GE Hitachi Nuclear Energy

NEDO-34171
Revision A
January 2025

US Protective Marking: Non-Proprietary Information
UK Protective Marking: Not Protectively Marked

BWRX-300 UK Generic Design Assessment (GDA)
Chapter 9A – Auxiliary Systems

NEDO-34171 Revision A

INFORMATION NOTICE

This document does not contain proprietary information and carries the notations "US Protective Marking: Non-Proprietary Information" and "UK Protective Marking: Not Protectively Marked."

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

The design, engineering, and other information contained in this document is furnished for the purpose of obtaining the applicable Nuclear Regulatory Authority review and determination of acceptability for use for the BWRX-300 design and licensing basis information contained herein. The only undertakings of GEH with respect to information in this document are contained in the contracts between GEH and its customers or participating utilities, and nothing contained in this document shall be construed as changing those contracts. The use of this information by anyone for any purpose other than that for which it is intended is not authorized; and with respect to any unauthorized use, no representation or warranty is provided, nor any assumption of liability is to be inferred as to the completeness, accuracy, or usefulness of the information contained in this document. Furnishing this document does not convey any license, express or implied, to use any patented invention or any proprietary information of GEH, its customers or other third parties disclosed herein or any right to publish the document without prior written permission of GEH, its customers or other third parties.

UK SENSITIVE NUCLEAR INFORMATION AND US EXPORT CONTROL INFORMATION

This document does not contain any UK Sensitive Nuclear Information (SNI) subject to protection from public disclosure as described in the Nuclear Industries Security Regulations (NISR) 2003, does not contain UK Export Controlled Information (ECI), and does not contain US Export Controlled Information (ECI) subject to the export control laws and regulations of the United States, including 10 CFR Part 810.

EXECUTIVE SUMMARY

This Preliminary Safety Report (PSR) chapter has two main parts. Chapter 9A provides information about the auxiliary systems not included in other PSR chapters. Chapter 9B of the PSR provides information on the civil structures of the plant.

The purpose of this chapter is to describe the BWRX-300 Auxiliary Systems, and how they will comply with design and safety requirements, including:

- Fuel Storage and Handling Systems
- Water Systems
- Process Auxiliary Systems
- Air and Gas System
- Heating, Ventilation and Air Conditioning Systems
- Fire Protection Systems
- Supporting Systems for Diesel Generators
- Overhead Lifting Equipment
- Miscellaneous Auxiliary Systems

The chapter presents a level of detail commensurate with a 2 Step Generic Design Assessment (GDA) and is structured in line with the high-level contents of SSG-61.

This PSR chapter describes how the above systems will comply with their associated design and safety/non-safety requirements. The scope of this chapter is the Auxiliary Systems. System interfaces/dependencies will be identified, and suitable cross references used to direct the reader to the relevant chapter of the PSR. The BWRX-300 approach to classifying of Structures, Systems and Components (SSCs) is discussed in PSR Ch. 3, Section 3.2.

Claims and arguments relevant to GDA step 2 objectives and scope are summarised in Appendix A, along with an As Low As Reasonably Practicable (ALARP) position. Appendix B provides a Forward Action Plan (FAP), which includes future work commitments and recommendations for future work where ‘gaps’ to GDA expectations have been identified.

ACRONYMS AND ABBREVIATIONS

Acronym	Explanation
ABWR	Advanced Boiling Water Reactor
AHU	Air Handling Unit
ALARP	As Low As Reasonably Practicable
AOO	Anticipated Operational Occurrence
AOV	Air Operated Valve
ASD	Adjustable Speed Drive
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
BIS	Boron Injection System
BPVC	Boiler and Pressure Vessel Code
BWR	Boiling Water Reactor
CAE	Claims, Argument, Evidence
CB	Control Building
CCS	Containment Cooling System
CEAP	Continuous Exhaust Air Plenum
CFD	Condensate Filters and Demineralisers System
CFS	Condensate and Feedwater Heating System
CHE	Cranes, Hoists, and Elevators
CIS	Containment Inerting System
CIV	Containment Isolation Valve
CRB	Control Rod Blade
CRD	Control Rod Drive
CRE	Control Room Envelope
CUW	Reactor Water Cleanup System
CWE	Chilled Water Equipment
CWS	Circulating Water System
D-in-D	Defence-in-Depth
DBA	Design Basis Accident
DCIS	Distributed Control and Information System
DFS	Dry Fuel Store
DL	Defence Line
DL2	Defence Line 2
DL3	Defence Line 3
DL4a	Defence Line 4a
DL4b	Defence Line 4b

Acronym	Explanation
DZO	Depleted Zinc Oxide
EFAN	Exhaust Fan
EFS	Equipment and Floor Drain System
EFU	Emergency Filter Unit
EHC	Electro-Hydraulic Control
EME	Emergency Mitigating Equipment
EMIT	Examination, Maintenance, Inspection and Testing
EPRI	Electric Power Research Institute
EQ	Environmental Qualification
FAC	Flow Accelerated Corrosion
FAP	Forward Action Plan
FCU	Fan Coil Unit
FCV	Flow Control Valve
FE	Flow Element
FHA	Fire Hazards Assessment
FP	Fire Protection
FPC	Fuel Pool Cooling and Cleanup System
FPP	Fire Protection Program
FPS	Fire Protection System
FSSA	Fire Safe Shutdown Analysis
FT	Flow Transmitter
FW	Feedwater
GDA	Generic Design Assessment
GEH	GE Hitachi Nuclear Energy
GEZIP	General Electric Zinc Injection Passivation
HCW	High Conductivity Waste
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
HVS	Heating Ventilation and Cooling System
HX	Heat Exchanger
I&C	Instrumentation and Control
IAEA	International Atomic Energy Agency
IC	Isolation Condenser
ICC	Isolation Condenser Cooling & Cleanup System
ICS	Isolation Condenser System
IGSCC	Intergranular Stress Corrosion Cracking

Acronym	Explanation
ISI	In-Service Inspection
IST	In-Service Testing
LED	Light Emitting Diode
LfE	Learning from Experience
LOCA	Loss-of-Coolant Accident
LOPP	Loss-of-Preferred Power
LWM	Liquid Waste Management System
MCA	Main Condenser and Auxiliaries
MCR	Main Control Room
MERV	Minimum Efficiency Reporting Value
MFAP	Main Fire Alarm Panel
MSR	Moisture Separator Reheater System
MSRIV	Main Steam Reactor Isolation Valve
MTE	Main Turbine Equipment
NEI	Nuclear Energy Institute
NFPA	National Fire Protection Association
NHS	Normal Heat Sink
NPP	Nuclear Power Plant
NPSH	Net Positive Suction Head
OGS	Offgas System
OLNC	On-Line NobleChem™
OPEX	Operational Experience
PAM	Post-Accident Monitoring
PCCS	Passive Containment Cooling System
PCW	Plant Cooling Water System
PLSA	Plant Services Area
PPS	Plant Pneumatics System
PREMS	Process Radiation and Environmental Monitoring System
PSR	Preliminary Safety Report
PVS	Plant Vent Stack
RB	Reactor Building
RBS	Reactor Building Structure
RCS	Reactor Coolant System
RES	Refueling and Servicing Equipment System
RGP	Relevant Good Practice
RIV	Reactor Isolation Valve

Acronym	Explanation
RP	Requesting Party
RPV	Reactor Pressure Vessel
RWB	Radwaste Building
RWST	Refuelling Water Storage Tank
SBO	Station Blackout
SC1	Safety Class 1
SC2	Safety Class 2
SC3	Safety Class 3
SCCV	Steel-Plate Composite Containment Vessel
SCDS	Safety Case Development Strategy
SCN	Non-Safety Class
SCR	Secondary Control Room
SDC	Shutdown Cooling System
SDD	System Design Description
SDG	Standby Diesel Generator
SSCs	Structures, Systems and Components
SSE	Safe Shutdown Earthquake
SWM	Solid Waste Management System
TB	Turbine Building
TBS	Turbine Building Structure
TCPL	Temperature Control Panel
TMR	Triple Modular Redundant
TS	Technical Specifications
UHS	Ultimate Heat Sink
UK	United Kingdom
UL	Underwriters Laboratory
USNRC	U.S. Nuclear Regulatory Commission
WGC	Water, Gas, and Chemical Pads

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

REVISION SUMMARY

Revision #	Section Modified	Revision Summary
A	All	Initial Issuance

9A AUXILIARY SYSTEMS

Chapter 9 of the PSR has two main parts. PSR Ch. 9A provides information about the auxiliary systems not included in other PSR chapters. PSR Ch. 9B: Civil Structures (Reference 9A-1) provides information on the civil structures of the plant.

The purpose of this chapter is to describe the BWRX-300 Auxiliary Systems, and how they will comply with design and safety requirements, including:

- Fuel Storage and Handling Systems
- Water Systems
- Process Auxiliary Systems
- Air and Gas System
- Heating, Ventilation and Air Conditioning Systems
- Fire Protection Systems
- Supporting Systems for Diesel Generators
- Overhead Lifting Equipment
- Miscellaneous Auxiliary Systems

The chapter presents a level of detail commensurate with a 2 Step GDA (claims and arguments only) and is structured in line with the high-level contents of SSG-61.

This chapter will also describe how the above systems will comply with their associated design and safety requirements. The scope of this chapter is the Auxiliary Systems. System interfaces /dependencies will be identified, and suitable cross references used to direct the reader to the relevant chapter of the PSR. The BWRX-300 approach to classifying of SSCs is discussed in PSR Ch. 3: Safety Objectives and Design Rules for SSCs (Reference 9A-2), Section 3.2.

Claims and arguments relevant to GDA step 2 objectives and scope are summarised in Appendix A, along with an ALARP position. Appendix B provides a FAP, which includes future work commitments and recommendations for future work where ‘gaps’ to GDA expectations have been identified.

9A.1 Fuel Storage and Handling Systems

9A.1.1 Fresh Fuel Storage and Handling System

The description below of the BWRX-300 fuel storage and handling system aligns with 006N5377 “Refueling and Servicing Equipment” System Design Description (SDD) (Reference 9A-3). The BWRX-300 design does not include separate new fuel storage facilities such as new fuel storage vaults, new fuel storage pool, and new fuel storage racks. Following receipt and inspection, new fuel is placed in storage racks located in the fuel pool. The storage racks used for new fuel storage are the same as those used for spent fuel storage. Because new fuel is stored with spent fuel in the same fuel pool, the Design Basis, Facilities Description, and Safety Evaluation associated with spent fuel, as presented in Section 9A.1.2, also addresses storage of new fuel in the fuel pool.

The following information is provided in support of the requirements of International Atomic Energy Agency (IAEA) SSR2/1 Requirement 80 (Reference 9A-4) relative to new fuel storage and handling:

1. Nuclear criticality safety, refer to Section 9A.1.2.3.1 (Nuclear criticality safety).
2. Maintenance, periodic inspection, and testing of components important to safety, refer to Section 9A.1.2.8 (Monitoring, Inspection, Testing, and Maintenance).
3. Inspection of non-irradiated fuel, refer to PSR Ch. 28: Safeguards Annex (Reference 9A-5) and PSR Ch. 4: Reactor (Fuel and Core) (Reference 9A-6).
4. Prevent loss of or damage to the fuel, Section 9A.1.2.3.10 addresses the identification of specific fuel bundles, Section 9A.1.2.3.5 addresses the design for precluding dropping of the fuel, Section 9A.1.4 addresses fuel handling and cask loading equipment and Section 9A.8 addresses movement of heavy loads in the vicinity of the fuel pool.
5. Meet safeguards requirements for recording and reporting accountancy data, and for monitoring flows and inventories related to non-irradiated fuel containing fissile material, refer to PSR Ch. 28: Safeguards.

9A.1.2 Spent Fuel Storage and Handling System

The description below of the BWRX-300 Spent Fuel Storage and Handling System aligns with 006N5377 (Reference 9A-3). The fuel pool is used to store spent fuel after discharging and new fuel after delivery to the site and before core loading. The fuel pool is in the Reactor Building (RB). The refueling equipment and servicing system provides the equipment and facilities for receipt, storage, and installation of new fuel assemblies, as well as removal and storage of spent fuel assemblies. In support of refueling outages, the refueling equipment and servicing system also provides equipment and facilities for servicing the Reactor Pressure Vessel (RPV) pressure boundary and internal components, refuel cavity seal, and containment closure head.

The refueling equipment and servicing system includes general plant facilities required to support handling of nuclear fuel elements and radioactive equipment.

The above grade portion of the RB structure houses the refueling floor, refueling and fuel handling systems (Reference 9A-3), fuel pool, and Reactor Building Polar Crane.

9A.1.2.1 System and Equipment Functions

System and equipment functions associated with the Fuel Storage and Handling System include the following (Reference 9A-3):

Normal Functions (Non-Safety Category)

The refueling and servicing equipment system provides the following normal non-safety functions:

- Permit disassembly and re-assembly of containment and reactor.
- Permit reactor refueling.
- Permit new and spent fuel storage in fuel pool.
- Permit replacement of reactor mechanical components.
- Permit replacement of nuclear instrumentation.
- Support various outage maintenance.
- Maintain subcriticality during fuel and core component handling operations.

Normal Functions (Safety Category)

The fuel pool provides the following Safety Category 1 functions to assure the subcriticality of stored nuclear material:

- Maintain the fuel assemblies in a safe and subcritical array.
- Provide a safe means of loading the spent fuel assemblies into shipping or storage containers.

Off-Normal Functions (Non-Safety Category)

- Fuel Storage and Handling System does not perform any Non-Safety Category functions during off-normal conditions.

Off-Normal Functions (Safety Category)

- Fuel Storage and Handling System does not perform any Safety Category functions during off-normal conditions.

9A.1.2.2 Safety Design Bases

The majority of refueling equipment and servicing system components are classified as Non-Safety Class (SCN) and Non-Seismic, and some non-pressure boundary components have augmented structural quality requirements. The system components which are categorised otherwise are as follows:

- The refueling platform is Safety Class 3 (SC3) and Seismic Category 2. Quality requirements for the refueling platform are augmented due to its unique function of handling fuel.
- The fuel storage rack is SC3 and Seismic Category 1B.
- The auxiliary work platform and 360 work platform are SCN and Seismic Category 2.

The BWRX-300 Steel-Plate Composite Containment Vessel (SCCV), described in NEDC-33926 “BWRX-300 Steel-Plate Composite Containment Vessel (SCCV) and Reactor” (Reference 9A-7), and the main RB structure including the reactor cavity, equipment pool and fuel pool are classified as Safety Class 1 (SC1) and Seismic Category 1A (005N9341, “BWRX-300 General Civil Structural Design Criteria” (Reference 9A-8)).

9A.1.2.3 Description of System

The reactor building fuel pool provides for storage of new and spent fuel, along with the in-core components removed from the RPV during refueling. The fuel pool is directly adjacent to the reactor cavity, with the capability of being isolated by means of a removable gate. The fuel pool base mat is located at the power block grade elevation and the fuel pool extends up to the refuel floor elevation. The structure of the fuel pool is composed of Diaphragm Plate - Steel Plate Composite walls that are lined for corrosion protection and resistance to abrasion and damage from radiation exposure.

The fuel pool size is determined by the volume of cooling water, size of the fuel storage racks, with control rod blade guides, other equipment required to be stored in the pool and lay-down areas. Refueling outage equipment such as lights, test weights, dummy fuel bundles, and control blades are also stored in the fuel pool. The fuel preparation machine is located on the fuel pool periphery. The new fuel inspection stand is mounted on the refuel floor away from the fuel pool periphery and only used for new fuel before it is installed into the water and to the fuel prep machine. Used reactor core instruments may also be stored in the fuel pool, until such time as they are cut up and packaged.

Additional information pertaining to the design of the new and spent fuel storage system is presented below.

9A.1.2.3.1 Nuclear Criticality Safety

Regarding criticality safety of new and spent fuel storage, the following guidance documents are considered and applied as applicable in the design of the storage and handling for new and spent fuel assemblies: ANSI/ANS-57.2 and ANSI/ANS-57.3.

Within the pool are fuel storage racks in a grid pattern, the racks are capable of maintaining new and spent fuel subcritical. A full array in the loaded fuel rack is designed to be subcritical by at least 5% Δk.

The fuel storage racks are made of stainless steel and borated stainless steel based on Type 304 stainless steel. The storage rack geometry and material are designed to preclude the possibility of criticality under normal and credible abnormal conditions. The design of the fuel storage racks does not require loading patterns or zones for storage of the fuel assemblies. The design of the fuel storage racks eliminates the possibility of an inadvertent criticality occurring due to the selection of an inappropriate storage location or region.

The fuel handling system (i.e., Light Load Handling System) conforms to the applicable guidance of ANSI/ANS-57.1 to handle fuel units and control components in a safe and reliable manner. As described in Section 9A.1.2.3.5, safety devices such as interlocks on the fuel handling equipment assist operators to prevent damage to an assembly and help minimise mishandling and movements not allowed by plant approved procedures.

Plant programs and procedures track fuel assembly storage locations in accordance with special nuclear material regulations. In addition, the design of the Light Load Handling System precludes system malfunctions or failures that could cause a criticality event.

9A.1.2.3.2 Heat Removal in Operational States, Design Basis Accidents and Design Extension Conditions

Removal of heat from the fuel pool during operational and design basis accident conditions is described in Section 9A.1.3. The design of the Fuel Pool contains provisions for Fuel Pool Design Extension Conditions by:

1. Ensuring that boiling in the pool does not result in structural damage.
2. Providing temporary connections to enable the refill of the pool using temporary supplies (Section 9A.1.3.1).
3. Providing temporary connections to heat removal systems for power and cooling water (Section 9A.1.3.10).
4. Ensuring that the design of the fuel pool is such that a Fuel Handling Accident does not exceed site Design Basis Accident dose acceptance criteria (PSR Ch. 15: Safety Analysis (Reference 9A-9)).
5. Ensuring that severe accident management actions related to the fuel pool can be carried out (PSR Ch. 15).

9A.1.2.3.3 Inspection of Irradiated Fuel

The handling and storage systems are used primarily to support refueling and core shuffling, and the same equipment supports periodic inspections as needed of irradiated fuel. Plant equipment utilised for servicing irradiated fuel includes the following:

Fuel Preparation Machine

Two Fuel Preparation Machines are provided for handling fuel assemblies while removing or installing channels on the fuel bundles. Each machine consists of a fuel bundle carriage, which rides on a frame that is mounted on the edge of the fuel pool and extends down to depth along the pool wall and a work platform. The work platform includes handrails and extends out over the pool to facilitate viewing of the channelling operations.

Fuel Inspection Fixture

The Fuel Inspection Fixture is used in conjunction with the Fuel Preparation Machine to permit remote inspection of fuel elements. The Fuel Inspection Fixture, when installed, permits rotation of the fuel assembly in the carriage, and in conjunction with the vertical movement of the carriage provides complete access to all quadrants of fuel assembly inspection.

New Fuel Inspection Stand

The New Fuel Inspection Stand is stored on the refueling floor of the reactor building. It consists of a single “U” shaped platform with guardrails, a column which supports two fuel assemblies in a vertical position, and a personnel lift which raises or lowers the work platform along the fuel assemblies for inspection purposes. The lower base of the fuel assembly sits in the fuel seat at the bottom of the stand. The fuel assemblies are mounted on rotatable bearing surfaces which allow for rotation to desired quadrants for inspection.

Channel Handling Tool

The Channel Handling Tool is used in conjunction with the Fuel Preparation Machine to remove, install, and handle fuel channels in the fuel storage pool. The bail hangs from a load balancer on the channel handling boom mounted adjacent to the Fuel Prep Machines.

Channel Transfer Grapple

The Channel Transfer Grapple is an air actuated device consisting of a frame, air cylinder, and two jaws. It is used with the Refueling Platform auxiliary hoist (007N1897, “BWRX-300 Refueling Platform Design Specification” (Reference 9A-10)) to transport individual irradiated fuel channels between working and storage facilities in the fuel pool.

Channel Bolt Wrench

The Channel Bolt Wrench is a manually operated device used for removing and installing the Channel Fastener.

Channel Handling Boom

The Channel Handling Boom is located in a socket adjacent to the fuel preparation machines and adjacent to the fuel pool. The boom supports the channel handling tool and spring balancer over the Fuel Preparation Machine during channel removal and installation operations.

Inspection Camera

Cameras and tooling for inspections and measurements are curb-mounted next to the Fuel Preparation Machine in support of underwater inspection activities. Assorted hand tools (handling poles) and grapples are used in inspections. Sometimes, inspections are conducted during outages, other times, inspections on discharged fuel occurs post-outage (during the operating cycle).

9A.1.2.3.4 Periodic Inspection and Testing of Components Important to Safety

For information pertaining to periodic inspection and testing of components refer to Section 9A.1.2.8 (Monitoring, inspection, testing, and maintenance).

9A.1.2.3.5 Design for Precluding the Dropping of Irradiated Fuel in Transit

The RB is supplied with a Refueling Platform for fuel movement and reactor servicing support tasks (Reference 9A-10). The Refueling Platform is a gantry type crane that spans the reactor cavity and fuel pool and is used to transfer new and irradiated fuel between the RPV and fuel storage racks located in the RB fuel pool. The Refueling Platform is also used for in-core maintenance activities such as fuel shuffling, RPV inspections, Control Rod Blade (CRB) exchanges, and dry tube replacements. The Refueling Platform is primarily used during refueling outages but is also used to stage new fuel during reactor operation.

The Refueling Platform consists of a bridge which spans the width of the Fuel Pool and Reactor Cavity. A trolley rides on the bridge, traversing the width of the bridge to the maximum width. A full length sized working platform where refueling, servicing, and inspection personnel perform their work support tasks spans the length of the bridge. The Refueling Platform rides on four wheels running on two rails set into the refuel floor.

The Refueling Platform is equipped with a traversing trolley, an operator control console, a main hoist with a telescoping mast and fuel grapple, an auxiliary, and a monorail hoist. An air compressor on the Refueling Platform provides compressed air to the pneumatic system for the fuel grapple and reactor service tooling. A frame mounted hoist and a monorail hoist support handling the smaller core components and tooling.

The Refueling Platform is a rigid structure built to ensure accurate and repeatable positioning during the refueling process. The telescoping mast and grapple are suspended from a trolley system and is used to lift and orient fuel bundles for placement in the core or storage racks. The Refueling Platform includes a control console providing the operator precise control of the motions of bridge, trolley, and all hoists. Bridge, trolley, and mast grapple elevation readouts are located in a clearly understandable and convenient position for the operators to monitor as they position the Refueling platform. The control console includes a light indication to monitor hoist functions and refueling interlocks.

The main hoist and fuel grapple has a redundant load path so that no single component failure results in a fuel bundle drop.

Interlocks on the platform ensure that a fuel assembly is not hoisted over the reactor core unless the all-control rod-in permissive is present, shielding is maintained by limiting the vertical travel of the fuel grapple, and fuel grapple hook and load engagements are present.

Upon completion of fuel movement operations, a core verification task is accomplished in which individual fuel assemblies are verified to be installed in the correct position using serial numbers assigned to the fuel assemblies.

Spent fuel is transferred from the fuel pool in a Transfer Cask using the single failure proof RB Polar Crane. Refer to Section 9A.8.3.1 for further information pertaining to the design and operation of the RB Polar Crane.

9A.1.2.3.6 Handling Stresses on Fuel Elements or Fuel Assemblies

The structural adequacy of the fuel assembly components is demonstrated by evaluations (analysis or testing) that specifically address the operational duty that results from the BWRX-300 environment. This duty results from steady-state operation (including handling loads), mechanical loads associated with anticipated transients, and accident loads due to external conditions. The fuel assembly structural components are evaluated to ensure that the components do not fail due to stresses exceeding the fuel assembly component mechanical capability.

9A.1.2.3.7 Inadvertent Dropping of Heavy Objects and Equipment on Fuel Assemblies

Refer to Section 9A.8.2 (Safety Design Bases) for information pertaining to the controls in place to avoid inadvertent dropping of heavy objects and equipment on fuel assemblies.

9A.1.2.3.8 Inspection and Safe Storage of Suspect or Damaged Fuel Elements or Fuel Assemblies

Although rare, mechanical damage to a fuel assembly can occur due to fuel rod cladding wear from fretting or from a fuel handling accident. In the unlikely event that a fuel handing accident does occur, visual inspections are performed to assess the extent of damage followed by an action plan. The damaged assembly is recovered under a special written procedure lifting from the normal bail handle and stored in a fuel storage rack.

9A.1.2.3.9 Radiation Protection

Radiation monitoring is provided for the fuel pool storage area and the associated ventilation paths (PSR Ch. 11: Management of Radioactive Waste (Reference 9A-11), Section 11.5.3). The Refueling Platform, hoist, and grapple include interlocks to prevent potential refueling errors and reduce the possibility of exposure of plant workers (Reference 9A-3). The Refueling Platform telescoping mast design provides a rigid mechanical stop that makes it physically impossible to raise fuel above the safe level below the water.

The fuel pool is designed to ensure the area dose rate is less than 25 µSv/hr. Fuel handling equipment design ensures that the operator is not exposed to 25 µSv/hr when fuel and irradiated components are being stored or handled in accordance with ANSI 57.1, “Design Requirements for Light Water Reactor Fuel Handling System” (Reference 9A-12).

The air above the fuel pool and refuel floor equipment areas is monitored. In the event of a fuel handling accident in the Fuel Handling Machine area, a radiation monitor alarm initiates closure of the RB isolation dampers.

