power (except for emergency supply)	-	No claim	Normal Operations	MUWC SFC 5-10.1	The MUWC supplies required to condensate to each component.
2	2	Fuel Cooling	2-1	Functions to cool reactor core	-	No claim	Fault Conditions	MUWC SFC 2-1.1	The CST is used as a water source for the Reactor Core Isolation Cooling System (RCIC) and High Pressure Core Flooding System (HPCF) in the event of frequent and infrequent faults such as LOCA.
3	4	Confinement / Containment of radioactive materials	4-7	Functions to contain reactor coolant	-	No claim	Fault Conditions	PCIS SFC 4-7.21	The MUWC components within the PCVB are completely isolated by the PCIS in order to form barrier to confine the radioactive material within the containment boundary and prevent its dispersion to the environment in the event of faults.
4	4	Confinement / Containment of radioactive materials	4-3	Functions to contain reactor coolant	-	No claim	Normal Operations and Fault Conditions	MUWC SFC 4-3.1	The MUWC contains reactor coolant which is beyond the reactor coolant pressure boundary .

16.1.9.5 Appendix-5: Claim tree for Ch.16.1.5.1 (HECW)

	Top Claim for mechanical system						Safety Functional Claim (SFC) for the mechanical system and components		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)		PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
1	5	Others	5-2	Supporting functions especially important to safety	-	No Claim	Normal Operations	HECW_SFC_5-2.1	The HECW provides chilled water for the Normal/Emergency HVAC during normal operation, shutdown and refuelling outage.
2	5	Others	5-2	Supporting functions especially important to safety	5.1	Short term LOOP	Fault Scenarios	HECW_SFC_5-2.2	The HECW provides chilled water for the Normal/Emergency and Emergency HVAC during fault conditions such as LOCA and LOPA.
					5.1.2	Short-term LOOP with CCF of initiation signal			
					5.1.3	Short-term LOOP with digital CCF			
					5.2	Medium term LOOP			
					5.2.2	Medium term LOOP with CCF of initiation signal			
					5.2.3	Medium term LOOP with digital CCF			
					5.3	Long term LOOP			
					5.3.2	Long term LOOP with CCF of initiation signal			
					5.3.3	Long term LOOP with digital CCF			
					7.1	LOCA - RPV bottom drain line break			
					7.2	Small line break LOCA			
					8.1	LOCA - HPCF line break			
					8.2	LOCA - LPFL line break			
					9.1	LOCA - FWD line break			
					9.2	LOCA - MS line break			
					9.3	LOCA - RHR line break			
					10.1	LOCA outside PCV - MS line break			
					10.2	LOCA outside PCV - CUW line break			

16.1.9.6 Appendix-6: Claim tree for Ch. 16.1.5.2 (HNCW)

	Top Claim for mechanical system						Safety Functional Claim (SFC) for the mechanical system and components		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)		PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
1	5	Others	5-3	Supporting functions to supply power (except for emergency supply)	-	No Claim	Normal Operations and Fault Scenarios	HNCW_SFC_5-3.1	The HNCW provides chilled water for the DWC Dehumidifiers and the cooling coils of the various Normal HVAC Supply Air Treatment Facilities and the Normal Local Cooling Units. In the event of faults such as LOCA and LOOP, the HNCW is inoperable.
2	4	Confinement/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	-	No Claim	Fault Conditions	PCIS_SFC_4-7.20	The HNCW components within the PCVB are completely isolated by the PCIS in order to form barrier to confine the radioactive material within the containment boundary and prevent its dispersion to the environment in the event of faults.

16.1.9.7 Appendix-7: Claim tree for Ch. 16.1.6.2 (EECW)

	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)		PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
1	5	Others	5-3	Function of alternative supporting systems	1.1	Generator load rejection	Fault Conditions	EECW_SFC_5-3.1	The EECW is the principal means to remove heat from the Backup Building Generator (BBG) auxiliaries so that power can be supplied to the BBG loads in the event of frequent design basis faults with failure of the Class 1 core cooling system.
					1.2	Partial loss of reactor flow (trip of 4 RIPs)			
					1.3	Loss of reactor flow (trip of all RIPs)			
					1.4	Feedwater controller failure - Maximum demand			
					1.5	Recirculation flow control failure (runout of all RIPs)			
					1.6	Loss of feedwater heating			
					1.7	Reactor pressure regulator failure in the closed direction			
					1.8	Inadvertent control valve closure			
					1.10	Inadvertent opening of all ADS			
					2.1	Inadvertent MSIV closure			
					2.2	Reactor pressure regulator failure in the open direction			
					2.3	Loss of main condenser vacuum			
					2.4	Radiation monitor failure			
					3.1	Loss of all feedwater flow			
					3.2	Inadvertent startup of all injection system			
					4.1	Control rod withdrawal error at reactor startup			
					4.2	Control rod withdrawal error at power			
					4.4	Inadvertent reactor SCRAM (CRD pump trip)			
					4.6	SRNM or APRM sensor failure			
					5.1	Short term LOOP			
					5.1.2	Short-term LOOP with CCF of initiation signal			
					5.1.3	Short-term LOOP with digital CCF			
					5.2	Medium term LOOP			
					5.2.1	Medium term LOOP with CCF of EDGs			
					5.2.2	Medium-term LOOP with CCF of initiation signal			
					5.2.3	Medium-term LOOP with digital CCF			

	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)		PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
					5.3	Long-term LOOP			
					5.3.1	Long-term LOOP with CCF of EDGs			
					5.3.2	Long-term LOOP with CCF of initiation signal			
					5.3.3	Long-term LOOP with digital CCF			
					5.3.4	Long term LOOP with CCF of EDGs and CCF of B/B DGs			
					6.1	Inadvertent opening of a SRV			
					7.2	LOCA - small line break			
2	5	Others	5-3	Function of alternative supporting systems	-	TBD	Beyond Design Basis Fault Conditions	EECW_SFC_5-3.2	The EECW is the principal means to remove heat from the Backup Building Generator (BBG) auxiliaries so that power can be supplied to the BBG loads in the event of beyond design basis faults and severe accidents.