9A.1.2.3.10 Identification of Individual Fuel Bundles

Every fuel bundle contains a serial number on top of the bail handle which is part of the upper tie plate. Not only are these serial numbers used to specify each bundle’s location in the core for each cycle but ultimately to track every bundle from manufacturing to ultimate disposal. All special nuclear material accountability rules are strictly followed, and records are retained for every movement of a bundle over the bundle’s life.

9A.1.2.3.11 Maintenance and Decommissioning of Fuel Storage and Handling Facilities

Proper maintenance and operation of Fuel Pool systems is necessary to maintain water quality and radionuclides at acceptable levels. Maintenance of water quality is necessary to prevent degradation of the spent fuel and other materials stored in the fuel pool (i.e., control rod blades or in-core instrument strings). Fuel pool water treatment and system maintenance programs prevent the buildup of excessive concentrations of contaminants and radionuclides and mitigate the consequences of any potential release from the fuel pool (Section 9A.1.3).

Scheduled maintenance ensures that structures and systems required for containing, cooling, cleaning, level monitoring and makeup of water in the fuel pool are operable consistent with the licensing basis. The application of scheduled maintenance reduces high levels of contaminants and radionuclides in the pool water that can have adverse effects on stored fuel, the fuel pool, fuel transfer components, and related equipment.

Operating procedures coupled with surveillances and observations, indicate changes in fuel pool level. Procedures address appropriate maintenance, calibration, and surveillance of available monitoring equipment.

Plant decommissioning and dismantling activities considered at the design phase include considerations of experience gained from the decommissioning of existing plants, as well as those plants that are in long-term safe storage. Refer to PSR Ch. 21: Decommissioning and End of Life Aspects (Reference 9A-13) for information related to decommissioning of the BWRX-300.

9A.1.2.3.12 Decontamination of Fuel Handling and Storage Areas and Equipment

Decontamination of fuel handling and storage areas and equipment is performed as required to comply with ALARP requirements as discussed in PSR Ch. 12: Radiation Protection (Reference 9A-14) and prevent the spread of contamination.

New and spent fuel is stored in the fuel pool. As part of typical operating practice, areas outside of the fuel pool where fuel is handled are surveyed for contamination. The plant is supplied with equipment and features to accomplish effective decontamination without spreading contamination. Wash-down areas and sink drains are routed to the liquid radioactive waste system (PSR Ch. 11, Section 11.2). The Reactor Building Ventilation System (Section 9A.5.1) maintains negative pressurisation of potentially contaminated areas to control leakage of potentially radioactive effluent to the atmosphere. Vendor-supplied services may also be utilised for handling and storage area decontamination.

In the event radiation surveys of tools indicate additional decontamination is required the tools may be sent to a decontamination room for processing.

Design considerations for environment and safety are imposed upon tooling to facilitate operator safety and to ensure ALARP guidance and best practices are incorporated into the design process. Typical design considerations for the decontamination of fuel handling and storage areas and equipment includes:

1. Ease of decontamination
2. Elimination of crevices which facilitates crud removal.
3. Minimisation of crud buildup which facilitates decontamination and cleaning of equipment, components, and contaminated areas, and helps to prevent airborne contamination dispersion.
4. Use of the best construction materials (smooth surface)
5. Use of High Efficiency Particulate Air (HEPA) filters as required to support cleaning of equipment post use.

Criteria for selecting tools, materials, and equipment for use in contaminated areas includes minimising the use of porous or other materials that are difficult to decontaminate.

9A.1.2.3.13 Component Description

Storage Racks

The fuel racks consist of a stainless steel structure composed of neutron absorbing material in a series of square vertical tubes (cells). The fuel storage racks are top entry racks with bail extended above the rack and designed to preclude the possibility of criticality.

The fuel assemblies are stored in the fuel storage racks that are arranged in the fuel pool as shown in Figure 9A-1. The fuel storage racks provide space for storage of fresh fuel as well as space for longer term storage of the spent fuel assemblies for cooling prior to transfer to onsite storage or off-site shipment.

The BWRX-300 design includes storage for approximately 600 new and spent fuel assemblies. The fuel racks can hold an entire reload of fresh fuel and up to approximately eight years of spent fuel and have space remaining to accept a full core of off-loaded fuel.

Liner

The fuel pool liner is capable of withstanding all design loads as discussed in PSR Ch. 9B. Under certain conditions the fuel pool boils to provide cooling of the spent fuel. The design of the fuel pool liner is capable of withstanding the high temperatures associated with a boiling pool. A leak detection system is provided to detect fuel pool leaks.

For normal conditions of operation, the spent fuel assemblies are cooled by the Fuel Pool Cooling and Cleanup System (FPC). In the event of a loss of the fuel pool cooling and cleanup functions (such as station blackout) the primary defence line maintaining fuel pool temperature is boiling of the fuel pool. Refer to Section 9A.1.3 for a description of the FPC.

Refueling Platform

The refueling platform (Reference 9A-10) is a gantry-type crane that spans the reactor vessel cavity and fuel pool and is employed to handle fuel and perform other ancillary tasks in the reactor building. It is equipped with a traversing trolley on which is mounted a telescoping mast and a fuel grapple.

The refueling platform is a rigid structure built to precise engineering standards to ensure accurate and repeatable positioning during the refueling process. Additional information pertaining to the refueling platform is provided in Section 9A.1.2.3.5 (Design for precluding the dropping of irradiated fuel in transit).

9A.1.2.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials through material chemistry, heat treatment, contamination, and material processes controls.

9A.1.2.5 Interfaces with Other Equipment or Systems

Interfaces associated with the Fuel Pool include those identified for the FPC as well as the Fuel Handling Systems for Cask Loading, (Section 9A.1.4), Reactor Building Polar Crane (Section 9A.8), and RB Heating, Ventilation, and Air Conditioning (HVAC) (Section 9A.5.1).

9A.1.2.6 Systems and Equipment Operation

Refer to Section 9A.1.3 for information related to the operation of the FPC. Refer to Section 9A.1.4 for information pertaining to cask loading operations, Section 9A.5.1 for information pertaining to Heating Ventilation and Cooling System (HVS), and Section 9A.8 for information pertaining to the operation of cranes, hoists, and elevators.

9A.1.2.7 Instrumentation and Control

Section 9A.1.3 “Fuel Pool Cooling and Cleanup” describes the fuel pool water temperature and water level instrumentation. Section 9A.5.1.7 (Instrumentation and control) describes the HVS instrumentation.

9A.1.2.8 Monitoring, Inspection, Testing, and Maintenance

Fuel pool level instrumentation permits routing testing and calibration in-situ. Inspection and testing are to verify that there is no corrosion of the fuel pool liner or fuel storage racks, no buildup of crud or debris that may obstruct coolant flow in the fuel pool, as well as no degradation of any strong fixed neutron absorbers. The design of the fuel pool liner and fuel storage racks facilitates inspections and testing. Most surfaces of these structures are accessible for underwater inspection.

Neutron absorbing material coupons are provided with the spent fuel racks for the purpose of monitoring for potential degradation of the material over the design life of the equipment.

The design of the fuel pool provides monitoring for the loss of decay heat removal capability using the temperature measuring instruments in the FPC as described in Section 9A.1.3. Radiation monitors are provided in the Fuel Pool area to detect both general area radiation levels and airborne contamination levels as described in PSR Ch. 12, Section 12.3.4.

9A.1.2.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3 (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

The design of the fuel pool minimises buildup of contamination and provides shielding. The surface finishes of the components for the fuel storage racks are smooth to minimise accumulation of radioactive materials and to facilitate surface decontamination. The depth of the water above the fuel assemblies and the thick concrete walls of the fuel pool provides shielding for the assemblies.

9A.1.2.10 Performance and Safety Evaluation

The fuel storage racks, and fuel pool (including liner) are located inside of the RB. The design of the RB withstands combinations of mechanical, hydraulic, and thermal loads and natural phenomena effects, including severe winds such as hurricanes and tornadoes, floods, external and turbine-generated missiles. The RB protects the fuel pool, liner, and fuel storage racks from these hazards.

The design of the fuel storage racks is such that K_{eff} remains less than or equal to 0.95 under design basis conditions, including fuel handling accidents. Drop of a fuel assembly onto fuel assemblies stored in the fuel pool is discussed in PSR Ch. 15. Handling equipment capable of carrying loads heavier than fuel components are prevented by design and administrative controls from carrying loads over the fuel pool (Section 9A.8).

9A.1.3 Spent Fuel Pool Cooling and Cleanup System

The description below of the BWRX-300 Spent Fuel Pool and Cleanup System (FPC) aligns with the SDD 006N7941, “BWRX-300 Fuel Pool Cooling and Cleanup System” (Reference 9A-15). The primary function of the FPC is to provide continuous cooling of the water volume in the fuel pool to remove decay energy from spent fuel, and to provide replacement coolant inventory from a variety of sources, both to ensure spent fuel is kept cool and submerged throughout the life of the plant. In addition, FPC includes demineralisation and particulate filtration to maintain coolant quality and to reduce general area dose. FPC can be realigned to provide cooling and cleanup to the reactor cavity and equipment pools as necessary.

The FPC system is generally classified as SC3. Functions that support normal operation are part of Defence Line 2 (DL2), the portion of the system that provides makeup capacity to the pool is part of Defence Line 4b (DL4b).

9A.1.3.1 System and Equipment Functions

System and equipment functions associated with the FPC system include the following.

Normal Functions (Non-Safety Category)

1. The FPC system maintains the water quality of the Fuel Pool, Reactor Cavity Pool, and Equipment Pool through filtration and demineralisation during Modes 1-6. Refer to PSR Ch. 16: Operational Limits and Conditions (Reference 9A-16), Section 16.6 for definitions of operating Modes.

Normal Functions (Safety Category)

1. The FPC system provides cooling of the Fuel Pool, Reactor Cavity Pool, and Equipment Pool during Modes 1-6.
2. The FPC system provides makeup capacity for the Fuel Pool, Reactor Cavity Pool, and Equipment pool during Modes 1-6 delivered directly to the surge tanks and circulated to the pools.
3. The FPC system maintains the water level of the Fuel Pool for shielding and cooling.

Off-Normal Functions (Non-Safety Category)

1. The FPC system is able to restore the Fuel Pool temperature to normal operating limits from elevated temperatures due to an off-normal event upon restoration of the forced cooling components of the system.

Off-Normal Functions (Safety Category)

1. The FPC system provides makeup capacity for the Fuel Pool during off-normal events, independent of the forced cooling portion of the system.
2. The FPC system maintains the water level of the Fuel Pool for shielding and cooling during off-normal events.
3. The FPC system provides a heat sink for the Passive Containment Cooling System (PCCS) which exchanges heat with the equipment pool and reactor cavity pool for small and large pipe breaks inside containment.
4. The FPC system provides a heat sink and scrubbing of the Containment Inerting System over-pressure protection line in the equipment pool.

9A.1.3.2 Safety Design Bases

The FPC provides continuous cooling normal plant operations, and makeup capacity for the fuel pool during normal and off-normal plant operations. Shielding is afforded by maintaining fuel pool water levels. The FPC System provides high heat load cooling of the Fuel Pool and Reactor Cavity Pool during Plant Modes 4, 5, and 6 (Stable Shutdown, Cold Shutdown, and Refueling, respectively).

The FPC has sufficient heat removal capabilities to maintain the SFP bulk temperature below a maximum value of 60ºC (140°F) under the most conservative conditions for pool heat load (including a full core offload), maximum cooling water temperature, and consideration for heat exchanger fouling and tube plugging).

9A.1.3.3 Description

The BWRX-300 includes capabilities for the handling and storage of new and spent fuel to support operation of the plant with fuel cycle durations from 12 to 24 months.

The FPC provides cooling and cleaning of the water in the Fuel Pool, reactor cavity pool, and equipment pool during power operations.

The FPC and its supporting cooling system functions are capable of maintaining the Fuel Pool temperature within a set upper limit as described above.

The FPC provides make up capacity to the Fuel Pool during Off-Normal events to maintain adequate fuel coverage. The FPC system is constructed such that any breach of the system cannot cause draining of the Fuel Pool to a level below 3.05 m above the top of active fuel.

The FPC processes water from the three pools to maintain pool temperature and water quality within prescribed limits for the plant. Figure 9A-2 presents a simplified illustration of the FPC The FPC receives the pool water from the skimmers (scuppers) along the perimeter of the pool(s). The skimmers direct the pool water to two cross-connected skimmer surge tanks. The tanks are normally cross connected to provide equal pool flow distribution and maximise Net Positive Suction Head (NPSH) available to two 100% capacity pumps.

The pumps discharge to individual FPC trains with 100% particulate filtration and a single deep bed demineraliser capable of processing 50% of either the A or B train and discharging to the desired train. The deep bed demineraliser can by bypassed based on plant conditions and operational needs. The deep bed demineraliser discharge is returned to its applicable train.

Flow is then routed to two 50% shell and tube heat exchangers in the A and B trains. Each train consists of two heat exchangers to minimise the equipment footprint and utilise the vertical space within the FPC heat exchanger room. Both the A and B trains have a return line to the fuel pool, equipment pool, and reactor cavity pool.

9A.1.3.3.1 Component Description

The following information is provided relative to the major equipment and components in the FPC.

Surge Tank Description

The surge tank(s) receive inventory from the equipment pool, reactor cavity pool and fuel pool as it overflows weirs located near the top of the pools. Surge tank(s) are utilised to provide protection from a breach in the system draining either pool volume (versus direct suction) and provide a dampening effect for volume changes in the pools due to outage or dry cask evolutions. The primary advantage of a separate surge volume is that the pool level can be constant, while natural evaporation or addition or removal of submerged equipment only varies the level of the surge tank. Coolant inventory addition can be added directly to the surge tank during normal operating conditions. The FPC system surge tanks meet the requirements of American Society of Mechanical Engineers (ASME) Section III NCA and NCD.

Pumps

Each pump represents the beginning of two separate trains of the FPC system. They can be run individually during normal heat removal and cleanup modes (A1, A2) or in combination for high heat load (B, C) operating modes. Pumps are sized for maximum efficiency at the normal operating point. Pump internal recirculation cavitation is avoided within the entire range of operation. The pump selection, installation and system design assure that the minimum available NPSH and minimum submergence meet the Hydraulic Standards Institute guidelines for all steady-state and transient conditions of operation. If parallel operation is specified, the head rise from rated point to shutoff is at least 10%.

The FPC system pumps meet the requirements of ASME Section III NCA and NCD.

Heat Exchangers

Each train includes two heat exchangers (four in total) used to reject waste heat to the Plant Cooling Water System (PCW) (Section 9A.2.1). Each heat exchanger is a shell and tube design, with reactor coolant flowing on the tube side to take advantage of inherent shielding and reduce dose. Each heat exchanger is sized to fit within the RB hatch to allow removal or replacement during the operating life and decommissioning of the plant. Heat exchangers are designed, manufactured, installed, and tested in accordance with applicable codes and standards, including Thermal Exchanger Manufacturers Association, API-662, ASME Boiler and Pressure Vessel Code (BPVC), Section III and ASME BPVC Section VIII. Large shell and tube heat exchangers are designed with provisions for either tube bundle replacement or individual tube replacement and individual tube plugging in place. Heat exchanger fouling factors are established considering conservative predictions of material buildup based on actual system and equipment designs and expected plant operating conditions. Heat exchanger tubes are seamless.

Piping/Valving

Piping in radioactive systems such as the FPC System have butt-welded connections, rather than socket welds, to reduce crud traps. Features to prevent flow discontinuities that can lead to retention of corrosion products (crud traps) in the walls of the equipment and components are incorporated into the design. Bends, branches, corners, dead legs, and low points are avoided in piping and piping layout. Mitigating engineering features are added where avoidance is not possible. These piping and valve design features reflect implementation of ALARP guidance as presented in PSR Ch. 12 (Reference 9A-14).

FPC system piping potentially containing resin is designed to be continuously sloped downward to the receiving system or tank. The FPC system piping, and valves meet the requirements of ASME Section III NCA and NCD.

Demineraliser / Filters

Each train of the FPC contains a particulate filter which can support 100% of the train's flow. The filter may be backwashed to the Solid Waste Management System (SWMS). Further details of the SWMS are provided in Section 11.3 of PSR Ch. 11 (Reference 9A-11) to remove accumulation and reduce dose. A single deep bed mixed resin demineraliser can be aligned to either FPC train and can support 50% of a single train's flow. The demineraliser operates in both normal (A1, A2) and high heat (B) modes, but can also be bypassed if the temperature of the system coolant exceeds the operational limits of the demineraliser (C)

Process equipment that accumulates a radiation source from filtering process streams such as the Condensate Filters and Demineralisers System (CFD) (PSR Ch. 10: Steam and Power Conversion Systems (Reference 9A-17), Section 10.2.1), and the FPC systems are remotely operated, including the backwashing operations. Provisions are made for remotely backflushing the filters and demineraliser. FPC system filters are backwashed into a backwash receiving tank, which then is routed to the SWMS. All FPC System valves (e.g., inlet, outlet, recycle, vent, and drain) on the filters and demineraliser are located outside the shielded cubicles in a separate shielded cubicle or area together with associated piping, headers, and instrumentation.

Off-Normal Makeup

The Off Normal makeup portion of the system is intended to provide replacement inventory to the fuel pool. It utilises multiple sources to maintain pool level in the event of a failure of the active cooling portion of FPC. Portions of the piping in or near the fuel pool are Seismic Class 2, whilst Emergency Mitigating Equipment (EME) piping is Seismic Category 1B.

9A.1.3.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials specifically from Intergranular Stress Corrosion Cracking (IGSCC) (as applicable) through material chemistry, heat treatment, contamination, and material processes controls.

Features to prevent flow discontinuities that can lead to retention of corrosion products (crud traps) in the walls of the equipment and components are incorporated into the design. Bends, branches, corners, dead legs, and low points are avoided in piping and piping layout.

9A.1.3.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-1 for FPC interfaces with other equipment or systems.

9A.1.3.6 System and Equipment Operation

The FPC system is primarily intended to maintain pool temperatures during all operating modes. During Modes 1-5, a single train of FPC is running to provide cooling and cleanup of the Fuel Pool, Reactor Cavity, and Equipment Pool inventory (Mode A1 and A2.) Immediately following a refueling outage, two trains of FPC may be in service to maintain pool temperatures low (System Mode B). Supply to each pool may be balanced based on temperature variations and heat loadings in each volume.

During refuel outages (Mode 6) the FPC system may be run in normal (FPC mode A1 or A2) or High Heat Mode (FPC mode B) as the temperature of the Reactor Cavity and Fuel Pool dictates. In the event of elevated pool temperatures, which exceed the operating specifications of the demineraliser such as restoration from an Off-Normal event, the FPC system may be run in High Heat – Bypass (FPC mode C) which utilises both equipment trains of pumps and heat exchangers to provide maximum cooling without cleanup. Once the pool temperature returns to acceptable levels, the FPC system may then return to Mode B or Mode A as required.

Initial Configuration (Pre-Startup)

As a system intended to always be in operation, there are no specific pre-startup conditions. Operation of the FPC system is independent of reactor operation.

System Startup

Generally, a single train of FPC is running continuously.

Startup of a train includes the following:

- Confirm initial configuration has been performed
- Open FPC pump suction
- Start FPC pump
- Align to cleanup if desired
- Ensure system response has been monitored during previous steps

This same process may be used to add a second train during high heat modes. In the changeover from one train to the other, it is preferable to start the second train and confirm normal operation prior to shutting down the first train.

Normal Operations

During normal operations the FPC system operates in the following modes:

Mode A – Normal Heat Load

The most frequent mode of operation of the FPC system is “normal heat load” operation, intended to be used during plant operating Modes 1-5. This mode includes a single train of the FPC system operating to remove heat generated by spent fuel stored in the fuel pool, as well as any thermal contribution from the PCCS to the equipment pool, or thermal leakage from containment to the reactor cavity pool. Further discussion of the PCCS is presented in Section 6.5.4 of PSR Ch. 6: Engineered Safety Features (Reference 9A-18)

Cleanup consisting of particulate filtration and demineralisation of 100% of the water passing through the system is performed. During Mode A, coolant inventory can be added from the condensate storage tank as required to makeup evaporation losses or overboarded to the condensate storage tank after cleanup and cooling to create additional pool volume for submersion of spent fuel dry cask equipment. Mode “A1” and “A2” may be used to signify which train is in operation, both trains function identically.

Mode B – High Heat Load

Mode B utilises both trains of FPC equipment running simultaneously to double the volume of water cooled and cleaned. This mode still retains 100% filtration and demineralisation (for a single train) and is intended to be used predominately during plant operating Mode 6 “Refueling,” when high activity spent fuel is transferred to the fuel pool, and water clarity and dose are of particular concern. As with Mode A, coolant inventory can be added or overboarded to support outage operations and maintain water level.

Off-Normal Operations

Mode C – High Head Load – Bypass

Mode C functions identically to Mode B, except the demineraliser is isolated from the system and a bypass is utilised. Mixed bed resin demineralisers tend to have modest thermal operating limits, typically less than 60 °C which when exceeded can cause resin excursions contaminating plant equipment and pools. To retain the high heat removal capacity but prevent damage to the resin beds during high pool temperature events, Mode C may be utilised until the water temperature is restored to a threshold allowing Mode B service.

Mode D – Active Cooling Inoperative

Mode D is an off-normal condition where the active cooling and cleanup portion of the FPC system is unable to be operated such as during a site blackout. Mode D operations allows for multiple sources of coolant addition directly to the Fuel Pool, bypassing the remaining system or any potential breeches that may have occurred. The plant sources include the condensate storage tank, and the Fire Protection system. Mode D also includes an EME connection allowing addition of coolant through temporary means. The Fuel Pool volume is intended to contain sufficient water inventory to allow seven days of spent fuel decay heat to be absorbed while maintaining sufficient coverage of 3.05 m over fuel. Operations in Mode D is required for additional inventory to be added to meet the 30-day event criteria.

System Shutdown

The FPC system is intended to operate, with at least a single train, during all modes of plant operation. Individual trains may be idled or placed in standby through shutdown of pumps and isolation of equipment as heat load or maintenance and testing require.

9A.1.3.7 Instrumentation and Control

Control of the FPC system is performed by the Reactor Auxiliaries Control System through indication of pool temperature and water level. During normal operation, pumped capacity is varied through use of one or both system trains, with output balanced through motor operated control valves to the equipment, reactor cavity, and fuel pool to distribute cooled water in a manner best matching the sources of thermal energy. Addition or reduction of inventory, both as a natural function of environmental conditions, as well as supporting maintenance and outage evolutions, can be performed manually.

During off-normal events, with the forced cooling portion of the system assumed to be inoperable, make up capacity can be initiated from various sources as Fuel Pool level indication requires. Major components (pumps, demineraliser, heat exchangers) have performance indication, and component protection such as bypassing of the demineraliser if system temperature exceeds limits and stopping of pumps on low flow and low suction pressure signals are automated.

9A.1.3.8 Monitoring, Inspection, Testing, and Maintenance

Maintenance and testing support equipment reliability. SSC are designed to facilitate operation and maintenance. Because at least a portion of the FPC is assumed to operate continuously during all plant modes, a surveillance program monitoring the continued operation of key components, utilising embedded instrumentation, will be established. Trending of operational characteristics of equipment such as demineraliser, filters, and heat exchangers identifies reductions in performance signalling that maintenance is required. In System Mode A Trains are switched periodically to balance equipment usage and provide surveillance opportunity to both trains. In-Service Inspection (ISI) and In-Service Testing (IST) requirements are established and include inspection/test frequency for SSC.

Maintenance activities related to the FPC system fall into two categories:

1. Ongoing/Frequent Maintenance: Anticipated maintenance activities such as backflushing of particulate filters, flushing and replacement of spent resin in the demineraliser, and decontamination of lines to reduce area dose.
2. Infrequent Maintenance: Anticipated activities that occur during the life of the plant which includes equipment replacement of components such as pump impellors, motors, valves, heat exchangers, and filter cartridges. These maintenance evolutions

take place as a response to long-term trending of system performance or as preventive maintenance scheduled based on anticipated component life span.

In both cases, maintenance on the FPC system is performed predominately during Plant Mode 1 operation, when thermal loads in the Fuel Pool are low allowing a single operable train to satisfy plant needs while the other may be isolated for work.

Maintenance practices consider industry best practices and operating experience and conform with plant safety requirements to minimise potential for personnel injury. Maintenance activities implement ALARP practices to minimise work activity dose. Maintenance activities involving plant equipment may require involvement of vendors or industry specialists.

9A.1.3.9 Radiological Aspects

The Fuel Pool Cooling systems supports minimisation of airborne radioactivity by sweeping the spent fuel pool surface and preventing evaporative pool losses and gases from mixing with the area atmosphere.

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.1.3.10 Performance and Safety Evaluation

The FPC is designed to perform its function in a reliable and failure tolerant manner. This reliability is achieved with the use of rugged and redundant equipment. Each set of components (pumps, filters, heat exchangers) are placed in parallel to provide single train operation and cross connecting of trains should a component fail. A single train is sufficient to prevent bulk boiling in the fuel pool. If both trains are rendered inoperable, the fuel pool is sized such that it can retain sufficient coverage of the fuel for seven days, and FPC can provide makeup capacity independently of the forced cooling trains.

The FPC System Safety Category functions during Normal and Off-Normal conditions include providing makeup capacity to the Fuel Pool, maintaining the water level of the Fuel Pool for shielding and providing Fuel Pool Cooling. In addition, Off-Normal makeup piping and valves are provided to allow remote addition of water to the Fuel Pool during Off-Normal conditions through temporary means thereby ensuring spent fuel is cooled and fuel pool water levels are maintained.

The Fuel Pool is located in the RB which provides protection against natural phenomena; supporting the ability of the FPC System to perform its Safety Category functions.

9A.1.4 Fuel Handling Systems for Fuel Cask Loading

9A.1.4.1 System and Equipment Functions

The description below of the BWRX-300 fuel handling systems for fuel cask loading aligns with 006N5377 “BWRX-300 Refueling and Servicing Equipment SDD” (Reference 9A-3). The system and equipment functions associated with the handling system for fuel cask loading, provide the means to transfer spent fuel located in the fuel pool into a spent fuel storage cask and transport of the spent fuel storage cask to a location for long-term storage. The following information is provided relative to demonstrating compliance to the requirements given in IAEA SSR-2/1 Requirement 80 (Reference 9A-4) as it pertains to fuel cask loading.

9A.1.4.2 Safety Design Bases

PSR Ch. 3 describes the classification process for SSCs. The refueling platform is SC3 and Seismic Category 2 to prevent toppling onto the fuel rack and fuel as an initiating event.

Safety aspects for fuel cask loading include the following:

1. Fuel handling devices have provisions to avoid dropping or jamming of spent fuel assemblies during transfer operations.
2. Handling equipment used to raise and lower spent fuel has a limited maximum lift height so that the minimum required depth of water shielding is maintained.
3. Criticality during fuel handling operations is prevented by maintaining a geometrically safe configuration throughout the spent fuel transfer operation. Operators follow a strict movement plan and procedure and that includes pick up and set down locations for each step and those are followed and verified concurrently as each step is started and completed.
4. In the event of a Safe Shutdown Earthquake (SSE), handling equipment cannot fail in such a manner as to prevent required function of Safety Category 1 SSC.
5. Physical safety features are provided for personnel who operate handling equipment.

Refer to Section 9A.1.2 for the Safety Design Bases associated with the Fuel Pool. Refer to Section 9A.8 for the Safety Design Bases associated with the Cranes, Hoist, and Elevator System.

9A.1.4.3 Description

Refueling Platform

The Refueling Platform (Reference 9A-10) is a gantry type crane that spans the reactor cavity and fuel pool and is used to handle fuel and perform other ancillary tasks in the RB. It is equipped with a traversing trolley, an operator control console, a main hoist with a telescoping mast and fuel grapple, an auxiliary, and a monorail hoist. The Refueling Platform is a rigid structure built to ensure accurate and repeatable positioning during the refueling process.

Irradiated Fuel Canister Loading

The spent fuel is stored in the Fuel Pool before being loaded into a canister. Typical loading of a canister includes the following. Loading of the canister is performed in the Fuel Pool. The canister containing the spent fuel is then loaded into a concrete overpack. Canister loading patterns are determined by the age of fuel, exposure, and decay heat. A campaign normally involves loading the spent fuel canister while the unit is on-line.

An empty canister placed in a transfer cask for shielding is moved into the fuel pool. The selected bundles are moved under water from the spent fuel racks to the allotted location in the spent fuel canister. Once a spent fuel canister is filled with spent fuel, a video recording of the bundle serial numbers is performed, and the lid is placed on the canister. The canister is lifted from the fuel pool, drained, rinsed, and set on the cask pad on the refueling floor where the canister is decontaminated. The canister is vacuum dried and sealed by welding the lid using remote welding techniques to minimise radiation exposure to workers. The canisters are filled and slightly pressurised with an inert gas, such as helium. The sealed canisters are leak tested and a non-destructive examination is performed on the weld. The shielded canister is installed into an overpack and then fitted with an overpack lid and placed in long-term storage.

Each spent fuel canister may contain several damaged fuel bundles; however, the specific loading is vendor dependent. The failed fuel bundles can stay in the fuel pool indefinitely without any special controls. If desired, fuel bundles can be reconstituted with new fuel or dummy rods replacing damaged rods. This is done on the fuel inspection stands in the fuel pool with long handled tools.

Irradiated Fuel Canister Movement to Dry Fuel Store

Typical canister movement from the fuel pool to the Dry Fuel Store (DFS) is performed under the guidance and participation of Security and Health Physics. The RB Polar Crane is used to lift the transfer cask to the refuel floor and subsequently to the truck bay. The canister is transferred from the transfer cask to the storage cask and placed in long-term storage.

Further details of the proposed DFS are provided in PSR Ch. 26: Interim Storage of Spent Fuel (Reference 9A-82).

9A.1.4.4 Materials

Materials selected for use in the Handling Systems for Fuel Cask Loading are chosen based upon the operating conditions to which they are required to function. The fuel storage racks use surveillance coupons for monitoring and evaluation of neutron absorber material.

9A.1.4.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-2 for Handling System for Fuel Cask Loading interfaces with other equipment or systems. Note that this is a subset of the list of Refueling and Servicing Equipment System Interfaces presented in Table 4-1 of 006N5377 (Reference 9A-3).

9A.1.4.6 System and Equipment Operation

The handling of irradiated fuel inside the fuel pool is described in Section 9A.1.2. Handling of irradiated fuel from the fuel pool to a storage canister is discussed above. Handling of the overpack during transport to long-term storage is discussed in PSR Ch. 26 (Reference 9A-82).

9A.1.4.7 Instrumentation and Control

Refer to Section 9A.1.3 (Instrumentation and Control) for information pertaining to instrumentation and control associated with the fuel pool and Section 9A.8 for information pertaining to instrumentation and control associated with the RB Polar Crane.

9A.1.4.8 Monitoring, Inspection, Testing, and Maintenance

Maintenance of refueling equipment and tooling is performed prior to an outage to promote optimum reliability.

9A.1.4.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.1.4.10 Performance and Safety Evaluation

The fuel handling equipment is designed such that probability of dropping a fuel assembly following a safe shutdown earthquake has been minimised.

Each fuel assembly and control rod is placed strategically to maintain a non-critical configuration by following a specific fuel movement plan.

Underwater transfer of spent fuel assemblies provides radiation shielding. The fuel handling equipment has provisions to limit maximum height to maintain sufficient water inventory above the top of the fuel assembly.

The fuel handling equipment includes controls and interlocks that impose limits upon system operations, ensuring clearance between structures, systems, and components, thereby preventing the potential for mechanical damage to fuel during fuel transfer operations.

9A.2 Water Systems

9A.2.1 Plant Cooling Water System

The description below of the BWRX-300 PCW aligns with 006N7769 “BWRX-300 Plant Cooling Water (PCW) System SDD” SDD (Reference 9A-19). The PCW provides cooling water to Non-Safety and SC3 components and provides a barrier against radioactive contamination of the Circulating Water System (CWS) (006N7761, “Circulating Water System SDD (N71)” (Reference 9A-20)) (PSR Ch. 10, Section 10.4.5). It consists of two piping subsystems, Reactor Component Cooling Water Piping Distribution and Turbine Component Cooling Water Piping Distribution, that provide cooling water to various heat exchangers.

The safety classification of the PCW as well as interfacing SSC is consistent with the requirements of IAEA SSG-30 "Safety Classification of Structures, Systems and Components in Nuclear Power Plants" (Reference 9A-21).

9A.2.1.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

The PCW system provides cooling functions related to the non-safety classified Isolation Condenser System Pool Cooling and Cleanup System (ICC) heat exchangers.

PCW operation is normally automatic based on plant operational mode but can be started or stopped manually from the Main Control Room (MCR) and can operate at any time, regardless of the operational status of the generating unit.

The PCW design supports the redundant Reactor Component Cooling Water Piping Distribution and single Turbine Component Cooling Water Piping Distribution.

The cooling water temperature is maintained by a temperature control valve arrangement that bypasses the PCW heat exchangers with a portion of the return water.

Normal Functions (Safety Category)

The PCW system provides the following normal Safety Category 3 functions:

- Provides cooling water to the FPC heat exchangers.
- Provides cooling water for the Shutdown Cooling System (SDC) heat exchangers.
- Provides cooling water for Plant Pneumatics System (PPS) compressor aftercooler.
- Provides a barrier against radioactive contamination of the CWS.
- Provides cooling water to SC3 Turbine Building (TB) heat exchangers.

Off-Normal Functions (Safety Category)

The PCW system does not perform any additional Safety Category functions during off-normal conditions.

Upon a Loss-of-Preferred Power (LOPP), the operating PCW pump(s) will trip. The pumps are automatically repowered from the standby diesel generators.

Off-Normal Functions (Non-Safety Category)

The system does not perform any additional Non-Safety Category functions during off-normal conditions.

9A.2.1.2 Safety Design Bases

The PCW system components perform make-ready and supporting functions to different safety classified components that perform fundamental safety functions. Components and piping associated with cooling safety classified heat exchangers or other equipment are classified as SC3.

SCN components and their related piping are those associated with make-up water supply to PCW system as well as cooling functions related to the non-safety classified Isolation Condenser System Pool Cooling and Cleanup System (ICC) heat exchangers.

9A.2.1.3 Description

Figure 9A-3 depicts the Plant Cooling Water System.

The PCW system consists of two trains, each containing one pump and one heat exchanger, that handle the Reactor Component and Turbine Component cooling loads. One train is normally in operation while the other is on standby, to be started in event the operating train needs to be shutdown.

These independent trains are cross connected using manual cross ties to allow for online maintenance. If necessary, the Turbine Component Cooling Water Piping Distribution can be isolated from each Reactor Component Cooling Water Piping Distribution by closing the supply and return header valves on each train, and each Reactor Component Cooling Water train operates independent of the other.

Cooling water supplied by the PCW is continuously circulated through various auxiliary equipment heat exchangers and rejects the heat transferred to the CWS. The Turbine Component Cooling Water Piping Distribution is a single piping distribution that serves all equipment in the TB that do not support reactor cooling functions. The Reactor Component Cooling Water Piping Distribution consists of two redundant piping distributions that support all RB equipment cooling functions, PPS and any equipment located outside the RB associated with reactor cooling activities.

Although PCW supports all plant equipment cooling functions, the design redundancy and isolation capability is centred around the ability to provide redundant cooling supply to nuclear systems.

One train of PCW equipment is normally in operation and in the event that train is lost, the standby train is started. During plant shutdown both trains of cooling equipment are used to provide required flow for TB and RB cooling functions. The Reactor Component Cooling Water Piping Distribution cools redundant equipment associated with nuclear cooling functions, thus if one train of the Reactor Component Cooling Water Piping Distribution is lost all redundant equipment will operate on the remaining train.

The PCW pumps and heat exchangers are in the TB. The pumps in each train are powered from separate busses. During a LOPP, the pumps are powered from the two SC3 standby diesel generators.

The PCW utilises plate and frame type heat exchangers to reject waste heat to the Normal Heat Sink (NHS) (Section 9A.2.5) via the service water subsystem of the CWS. This design mitigates cross-contamination of either PCW or CWS.

Temperature control valves in the system are provided to maintain the cooling water temperature within an allowable range.

Surge tanks provide a constant pump suction head and allow for thermal expansion of the PCW inventory. Makeup to the PCW inventory is from the PCW surge tank which is supplied from the Makeup Water System (Section 9A.9.5 (System and equipment functions)) through an automatic level control valve.

A chemical addition tank tie-in allows for manual introduction of corrosion inhibitor and pH control chemicals into the system.

The TB cooling loop serves but is not limited to the following equipment:

- Feedwater Pump Motors
- Feedwater Pump Adjustable Speed Drives
- Condensate Pump Motors
- Vacuum Pump Skid
- Generator Coolers
- Isophase Coolers
- Lube Oil Coolers
- Electro-Hydraulic Control (EHC) Coolers

The redundant RB cooling loops serve the following equipment:

- Fuel Pool Cooling and Cleanup Heat Exchangers
- Isolation Condenser System Pool Cooling and Cleanup System (ICC) Heat Exchangers
- SDC Heat Exchangers
- Plant Pneumatics System Cooler

PCW equipment is designed for the plant normal operating environmental conditions specified for its location within the TB and RB. Refer to PSR Ch. 3, Section 3.9 (Reference 9A-2) for information pertaining to Equipment Qualification of BWRX-300 SSC's.

Component Description

PCW Pumps

The PCW pumps are designed to meet the requirements of ANSI/HI 1.3 "Rotodynamic Centrifugal Pumps for Design and Application" (Reference 9A-22). The pumps are constant speed, electric motor driven, horizontal centrifugal pumps. Pump impellers are less than the maximum diameter available for the pump casing. The pumps' mechanical seals minimise the potential for leakage and reduce the need to perform maintenance on shaft seal packings.

PCW Heat Exchangers

The PCW heat exchangers are designed to meet the requirements of ASME BPVC, Section VIII (Reference 9A-23). PCW is capable of performing design functions during all modes of operation.

Plate and frame heat exchangers are used to minimise the probability of possible cross-contamination between PCW and CWS. Strainers are installed on the raw water side of the exchangers due to the narrow passages plate and frame heat exchangers present. Leakage through holes or cracks in the plates is not considered credible based on industry experience with plate type heat exchangers. In addition, the heat exchangers are designed such that any gasket leakage from either PCW or CWS drains to the Equipment and Floor Drain System (EFS) (Section 9A.9.3).

The service water subsystem of the CWS utilises 2 x 100% (i.e., duty and standby) pumps to provide cooling water from the NHS to the raw water side of the PCW Heat Exchangers. Further details of the CWS are provided in the CWS SDD (Reference 9A-19).

There is a bypass line provided for the PCW Heat Exchangers with an air-operated bypass temperature control valve. The flow of cooling water through the PCW Heat Exchangers is controlled by the PCW Heat Exchanger temperature control system aiming to achieve target temperature based on the PCW Heat Exchangers outlet temperature readings sent to the Distributed control and Information System.

PCW Surge Tanks

The PCW surge tanks are atmospheric corrosion-resistant tanks which are designed to meet the requirements of American Water Works Association D100 (Reference 9A-24). The surge tanks are sized to provide a pump suction head and to allow for thermal expansion. The surge tanks are located above the highest points in the PCW system. The makeup water supply is provided to maintain the water level in the tanks within the correct operating conditions.

Piping and Valves

All Non-Safety Category function piping is designed to meet the requirements of ASME B31.1, “Power Piping” (Reference 9A-25).

Isolation valves are provided at the inlet and outlet of each heat exchanger and pump for maintenance and efficiency purposes. Isolation valves are provided at the interfaces with the components being cooled by PCW to allow for maintenance on those items without impact to the PCW system operation. These isolation valves add the ability to remove heat exchangers from the system cooling requirements without shutting down the entire PCW system.

For the PCW pump and heat exchanger train section, there are isolation valves around the pumps and heat exchangers. Each pump discharge line is provided with a check valve to prevent backflow through the pump.

Vents are located in high points and drains are located in all low points. This ensures that the system is completely filled with water and that there are no air pockets. Vents reduce the chance for water hammer after a pump start. Valve opening and closing times are selected to minimise water hammer effects.

Each flow path to the interface system heat exchangers is designed to have flow balancing features that may include fixed plate orifices and/or control or manual valves.

Chemical Pot Feeder

The chemical pot feeder is designed to meet ASME BPVC, Section VIII requirements. The chemical pot feeder is used to manually add corrosion inhibitors, pH control chemicals, and biocides into the system on a periodic basis. Chemicals are compatible with radwaste processing equipment if PCW water becomes contaminated.

9A.2.1.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials through material chemistry, heat treatment, contamination, and material processes controls.

9A.2.1.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-3 for PCW interfaces with other equipment or systems.

9A.2.1.6 System and Equipment Operation

Normal Operational Concept

For normal start up, the PCW is filled through the surge tank. When surge tank levels reach low level, the Makeup Water System (Section 9A.9.5.1) refills the surge tank through an automatic level control valve.

For normal operation, one train which consists of one pump and one heat exchanger is in operation while the other train is on standby. If one heat exchanger fails, the standby heat exchanger has enough capacity to handle cooling requirements.

Plant cooling water flows through to heat exchangers and coolers throughout the TB and RB by way of the Turbine Closed Cooling Water Subsystem piping and Reactor Closed Cooling Water Subsystem piping.

The CWS water flows on the other side of the PCW main heat exchanger to absorb the heat load. There is a bypass line provided for the PCW Heat Exchangers with an air-operated bypass temperature control valve. The flow of cooling water through to the PCW Heat Exchangers is controlled by the PCW Heat Exchanger temperature control system based on the PCW Heat Exchangers outlet temperature.

Off-Normal Operational Concept

If any deviations from the normal process are observed by operators while monitoring from the MCR, the surge tanks level transmitters and heat exchangers differential pressure transmitters should indicate if any leaks or water losses occur in the process. If leakage resulting in a low surge tank level signal is observed, the Water Gas and Chemical Pads (WGC) plant system continues to account for level drops and the PCW standby train should be started by the operator.

The reactor components Cooling Water Piping Distribution line should then be isolated with the other train operating in parallel, while surge tank levels and heat exchangers differential pressures are monitored to indicate where the source of leak is coming from. If losses continue to occur, the leaking train will eventually trip on low suction head, leaving at least one train of PCW preserved.

In cases of LOPP and turbine trip, the PCW pumps will trip and restart upon being re-powered from the standby diesel generators.

When the Turbine-Generator and most heat loads are taken out of service, the PCW cooling flow can be lowered and even isolated from portions of its system. Check valves are provided in the discharge lines to prevent backflow.

9A.2.1.7 Instrumentation and Control

In normal operation one cooling train is operating while being controlled by the Distributed Control and Information System in order to achieve the desired target temperature for each cooled line in the Reactor Component Cooling Water Piping Distribution and Turbine Component Cooling Water Piping Distribution. In events of failure of the operating train or pump discharge pressure drop, an automated process switches operations to the standby train.

Temperature is monitored downstream of each system heat exchanger and readings are reported back to the main control room to monitor the heat exchanger performance.

For designated heat exchangers, bypass and discharge temperature control valves operating in split range control mode are used to control temperature. Instrumentation Temperature monitoring is provided, but not limited to the following locations:

- At the outlets of all equipment coolers.
- Downstream and upstream of each PCW heat exchanger.

Pressure monitoring is provided, but not limited to the following locations:

- At the suction and discharge of each PCW pump.
- Downstream of the PCW heat exchangers.

Differential Pressure monitoring provided, but not limited to the following locations:

- Across each PCW heat exchanger.

- Across equipment coolers.
- Across the pump suction strainers.

Flow monitoring provided, but not limited to the following locations:

- At the outlet of each PCW heat exchanger.
- At the inlets of selected system heat exchangers as needed.

Level monitoring is provided at the following locations:

- On each surge tank.

Temperature Control Valves are provided at the following locations:

- Downstream and Across (bypass) each SDC heat exchanger.
- Downstream and Across (bypass) the Generator Coolers.
- Downstream and Across (bypass) the Lube Oil Coolers.
- Downstream and Across (bypass) each PCW heat exchanger.

Controls

The PCW system is monitored from the MCR. PCW controls and interlocks for the main components are described below:

1. Temperature monitoring is provided downstream of the PCW heat exchangers on the main cooling water supply line, that send a signal to the Distributed Control and Information System (DCIS) to control cooling water temperature by bypassing a portion of the water around the PCW heat exchangers. This is accomplished using an air-operated temperature control valve on the bypass line and an air- operated temperature control valve at the heat exchanger discharge header, and both are controlled by the DCIS. These valves regulate the supply temperature. The bypass and discharge valve have the ability to be manually controlled. The bypass valve fails closed and the discharge valve fails open.
2. The PCW surge tank makeup flow is controlled by an air-operated block valve. The valve automatically opens and closes and can be manually controlled. The block valve opens when the PCW surge tank level drops to a predetermined low level. The block valve closes when the surge tank level rises to a predetermined high level. The surge tank makeup water inlet block valve fails closed.
3. The cooling water temperature to the Turbine Lube Oil coolers is regulated by two temperature control valves, one at the Turbine Lube Oil cooler discharge and one on the bypass around the cooler, which operate in split range control mode. This type of flow will naturally balance the flow around the coolers. The bypass and discharge valves have the ability to be manually controlled. The bypass valve fails closed and the discharge valve fails open.
4. The cooling water temperature to the Generator Air Coolers is regulated by two temperature control valves, one at the Generator Air Coolers discharge and one bypass around the coolers, which operate in split range control mode. This type of control will naturally balance the flow around the coolers. The bypass and discharge valves have the ability to be controlled manually. The bypass valve fails closed and the discharge valve fails open.
5. The cooling water temperature to the Shutdown Cooling Heat Exchangers is regulated by two temperature control valves, one at the Shutdown Cooling Heat Exchanger discharge and one bypass around the cooler, which operate in split range control

mode. This type of control will naturally balance the flow around the heat exchangers. The bypass and discharge valves have the ability to be controlled manually. The bypass valve fails closed and the discharge valve fails open.

6. Upon a low surge tank level signal, the standby train of PCW isolates the Reactor Component Cooling Water Piping Distribution line and automatically places any non-operating equipment in bypass. The train that continues to lose water will eventually trip on a low suction head signal, but at least one train of PCW is preserved in order to support nuclear D-in-D functions.
7. Normally one PCW pump and heat exchanger train is in service with the other on standby. A pump trip signal results in the starting of the standby PCW train and CWS train.
8. The PCW Heat Exchangers interfaces directly with the CWS system. PCW trains cannot be started until the associated CWS train is running. The system connects such that an automated standby train of either CWS or PCW results in automatic realignment. The isolation valves are automatic with manual overrides available.

PCW controls, displays, and alarms include, but are not limited to, the following:

Main Control Room Panel Controls:

- PCW pump(s) start/stop and pump selection controls.
- PCW heat exchanger(s) outlet valve open/close controls.
- PCW supply temperature control valve(s) controls.
- Surge Tank Makeup water valve open/close control.
- PCW Heat Exchanger temperature control Air Operated Valves (AOVs).

Main Control Room Displays:

- PCW pump discharge pressures.
- PCW pump operation status.
- PCW operating temperatures (All heat exchanger outlet temperatures).
- PCW surge tank levels.
- AOV open/close status.
- PCW system flow rates.

Main Control Room Alarms:

- PCW pump header low/high discharge pressure.
- PCW cooling water supply high outlet temperature.
- PCW cooling water supply low outlet temperature.
- PCW surge tank high and low levels.
- PCW heat exchanger high differential pressure.

9A.2.1.8 Monitoring, Inspection, Testing, and Maintenance

The PCW is designed such that major equipment is provided adequate equipment removal paths and personnel access points.

The equipment and components of the PCW are designed for inspection and maintenance during plant operation without requiring complete loss of the TB cooling loop or the RB cooling loops.

Provisions to isolate the TB cooling loop or the RB cooling loops using AOV is provided. This design feature supports inspection, testing, and maintenance activities.

Provisions for PCW drainage to the EFS are provided due to its high probability of having chemical content. If the PCW captured water is not chemically contaminated, the water is recycled back to the PCW surge tank.

Routine testing of the PCW system is conducted in accordance with normal power plant requirements for demonstrating system and component functionality and integrity. This includes testing for heat exchanger performance, surge tank levels and water quality standards.

The PCW design includes provisions to take periodic samples for analysis to ensure the water quality meets the chemistry specifications.

9A.2.1.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.2.1.10 Performance and Safety Evaluation

System reliability is enhanced through the use of periodic system testing, and preventive maintenance.

The PCW is Non-Seismic Category; components associated with Makeup Water supply to the surge tanks and ICC system cooling are SCN whilst all other PCW components are SC 3. The redundant design elements of the PCW design ensures that the safety function of the system is maintained.

9A.2.2 Reactor Water Cleanup System

The description below of the BWRX-300 Reactor Water Cleanup System (CUW) aligns with 006N7609 “Reactor Water Cleanup System SDD” (Reference 9A-26).

The CUW provides blowdown-type cleanup flow for the RPV during the reactor power operating mode. Cleanup or filtration and ion removal is performed by the CFD (PSR Ch. 10, Section 10.2.1). The CUW provides an overboarding flow path to the Main Condenser and Auxiliaries (MCA) system (condensate pump suction) or Liquid Waste Management System (LWM) (PSR Ch. 11, Section 11.2) directly from the RPV lower region (Reference 9A-27). CUW piping can be utilised to reduce reactor temperature stratification with reverse flow from the Shutdown Cooling System (Section 9A.2.3).

9A.2.2.1 System and Equipment Functions

Refer to PSR Ch. 1: Introduction (Reference 9A-28), Section 1.8 for a description of plant operating modes.

The CUW performs the following functions during normal and off-normal conditions.

Normal Functions (Non-Safety Category)

- Mode A
    - Normal Reactor Water Cleanup (1% Flow) Plant mode 1, 2, 3, and 4).

- Mode B – Overboarding
  - Mode B1-A – Overboarding from Reactor Coolant System (RCS) (PSR Ch. 5: Reactor Coolant System and Associated Systems (Reference 9A-29)) to MCA (PSR Ch. 10, Section 10.4.1) (Plant mode 1, 2, 3, and 4).
  - Mode B1-B – Overboarding from RCS to LWM (PSR Ch. 11, Section 11.2) (Plant mode 1, 2, 3, and 4).
  - Mode B2-A – Overboarding from SDC through CUW to MCA (Plant mode 2, 3, 4, and 5).
  - Mode B2-B – Overboarding from SDC through CUW to LWM (Plant mode 2, 3, 4, and 5).
  - Mode B2-C – Overboarding from SDC though CUW bypassing Heat Exchanger (HX) and pressure reduction to MCA (Plant Modes 2, 3, 4, 5, and 6)
  - Mode B2-D – Overboarding from SDC though CUW bypassing HX and pressure reduction to LWM (Plant Modes 2, 3, 4, 5, and 6)
- Mode C
  - RPV thermal stratification reduction (plant mode 2).

Overboarding

During overboarding, the heat exchanger is in service to cool the reactor water to minimise flashing and two-phase flow in the pressure reducing components and downstream piping. Flow can be directed to the MCA, or manually shifted to the LWM.

Thermal Stratification Reduction

The system is designed to provide flow through the bottom head connections in the CUW during startup operations to reduce thermal stratification caused by the continuous input of cold Control Rod Drive (CRD) flow through the control rod drives.

Cleanup Flow to Condenser

During Plant Operational Modes 1, 2, 3, and 4, CUW provides the equivalent of one percent of Feedwater (FW) nominal flow to downstream of a condensate pump for remixing and filtration.

Normal Function (Safety Category)

To ensure the safety of the plant, the system continuously monitors for leakage utilising density compensated differential flow measurements. If a leak is detected, the containment isolation function isolates the system from the Reactor Coolant Pressure Boundary through the closure of the Containment Isolation Valve (CIV) and Reactor Isolation Valves (RIVs).

Off-Normal Functions (Non-Safety Category)

The CUW system does not perform any Non-Safety Category functions during off-normal conditions.

Off-Normal Functions (Safety Category)

The CUW system performs Leak Detection and Isolation functions in Off-Normal conditions. Off-Normal functions for leak detection are the same as described in Normal functions (Safety Category).

9A.2.2.2 Safety Design Bases

CUW components are primarily SC3 and categorised as Non-Seismic, except for the following items that are SC1 or SC2.

The following represents the CUW safety design bases:

1. SC1 leak detection actuates CUW isolation on CUW line break indication in Modes 1, 2, 3, and 4.
2. The CUW provides SC1 containment isolation valves on piping that penetrates the containment boundary. The containment isolation valves are designed to close upon receiving an isolation signal from SC1 I&C System.
3. Upon detecting a CUW line break in Modes 1, 2, 3, and 4 the SC1 I&C System actuates CUW isolation. The CUW isolation valves are designed to close upon receiving an isolation signal from the SC1 I&C System.
4. Diverse SC2 leak detection actuates CUW line isolation on break indication in the CUW lines in Modes 1, 2, 3, and 4. Upon detecting a CUW line break in modes 1, 2, 3, and 4 the SC2 Diverse I&C System actuates CUW isolation. The CUW isolation valves are designed to close upon receiving an isolation signal from the SC2 Diverse I&C System.

9A.2.2.3 Description

Figure 9A-4 depicts a simplified flow diagram of the CUW and interfacing systems.

The CUW system consists of one train fed by two nozzles located on the RPV. The train's inlet is independently connected to RPV penetrations located at about the mid-vessel height which take inlet flow from nozzles located near the RPV bottom head. This piping up to the RPV isolation valves are a part of the RCS. The inlet piping connects to the reactor vessel and combines inside containment to form one discharge line. This line is provided with a CIV where it penetrates containment. This valve will receive a signal from the CUW leak detection system and will close upon a detected leak. CUW continues through a regenerative heat exchanger and a pressure reduction station. The heat exchanger and pressure reduction station are designed to condition the water to acceptable temperatures and pressures for processing to the condensate system or overboarding. The heat exchanger is designed to recover heat back to the condensate and feedwater system. Discharge piping is connected either to a condensate line for the normal CUW function or routed to the MCA or LWM for overboarding.

The leak detection and isolation subsystem perform both a Defence Line 3 (DL3) and Defence Line 4a (DL4a) function to identify leaks and line breaks in the CUW and to initiate automatic response actions by other systems. For DL3, in MODES 1-6, the detection of a leak or line break in the CUW initiates isolation of the CUW system. For DL4a, in MODES 1-4, the detection of a leak or line break in the CUW initiates isolation of the CUW system.

For the DL3 function, the leak detection and isolation subsystem utilise a single Flow Element (FE) in the intake flow path and a single FE in each discharge flow path. Each FE serves independent, redundant sets of divisional Flow Transmitters (FTs), three FTs each for the DL3 line break detection functions. The basis for this arrangement is that a leak or break near the end of a discharge flow path may not be detectable by a single FE/FT feature located in the intake location of the system due to the physical distance between those locations. The design is intended to ensure that a leak or break can be identified by any of the FE/FTs at a detection point, or by differential flow between an upstream and downstream FE/FT detection point. Hence the use of detection features at the intake and at the discharge flow paths allows for detection of differential flow between the intake and any discharge flow path, or detection of a leak or break within detection proximity of any single FE.

The FT readings are density compensated by sets of three independent, redundant SC1 temperature transmitters. This feature accounts for density changes in the water across the heat exchanger that is between the FE located in the intake flow path and the FEs located in each discharge flow path. Density compensation is used to avoid spurious isolation of the CUW and spurious generation of a signal that would initiate unwanted response actions by other systems.

For the DL4a function, the leak detection and isolation subsystem utilises triplicated area temperature sensors in the CUW heat exchanger room. CUW will also utilise NBS's area temperature monitors for leaks in the steam tunnel.

Equipment Qualification of Safety-Class SSC's is provided as applicable as discussed in PSR Ch. 3, Section 3.9.

Component Description

The following provides description of CUW components.

Piping and Valves

The system piping is sized to ensure it can withstand the maximum pressure and temperature combination while keeping the maximum flow velocities within the acceptable limits.

The piping and the wetted parts of the valves are stainless steel to help with ALARP (PSR Ch. 12, Section 12.3) concerns because this system is in contact with potentially radioactive water.

All valves in the system are used for isolation (on/off) except for a throttling valve in the pressure reduction station. This valve is used to throttle the system to achieve desired flow rates.

The Containment Isolation Valves (CIVs) for CUW fail in the closed position, with valve actuators designed to maintain the valves closed by positive mechanical means.

Regenerative Heat Exchanger

The CUW heat exchanger is a regenerative heat exchanger cooled by the Condensate and Feedwater Heating System flow (PSR Ch. 10, Section 10.2.2). The heat exchanger is designed to reduce the temperature of the inlet flow. Most of the heat of the CUW water is transferred to the condensate returning to the reactor.

System Pressure Reduction Station

At the pressure reduction station, a breakdown orifice (or pressure reduction valve) is used to reduce pressure before the water enters the Condensate and Feedwater Heating System (CFS) downstream of the condensate pumps, where it is mixed with the condensate and cleaned in the CFD cleanup filters and demineralisers. This pressure is greater than condensate pressure at the connection point to ensure positive flow. The breakdown orifice (or pressure reduction valve) and associated instrumentation are located downstream of the heat exchanger and upstream of the condensate pump discharge tie-in location in the TB.

9A.2.2.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials specifically from IGSCC (as applicable) through material chemistry, heat treatment, contamination and material processes controls.

9A.2.2.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-4 which provides the description and boundary for each interfacing system.

9A.2.2.6 System and Equipment Operation

Initial Configuration (Pre-Startup)

The CUW is initially idle with the system isolation valves closed. The CUW is shutdown water solid, but because it is idle for long periods, the system pressure may need to be checked to ensure there was no leakage while shutdown. If necessary, the system piping is filled and vented to ensure there is no water hammer upon CUW startup.

System Startup

When the CUW is actuated from the MCR, it first enters a stage of pre-warming. The system SSC are at ambient temperature due to inactivity in Plant Operating Mode 1. The water coming from the RPV is expected to be much warmer; therefore, this pre-warming stage is important to allow the system to gradually heat up to prevent over stressing the components due to thermal growth. The pre-warming is controlled by slowly initiating flow through the CUW through the use of the flow control valve and eventually ramping up to full flow before transitioning to normal operations.

Normal Operations

Operations under normal conditions are described below. Table 9A-5 presents the plant operating Modes and corresponding CUW operational modes.

Mode A – Power Operation:

During power operation (plant Mode 1), the CUW system is in-service, taking input from the bottom of the RPV through two inlet lines. Water flows through piping internally mounted inside the RPV downcomer region and exits the vessel about four meters above top of active fuel. At the top of the piping outside the RPV, there are double isolation valves integral to the vessel which close to prevent RPV inventory from exiting the CUW line in case of a pipe break. Except for the containment isolation and leak detection related functions, the CUW is an SC3 system, and all other system functions defined below are SC3.

The two inlet lines join into a single line outside the RPV where it exits the containment vessel, routes through piping in the steam tunnel and into the TB. The system contains a regenerative heat exchanger in which the CUW water is cooled by the CFS. Most of the heat of the CUW water is transferred to the condensate returning to the reactor. A breakdown orifice is used to reduce pressure before the water enters CFS downstream of the condensate pumps where it is mixed with the condensate and cleaned in the CFD (PSR Ch. 10, Section 10.2.1).

During plant mode 2, 3, & 4 CUW can operate in Mode A. However, due to relying on the reactor for motive pressure for flow through CUW, sufficient reactor pressure is required to overcome system flow resistance for CUW flow to be achieved, with flow being maintained through throttling as reactor pressure increases.

Mode B1-A:

When there is sufficient pressure in the RPV for flow in CUW, CUW can overboard to the MCA. In this mode CUW operates the same as Mode A, with the exception of flow being diverted to the MCA. This function is available in plant modes 1, 2, 3, & 4.

Mode B1-B:

When there is sufficient pressure in the RPV for flow in CUW, CUW can overboard to LWM. In this mode CUW operates the same as mode A, except for flow being diverted to LWM. This function is available in plant Modes 1, 2, 3, & 4.

Mode B2-A:

When there is insufficient pressure in the RPV for flow in CUW, SDC can overboard through the CUW to the MCA. The SDC interfaces with CUW in the steam tunnel, and continues on the same path as described in mode B1-A. Mode B2-A is available in plant modes 2, 3, 4, 5, & 6.

Mode B2-B:

When there is insufficient pressure in the RPV for flow in CUW, the SDC can overboard through the CUW to LWM. SDC interfaces with CUW in the steam tunnel, and continues on the same path as described in mode B1-B. Mode B2-B is available in plant modes 2, 3, 4, 5, & 6.

Mode B2-C:

In the case that Mode B2-A is unavailable due to system maintenance or other unforeseen circumstance, mode B2-C allows for an alternative flow path allowing SDC to overboard though CUW to the MCA while bypassing CUW’s heat exchanger and pressure reduction station.

Mode B2-D:

In the case that Mode B2-B is unavailable due to system maintenance or other unforeseen circumstance, mode B2-D allows for an alternative flow path allowing SDC to overboard though CUW to the LWM while bypassing CUW’s HX and pressure reduction station.

Mode C:

To help reduce vessel stratification, caused by continuous input of cold CRD flow through the control rod drives, while shut down and during preparation for startup, the SDC water can be routed to the RPV lower region through the normal CUW inlet lines. The SDC thermal stratification reduction line interfaces with the CUW system between the regenerative heat exchanger and the isolation containment valve. Mode C is only available in plant mode 2.

Mode 1 – Power Operation:

During power operation, the CUW system is in service in system Mode A, with flow from the bottom of the RPV through two inlet lines. Water flows through piping internally mounted inside the RPV downcomer region and exits the vessel about four metres above top of active fuel. At the top of this piping outside the RPV, there are double isolation valves integral to the vessel, which prevents RPV inventory from exiting the CUW line in case of a pipe break.

The two inlet lines join into a single line outside the RPV, and the CUW water then is routed through piping in the steam tunnel. There is a regenerative heat exchanger in which the CUW water is cooled by the CFS. Most of the heat of the CUW water is transferred to the condensate returning to the reactor, thus losing almost no thermal value. A breakdown orifice is used to reduce pressure before the water enters CFS downstream of the condensate pumps, where it is mixed with the condensate and cleaned in the CFD.

Mode 2 – Startup:

During startup Mode, CUW operation is the same as during power operation. However, due to relying on reactor pressure for flow through CUW, sufficient reactor pressure is required to overcome system flow resistance for CUW flow to be achieved, with flow increasing as reactor pressure increases.

During startup or shutdown, CUW can function to let down (overboard) the excess reactor inventory if there is enough pressure (CUW Mode B1-A and B1-B). If not, the SDC system can be used to let down the excess reactor inventory (CUW Mode B2-A, B2-B, B2-C and B2-D). The primary SDC letdown line interfaces with the CUW upstream of the regenerative heat exchanger. The secondary SDC letdown line interfaces with CUW downstream of the pressure reduction station. Overboard flow can be directed to the MCA or LWM. In this mode, reactor vessel water level is maintained by the control rod drive water.

To help reduce vessel stratification during preparation for startup, SDC water can be routed to the RPV lower region through the normal CUW inlet lines (CUW Mode C).

Mode 3 – Hot Shutdown:

During hot shutdown operation, the CUW system is in-service if the RPV is pressurised. This mode is with reactor temperature >215.6 °C. Vessel letdown can be performed as discussed above under the startup mode.

Mode 4 – Stable Shutdown:

During stable shutdown operation, the CUW system is isolated from the reactor. This mode is with reactor temperature ≤215.6 °C and >93.3°C. If CUW is isolated at the vessel, SDC can be used via CUW if overboarding is required.

Mode 5 – Cold Shutdown:

During cold shutdown operation, the CUW system is isolated at the vessel. This mode is with reactor temperature ≤93.3 °C. SDC can be used via CUW if overboarding is required.

Mode 6 – Refueling:

During refueling operation, the CUW is isolated at the vessel. In this mode reactor temperature is ≤93.3°C. SDC can be used via CUW if overboarding is required.

Off-Normal Operations

No manual operator actions are required to initiate or assure the completion of fundamental safety functions. The RPV isolation valves and containment isolation valve fail in the closed position, with valve actuators designed to maintain the valves closed by positive mechanical means.

For large FW line breaks and reactor water cleanup breaks outside of containment, leak detection systems identify the break condition and provide signals to close the affected system isolation valves.

System Shutdown

The system is capable of overboarding in plant operating Mode 6 in conjunction with the SDC.

Upon shutdown, the system isolation valves are closed. The system remains water solid while shutdown.

9A.2.2.7 Instrumentation and Control

During plant operation and after plant shutdown (with sufficient reactor pressure), CUW removes water from the bottom of the reactor and routes it to the condensate system or overboards excess swell when required, to the MCA or LWM. These functions require both monitoring and control.

The input signals to the control functions are triply redundant and the actuators receive two out of three voted commands from the CUW controller. The CUW controller is triply redundant and is dual ported to the plant balance of plant segment network. As with all Triple Modular Redundant (TMR) controllers, extensive hardware and software diagnostics are provided for operator monitoring and alarms. The CUW controller is also designed to support plant automation. Refer to PSR Ch. 7: Instrumentation and Control (Reference 9A-30) for information pertaining to TMR.

The CUW can be controlled from the main control room. The CUW controller can receive commands from the Plant Automation System or be manually operated. The controller automates the operation of the system.

Flow

There is one SC1 flow element along with triply redundant SC1 transmitters on the system supply line at the containment boundary inside the steam tunnel. This flow indication is used in conjunction with identical flow elements and transmitters located at the end of each flow path. When used as a pair they monitor for system leakage. CUW Isolation are actuated on CUW line break indication in Plant Modes 1-6.

There are triply redundant SC3 transmitters used for the control of the pressure reduction station.

Temperature

There are triply redundant SC1 temperature sensors that accompany the SC1 flow transmitters on the containment boundary and at the end of each flow path. These temperatures are used to provide input for the density compensation of the flow transmitters.

There are triply redundant SC2 area temperature sensors used to monitor for leaks in the CUW heat exchanger room. There is one SC3 temperature sensor downstream of the heat exchanger and prior to the entrance of the pressure reduction station.

Pressure

Pressure Reduction Station Inlet:

One set of triply redundant SC3 pressure instruments are provided at the inlet of the pressure reduction station. These pressure instruments are used to control the pressure reduction station.

Pressure Reduction Station Outlet:

Three SC3 pressure instruments are provided at the discharge of the pressure reduction station. These pressure instruments are used to monitor the discharge pressure of the pressure reduction station, to monitor status and performance.

9A.2.2.8 Monitoring, Inspection, Testing and Maintenance

Maintenance and testing support equipment reliability. SSCs are designed to facilitate operation and maintenance. Maintenance activities, including post-maintenance and post-modification testing, are controlled by plant procedures. Maintenance activities restore SSCs to their original condition or involve a temporary alteration in accordance with plant procedures.

Maintenance practices consider industry best practices such as Institute of Nuclear Power Operations and operating experience and conform with plant safety requirements to minimise potential for personnel injury. Maintenance activities comply with Technical Specifications (TS) as required. Maintenance activities implement plant ALARP practices to minimise work activity dose. Maintenance activities involving critical plant equipment may require involvement of vendors or industry specialists.

Inspections, checks, and tests conducted during the performance of maintenance activities are considered “In-Process Maintenance Tests” and are governed by the in-use maintenance procedures and processes.

Inspections, checks, and tests conducted following the conclusion of maintenance activities are considered “Post-Maintenance Tests” and are governed by plant Post-Maintenance Test procedures. ISI and IST requirements are established and include inspection/test frequency for SSCs. Remote monitoring of key parameters assists in the trending of component performance as part of condition-based predictive maintenance.

9A.2.2.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions. To control and minimise personnel exposure, radioactive equipment is designed to minimise crud buildup and provide for decontamination and maintenance.

9A.2.2.10 Performance and Safety Evaluation

System reliability is enhanced through the use of periodic system testing, preventive maintenance, and application of redundant instrumentation.

The CUW Safety Category 1 functions during normal conditions and off-normal conditions include continuous monitoring for leakage utilising density compensated differential flow measurements. If a leak is detected, in either normal or off-normal conditions the system is isolated from the reactor coolant pressure boundary using system isolation and containment isolation valves.

The arrangement of SSCs minimise the possibility of compromising the functionality of both the Safety Category 1 functions and their backup systems and equipment for any credible events that could cause damage to one region of the plant. The portions of the CUW responsible for performing containment isolation are located in the RB which provides protection against natural phenomena ensuring the ability of the CUW to perform its Safety Category functions.

9A.2.3 Shutdown Cooling System

The SDC provides for decay heat removal when shutting down the plant. The system is also used to reduce reactor pressure vessel inventory and can be used in conjunction with CUW (Section 9A.2.2) piping to reduce reactor pressure vessel thermal stratification.

9A.2.3.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

RPV Thermal Stratification Reduction

The SDC is designed to provide flow through the CUW inlet lines into the bottom head region of the RPV during startup operations to reduce thermal stratification caused by the continuous input of cold CRD flow through the control rod drives.

Thermal stratification reduction is considered part of SDC system Mode C1 and is available in plant operating Mode 2.

Leak Detection:

When the SDC system is operational, the system continuously monitors for leakage utilising area temperature monitors. If a leak is detected via an increase in area temperature, an alarm initiates in the MCR.

Normal Functions (Safety Category)

The SDC system for the BWRX-300 has three Safety Categorised functions:

Decay Heat Removal (DL2/Safety Category 3)

In conjunction with the heat removal capacity of either the main condenser and/or the isolation condensers, the SDC is used to reduce the RPV pressure and temperature during cooldown operation from the rated design pressure and temperature to below saturation temperature at atmospheric pressure in less than one day.

The shutdown cooling function of the SDC provides decay heat removal capability at normal reactor operating pressure as well as at lower reactor pressures. The redundant trains of SDC permit shutdown cooling even if one train is out of service; however, cooldown time is extended when using only one train.

Decay heat removal is considered part of SDC Mode A1 and is available in plant operating Modes 2-6.

Leak Detection and Isolation (DL3/Safety Category 1)

When the SDC is operational, the system continuously monitors for leakage utilising differential flow measurements. If a leak is detected, the system is isolated from the reactor through a number of system isolation and containment isolation valves to prevent the excessive reduction of reactor water inventory.

Overboarding (Safety Category 3):

During reactor startup, it is necessary to remove the CRD purge water injected into the RPV as well as the excess reactor water volume arising from thermal expansion due to reactor heatup. The SDC system accomplishes these volume removals and thereby maintains proper reactor level until the reactor pressure is sufficient to allow use of the CUW overboard flow path.

During overboarding, the Heat Exchanger (HX) is in service to cool the reactor water to minimise flashing and two-phase flow in the downstream piping. The preferred overboarding destination is the LWM system; however, in the event high temperature is detected, the overboarding flow is manually shifted to the MCA system.

Overboarding is considered part of SDC system Mode B1-4 and is available in Plant Modes 2-6.

Off-Normal Functions (Non-Safety Category)

There are no non-safety category functions in the SDC system during off-normal conditions.

Off-Normal Functions (Safety Category)

Loss of Feedwater Flow Modes 2-4:

Operator initiates SDC or Isolation Condenser System (ICS).

Small Line Break Inside Containment Modes 3-4:

On identification of a small line break inside containment with or without preferred power during Modes 3-4, the SDC will initially be used for decay heat removal until the containment is isolated at which time the ICS is initiated to remove the decay heat.

9A.2.3.2 Safety Design Bases

The SDC has three Safety-Class functions, Decay Heat Removal, Leak Detection and Isolation, and overboarding.

SDC components are primarily SC3 and categorised as non-seismic, except for leak detection equipment which supports higher safety category functions.

9A.2.3.3 Description

System Description

The SDC comprises two independent pump and heat exchanger trains. These trains together provide redundant decay heat removal capacity such that each train is designed to remove 100% of decay heat as soon as 4 hours after reactor shutdown. The major components of each train are a pump and HX, along with valves, piping, instrumentation and controls, and power inputs. The two trains operating in parallel provide the systems full rated shutdown cooling performance. Bypass lines and valves are included around the tube side of each HX to allow bypassing of the HX for SDC functions such as reducing RPV thermal stratification.

Each train’s suction is independently connected to a separate ICS (PSR Ch. 5, Section 5.6) condensate return line outside of containment, and downstream of the ICS containment isolation valves. Each SDC train's return piping is independently connected to a separate CFS (PSR Ch. 10, Section 10.2.2) feedwater line outside of the containment isolation valves. This arrangement helps to prevent short circuiting of the flow inside of the RPV because the SDC suction is taken from the ICS return nozzle which originates in the chimney region over the core and the SDC return flow utilises the CFS return which terminates outside this region in the downcomer area.

Decay Heat Removal Subsystem

The subsystem comprises the flow path from the ICS to the SDC pump, through the tube side of the SDC heat exchanger, and then returned to the RPV through the CFS as depicted in Figure 9A-5. The subsystem is available in Plant Modes 2 through 6, though the condenser and ICS are expected to be used initially to cool the reactor after shutdown. The subsystem is initially operated at low flow to allow the system Structures, Systems, and Components, to be brought up to operating temperature without overstressing the components. Once the system is up to temperature, the flow rate increases and is controlled to maintain PCW (Section 9A.2.1) heat exchanger cooling water exit temperature within the interface requirements of 54.4°C for two SDC trains running and 60.0°C for one train running.

Overboarding Subsystem

The overboarding subsystem supports RPV level control during Plant Modes 2 through 6 when the fuel pool gate is installed and the CUW (Section 9A.2.2) is not available for use. The subsystem comprises the flow path from the ICS to the SDC pump, through the tube side of the SDC heat exchanger, and then through the overboard flow path (see Figure 9A-6). The figure shows multiple overboard flow pathways highlighted; however, only one overboard path is implemented at a time by controlling the position of the valves on each flow path. The SDC trains share the overboard control valves and each train has its own isolation valve to prevent inadvertent overboarding. Each overboard flow path has been designed to provide adequate overboarding flow to support the worst-case scenario (fastest) heat-up rate of the reactor combined with the expected water input from the CRD (PSR Ch. 4, Section 4.4).

The preferred overboard flow path is from the SDC to the LWM system; however, in the event that high temperature is detected in the effluent, the flow path is manually switched from the LWM to the MCA system. The overboarding flow pathways through the CUW are utilised in the event of failure of any of the other overboard pathway isolation valves, or if the pressure in the SDC is too high for the interfacing system, in which case, the CUW pressure reduction station is utilised to reduce the fluid pressure to protect the interfacing system.

Each overboard flow pathway from the SDC has two fail-closed valves in series. There are two valves in series to prevent exposing a lower design pressure system or subsystem to a higher design pressure system in the event of an inadvertent opening of a single valve.

Thermal Stratification Reduction Subsystem

The subsystem comprises the flow path from the ICS to the SDC pump, through the SDC heat exchanger bypass line, and then through the overboard flow path through the CUW and back to the RPV through the RCS as depicted in Figure 9A-7. The subsystem provides approximately 45.4 m^3/h to the bottom region of the RPV to counter act the constant 4.5 m^3/h flow from the CRD through the control rod drives. The 10:1 flow ratio is expected to provide sufficient heat to overcome the cooling effect of the CRD flow. Also, the velocity at the discharge of the piping into the RPV is sufficient to promote mixing in the bottom head region to minimise thermal stratification.

Leak Detection and Isolation Subsystem

The leak detection and isolation subsystem are comprised of three flow elements per train along with two sets of triply redundant transmitters per flow element to support DL3. The readings are utilised to account for temperature change across the heat exchanger. This is done to avoid spurious isolation of the SDC which would reduce the SDC capacity, or if both trains are isolated, would require the restart of ICS.

The control system compares the density compensated flow readings from the supply flow transmitters against flow readings from the return and overboard flow transmitters. If the system detects a flow differential greater than the acceptable leakage value, the control system actuates Main Steam Reactor Isolation Valve (MSRIV) Isolation, Feedwater Isolation, and SDC Isolation.

Component Description

Shutdown Cooling System Piping and Valves

The SDC piping material is 304L stainless steel. The pipe wall thickness has been sized to ensure it can withstand the maximum pressure and temperature combination while the diameter has been chosen to ensure the maximum flow velocities stay within the acceptable limits. The piping and the wetted parts of the valves are stainless steel which supports ensuring ALARP goals because this system is in contact with potentially radioactive water.

All valves in the system are used for isolation (on/off) except for the heat exchanger bypass valve overboard control valve, and recirculation control valve. The heat exchanger bypass valve is used to throttle the bypass around the heat exchanger and can be used in conjunction with the SDC pump speed control to control the exit temperature of the heat exchanger.

SDC leak detection piping and valves are designed, manufactured, and tested in accordance with ASME BPVC Section III, Class 3. Heat removal and overboarding piping and valves are designed, manufactured, and tested in accordance with ASME B31.1.

Shutdown Cooling System Pumps and Valves

Each train of the SDC contains one SC3 horizontal centrifugal pump sized to allow sufficient flow to remove 100% of the decay heat generated by the core 4 hours after shutdown. The SDC pumps are designed to pump the maximum flow required by the system to meet SDC cooldown requirements for decay heat removal. The pump is installed below the RPV inlet nozzle which provides adequate NPSH at maximum flow conditions. Each pump is paired with a flow control valve to allow for control of the cooldown rate and the reactor temperature during shutdown.

The flow control valves on the recirculation line and overboard line allow the flow to be adjusted to meet all expected system flow design points.

SDC pumps are designed, manufactured, and tested in accordance with ASME BPVC Section VIII. SDC pump wetted parts are manufactured from stainless steel.

Shutdown Cooling System Heat Exchangers

Each train of the system contains one SC3 shell and tube heat exchanger sized with sufficient capacity to remove 100% of the decay heat generated by the core 4 hours after shutdown. The heat is transferred from the SDC process fluid to the PCW.

SDC heat exchangers are designed, manufactured, installed, and tested in accordance with ASME BPVC Section VIII, Division 1. SDC heat exchanger tubes are constructed of stainless steel.

9A.2.3.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials specifically from IGSCC through material chemistry, heat treatment, contamination, and material processes controls.

9A.2.3.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-6 for SDC interfaces with other equipment or systems.

9A.2.3.6 System and Equipment Operation

Plant cooldown following shutdown is accomplished using a combination of the main condenser, ICS, and SDC systems. Although the SDC system is qualified for high temperature and pressure operation, the main condenser and ICS condensers are the preferred cooldown sources immediately following shutdown.

Initial Configuration (Pre-Startup)

The system is initially idle with the system isolation valves closed. When the system is shutdown, it is water solid, but because it is idle for long periods, the system pressure may need to be checked to ensure there was no leakage while shutdown. If necessary, the system piping is filled and vented to ensure there is no water hammer upon system startup.

System Startup

When the system is actuated from the control room, it first enters a stage of pre-warming. It is expected that the system SSCs are at ambient temperature due to inactivity in Plant Mode 1, but the water coming from the RPV is expected to be much warmer; therefore, this pre-warming stage is important to allow the system to gradually heat up to prevent over stressing the components due to thermal growth. The pre-warming is controlled by initiating low flow through the SDC using the flow control valve and eventually ramping up to full flow before transitioning to normal operations.

Normal Operations

The normal and off-normal operational modes of the SDC are described below. This includes how the plant transitions from a shutdown condition to full power, how steady-state full power operation is maintained, how the transition from full power to shutdown is achieved, and how a refueling outage is performed. Table 9A-7 lists the plant operational modes and the corresponding operational modes of SDC. The SDC system modes and functions are discussed in more detail below.

Plant Mode 1 - Power Operation

During power operation, the SDC is not in-service.

Plant Mode 2 - Startup Mode

The SDC is a manually initiated system.

During startup operation, the SDC is initially in-service to provide a reactor water reject flow path for RPV level control. The SDC is eventually taken out of service when the RPV pressure is high enough to establish CUW flow and when the SDC has inadequate net positive suction head due to voiding in the chimney section.

If the SDC is required to reduce vessel thermal stratification, SDC Mode C1 is utilised. After flow from SDC enters the CUW it is routed reverse the normal flow direction and discharges from the CUW inlet lines into the RPV bottom head region.

Plant Mode 3 - Hot Shutdown Operation

During hot shutdown operation, the SDC is not normally in-service because heat removal by steam condensation is more efficient. The SDC requires adequate water level in the chimney after shutdown before it is placed into service.

Plant Mode 4 - Stable Shutdown Operation

During stable shutdown operation, the SDC system can be in service if cold shutdown mode transition is planned. SDC system operation can be initiated after there is an adequate water level in the chimney to provide the necessary NPSH for the SDC pump and for overflow of water through the steam separator. The system pressure rating is such that it can be started up at any pressure up to full reactor design pressure for operational flexibility. Each train of the SDC system can remove the total decay heat generated after 4 hours following reactor shutdown.

When RPV pressure drops to a point that the normal reactor water reject flow path is ineffective, the SDC can be placed into service to provide this function through an interface connection to the CFS and LWM.

Plant Mode 5 - Cold Shutdown Operation

During cold shutdown operation, the SDC is in-service. Each train of SDC can separately remove 100% of the decay heat generated 4 hours following reactor shutdown. Both trains of the SDC are normally available in cold shutdown conditions, but one train may be taken out of service at a time for maintenance if needed.

With the RPV depressurised, the SDC also provides water reject flow through an interface connection to the MCA and LWM.

Plant Mode 6 - Refueling Mode

At any time when the fuel pool gate is installed and water level is being held constant, the SDC is overboarding to the LWM to offset the CRD purge flow.

During refueling operation, the SDC system is in service. Each train can separately remove 100% of the decay heat 4 hours following reactor shutdown. The SDC system reject flow path is coordinated with the water level in the RPV, position of the FP gate, and availability of the Fuel Pool Cooling and Cleanup System. When fully flooded and connected to the fuel pool, the Fuel Pool Cooling and Cleanup System can maintain a constant level. Refer to Table 9A-8 for information pertaining to SDC configuration during refueling mode.

Off-Normal Operation

Loss of Feedwater Flow Plant Modes 2-4

Operator initiates SDC or ICS.

Small Line Break Inside Containment Plant Modes 3-4

On identification of a small line break inside containment with or without preferred power during Plant Modes 3-4, the SDC is used for decay heat removal until the containment is isolated at which time the ICS is initiated to remove the decay heat.

Spurious Closure of Valve in Pump Suction or Discharge Path:

An obstruction to flow trip will be derived utilising the leak detection flow instrumentation on the supply, return, and overboard flow paths. Upon detection of a significant drop in total SDC mass flow rate, the control-room operator is presented with a 2 out of 3 (2oo3) logic confirmed Off-Normal condition. A suitable time delay allows for operator action to quickly resolve the issue with the SDC pump tripping after the time delay if the issue is unresolved.

System Shutdown

The SDC is shutdown as the plant heats up in Plant Mode 2. The cooling function is no longer required since heat is being intentionally added to the RPV and the overboarding function transitions from the SDC to the CUW when the RPV pressure is sufficient to drive the necessary flow through the CUW to the overboarding destination. The thermal stratification reduction function won’t be necessary once the CUW is overboarding since any cold spots developing near the piping terminations are overboarded or mixed with the flow entering the core.

Upon shutdown, the pump is turned off and the system isolation valves closed. The system remains water solid while shutdown.

9A.2.3.7 Instrumentation and Control

The SDC is a manually initiated system but is designed for automatic control of functions such as SDC system piping pre-warming, adjusting the system heat removal rate to stay within vessel and HX cooling water limitations, as well as allowing the operator to input a temperature rate setpoint that allows automatic vessel water temperature cooldown rate. Additionally, during reactor heat-up, the SDC controllers receive flow demand signals from the Reactor Level Control to allow swell to be overboarded to maintain reactor level. The SDC can be controlled from the MCR as well as the Secondary Control Room (SCR).

The SDC has its own (triply redundant) sensors for control and its own actuators. It is possible to validate the temperature signals used for control with reactor water temperature measurements and (when steaming) reactor pressure measurements. The SDC controllers are triply redundant and are dual ported to the plant nuclear segment network. As with all Triple Modular Redundant controllers, extensive hardware and software diagnostics are provided for operator monitoring and alarms. Refer to PSR Ch. 7 for information pertaining to TMR.

Flow

Supply Flow

There is one SC1 flow element along with triply redundant SC1 transmitters on the system supply line upstream of each SDC pump. The instruments are used in conjunction with the return flow and overboard flow instruments to support the DL3 function of monitoring for system leakage. MSRIV Isolation, Feedwater Isolation, and SDC Isolation are actuated on SDC line break indication in Plant Modes 1-4.

Return Flow

There is one SC1 flow element along with triply redundant SC1 transmitters on the system return line downstream of the overboarding branch connection. This flow indication is also used in conjunction with the supply flow and overboard flow instruments to support the DL3 function of monitoring for system leakage respectively.

Overboard Flow

There is one SC1 flow element along with triply redundant SC1 transmitters on the system overboard line upstream of the point where the two system trains connect. This flow indication is also used in conjunction with the supply flow and return flow instruments to support the DL3 function of monitoring for system leakage respectively.

Pump Seal Purge Flow

There is one SC3 flow element along with one SC3 flow transmitter on the pump seal purge line. This flow instrument is used to monitor flow from the CRD system to the SDC pump to ensure seal purge flow is within acceptable limits.

Temperature

Heat Exchanger Inlet Temperature

There are triply redundant SC1 temperature sensors upstream of the pump. This temperature is used to provide input for the density compensation of the SC1 supply flow transmitters respectively.

The SC1 temperature sensors along with the heat exchanger discharge temperature is used to monitor the performance of the SDC heat exchanger. In Plant Modes 3 and 4, when the SDC is operational, these temperature elements are used to determine the average reactor coolant temperature.

Heat Exchanger Discharge Temperature

There are triply redundant SC1 temperature sensors on the discharge of the heat exchanger. This temperature is used to provide input for the overboard flow and return flow transmitters.

The SC1 temperature sensors along with the heat exchanger inlet temperature is used to monitor the performance of the SDC heat exchanger. This temperature is also used to modulate the heat exchanger bypass valve to allow the combined discharge temperature from the heat exchanger and bypass to meet a pre-set value.

Overboard Temperature

There is one SCN temperature sensor on the overboard line. This temperature is measured prior to discharge to MCA / LWM / CUW to ensure that the temperature of the fluid is acceptable for the interfacing system.

Area Temperature

There are two SCN area temperature sensors provided for each of the five SDC rooms. The area temperature is monitored to help inform the operator of any potential leakage.

Pressure

SDC Pump Suction Pressure

There is one SC3 pressure instrument provided at the suction of each SDC pump. This pressure instrument is used to monitor the suction pressure of the SDC pumps, in order to monitor pump status and performance.

SDC Pump Discharge Pressure

There is one SC3 pressure instrument provided at the discharge of each SDC pump. This pressure instrument is used to monitor the discharge pressure of the SDC pumps, in order to monitor pump status and performance.

Heat Exchanger Differential Pressure

There is one SC3 differential pressure instrument provided to measure the pressure drop across the tube side of the heat exchanger. This pressure drop is monitored to help inform the operator of needed maintenance.

9A.2.3.8 Monitoring, Inspection, Testing, and Maintenance

Maintenance and testing support equipment reliability. SSCs are designed to facilitate operation and maintenance. ISI and IST requirements are established and include inspection/test frequency for SSCs. Remote monitoring of key parameters assists in the trending of component performance as part of condition-based predictive maintenance. Testing is performed to ensure required functional operability is maintained under design conditions. The Safety Category Functions of the SDC that support decay heat removal are tested in accordance with ASME BPVC Section XI as applicable. Testing is performed in accordance with plant procedures. Testing in support of plant pre-operational testing, startup, and commissioning is addressed in PSR Ch. 14, Section 14.3.

Maintenance practices consider industry best practices and operating experience and conform with plant safety requirements to minimise potential for personnel injury. Maintenance activities implement ALARP practices to minimise work activity dose. Maintenance activities involving plant equipment may require involvement of vendors or industry specialists.

9A.2.3.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions. In addition, the following design features are employed to reduce dose:

1. Process piping from the containment penetrations to the overboard lines should be routed through shielded areas or pipe chases to reduce the dose rates to the general areas of the reactor building.
2. Components within a compartment are arranged to facilitate rapid maintenance and inspection and allow for the addition of temporary shielding. Reducing the time for maintenance and inspection activities minimises the duration and intensity of radiation exposure and assists with meeting ALARP goals.
3. Field located instruments and/or indicators are visibly and conveniently mounted outside of secondary shielding walls. This arrangement avoids unnecessarily exposing personnel to radiation during routine monitoring and maintenance.
4. SDC heat exchangers are manufactured with all-welded construction with flanged connections where accessibility to internal components is required for maintenance, inspection, or replacement. Maximising welding reduces crevices in the heat exchanger and flanging the connections for accessibility helps reduce maintenance time – both of which support ALARP goals.

9A.2.3.10 Performance and Safety Evaluation

System reliability is enhanced through the use of periodic system testing, preventive maintenance, and application of redundant instrumentation.

The SDC Safety Category functions during normal conditions include decay heat removal and, leak detection and isolation as discussed in Section 9A.2.3.1. There are no Safety Category functions associated with Off-Normal conditions.

Containment isolation is provided in accordance with IAEA SSR-2/1 Requirement 56 (Reference 9A-4). Refer to PSR Ch. 6, Section 6.3.4 for a discussion related to BWRX-300 containment isolation and containment isolation valves.

The SDC is located in the RB which provides adequate protection against natural phenomena ensuring the ability of the SDC to perform its Safety Category functions.

9A.2.4 Chilled Water Equipment System

The description below of the BWRX-300 Chilled Water Equipment (CWE) aligns with 006N7765 “BWRX-300 Chilled Water Equipment (CWE) SDD” (Reference 9A-31).

The CWE is a closed loop chilled water system that supplies chilled water to various non-safety category Air Handling Unit (AHU) cooling coils and plant equipment coolers in the TB, Radwaste Building (RWB), RB, and Control Building (CB). Heat absorbed by the CWE is rejected to atmosphere from the CWE chiller condensers mounted on the roof of the CB.

9A.2.4.1 System and Equipment Functions

System and equipment functions associated with the CWE are specified as follows.

Normal Functions (Non-Safety Category)

CWE provides the following Non-Safety Category functions:

1. Provides chilled water to cooling coils in HVAC for Non-Safety equipment in the following buildings or areas: CB, RB, TB, and RWB

2. Provides chilled water to selected non-safety equipment coolers

Normal Functions (Safety Category)

The CWE provides the following Safety Category functions:

1. As part of a Safety Category 3 function the CWE supplies chilled water to the Containment Cooling System (CCS) Air Handling Units (AHUs).
2. The CWE supplies chilled water to SC3 equipment.

Off-Normal Functions (Non-Safety Category)

The CWE performs no Non-Safety Category functions during Off-Normal conditions.

Off-Normal Functions (Safety Category)

As part of DL3 and DL4a, CWE containment isolation valves are designed to close upon receiving an isolation signal from either the SC1 or SC2 I&C Systems.

9A.2.4.2 Safety Design Bases

CWE components are primarily SC3 and categorised as non-seismic except for containment penetration, isolation, and piping between CIVs which are SC1 and Seismic Category 1A. Components supporting HVAC for non-safety equipment, and glycol auto-fill and chemical bypass units are SCN.

As part of DL3, CWE containment isolation valves on piping that penetrate the containment boundary are designed to close upon receiving an isolation signal from the SC1 I&C system.

As part of DL4a, the CWE containment isolation valves will close when signalled to do so by SC2 Instrumentation & Control (I&C) system.

9A.2.4.3 Description

CWE is a closed loop chilled water system that supplies chilled water to various AHU cooling coils and plant equipment coolers in the TB, RWB, RB, and CB. Heat absorbed by the CWE is rejected from the CWE chiller condensers mounted on the CB roof to atmosphere.

The CWE is comprised of four (4) air-cooled chillers, four (4) pumps, one (1) expansion tank, four (4) air separators, one (1) chemical bypass feeder, one (1) glycol auto-fill unit, piping, valves, instruments, and controls. The CWE shares a common header and is split into two different sets of AHU and Fan Coil Unit (FCU) supporting redundant D-in-D equipment. The CWE common header consists of four chillers, four pumps, four air separators, an expansion tank, glycol auto-fill unit and chemical bypass feeder.

The CWE common header is cross-tied using manual valves, which are normally open, to allow for the three active chillers to evenly share the heat load; however, these valves can be closed for maintenance separation.

Figure 9A-8 depicts a simplified flow diagram of the CWE system.

Four 33% capacity air-cooled chillers are provided to reject heat from the closed chilled water loop to the environment. During normal operation, three chillers are in service while the fourth is in standby mode. Each chiller consists of an evaporator section, condenser section, refrigerant compressor, controls, and an integrated waterside economiser which allows for the chillers to run at reduced electrical loads at lower ambient temperatures. The CWE chillers utilise a specific site approved refrigerant to exchange heat with the propylene glycol/water mixture. Each CWE chiller is provided with built-in protection against freezing.

Four 33% capacity in-line chiller pumps deliver chilled water from the CWE return header to the dedicated chiller. During normal operation, three pumps are in service while the fourth is in standby mode.

The CWE system trains are powered by separate generator load groups as part of the D-in-D protection function.

Four air separators are provided to remove entrained air. An air separator is connected to the chilled water return header upstream of each chiller pump. The air that is removed by the air separators is piped to the expansion tank to provide the gas cushion for chilled water expansion and contraction.

The expansion tank is connected to the main chilled water return line and provides a reservoir of demineralised makeup water to account for small amounts of system leakage and accommodate thermal expansion and contraction of water within the system while maintaining the system pressure. The expansion tank level is also used to determine the need for additional makeup fluid. The expansion tank is shrouded to prevent rain, snow, and other debris from collecting in the expansion tank curbed area. The shroud is fitted with sight glasses for operators to manually inspect the curbed area for any liquid that has been collected.

The glycol auto-fill unit has a connection to the Water, Gas, Chemical Pads System (Section 9A.9.5) to provide demineralised water to maintain a predetermined propylene glycol/water mixture.

Isolation valves are provided at the interfaces with the components being cooled by CWE to allow for maintenance on those items without impact to the CWE system operation.

The supply line penetrations have electrical controls for pneumatic ASME Division I isolation valves outside containment and a Safety Class check valve inside containment, and ASME Class 2 piping into the primary containment The return piping inside of primary containment is provided with relief valves to protect against overpressure caused by thermal expansion.

The return lines through the containment penetrations have electrical controls for pneumatic ASME Division I and Division II isolation valve outside and inside containment, respectively and ASME Class 2 piping into the primary containment.

The CWE containment isolation valves are designed to operate in environments associated with the normal and accident conditions in the RB to which they are exposed. Refer to PSR Ch. 3, Section 3.9.4 for information pertaining to Equipment Qualification.

The CWE expansion tank, glycol auto-fill unit, chemical bypass feeder, and chillers pumps are all surrounded by a permanent curb to prevent the accidental excursion of propylene glycol into the Equipment and Floor Drainage System (Section 9A.9.3) sumps. To minimise dose exposure to plant personnel, the isolation valves for the FCUs located inside the bioshield area of the TB are positioned outside the bioshield area.

Component Description

Air-Cooled Chillers

Four (4) 33% capacity air-cooled chillers are provided. Each chiller consists of an evaporator section, condenser section, refrigerant compressor, controls, and environmental condition waterside economiser which allows for the chillers to run at reduced electrical loads at lower ambient temperatures. The chillers have individual temperature controls and modulating inlet vanes for capacity control.

Refrigerant piping is designed and fabricated per AMSE B31.5 (Reference 9A-25).

Each chiller is equipped with pressure relief valves which relieves excess pressure of the refrigerant charge to the atmosphere.

The chiller capacities include a 15% margin to accommodate unaccounted hot surfaces, higher than anticipated latent loads, and other unknown cooling loads.

Pumps

Four (4)x33% capacity centrifugal, electric motor driven pumps are provided.

Chemical Bypass Feeder

A carbon steel chemical bypass feeder tank is provided to treat the glycol water mixture and prevent the development of organics within the closed cooling water loop. The bypass feeder tank is designed to meet the requirements of ASME BPVC, Section VIII.

Expansion Tank

The expansion tank is connected to the main chilled water return line and provide a reservoir of demineralised makeup water to account for small amounts of system leakage and accommodate thermal expansion and contraction of water within the system while maintaining the system pressure.

Glycol Auto Fill Unit

The packaged, glycol auto fill unit maintains the glycol system pressure by providing glycol make-up automatically upon a drop in system pressure. The glycol auto-fill unit has a connection to the Water, Gas and Chemical Pads system to provide demineralised water to maintain a predetermined propylene glycol/water mixture. Upon a drop in liquid level in the expansion tank, the integrated side suction peripheral pump starts adding fluid from the glycol auto fill tank to the CWE System expansion tank until the setpoint level is reached.

Piping and Valves

All non-refrigerant piping is designed in accordance with the requirements of ASME B31.1 with the exception of the containment penetration portion. The containment isolation valves and lines that supply and return chilled water to the containment cooling system cooling coils are SC1, designed to the requirements of BPVC Section III, Division 1- Subsection NCD; and are Seismic Category 1A. The containment isolation valves are designed to fail-closed on a loss of air or signal.

Refrigerant piping inside the air-cooled chillers is designed and fabricated in accordance with the requirements of American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 15 (Reference 9A-32).

Overpressure relief valves are provided on the CWE return lines located both inside and outside of containment.

CWE piping is provided with insulation to prevent pipe sweating as required. The pipe insulation meets the combustibility requirements in compliance with fire protection codes and standards.

9A.2.4.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials through material chemistry, heat treatment, contamination, and material processes controls.

Materials are selected in accordance with applicable codes, standards, and industry practice for the design, service, and test conditions and expected ambient conditions. Materials are compatible with the internal process and external environmental conditions during normal, abnormal, accident, and beyond design basis accident conditions as appropriate. Building construction utilises non-combustible materials as defined in the fire protection Codes and Standards.

9A.2.4.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-9 for Chilled Water Equipment interfaces with other equipment or systems.

9A.2.4.6 System and Equipment Operation

Normal Operational Concept

During normal operation, three chillers are in service while the fourth is in standby mode. Each chiller consists of an evaporator section, condenser section, refrigerant compressor, controls, and environmental condition waterside economiser which allows for the chillers to run at reduced electrical loads at lower ambient temperatures. The chillers have individual temperature controls and modulating inlet vanes for capacity control.

The chilled water temperature control valves modulate in response to room or supply air temperature controllers for the CB and RB, which are part of the HVS per 006N7781 “BWRX-300 Heating Ventilation and Cooling System SDD” (Reference 9A-33) except for the CCS (Section 9A.5.6) AHUs. As the cooling loads decrease, the control valves modulate to decrease the chilled water flow.

The glycol auto-fill unit will automatically be switched on and off based on the level transmitter in the expansion tank. Upon receiving a low-level signal, the glycol auto-fill unit will switch on and add additional fluid to the CWE expansion tank.

Chillers and pumps are normally cross tied together such that flow from the RWB, TB, RB, and CB are shared proportionally between the common header based on the number of active chillers. Chill water flow is maintained through all headers regardless of whether the component is running or in standby.

Depending on the ambient conditions, the chillers are able to operate in one of three different modes: mechanical cooling only, hybrid cooling, or free cooling only. When the ambient temperature is too warm to provide free cooling, an integrated three-way valve at the chiller inlet allows the glycol/water mixture to only run through the condenser coils. When the temperature reaches an ambient temperature where some free cooling is feasible, the three-way valve diverts some flow through the free cooling coils which then enters the chiller evaporator. If further fluid temperature reduction is required, the chillers will perform the remaining mechanical cooling.

As the ambient temperature continues to decrease, there will be a point where the supply temperature can be met by free cooling operation alone and the mechanical cooling can be shut off completely. During free cooling mode, the chillers operate using significantly less power because the waterside economiser does not use a refrigerant loop and the section requires fewer hot air discharge fans.

When one or multiple FCUs located inside the TB bioshield area are manually isolated because of a leak, the chilled water trapped between the isolation valves is drained to prevent damage to the CWE distribution pipe or FCUs tubes due to thermal expansion.

Off-Normal Operational Concept

During a LOPP the chillers and pumps are tripped and then one (1) CWE chiller and one (1) pump is required to restart on the sequential standby diesel generator. In the case if the sequential standby diesel generator fails to start, the MCR will place the available chiller and pump on the train in service. The supply header isolation AOVs in the TB and RWB will close automatically, so that the chilled water will only flow through the equipment in the RB and CB required for the safe shutdown of the plant.

Upon station blackout, the CWE is not operating.

9A.2.4.7 Instrumentation and Control

Instrumentation

CWE contains sufficient instrumentation to:

1. Verify chilled water pump performance, by monitoring pump suction and discharge pressure.
2. Verify chiller performance, by monitoring the inlet and outlet pressure, CWE flowrate, and the inlet and outlet temperatures for each chiller.
3. Verify chilled water return and supply header temperatures.
4. Verify pressure loss through the system.
5. Provide remote status indication of the air-operated containment isolation valve to the MCR and SCR.

Controls

System and component operating status, including the state of manual overrides, and the state of the A and B trains are provided at the MCR and SCR. Manual initiation and shutdown of CWE is provided from the MCR.

The CWE is expected to run continuously with three of the four chillers and pumps running while the other chiller and pump are on standby. The operator manually brings the standby chiller/pump combo online by selecting an operating chiller to put into standby. Upon receiving the standby command, the standby pump will start, followed by the chiller. Once the MCR or SCR receives confirmation that the pump and chiller are both on, the operating chiller will stop, followed by the pump. The chillers and chiller support systems are capable of automatically starting and stopping based on the CWE supply header temperature; however, the chillers and CWE pumps can be operated remotely from the MCR.

A chilled water temperature control valve located in the return piping at each AHU cooling coil bank, is designed to maintain air discharge temperature of the upstream AHU. The chilled water control valves modulate in response to room or supply air temperature controllers, which are part of the HVS except for the CCS AHUs. The temperature control valves downstream of the CCS AHU cooling coils modulate in response to the air discharge temperature of the CCS AHUs. As the cooling loads decrease, the valves modulate to decrease the chilled water flow causing a differential pressure increase across the supply and return mains.

9A.2.4.8 Monitoring, Inspection, Testing, and Maintenance

Pre-operational testing is performed in accordance with applicable codes and manufacturer recommendations.

Component specific maintenance procedures are outlined in the vendor manuals provided as part of each procurement package and are a part of a maintenance program conforming to ASME Code OM 2020.

Areas requiring inspection are provided with access and removable insulation.

CWE piping and valves for the containment penetrations are tested in accordance with appropriate standards. Test and vent connections are provided at the containment isolation valves in order to verify that the valves meet the local leak rate limits.

The containment isolation valve closure time is monitored during the valve operability test and the leakage is monitored or verified during the valve leakage test as specified in the containment leakage testing program. Leak detection and inspection for primary containment isolation features is designed to ASME BPVC Section III, Division 1, Class 1 (Reference 9A-34). A test connection is provided to support local leak rate testing of the primary containment boundary. The test connections minimise the amount of water that must be drained to permit periodic testing of containment isolation valves that include operability testing, leak rate testing, valve status verification, and test frequency.

Containment isolation valve testing, stroke time testing, and leakage rate testing are incorporated to ensure proper and safe functionality of the valves.

Isolation valves are provided at each piece of equipment, control valve, and piping circuit so they can be isolated for maintenance and repair.

Chillers and pumps are arranged to provide adequate floor space and unobstructed clearance to permit monitoring, maintenance, and inspection of each unit.

Isolation valves are provided at the interfaces with the components being cooled by CWE to allow for maintenance on those items without impact to the CWE system operation.

9A.2.4.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.2.4.10 Performance and Safety Evaluation

The CWE is split into two trains which allows for the isolation of the two different sets of AHUs and FCUs supporting redundant defence in depth equipment.

CWE is designed with sufficient redundancy to assure that chilled water is normally available during all modes of plant operation, including startup and shutdown. Certain equipment needed during a Loss-of-offsite power are provided Diesel Generator backup power.

As part of DL3, the CWE performs a Safety Category 1 containment isolation function. The CIVs are designed to close upon receipt of an isolation signal from the SC1 Instrument and Control System.

9A.2.5 Normal Heat Sink System

The NHS System provides heat rejection for the CWS and the PCW during normal operation and shutdown. Refer to PSR Ch. 10, Sections 10.4.5, and Section 9A.2.1 for information related to the CWS and PCW respectively.

Refer to PSR Ch. 9B: Civil Structures Section 9B.3.5 for information pertaining to the Pumphouse, Forebay, and Tunnels.

Figure 9A-9 presents a simplified line diagram of the CWS showing the interface with the NHS.

9A.2.5.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

The NHS provides the supply of cooling water for the circulating water pumps, which removes heat from the main condenser and provides the supply of cooling water for the service water pumps which remove heat from the PCW heat exchangers. The NHS accepts the water return flow from both CWS sub-systems. NHS performs this function at all times for all plant modes of operation.

Normal Functions (Safety Category)

The NHS performs the following Safety Category 3 functions during normal conditions:

- Provides cooling water as a means to reject heat from the MCA to the environment
- Provides cooling water as a means to reject heat from the PCW heat exchangers to the environment

Off-Normal Functions (Non-Safety Category)

The system does not perform any Non-Safety Category functions during off-normal conditions.

Off-Normal Functions (Safety Category)

Upon a LOPP, the NHS continues to provide a cooling water source and heat rejection functions for the service water sub-system to support continued PCW cooling function.

9A.2.5.2 Safety Design Bases

The NHS provides cooling water to the two CWS service water pumps (2A and 2B) (PSR Ch. 10, Section 10.4.5), which in turn are relied upon to provide cooling water to the PCW heat exchangers, to support Safety Category 3 functions for FPC (Section 9A.1.3) and SDC (Section 9A.2.7).

The NHS provides water to the two CWS circulating water pumps (1A and 1B) (PSR Ch. 10, Section 10.4.5) which in turn provide cooling water to support the Category 3 function of heat rejection from the MCA.

9A.2.5.3 Description

The NHS is a once-through cooling water system design. Water will flow into the intake structure forebay from the local water source by means of an intake tunnel. The water is strained prior to pumping by the CWS pumps.

The circulating water pumps provide cooling water as a means to reject heat from the MCA to the environment. The service water pumps provide cooling water as a means to reject heat from the PCW heat exchangers to the environment.

The returned water is discharged back into the local water source through the discharge structure. A recirculation line from the CWS discharge line to the intake is provided to moderate NHS temperature at the Forebay of the NHS, as needed, during cold weather conditions.

9A.2.5.4 Materials

Material and process control requirements for the BWRX-300 structures and components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials specifically from corrosion (as applicable) through material chemistry, heat treatment, contamination, and material processes controls.

9A.2.5.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-10 for system interfaces.

9A.2.5.6 System and Equipment Operation

See System and Equipment Functions above.

9A.2.5.7 Instrumentation and Control

The NHS has no instrumentation and controls associated with the system. All NHS parameters are measured within CWS.

9A.2.5.8 Monitoring, Inspection, Testing, and Maintenance

Maintenance and inspection is based upon integrating proactive, reactive, preventive, and predictive maintenance and operating experience. Implementation of maintenance and inspection increases the probability that the NHS structures, systems, and components function in the required manner over their design life cycle. Operational testing is performed in accordance with plant procedures.

9A.2.5.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.2.5.10 Performance and Safety Evaluation

The NHS is capable of performing its design functions during all modes of operation. Upon a LOPP, NHS continues to provide a cooling water source and heat rejection functions for the service water sub-system to support continued PCW cooling function.

9A.2.6 Isolation Condenser Pools Cooling and Cleanup System

The description below of the Isolation Condenser Pools Cooling and Cleanup System (ICC) aligns with the SDD 006N7345 “Isolation Condenser Pools Cooling and Cleanup System” (Reference 9A-35). The ICC processes water from the three Isolation Condenser Cubicle Pools and surrounding Isolation Condenser Outer Pools, to maintain water temperature within prescribed safety analysis and administrative limits established for the plant. The ICC also purifies the Isolation Condenser (IC) pool water to maintain established plant water quality standards.

The ICC has overall responsibility for the water contained in the IC pool compartment structure, including responsibility for designed safety features such as pool atmospheric vents, long-term EME makeup water replenishment, and unidirectional pool makeup conduits that supply makeup water from the outer pool segments to the inner pools during off-normal conditions.

9A.2.6.1 System and Equipment Functions

The ICC performs the following functions during normal and off-normal conditions.

Normal Functions (Non-Safety Category)

- The ICC maintains the level of the IC Pools within a nominal range during normal operations that ensures sufficient volume for 7 days of passive heat removal during off-normal operation.
- The ICC extracts heat from the IC Pool water to maintain IC Pool temperature within a bulk temperature limit that permits safe comfortable working conditions on the refueling floor.
- The ICC removes impurities from the IC Pool water to comply with plant water quality requirements.

Normal Functions (Safety Category)

The principal Safety Category functions provided by the ICC are associated with the suction and return pipe penetrations into the ICS pools. The Suction Surge Tank is one of two primary interfaces with the Reactor Building Structure (RBS) ICS Pool Structure and is categorised as an SC1 and Seismic 1A component.

The Return Guard Pipe is the second of two primary interfaces with the RBS ICS Pool Structure and is likewise categorised as an SC1 and Seismic 1A component. The principal function of these two components is to prevent draining of the ICS Outer Pools in the event of a break in ICC piping below the ICS pools.

Off-Normal Functions (Non-Safety Category)

The ICC does not provide any Non-Safety Category functions during off-normal conditions.

Off-Normal Functions (Safety Category)

The following designed safety features of the IC Pools provide safety category functions during off-normal plant conditions:

- The IC Pools Atmospheric Vents perform the Safety Category 1 function of minimising pressurisation of the IC pools compartment by providing a low-resistance flow path for steam to be released to the environment during IC deployment.
- The EME Makeup Lines perform the Safety Category 3 function of providing long term makeup water to the IC pools from an external and independent clean water source following extended IC deployment with significant loss of pool water inventory due to boiloff.
- The Unidirectional Pool Makeup Conduits perform the Safety Category 1 function of allowing makeup water to flow from the IC outer pools into the IC cubicles following extended IC deployment with significant loss of pool water inventory due to boiloff.

The water in the IC pools is also part of the Ultimate Heat Sink (UHS) and performs the Safety Category 1 function of removing heat from the RPV during off-normal conditions and Design Basis Accidents (DBAs). Further detailed on the UHS is presented in Section 9A.2.9.

9A.2.6.2 Safety Design Description

Most ICC components are classified as SCN and categorised as Non-Seismic, with some exceptions. Specific exceptions to this classification apply to designed safety features of the IC Pools. The following components perform DL3 functions and are all classified as SC1, Seismic Category 1A:

- The Suction Surge Tank and Return Guard Pipe, which serve as the primary physical interface with the RBS IC Pool Structure.
- The IC Pools Atmospheric Vents, which minimise pressurisation of the IC pool compartment.
- The Unidirectional Pool Makeup Conduits, which allow makeup water to flow from the outer pools to the IC cubicles during off-normal conditions.

Additional exceptions to this classification apply to:

- The long-term EME pool makeup lines, which provide an independent and external source of clean makeup water during off-normal conditions; these components perform DL4b functions and are classified as SC3, Seismic Category 1B.
- The IC Pool Isolation Valves, which are attached to the pool penetrations that are contained within the Suction Surge Tank and Return Guard Pipe; these components perform DL3 functions and are all classified as SC1, Seismic Category 1B.

9A.2.6.3 Description

9A.2.6.3.1 IC Pool Water Subsystem

The IC Pool Water Subsystem consists of the IC pool water contained within the IC Pools compartment. The major components of the IC Pool Water Subsystem are described below:

Unidirectional Pool Makeup Conduits

Unidirectional pool makeup conduits are installed in the partition wall between the IC outer and inner pools at an elevation that is below the vertical midpoint of the IC condenser tubes. This elevation defines the usable volume level available in the inner pools for boiloff heat removal capacity.

These conduits allow passive makeup flow from the outer to the inner pool following extended IC deployment in which significant boiloff of IC pool water has left the inner pool level below the bottom of the connecting weir between the IC outer and inner pools. The difference in the levels of the outer and inner pools creates a hydrostatic pressure gradient across the conduit that permits flow from the outer pool to the inner pool. Two in-series check valves inside the conduit prevent flow in the reverse direction.

The unidirectional makeup conduits ensure that inner pool water inventory cannot be lost to the outer pools if the outer pools were to be ruptured and drained.

Atmospheric Vents

The IC Pool Atmospheric Vents provide the flow path that directs steam generated during the operation of the ICs outside the RB to minimise pressurisation of the IC Pools compartment. Each IC Inner and Outer Pool pair is equipped with an atmospheric vent that is located in the Outer Pool ceiling near the RB exterior wall. Generated steam flows from the Inner Pool to the Outer Pool through the weir opening in the partition wall separating the Inner and Outer Pools and then through the vent to the outside environment. Each vent consists of a vertical main vent pipe that penetrates the refuel floor. The main vent pipe has two horizontal branch pipes that penetrate the RB wall. The two vent branch pipes are covered at the outside of the RB by a louvered cover and screen that helps prevent foreign material from entering the IC pools from the outside environment through the vents.

EME Makeup Lines

An EME connection outside the RB is provided for long-term refilling of the IC pools. This connection allows clean makeup water from an external and independent source to be delivered to the IC Outer Pools. Check valves are installed to prevent draining the piping water column when the connection is utilised. Flush connections are provided in the individual fill lines to the IC pools for draining the lines as needed. The fill lines are designed to prevent siphoning of water from the IC pools.

9A.2.6.3.2 ICC Suction Subsystem

The ICC consists of two independent and identical 50% capacity trains which service the three Isolation Condenser Cubicle Pools. The two identical thermal processing trains can be operated together or operated with one train and the other train shutdown as needed to maintain conditions in the ICS pools.

Both ICC trains take suction from a single penetration in the Isolation Condenser Outer Pool B. An air-operated ICS Pool Isolation Valve is installed in the main suction pipe to stop flow from Outer Pool B. Processed ICS pool water is returned directly to the three IC cubicles. Return water can be directed to individual IC cubicles by controlling the flow of ICC effluent by aligning IC cubicle isolation valves as desired. The ICS Pool suction and return isolation valves are equipped with manual overrides and handwheels, which allows the valves to be manually operated if the valve actuator fails, thereby increasing system reliability.

Each ICC pump/heat exchanger train can be isolated as needed to maintain ICS readiness to allow both trains to operate simultaneously, or so that one train can operate separately to allow maintenance to be performed on the other train for continuous operation. Each ICC train includes a centrifugal pump with Adjustable Speed Drive (ASD), frame-and-plate Heat Exchanger (HX), associated piping, sensors, and valves. PCW (Section 9A.2.1) flows through the HX to extract heat from the ICS pool water which is rejected to the environment. The discharge from the two ICC pump/HX trains is processed by a skid-mounted demineraliser before being returned to the IC Cubicle Pools. All ICC flow passes through the demineraliser except when bypassed. The demineraliser can be bypassed when the temperature of the discharge exceeds the maximum temperature allowed for the demineraliser resins or when chemicals are injected into the water to inhibit corrosion and biological growth in the IC pools and ICC components. The ICC is equipped with a dosing pot for injecting chemicals for corrosion and biological control into the process fluid.

Because the ICC is of a lower safety class and quality group than the ICS and pools, design provisions are provided to ensure that a pressure boundary failure in its piping or components cannot adversely impact the higher safety class system, specifically draining of the ICS pools.

This is accomplished by a surge volume (Suction Surge Tank) that is a component of the seismically designed reactor building IC pools structure, from which the ICC takes suction. In the event of a failure in the ICC that creates a drainage path, only the surge volume can be drained with no impact on the safety class IC pools volume, and with minimal impact on the ICC components from flooding. Similarly, the discharge or return piping to the IC pools is routed through the seismic Return Guard Pipe, and then routed near the ceiling of the ICS Outer Pools and across the ICS cubicle wall through the connecting weir at which point the return pipes are submerged and routed to a distribution sparger that discharges the cooled and purified water directly to the ICS Cubicle near the bottom of the IC. The high point of the return piping contains an anti-siphon feature to prevent backflow in the event of an ICC pressure boundary failure.

Additionally, ICS pool isolation valves are located as close as possible to the pipe penetrations to minimise the impact to the ICS pools for any failure of ICC piping beyond the isolation valves.

Component Description

The following information is provided relative to the major components in the ICC system.

Suction Surge Tank

The Suction Surge Tank encloses the main suction pipe and penetration to the ICC to prevent draining the IC Outer Pool in the event of a pipe break below the IC pools. The Suction Surge Tank consists of flanged (removable) pipe spools. The top of Suction Surge Tank is below pool surface, which draws pool water from the hottest upper layer of the IC pools into the ICC to maximise the heat rejection function of the ICC. A cover plate with vent tube for the Suction Surge Tank is provided to permit the Suction Surge Tank to be drained for downstream maintenance activities without draining the IC Outer Pools.

Return Guard Pipe

The Return Guard Pipe encloses the individual return pipes to the IC cubicles and their penetrations through the IC pool floor to prevent draining the IC Outer Pool in the event of a pipe break below the IC pools. Similar in design to the Suction Surge Tank, the Return Guard Pipe consists of a removable pipe spool that can be disassembled as required to access the enclosed pipes and penetrations for maintenance and repair activities.

The Return Guard Pipe extends above the maximum water level of the IC pools to prevent draining the Outer Pools in the event of a pipe break below the IC pools. The Return Guard Pipe also eliminates heat transfer between the return pipes and the Outer Pool water so that the cooled IC pool water is returned directly to the IC cubicles to maximise heat transfer efficiency.

Filtration

The ICC employs graded filtration for increased system reliability starting with the coarse-mesh screen covering the Suction Surge Tank to prevent large debris from entering the Suction Surge Tank and potentially blocking the main suction line. A cylindrical metallic screen is installed at the main suction inlet inside the Suction Surge Tank for foreign metal exclusion. Inline Y Strainers with replaceable filter cartridges are installed in the pump suction pipes to remove minute suspended particulates to prevent clogging the narrow flow channels between plates in the HXs for maximum heat transfer effectiveness. This additional filtration also increases the service lifetime of the Demineraliser by removing suspended particles that might otherwise clog flow paths across the ion-exchange resin bed. All filtration components and surfaces in contact with the process fluid is made of Type 304/304L or 316/316L stainless steel.

Adjustable Speed Drive Pump Motors

The ICC pumps are driven by ASDs with electric motors to provide operational flexibility for: a) optimal performance in restoring ICS Pool Water temperature to TS requirements following deployment of one or more ICs; and b) efficient and economical performance in maintaining ICS Pool Water temperature and cleanliness during normal reactor operations.

Pumps

Pump suction and discharge connections are flanged. All pump components and surfaces in contact with the process fluid are made of Type 304/304L or 316/316L stainless steel. The ICC pumps are designed to comply with the requirements of ANSI/HI 1.3 (Reference 9A-22). Each pump is powered by an Adjustable Speed Drive with electric motor. The pumps have mechanical seals to minimise the potential for leakage and reduce the need to perform maintenance on shaft seal packings.

Heat Exchangers

Frame-and-plate HXs are used to reject heat from the process fluid in the ICC loop to the PCW. HX components and surfaces in contact with the process fluid are made of Type 304/304L or 316/316L stainless steel. HX inlet and discharge connections are flanged to facilitate removal as necessary for maintenance, repair, and replacement. Drainage taps are provided in HX or piping connections to allow the HX to be drained to facilitate maintenance or repair activities.

Demineraliser

An integrated skid-mounted demineraliser is used to clean the process fluid in the ICC loop.

Demineraliser components and surfaces in contact with the process fluid are made of Type 304/304L or 316/316L stainless steel. A drainage tap is provided to allow the Demineraliser tank to be drained to facilitate maintenance or repair activities. The Demineraliser is sized to process the effluent from a single ICC pump train. ICC Demineraliser spent resin media is discharged to the Solid Waste Management System (PSR Ch. 11, Section 11.4).

Dosing Pot

A dosing pot allows chemical injection into the process fluid to inhibit corrosion and biological growth in ICC piping and components and the ICS pools. All dosing pot components and surfaces in contact with the process fluid are made of Type 304/304L or 316/316L stainless steel. A drainage tap is provided to allow the dosing pot to be drained when not in use.

Anti-Siphon Devices

Anti-siphon devices are installed in the return piping to the IC cubicles to prevent inadvertently draining the IC cubicle pools in the event of an ICC piping failure below the ICS pools.

Distribution Spargers

The return water distribution spargers are installed in the IC cubicles. The spargers are installed at or near the bottom of the Isolation Condenser cubicles in a manner that promotes bulk flow of the water in the cubicle, particularly with respect to the Isolation Condenser HX. The distribution spargers are fabricated using seamless Type 304/304L or 316/316L stainless steel pipe. The distribution spargers include a flanged end connector to facilitate removal as necessary for maintenance, repair, and replacement.

Outer Pool Spargers

The outer pool spargers are installed the IC outer pool segments near the bottom of the partition wall separating the IC outer pool segments and the IC cubicle pools to recirculate pool water from the top level of the IC pools and directly inject chemicals into the bottom layer of the IC outer pools.

ICC Piping

Piping in contact with ICS pool water is made of Type 304/304L or 316/316L seamless, stainless steel. ICC piping in contact with PCW on the cold side of the HXs is made of seamless Grade B carbon steel. The ICC piping is designed to comply with ASME B31.1 (Reference 9A-25) requirements. Drainage taps are provided at low points in the ICC piping to allow the pipes to be drained to facilitate maintenance or repair activities. Vents are provided at the high points in the ICC piping to allow air to be purged from the ICC piping when filling with pool water and to allow the pool return pipes to be drained to facilitate maintenance or repair activities. Structural supports for piping systems and components inside the ICS Pool Compartment are in accordance with the rules and requirements of ASME BPVC-III NF, Subsection NF, "Supports" (Reference 9A-34).

ICC Valves

Valve surfaces in contact with ICS pool water are made of Type 304/304L or 316/316L stainless steel. The ICC valves are designed to comply with ASME B31.1 and ASME B16.34 (References 9A-36 and 9A-37) requirements. Valve internals in the ICC piping in contact with PCW is made of Type 304/304L or 316/316L stainless steel to maintain leak-tightness. Valves are provided with flanged inlet and outlet connections to facilitate removal as necessary for maintenance, testing, and replacement. The ICS pool suction isolation valve and pool return isolation valves are equipped with manual override and handwheel.

Instrument Requirements

ICC instrument housings and internals in contact with ICS Pool Water are made of Type 304/304L or 316/316L stainless steel. Where possible, instrument housings are provided with flanged connections to facilitate removal as necessary for maintenance, testing, and replacement.

9A.2.6.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, and corrodents through material chemistry, heat treatment, contamination, and material processes controls.

Components and surfaces that come in contact with ICS pool water are manufactured using corrosion-resistant material. Use of corrosion-resistant material reduces iron particulate introduced into the system and Flow Accelerated Corrosion (FAC).

9A.2.6.5 Interfaces with Other Equipment or Systems

Refer to Figure 9A-10 and Table 9A-11 for ICC interfaces with other equipment or systems.

9A.2.6.6 System and Equipment Operation

The ICC provides active cooling and purification of the IC pools when it is operating. The ICC cooling function is required when the ICs are in standby mode due to constant thermal leakage caused by a relatively small amount of condensing steam in the IC during normal reactor operations. The Adjustable Speed Drives allow the ICC to operate at a lower system flow rate during normal operations when the ICs are in standby mode for improved overall plant economy. The ICC purification function is provided by directing ICC flow through the ICC

Demineraliser, which is the normal flow path during routine system operation. The Demineraliser is bypassed for the following conditions:

1. The Demineraliser is bypassed if the temperature of the process fluid exceeds 53.3˚C to prevent thermal degradation of the demineraliser resins and early desorption of adsorbed contaminants that occurs with aging.
2. The Demineraliser is bypassed during the injection of chemicals into the process fluid to inhibit corrosion and biological growth in the ICS Pool Cooling and Cleanup System equipment, piping, and IC pools to prevent chemical degradation of the demineraliser resins.

Normal Operation

Refer to Table 9A-12, which provides a summary of the plant operating modes with corresponding ICC operating modes.

Mode 1: Power Operation

During Mode 1 power operation, the ICC is in service for all system operating modes:

- ICC Mode A2 – Both ICC trains A and B are operating at up to full capacity for maximum heat removal from the ICS pools
  - The Demineraliser is bypassed during Mode A2
- ICC Mode A1a – Only ICC Train A is operating at reduced capacity to purify ICS pool water and remove heat
  - The Demineraliser is bypassed if the HX effluent temperature exceeds 53.3 °C
  - The Demineraliser is bypassed if the flow rate exceeds the Demineraliser capacity
- ICC Mode A1b - Only ICC Train B is operating at reduced capacity to purify ICS pool water and remove heat
  - The Demineraliser is bypassed if the HX effluent temperature exceeds 53.3 °C
  - The Demineraliser is bypassed if the flow rate exceeds the Demineraliser capacity
- ICC Mode A2c – Both ICC trains are operating at full capacity for rapid injection of water treatment chemicals
  - The Demineraliser is bypassed during chemical injection
- ICC Modes A2O, A1aO, A1bO and A2cO – Outer Pool Sparger operation
  - The Outer Pool Sparger is operated concurrently with Modes A2, A1a, A1b, and A2c

One ICC pump/HX train can be isolated as needed for maintenance during power operation. Demineralised makeup water is automatically added to maintain ICS pool inventory during normal reactor operations.

Processed water is returned to individual ICS cubicles as required by aligning the ICS pool isolation valves to the desired ICS cubicle pools.

Mode 2: Startup Operation

During startup operation, the ICC is in service for all system operating modes described for power operation.

Mode 3: Hot Shutdown Operation

During hot shutdown operation, the ICC is in service for all system operating modes described for power operation.

Mode 4: Stable Shutdown Operation

During stable shutdown operation, the ICC is in service for all system operating modes described for power operation. In addition, the ICC can be completely removed from service during stable shutdown operation for system maintenance.

Mode 5: Cold Shutdown Operation

During cold shutdown operation, the ICC is in service for all system operating modes described for power operation. In addition, the ICC can be completely removed from service during cold shutdown operation for system maintenance.

Mode 6: Refueling Operation

During refueling operation, ICC is in service for all system operating modes described for power operation. In addition, ICC can be completely removed from service during refueling operations for system maintenance.

Off-Normal Operations

The ICC has the following active off-normal operating modes provided there is no loss of AC power:

- ICC Mode A2 – Both ICC trains A and B are operating at up to full capacity for maximum heat removal from the IC pools.
- ICC Mode A2O – Both ICC trains A and B are operating at slightly reduced capacity for maximum heat removal from the IC pools with concurrent Outer Pool Sparger operation.

In addition, the ICC performs the off-normal safety category functions described in Section 9A.2.6.1.

System Shutdown

The ICC can be completely removed from service for system maintenance during the following plant operating modes:

- Mode 4: Stable Shutdown
- Mode 5: Cold Shutdown
- Mode 6: Refueling

9A.2.6.7 Instrumentation and Control

SCN instrumentation and controls (PSR Ch. 7) provides control signals to ICC pumps and valves to initiate system operation and direct flow through system piping branches as needed. The SCN instrumentation and controls also receives data signals from instruments installed in the ICC piping to measure local process flow variables: water level, temperature, pressure, differential pressure, and conductivity. A local instrumentation monitoring panel is provided in the ICC equipment area for maintenance, diagnostic, and functional testing of the ICC and individual components.

Where possible, instrument housings are provided with flanged connections to facilitate removal as necessary for maintenance, testing, and replacement. Instruments are installed such that there is space surrounding the instrument to facilitate ready access to the instrument and the ability to perform maintenance or replacement.

ICC Control and Alarm and Monitoring functions are identified in Table 9A-13.

9A.2.6.8 Monitoring, Inspection, Testing, and Maintenance

Testing of the ICC is performed to demonstrate proper system and component functioning. ICC functionality is continuously demonstrated during normal plant operation. Provisions are made for periodic inspection of major components to ensure the capability and integrity of the system. Service platforms are installed to facilitate inspection of the Surge Tank and Return Guard Pipe. The design of the ICC allows for the inspection and testing of components under normal operating conditions.

Material and equipment selection for the ICC is based on a 60-year design life, with appropriate provisions for maintenance and replacement. Components that require replacement prior to the end of the 60-year design life include, but are not limited to, electrical and electronic equipment, gaskets and seals, lubricants, valve disks and internal components such as seats and packing, and bearings.

Isolation valves are provided near the ICC piping penetrations to the ICS Outer Pool B to permit maintenance and repair activities to be performed on pipe section below the ICS pools. Valves are installed with flanged connections to facilitate removal as needed for testing or repair. In addition, valves and other components are installed with plenty of space surrounding the component to facilitate ready access and the ability to perform maintenance, repair, or replacement activities.

Maintenance isolation valves and flanged connections are provided for the pumps and HXs so they can be isolated and removed for repair or replacement as required. Drain taps are provided at low points in piping sections to evacuate process water for maintenance and repair activities.

The design of the ICC provides adequate equipment removal paths and personnel access for maintenance and repair activities and equipment replacement.

Testing is performed to ensure required functional operability is maintained under design conditions. Testing is performed in accordance with plant procedures. Testing in support of plant pre-operational testing, startup, and commissioning is addressed in PSR Ch. 14: Plant Construction and Commissioning, Section 14.3 (Reference 9A-38).

9A.2.6.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.2.6.10 Performance and Safety Evaluation

Two features have been incorporated into the ICC design to increase system reliability.

1. Manual overrides with handwheels are specified for the main suction and for the return Air-Operated Block Valves to enable manual operation of these valves in the event of actuator failure.
2. Graded filtration elements have been incorporated to prevent system failure and long-term component degradation by excluding foreign materials from entering the principal ICC components and by removing suspended particles to prevent damage and blockage of small flow channels in the heat exchangers.

Safety Category functions provided by the ICC are associated with the suction and return pipe penetrations into the ICS pools. The Suction Surge Tank and Return Guard Pipe are categorised as SC1 and Seismic 1A components and function to prevent draining of the ICS Outer Pools in the event of a break in ICC piping below the ICS pools.

9A.2.7 Condensate Storage and Transfer Subsystem

The Condensate Storage and Transfer Subsystem is part of the Liquid Waste Management (LWM) system and consists of the Condensate Storage Tank (CST), two transfer pumps, and distribution headers which supply condensate to the TB, RWB, and the RB for various systems. The LWM is described in PSR Ch. 11.

9A.2.8 Refueling Water Storage and Cleanup Subsystem

The Refueling Water Storage and Cleanup Subsystem is part of the LWM system and consists of the Refuelling Water Storage Tank (RWST), two transfer pumps, a filter, and associated piping and valves. The RWST is used to hold the Reactor Cavity Pool volume to permit draining and filling the reactor cavity to support refueling outage activities. The LWM is described in PSR Ch. 11.

9A.2.9 Ultimate Heat Sink

The UHS for the BWRX-300 provides the Safety Category 1 function heat sink for DBAs and off-normal conditions when the NHS System is not available. The UHS consists of the water in the IC Pools, the Reactor Cavity Pool, the Equipment Pool, and the Fuel Pool (Figure 9A-11).

The UHS does not perform any functions under normal operating conditions except for water in the Fuel Pool. Normal cooling functions for the UHS pools are performed by the ICC for the IC Pools (Section 9A.2.6) and the FPC for the Fuel Pool, Equipment Pool, and Reactor Cavity Pool (Section 9A.1.3).

9A.2.9.1 System and Equipment Functions

The UHS performs the following functions during normal and off-normal conditions.

Normal Functions (Non-Safety Category)

None.

Normal Functions (Safety Category)

None.

Off-Normal Functions (Non-Safety Category)

None.

Off-Normal Functions (Safety Category)

The UHS provides the following off-normal safety category functions:

- Water in IC pools provides heat removal from the Isolation Condenser System (ICS) under off-normal conditions.
- Water in the Reactor Cavity Pool and the Equipment Pool provide heat removal from the PCCS under off-normal conditions.
- Water in the Fuel Pool provides heat removal from the fuel in the pool.

9A.2.9.2 Safety Design Bases

The UHS is SC1. The IC Pools, Reactor Cavity Pool, Equipment Pool, and Fuel Pool are part of the RB and are Seismic Category 1A structures to support the SC1 UHS.

9A.2.9.3 System Description

During plant operation and normal shutdown, the NHS System transfers heat from plant equipment to the environment. If the NHS System is not available, the Safety Category 1 function for heat removal is performed by the UHS. The UHS is a passive safety feature of the

BWRX-300. Figure 9A-11 shows the layout for the IC Pools, Reactor Cavity Pool, Fuel Pool, and the Equipment Pool. The UHS inventory is sufficient for 7 days without replenishment.

The IC Pool volumes are independent from the Equipment Pool, Fuel Pool, and Reactor Cavity Pool. During normal operation, the Equipment Pool and Reactor Cavity Pool volumes are merged as a single pool volume, with the Fuel Pool separated by an installed gate. During refueling, the Fuel Pool gate is open, and all three pools function as a single volume.

9A.2.9.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, and corrodents through material chemistry, heat treatment, contamination, and material processes controls.

Components and surfaces that come in contact with pool water are manufactured using corrosion-resistant material. Use of corrosion-resistant material reduces iron particulate introduced into the system and Flow Accelerated Corrosion.

9A.2.9.5 Interfaces with Other Equipment or Systems

The UHS interfaces with the ICC (Section 9A.2.6), FPC (Section 9A.1.3) and PCCS (PSR Ch. 6 (Reference 9A-18) Section 6.5.4).

9A.2.9.6 System and Equipment Operation

The UHS system operates under off-normal operational modes where the NHS is not available.

During power operation, the water in the IC Pools performs the UHS function for the ICS. When the ICS is actuated, the water in the IC Pools absorbs heat from the ICS, thereby cooling the reactor core. As IC Pool water is heated, steam is released through passive vents to the outside atmosphere. The IC Pools and Atmospheric Vents are described in Section 9A.2.6. The design and operation of the ICS is discussed in PSR Ch. 6 (Reference 9A-18) Section 6.2.1. The IC Pools also perform the UHS function for the reactor core during shutdown while the reactor vessel head is installed and the water level in the RPV is below the ICS steam lines.

For accident conditions that release fluid to containment, the water in the Equipment Pool and Reactor Cavity Pool provides a heat sink for the PCCS. The PCCS is described in PSR Ch. 6 (Reference 9A-18) Section 6.5.4. The PCCS removes heat from the containment and reduces the containment temperature and pressure in accident conditions, such as Loss-of-Coolant Accidents (LOCAs) and other line breaks. As the Reactor Cavity Pool and Equipment Pool heat up, vapor is released to the RB.

During refueling, the reactor vessel head is removed, and the reactor cavity is flooded. During this condition, the water in the RPV, Reactor Cavity Pool, the Equipment Pool, and Fuel Pool (when gate is open) serves as the UHS. The water in the Fuel Pool is the UHS for fuel in the pool at all times.

If NHS is lost during refueling, or if Fuel Pool Cooling is lost, water in UHS heats and vapor is released to the RB.

The RB is normally vented to atmosphere. The vent can be isolated in response to a high radiation alarm, or due to an LOPP.

9A.2.9.7 Instrumentation and Control

Levels and temperatures in the IC Pools, Equipment Pool, Reactor Cavity Pool, and Fuel Pool are monitored and maintained within administrative and Technical Specification limits, as appropriate.

9A.2.9.8 Monitoring, Inspection, Testing, and Maintenance

The IC Pools, Equipment Pool, Reactor Cavity Pool, and Fuel Pool, which support the UHS function, are part of the RB structure. An ISI and testing program is established for the RB to ensure the structure can fulfil its intended functions throughout its design service life.

9A.2.9.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.2.9.10 Performance and Safety Evaluation

Requirements for heat transfer to the UHS are met. In the event of a DBA during operational modes, heat is transferred from the fuel in the reactor and containment atmosphere to the water in the IC Pools, Equipment Pool, and Reactor Cavity Pool. Water in the IC inner pools is allowed to heat up and boil. The resulting steam is vented to the environment. The water volume in the smallest IC inner pool and the connected outer pools is sufficient to perform the Safety Category 1 function of transferring heat to the atmosphere for the initial 72-hours of an accident. The water volume of two smallest of the three IC inner pools plus the outer pools is sufficient to supply heat removal for 7 days. After 7 days, supplemental water can be provided through the IC Pool EME connection discussed in Section 9A.2.6. The water volume in the Equipment Pool and Reactor Cavity Pool is adequate to support PCCS for 7 days. The water volume in the fuel pool is also adequate to cool the fuel in the pool for 7 days.

9A.3 Process Auxiliary Systems

9A.3.1 Process Sampling System

The Process Sampling System is a subsystem of the Process Radiation and Environmental Monitoring System (PREMS) (Reference 9A-14). In addition to the Process Sampling subsystem, the PREMS is comprised of the following subsystems, Process Radiation Monitoring (PSR Ch. 11, Section 11.5), Area Radiation Monitoring (PSR Ch. 12, Section 12.3.4), and Containment Monitoring (PSR Ch. 12, Section 12.3.4).

The BWRX-300 design does not employ a Post-Accident Sampling System for assessing core damage as per IAEA SSG-12 (Reference 9A-39). In its place is a collection of Post-Accident Monitoring (PAM) inputs utilising real-time measurements of plant parameters which are deemed more accurate and/or more timely to measure core damage. The sensors and instruments designated for PAM are treated differently by the plant I&C architecture to ensure availability during and after the most severe accident or Beyond Design Basis Accident. Many of the other Post-Accident Sampling System samples were not needed for short severe accident scenario or the information is available from post-accident monitoring instruments such as radiation monitors, (containment, main steam and offgas) temperature and water level as discussed in NEDO-32991-A, “Regulatory Relaxation for BWR Post-Accident Sampling Stations (PASS)” (Reference 9A-40).

9A.3.1.1 System and Equipment Functions

The Process Sampling subsystem performs the following functions during normal and off-normal conditions.

Normal Function (Non-Safety Category)

The Process Sampling subsystem collects representative liquid and gaseous samples for analysis and provides the analytical information required for monitoring plant and equipment performance. This process subsequently guides changes to operating parameters. This subsystem is designed to function during all plant operational modes under individual system requirements.

Normal Function (Safety Category)

This subsystem does not perform any Safety Category functions during normal conditions.

Off-Normal Functions (Non-Safety Category)

This subsystem does not perform any Non-Safety Category functions during Off-Normal conditions.

Off-Normal Functions (Safety Category)

This subsystem does not perform any Safety Category functions during Off-Normal conditions unless designated a Post-Accident Monitoring function.

9A.3.1.2 Safety Design Bases

Process sampling equipment containing radioactive material supports the Fundamental Safety Function of confinement of radioactivity. The Process Sampling subsystem does not support any Defence Line (DL) functions. It is Safety Category N.

9A.3.1.3 Description

The Process Sampling subsystem collects representative liquid and gaseous samples for analysis and provides the analytical information required for monitoring plant and equipment performance.

For processes requiring continuous or frequent monitoring, sample tubing is routed from the process stream to automated sample panels. Sample conditioning equipment is provided within each panel for pressure, temperature, and flow adjustment. Online monitoring equipment is used to the greatest extent practicable, and provided for measurements such as conductivity, dissolved oxygen, dissolved hydrogen, total organic carbons, and silica. Grab sample taps are provided at the panels for infrequent/diagnostic sampling, online analyser checks, and instances in which online analysers are unavailable. Test connections are provided for equipment calibration or installation of temporary analysers.

Most processes requiring infrequent (or diagnostic only) sampling are collected via local grab sample stations. If necessary, sample conditioning equipment is provided with each station for pressure, temperature, and flow adjustment.

The Process Sampling subsystem consists of the following: permanently installed sample lines, sampling panels with analysers and associated sampling equipment, provisions for grab sampling, and permanent shielding. The division of sample lines versus grab samples are assessed during detailed design activities based on the availability of automation in the instrumentation, the need to limit personnel access (ALARP), the frequency of needed measurements, and other considerations. Sampling stations and associated process samples are listed in Table 9A-14.

Component Description

The Process Sampling subsystem consists of sample lines, sampling panels with analysers and associated sampling equipment, provisions for grab sampling, and shielding.

9A.3.1.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials specifically from IGSCC (as applicable) through material chemistry, heat treatment, contamination and material processes controls.

9A.3.1.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-14 which provides the description and boundary for each interfacing system.

9A.3.1.6 System and Equipment Operation

The Process Sampling subsystem operates continuously or in grab sample mode when the interfacing system being monitored is operational.

Initial Configuration (Pre-Startup)

The Process Sampling subsystem operates continuously or in grab sample mode.

System Startup

The Process Sampling subsystem operates continuously or in grab sample mode.

Normal Operations

Sampling equipment operates continuously with capability for grab samples from each process stream. Root valves for process system sampling points are included in the Process Sampling subsystem.

The safety requirements for root valves are determined by the safety requirements for the particular system.

Off-Normal Operations

There are no mitigating system functions tied to the Process Sampling subsystem.

System Shutdown

Process Sampling subsystem is performed in accordance with detailed operation procedures.

9A.3.1.7 Instrumentation and Control

The Process Sampling subsystem is supported by the SCN Distributed Control and Information System (PSR Ch. 7, Section 7.3.4). SCN classified functions are implemented on a hardware/software platform to provide the reliability needed to prevent controller failure from becoming an Anticipated Operational Occurrence (AOO).

9A.3.1.8 Monitoring, Inspection, Testing, and Maintenance

The Process Sampling subsystem design provides continuous availability regardless of the plant operating mode; therefore, Process Sampling subsystem functionality is continuously demonstrated during all phases of normal, shutdown, and off-normal conditions.

Routine maintenance and cleaning of the sampling subsystem is performed. The design accommodates easy access to sensors, instruments, and panels for maintenance. Additionally, devices for lifting or hoisting the Process Sampling subsystem components is provided to facilitate replacement if required.

Instrumentation is designed to facilitate calibration checks and troubleshooting.

Sampling racks and electronic modules are serviced and maintained in accordance with the operational instructions to ensure reliable operation. Such maintenance includes servicing and replacement of defective components and adjustments as required. Periodic testing or calibration checks is performed as part of the maintenance plan.

9A.3.1.9 Radiological Aspects

PSR Ch. 12, Section 12.1.2 (Activity control and monitoring systems) provides information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.3.1.10 Performance and Safety Evaluation

The system design provides continuous availability regardless of the plant operating mode. SCN functions are implemented on the Non-Safety I&C System which provides the reliability needed to prevent controller failure from becoming an AOO. The Process Sampling subsystem performs no Safety Category functions and is not required to prevent or mitigate the consequences of a design basis accident, to shut down the reactor and maintain safe shutdown conditions, or to maintain the integrity of the reactor coolant pressure boundary. Therefore, a nuclear safety evaluation is not required.

9A.4 Air and Gas System

9A.4.1 Plant Pneumatic System

The description below of the BWRX-300 PPS aligns with the SDD 006N7773 “BWRX-300 Plant Pneumatic System” (Reference 9A-41). The PPS provides a continuous supply of compressed air for tank sparging, filter/demineraliser backwashing, air operated tools, and other services. The PPS also provides dried and filtered compressed air to valve actuators, instrument control functions, and general instrumentation and valve services. In addition, the PPS supplies air to the portable breathing air filtration systems via a service box hookup to provide breathable quality air when needed.

9A.4.1.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

PPS provides the following Non-Safety Category functions:

1) The PPS provides dry, oil-free, filtered compressed air for valve actuators, instrument control functions, air operated tools, and miscellaneous equipment/services outside of containment in Mode 1, 2, 3, 4, 5, and 6.
2) The PPS provides the compressed air for tank sparging, filter/ demineraliser backwashing, air-operated tools and other services requiring air of lower quality in Mode 1, 2, 3, 4, 5, and 6.
3) The PPS provides the distribution of gaseous nitrogen, supplied by the Containment Inerting System (CIS) (Section 9A.4.2), to primary containment for valve actuators and other primary containment users in Mode 1, 2, 3, 4, and 5.
4) The PPS supplies instrument-quality air to nitrogen consumers when primary containment is open for personal access (e.g., major outages).
5) The PPS supplies oil-free air to service boxes inside Containment for breathable air.

Normal Functions (Safety Category)

The PPS provides dry, oil-free, filtered compressed air for valve actuators performing Safety Category 3 functions and instrument control functions outside of containment.

The PPS provides the distribution of gaseous nitrogen, supplied by CIS, to Primary Containment for Safety Category valves, controls, instrumentation, and other Primary Containment users.

The PPS provides a make-ready function for Safety Category 1 functions.

Off-Normal Functions (Non-Safety Category)

The PPS performs no Non-Safety Category functions during off-normal conditions.

Off-Normal Functions (Safety Category)

As part of DL3 the PPS provides containment isolation valves on piping that penetrates the containment boundary. These valves are designed to close upon receiving an isolation signal from the SC1 I&C System (PSR Ch. 7, Section 7.3.1).

9A.4.1.2 Safety Design Bases

The components of the PPS are primarily SC3 categorised as Non-Seismic, as the PPS is providing integral support functions for Safety Category 3 functions, as well as make-ready support functions for DL3 (Safety Category 1) functions, as defined in the System Interfaces.

The containment penetrating pipework is SC1 and seismic category 1A, whilst the containment isolation valves are SC1 and seismic category 1B. CIVs are provided on piping that penetrates the containment boundary. These valves are designed to close upon receiving an isolation signal from the SC1 I&C System.

9A.4.1.3 Description

Figure 9A-12 depicts the PPS.

The PPS consists of two 100% air compressors, two 100% capacity dryer trains, two service air receivers operating in parallel upstream of the dryers, and two instrument air receivers operating in parallel downstream of the dryers. The PPS provides service and instrument air for the majority of plant air needs.

Each compressor is capable of supplying 100% of the system's continuous air requirements. The compressors takes suction through an air intake filter/silencer which brings air from outside the TB. The air inlet is fitted with rain hood and bird screen. The lead compressor supplies air to both service air receivers, which will flow through the lead dyer train, to both instrument air receivers.

Distribution piping in the plant is by ring headers which allows for flexibility in distribution locations, maintenance, and ease of accommodating future requirements. The service air receivers distribute air to the service air header demands. The service air subsystem also connects to a separate utility containment penetration to provide service air to the service boxes inside containment. These service boxes are used to supply air to portable breathing air filtration systems to provide breathing air hookups to personnel entering containment when the atmosphere is not yet fully habitable or for areas where high levels of airborne contaminants cannot be eliminated efficiently by the HVAC.

The instrument air receivers will distribute air to the instrument air header demands. The instrument air subsystem also includes piping penetrating containment, connecting the CIS to pneumatic valves and other compressed gas users inside containment. During plant outages, the PPS supplies the pneumatic valves and other compressed gas users inside containment with instrument-quality air while the nitrogen supply from the CIS is isolated from inside containment.

During normal operation, the air supply is isolated from the primary containment vessel via double block and bleed valve configuration so that nitrogen from the CIS can be supplied to nitrogen users inside containment using the PPS primary containment piping penetrations. The block and bleed valves on the air supply prevent air from entering containment during normal operation and posing an explosion and fire risk. During plant shutdown, the nitrogen supply is isolated from the primary containment vessel via double block and bleed valve configuration, so that in the case of a leak in the PPS supply piping to primary containment, the primary containment does not turn into a confined space or pose an asphyxiation risk to plant personnel.

PPS is designed to meet the applicable requirements of Instrument Society of America 7.0.01 (Reference 9A-41).

Component Description

The following paragraphs provide information that pertains to the major equipment items in the PPS system.

Air Compressors

The two (2) compressors are oil-free, rotary screw, water-cooled, electric motor driven compressors. Each compressor can supply 100% of the system's continuous air requirements.

Noise reduction methods are incorporated to ensure that noise levels in habitable areas near the compressors are within the guidelines for industrial environments. The air compressor units are powered from the two (2) separate electrical busses. The service air piping includes a connection for adding an additional compressor. These compressors are commercially available skid packages.

Air Receivers

The system includes two service air receivers in parallel and two instrument air receivers in parallel. The design capacity of the receivers includes adequate reserve capacity to provide the following:

- At least 10 minutes of operating time following a trip with no air compressors in operation before the low pressure set point alarms are sounded in the control room.
- Enough time for the standby compressor to start and recharge the air receivers to operating pressure following a compressor trip. Including the case offsite power is lost and the standby diesels start and power the PPS system.

The receivers are ASME VIII designed and stamped.

A pressure-relief safety valve is installed on each receiver.

Dryer/Filter Trains

The PPS utilises two (2) 100% dryer trains in parallel. The dryers are regenerative desiccant air dryers.

Each desiccant dryer unit contains two drying vessels filled with activated alumina desiccant. The desiccant removes moisture from the air by adsorption. The towers automatically alternate between ‘in-service’ and ‘regeneration’. The dryers are preceded by a coalescing pre-filter. These filters are designed to be a 100% capacity coalescing 1cartridge type filter, used to remove water and oil droplets from the air, as well as rust scale, dust, and other solid objects. The dryers are followed by an after-filter. These filters are designed to be a 100% capacity plain cartridge type filter, used to remove the particles of desiccant that may be carried away from the dryer.

Piping and Valves

All PPS piping is welded stainless steel material.

The piping, other than that required for containment isolation, is designed to meet the requirements of ASME B31.1.

To ensure containment integrity at the Steel Composite Containment Vessel penetrations, the containment piping and isolation valves are designed to Seismic Category 1A and 1B, respectively; ASME BPVC, Section III, Division 1-Subsection NCD requirements.

PPS containment isolation piping includes an AOV outside of containment and a check valve inside of containment. During a DBA, if the AOV fails to close leakage out from inside containment is stopped by the air system if an air compressor is operating or by the check valve if an air compressor is not operating.

9A.4.1.4 Materials

The PPS is designed utilising materials that ensure that the functional requirements of the system are achieved. Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials through material chemistry, heat treatment, contamination, and material processes controls.

9A.4.1.5 Interfaces with Other Equipment or Systems

Table 9A-15 identifies PPS interfaces with other BWRX-300 Systems.

9A.4.1.6 System and Equipment Operation

The PPS operates in the normal plant environment and provides Non-Safety and Safety Category 3 functions. With the exception of the containment isolation valves the PPS is not required to operate after a design basis accident.

The system is designed for continuous operation during all modes of plant operation.

Normal Operational Concept

During normal operation, one 100% capacity air compressor operates to supply both service air receivers, one dryer train, both instrument air receivers, and both instrument and service air system distribution piping.

A compressor is chosen as the lead, continuously operating compressor. The other compressor serves as standby. The standby compressor automatically starts upon trip of the lead compressor, or when the air pressure in the system drops below the predetermined pressure set point. The assignment for lead and standby air compressors is switched periodically by operators in the MCR.

One 100% dryer/filter train operates, and one serves as standby. Automatic start of the standby dryer skid occurs when the differential pressure across a dryer filter, discharge pressure or the dewpoint reaches predetermined setpoints. The assignment for lead and standby dryers is switched periodically by operators in the MCR.

Off-Normal Operational Concept

The PPS containment isolation valves and associated piping are designed to be functional after a safe shutdown earthquake.

When a LOPP is detected, the operating compressor and dryer both trip and restart when power is received from the backup diesel generators.

9A.4.1.7 Instrumentation and Control

Instrumentation

The PPS contains instrumentation to remotely monitor (indicate and alarm) and control all equipment performance, control valve status, and necessary system parameters, such as pressure, temperature, and moisture content of the compressed air in the system. Data signals from the PPS instruments and equipment are displayed on the MCR and local instrumentation panels. Local control panels for the compressors and dryers are used to operate during testing, calibration, and changing standby compressor and dryer units.

Instrumentation associated with one or more control functions are redundant. For additional information refer to PSR Ch. 7, Section 7.3 “Distributed Control and Information System Functions.” This includes instruments such as vendor package (skid) instrumentation that send equipment trip signals or standby equipment start signals upon detecting specified abnormal operating conditions. Additionally, service and instrument air header pressure sensors that provide the main control parameters for the PPS are redundant, described in the Controls section below.

Controls

The PPS is automatically controlled from the plant DCIS. The start and stop of the PPS compressors and dryers are automatically or manually operated from the MCR. The instrumentation and control architecture in the PPS is designed to keep the instrument air available in all modes of operation. All automatic or remotely actuated valves in the PPS fail in the position most likely to keep the system operational and controllable with the exception of the PPS containment isolation valves.

The pressure in the service air header is the main control parameter in the system. The operating compressor loads/unloads based on pressure readings from the redundant pressure sensors on the service air header. Upon a loss of both compressors, or at a low pressure setpoint, the normally open service air isolation valve closes to shed the service air system load and conserve air for the instrument air subsystem to maintain control of the plant. Upon a loss of both dryers, or a low-low pressure indication from the redundant instrument air header pressure sensors, the dryer bypass line opens to allow the flow of service air to the instrument air users.

9A.4.1.8 Monitoring, Inspection, Testing, and Maintenance

All major components have manual isolation valves to permit maintenance activities without having to shut down the PPS. The maintenance boundary between the isolation valves is designed to permit the simultaneous maintenance of the maximum number of components as possible without impacting the ability of the system to remain in service.

PPS piping and valves for the containment penetrations are tested in accordance with 10CFR50, Appendix J (which is in turn consistent with the requirements of IAEA SSR-2/1). Test and vent connections are provided at the containment isolation valves and are used to verify that the valves meet the local leak rate limits.

The PPS outboard containment isolation valve is tested to ensure operational integrity by manual operation of the valve. The inboard containment check valve is periodically tested to ensure valve operability.

All PPS equipment is arranged to provide adequate pull space and clearance for personnel and testing equipment access to facilitate, testing, repair, and maintenance.

Breathing air is routinely sampled to ensure breathing air quality standards are met.

Instrument air and system functionality is tested to ensure the relevant instrument air quality standards are met.

9A.4.1.9 Radiological Aspects

PSR Ch. 12, Section 12.1.2 provides information pertaining to design measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.4.1.10 Performance and Safety Evaluation

The Safety Category 1 function performed by the PPS is containment isolation. The PPS CIVs are designed to maintain the leak tightness of the containment in the event of an accident and prevent radioactive releases to the environment that exceed prescribed limits. The PPS incorporates features that ensure its operation over the full range of normal plant operations.

9A.4.2 Containment Inerting System

The description below of the BWRX-300 CIS aligns with 006N7948, “Containment Inerting System SDD” (Reference 9A-43). The CIS is designed to establish and maintain an inert atmosphere (nitrogen) within the containment. An inert atmosphere is maintained in all operating modes except during plant shutdown for refueling, equipment maintenance, and during limited periods of time to permit access for inspection at low reactor power. Prior to reactor shutdown the CIS can de-inert the SCCV allowing for safe personnel access without the need of a breathing apparatus. The principal objective of the CIS is to preclude the development of a combustible atmosphere by maintaining an oxygen deficient atmosphere inside SCCV.

9A.4.2.1 System and Equipment Functions

The BWRX-300 CIS provides the following functions during Normal and Off-Normal conditions.

Normal Functions (Non-Safety Category)

The CIS provides the following non-Safety Category functions during normal conditions:

- Maintain a positive pressure within containment to prevent the infiltration of non-inert air during all normal plant operating modes, except plant shutdown.
- Establish a breathable de-inert atmosphere within containment during plant shutdown for refueling and maintenance.

Normal Functions (Safety Category)

The CIS provides the following Safety Category functions during normal conditions:

- The CIS penetrates containment and therefore must ensure containment boundary integrity and isolation capability, as a Safety Category 1 function.
- Establishes and maintain an inert atmosphere within containment for prevention of hydrogen combustion during normal plant operating modes, except plant shutdown, where a breathable non-inert atmosphere is required. This is a Safety Category 3 function.
- Provide a supply of nitrogen to the PPS for the users in primary containment, as a Safety Category 3 function.

Off-Normal Functions (Non-Safety Category)

None.

Off-Normal Functions (Safety Category)

The CIS provides the following Safety Category functions during Off-normal conditions:

- Protect against containment overpressurisation, which could occur during degraded core conditions after a severe accident.
- Containment isolation, where the remote-actuated CIVs close upon receipt of signal from I&C systems. This function supports DL3 and DL4a and is a Safety Category 1 function.

9A.4.2.2 Safety Design Bases

CIS components are primarily SC3 and categorised as Non-Seismic, except for the containment penetrations, isolation/check valves, rupture disc and associated piping which are SC1 and seismic category 1A/ 1B.

The CIVs and associated piping and penetrations are designed in accordance with the rules and requirements of ASME BPVC Code, Section III, Division 1, Subsection NE-Class MC Components, and Subsection NCD, Class 2 Components, in accordance with their quality group classification. The containment pipe penetrations are Seismic Category 1A and the CIVs are Seismic Category 1B.

The design and application of the CIS system meets IAEA requirements specified in SSR-2/1 Requirement 55 (Reference 9A-4) as related to preventing deflagration or detonation that could jeopardise the integrity or leak tightness of the containment. In addition, containment isolation is provided in accordance with IAEA SSR-2/1 Requirement 56.

9A.4.2.3 Description

Figure 9A-13 depicts the CIS. Components of CIS are located both inside and outside the reactor building. The nitrogen storage equipment, including the liquid nitrogen storage tank, nitrogen vaporiser, and heater are located in the yard.

The CIS provides the capability to supply containment with nitrogen to ensure that a non-combustible atmosphere is maintained following an accident that results in 100% reaction between the fuel cladding and water.

The CIS is capable of reducing the containment oxygen concentrations from atmospheric conditions to less than 3.5% by volume in less than 4 hours.

CIS is also capable of de-inerting the inerted containment to above 19.5% oxygen by volume within 4 hours to allow personnel safe access within containment without the use of a breathing apparatus.

The CIS consists of containment supply, containment exhaust, and containment overpressure venting flowpaths.

Containment Supply Flowpath

The containment supply flow path is used to inject nitrogen into containment for inerting (large nitrogen flow) and makeup (small nitrogen flow), inject breathable air into containment for de-inerting, and supply nitrogen to the PPS (Section 9A.4.1) to support actuation of air operated devices located inside containment. The containment supply flow path consists of a pressurised liquid nitrogen storage tank, vaporiser to convert the liquid nitrogen to a gaseous phase, electrical heater, piping, valves, instruments, and controls. Most of the components are located within the RB except for the storage tank, vaporiser, heater, associated valves, and piping, which are located in the yard. The containment supply flow path terminates in lower containment.

Containment Exhaust Flowpath

The containment exhaust flow path is used to discharge the containment atmosphere during the inerting, makeup, and de-inerting process. The containment exhaust flow path consists of piping, valves, instruments, controls, and a tee to the containment overpressure vent flow path. All of the components are located within the RB. The exhaust flow path starts in upper containment on the opposite side of containment from the supply injection point and connects to the HVS (Section 9A.5) before discharging to the vent stack.

Containment Overpressure Vent Flowpath

The containment overpressure vent flow path is used in case of a severe accident where containment failure by overpressure is threatened. The containment overpressure vent flow path consists of a rupture disc, a remote-actuated bypass valve, pressure indicator, isolation valve, check valve, sparger, and associated piping. The overpressure vent flow path connects to the containment exhaust flow path and terminates in the Reactor Equipment Pool. By relieving pressure into the Reactor Equipment Pool, water scrubbing is expected to occur, thereby reducing the contaminants. Additionally, the Reactor Equipment Pool is located inside the RB such that further holdup of any potential released contaminants is provided. A bypass line around the rupture disc allows for manual initiation of containment venting.

The rupture disk is designed in accordance with the rules and requirements of ASME BPVC, Section III, Class 2 Components.

Component Description

The following information is provided relative to the major equipment items in the CIS system.

Liquid Nitrogen Storage Tank

An insulated liquid nitrogen storage tank provides nitrogen supply to support CIS operations. The CIS liquid nitrogen storage tank is sized to provide enough nitrogen to support two consecutive nitrogen purges of containment. The tank includes level and pressure indicators, and the bottom of the tank is sloped to facilitate draining. Pressure is maintained automatically in the tank during nitrogen discharge by a circuit with an ambient heat exchanger fed by a pressure control valve. The vapor space can be manually vented to control tank internal pressure. The tank is fabricated of material suitable for cryogenic service in order to withstand low liquid nitrogen temperatures. The tank is equipped with quick disconnect/connect or equivalent type of connection to support refilling.

Vaporiser

The nitrogen vaporiser is used to convert the liquid nitrogen from the liquid nitrogen storage tank to the gaseous phase. The CIS nitrogen vaporiser is sized to provide at least 2.5 times the containment free volume of nitrogen within the 4-hour inerting period. The CIS nitrogen vaporiser is fabricated of materials suitable for cryogenic service.

Heater

A trim heater is used to increase the temperature of the nitrogen to greater than 10 ºC. Once connected, the heater continues to operate in automatic mode until deenergised. The heater is fabricated of material suitable for cryogenic services.

Rupture Disk

The rupture disk is part of the containment over-pressurisation vent flowpath and provides passive overpressurisation protection for containment. The CIS rupture disk burst pressure tolerance at the specified disk temperature does not exceed 5% of marked burst pressure.

9A.4.2.4 Materials

CIS SSCs are fabricated of materials suitable for cryogenic service as required.

9A.4.2.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-17 for CIS interfaces.

9A.4.2.6 System and Equipment Operation

Table 9A-16 provides a summary of the plant operating modes relative to CIS operations.

Initial Configuration (Pre-Startup)

The initial configuration of the CIS is set to inerting Mode with the CIVs closed. The CIS is in standby readiness condition prior to reactor startup.

System Startup

During System Startup (Mode 2), the containment hatches are closed, and the CIS is in-service. Coming out of shutdown where the containment was opened or any condition where the oxygen concentration is above the acceptable level, the CIS is set to inerting mode. Liquid nitrogen from the nitrogen storage tank is vaporised, heated, and subsequently injected into the lower containment while exhausting from the upper containment until the correct oxygen concentration is reached. The nitrogen is mixed with the containment atmosphere by the Containment Cooling System fans. Once the targeted oxygen concentration and pressure levels are reached, the CIS Containment Isolation Valves close.

Once inerting is complete, the CIS can be set to makeup mode to maintain the required oxygen concentration and a slightly positive pressure inside the containment to preclude oxygen infiltration from the RB. Liquid nitrogen from the nitrogen storage tank is vaporised, heated, and subsequently injected into the lower containment. During containment atmospheric heating conditions during plant startup, the exhaust line is opened to relieve excess containment pressure.

Normal Operations

During Power Operation (Mode 1), the containment hatches are closed, and the CIS is in-service. The CIS makeup mode is activated when the containment pressure drops below the desired setpoint and/or the oxygen concentration rises above the desired setpoint. Positive pressure is needed in the containment to preclude oxygen infiltration from containment leakage. Liquid nitrogen from the nitrogen storage tank is vaporised, heated, and subsequently injected into lower containment. During the maximum containment atmospheric heating conditions, the containment exhaust line is opened to maintain containment internal pressure.

During Refueling (Mode 6), the CIS is idle. The containment vessel is open, and the CIS is rendered ineffective.

Off-Normal Operations

In the event of a severe accident, resulting in containment flooding and elevated internal containment pressure, the rupture disc within the containment overpressure vent flowpath will passively open to vent the internal containment pressure. The rupture disc is passive requiring no operator action to open. However, an operator controlled manual bypass valve around the rupture disc can be used as an alternate method of venting.

The containment internal pressure is monitored in the MCR. The overall containment pressure decreases as venting continues. Once the containment internal pressure has been reduced to a safe level and normal containment heat removal capability has been regained, the containment overpressure protection air-operated isolation valve is closed to reestablish the containment pressure boundary. Radiological conditions associated with severe accidents will be presented in PSR Ch. 15, Section 15.3.

System Shutdown

During System Shutdown (Modes 3, 4, and 5), if the containment hatches are required to be opened to support personnel entry, the CIS is set to the de-inerting mode. De-inerting mode is used to achieve a safe, breathable atmosphere once the reactor reaches a setpoint temperature. In de-inerting mode, the CIS injects breathable air into the lower containment while exhausting from the upper containment until the correct oxygen concentration is reached. The breathable air is mixed with the containment atmosphere by the CCS fans. Once the targeted oxygen concentration is reached for a breathable atmosphere, the containment vessel hatches may be opened for personnel entry. With the hatches open, the CIS continues to operate in de-inerting mode to provide a constant fresh air supply for personnel inside containment.

If the containment vessel is not required to be opened during System Shutdown (Modes 3, 4, and 5), the CIS may be set to makeup mode to maintain an inerted atmosphere in containment.

Refer to PSR Ch. 1, Section 1.8 for a description of the operating modes.

9A.4.2.7 Instrumentation and Control

The following instrumentation features are included for monitoring CIS operations:

1) Flow transmitters for containment inerting flow indication.
2) Temperature elements to monitor the inerting nitrogen supply temperature.
3) Pressure transmitters for control of the inerting pressure control valves.
4) Containment Pressure indication provided by Process and Radiation Monitoring System (PSR Ch. 11, Section 11.5).

5) Position indication for all remotely operated valves.

Features provided for control of CIS operation include the following:

1) The electric heater activates and de-activates based on the temperature measured by the temperature elements. An interlock ensures that the heater activates only when there is nitrogen flow.
2) Supply line pressure control valves are self-regulating and set mechanically based on the downstream pressure, no control features are required.
3) Exhaust line control valves operate automatically based on control pressure indication provided by PREMS.
4) Inerting nitrogen supply temperature and pressure for control of the inerting and makeup process.

The following CIS displays and alarms are provided:

1) Main Control Console Indications:
    a) Position indication (full open and full closed) for all containment isolation valves.
    b) CIS control valves position indication.
    c) Containment oxygen concentration.
    d) Containment inlet temperature.
2) Main Control Room Alarms
    a) High and low nitrogen discharge temperature.
    b) Low nitrogen storage tank liquid level.
    c) Low and high containment inlet temperature.
    d) CIS valve operation failure.
    e) High oxygen levels in containment.

9A.4.2.8 Monitoring, Inspection, Testing, and Maintenance

The following pertains to testing and inspection of CIS components:

1) Periodic testing is performed to demonstrate the ability of CIS to meet design requirements. Each valve is exercised both open and closed and the position indication is verified. Trip and alarm logic signals are also checked. The tests assure correct functioning of all controls, instrumentation, piping and valves. System reference characteristics, such as pressure differentials and flow rates, are documented during the pre-operational tests and are used as baseline for measurements in the subsequent operational tests. Testing is performed both during operations and shutdown.
2) During plant operation, CIS valves, instrumentation, wiring and other components outside the containment can be inspected visually at any time.
3) Containment isolation valves are tested for leakage periodically in accordance with the requirements of 10 CFR 50 Appendix J, “Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors,” Type Test C.
4) The rupture disk is tested and replaced periodically, providing additional confidence of pressure.

Testing in support of plant pre-operational testing, startup, and commissioning is addressed in PSR Ch. 14, Section 14.3.

Testing is performed to ensure required functional operability is maintained under design conditions. The Non-Safety Category functions of the CIS are tested in accordance with ASME Code B31.1. The Safety Category functions of the CIS are tested in accordance with ASME BPVC-III.

Maintenance practices consider industry best practices and operating experience and conform with plant safety requirements to minimise potential for personnel injury. Maintenance activities implement ALARP practices to minimise work activity dose. Maintenance activities involving plant equipment may require involvement of vendors or industry specialists.

Other maintenance provisions include the following:

1) Isolation valves are provided on both sides of the supply and exhaust control valves to isolate the control valves and allow for maintenance and repair.
2) Pull spaces are provided around valves to allow for removal and maintenance.

9A.4.2.9 Radiological Aspects

PSR Ch. 12, Section 12.3 provides information pertaining to design measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.4.2.10 Performance and Safety Evaluation

The CIS Safety Category functions during normal conditions include ensuring containment boundary integrity and isolation capability. During Off-Normal conditions, CIS Safety Category functions include providing protection against containment overpressurisation.

The following features are incorporated into the design of the CIS to enhance reliability of the CIS Safety Category functions:

1) Periodic system testing, and preventive maintenance.
2) If the containment supply pressure control valve fails, a manual bypass valve can be opened to supply nitrogen to the containment. Pressure relief valves are positioned downstream of the pressure control valve to protect the downstream piping and provide for pressure control during manual bypass of the pressure control valve. The manual bypass function allows for continuous operation of CIS while the pressure control valve is out of service.
3) The CIS containment isolation valves are located outside of the SCCV which removes them from the harsh environment of the containment and protects them from the effects of flood and dynamic effects of pipe breaks. The CIVs are accessible for inspection and testing during reactor operation. Also, the CIVs fail closed on loss of air or control signal.
4) A manual bypass valve around the containment overpressure vent rupture disc can be used as an alternate method of venting. The bypass line is equipped with a local pressure indicator that can be used to support early containment venting during a beyond design basis accident.

The CIS structures, systems, and components that provide Safety Category functions are located in the RB which provides adequate protection against natural phenomena ensuring the ability of the CIS to perform its Safety Category functions.

9A.5 Heating, Ventilation and Air Conditioning Systems

The description below of the BWRX-300 HVS aligns with the system design description (Reference 9A-33). The HVS serves all areas of the power block during normal operation, with the exception of the primary containment which is serviced by the Containment Cooling System (Section 9A.5.6). HVS services containment in de-inerted modes of operation cross connected with the CIS (Section 9A.4.2). The HVS maintains space design temperatures, quality of air and pressurisation. It provides a controlled environment for personnel safety and comfort, and for the proper operation and integrity of equipment located in the power block.

The HVS consists of subsystems for fresh air and ventilation of each building. With the exception of the CB subsystem (Section 9A.5.2), all of the subsystems exhaust to a common plant exhaust stack during all normal operation modes. The plant exhaust stack is monitored for radiation. The CB is outside the radiologically controlled area and therefore the exhaust does not require radioactive monitoring.

The HVS consists of subsystems servicing the following buildings/areas:

- Control Building
- Reactor Building
- Radwaste Building
- Turbine Building
- Service Building
- Plant Vent Stack (PVS)
- Perimeter Buildings

9A.5.1 Reactor Building Heating, Ventilation and Air Conditioning System

The RB is a multi-level building that has levels both above and below grade. Both the Fuel Pool and the SCR are located within the RB.

9A.5.1.1 System and Equipment Functions

RB HVS, system, and equipment functions include the following:

Normal Functions (Non-Safety Category)

The RB HVS supports the following system generic HVS functions:

- Provides a controlled environment for personnel comfort and safety and comfort, and for the proper operation and integrity of equipment located in the power block. The HVS services all areas of the power block except for Primary Containment, which is served by the CCS (Section 9A.5.6).

Off-Normal Functions (Non-Safety Category)

The RB HVS supports the following HVS functions under Off-Normal conditions:

- Support the separation of fire areas to ensure that, in case of fire, at least one DL and at least one train of active shutdown systems is free of fire damage.

Normal Function (Safety Category)

The RB HVS performs the following Safety Category 1 function:

- Protection against wind-borne missiles through the provision of tornado dampers.

The HVS performs the following Safety Category 2 functions:

- Provide supplemental heating in areas of the plant containing SSCs relied upon to support DL functions to ensure the temperature remains within the environmental parameters to which those SSCs are qualified.
- Passively cool for the 72-hour battery coping time the SCR and SC1 DCIS and electrical equipment rooms within the RB, such that the SCR remains habitable, and the DCIS and electrical equipment rooms do not exceed the temperatures for which their equipment has been qualified.

Subsystems of the RB HVS have the following Safety Category 3 function:

- Provide isolation to the Refueling Floor when signaled to do so by I&C systems.

Off-Normal Functions (Safety Category)

The HVS performs the following Safety Category 2 functions:

- Provide isolation to the SCR when signaled to do so by I&C systems.
- Maintain temperature, quality of air, and pressurisation in the SCR and DCIS rooms of the RB.

9A.5.1.2 Safety Design Bases

The RB HVS performs a range of different Safety Category functions. The majority of components of the RB HVS are SC3, with some components classified as SC2.

The design of the HVS meets IAEA requirements specified in IAEA SSR-2/1 Requirement 73 (Reference 9A-4) as related to providing an HVAC system capable of maintaining the required environmental conditions for systems and components important to safety in all states. This is achieved through the following provisions:

1) Preventing unacceptable dispersion of airborne contaminants within the plant. Airborne contaminants are contained through the use of two 100% capacity RB Exhaust AHUs with HEPA filtration which take suction on the RB keeping it at negative pressure, ensuring that air flows into the RB from adjacent clean air spaces. The potential spread of airborne contamination is minimised by maintaining airflow from areas of lower potential for contamination to areas of greater potential for contamination.
2) Reducing the concentration of airborne radioactive substances to levels compatible with the need for access to each particular area is achieved by using shielding, ventilation, monitoring instrumentation and ALARP design concepts as discussed in PSR Ch. 12 to ensure the overall design minimises radiation exposure to workers and to the public.
3) Keeping the level of airborne radioactive substances in the plant below prescribed limits. The concentration of radionuclides in the air in areas accessible to personnel for normal plant surveillance and maintenance is below 0.1 the derived air concentration as specified in 10 CFR 20 Appendix B (Reference 9A-44) during normal power operation.
4) Application of ALARP design principles in normal operation as discussed in PSR Ch. 12.

5) Ventilating rooms containing inert or noxious gases without impairing the capability to control radioactive releases by using charcoal filters.

9A.5.1.3 Description

Figure 9A-14 depicts the RB HVAC Process Flow Diagram.

The RB, for HVAC purposes, is divided up into two main areas which includes the lower levels and the upper areas. The RB lower levels are supplied with conditioned air provided by one of two AHUs, located on the CB roof. These AHUs supply air through vertical duct chases down to the lowest elevation of the RB. The RB lower-level supply AHUs also supply outside air to the CIS (Section 9A.4.2) when required for containment de-inerting and to provide a habitable environment for maintenance personnel during refueling and maintenance operations.

Two 100% capacity RB Exhaust AHUs take suction on the RB keeping it at negative pressure, ensuring that air flows into the RB from adjacent clean air spaces. The operating exhaust AHU discharges through ductwork to the Continuous Exhaust Air Plenum (CEAP) and to the PVS. These AHUs are also provided ASDs to be able to adjust speed as necessary to maintain the RB and a negative pressure relative to outdoors. The normal lower level exhaust ductwork also receives air and inerting gases from the T31 system, when required, to be filtered and exhausted to the CEAP and to the PVS.

Each of the three Division Battery Rooms have Exhaust Fans (EFANs) which are provided with backup emergency power, exhausting to atmosphere in the event of a LOPP through ductwork and a louver mounted in a room up above. The Battery Rooms normally exhaust to the operating RB Exhaust AHU and the PVS. Hydrogen off-gassing of batteries require exhaust ventilation based on manufacturer's off-gassing rate, operated on a timer with hydrogen sensor backup.

The SCR is provided with Emergency Filter Units (EFUs) and pressurisation fans that supply ventilation air to the operators when automatically placed into service upon detection of radiation, toxic gas (if applicable), or smoke at the normal lower level supply AHUs. A loss of power to both normal supply AHUs will also initiate operation of the SCR EFUs and pressurisation fans. These two pressurisation fans draw outside air through dedicated ducting with blast resistant openings located in the Hallway and Truck Bay exterior walls. These units along with associated intakes, dampers, and ductwork, are Safety Category 2 and Seismic Category 1B. During Station Blackout (SBO) SCR operations, the SCR is passively cooled for 72 hours by the thermal mass of the surrounding concrete structure and heat transfer to the adjacent ground. When normal or diesel power is available, supplemental cooling is provided to the SCR by two FCUs. Electric duct heaters are provided in the SCR emergency supply air ducting to heat incoming outside air, if necessary.

The operating SCR pressurisation fan maintains a minimum positive pressure in the SCR with filtered makeup air, protecting the operators from potential radioactive gas, toxic gas (if applicable), and smoke. The SCR is normally provided filtered, conditioned air from the operating RB lower-level AHU.

Cooling in the RB lower levels is supplemented by chilled water supplied FCUs.

Supply duct from chilled water AHU and electric duct heaters are individually provided for each Battery Room to control to the battery manufacturer recommended room temperature, and for the SCR normal supply air.

A pressurisation fan is provided for each stairwell to bring in outside air in the event of smoke detection in the RB, to protect the stairwells from smoke.

During recovery from a fire, smoke is exhausted from the RB by operating normal supply AHUs in 100% outside air mode in conjunction with operation of one of the RB exhaust AHUs.

The RB HVS is provided tornado rated dampers at all RB penetrations to withstand high wind events and protect the RB structure.

Component Description

Design information related to the major components of the RB HVS is provided below.

Filters

The various building filtration levels are specified within each specific Subsection. Filters meet the applicable efficiency rating as stated below. ASHRAE Standard 52.2 (Reference 9A-45) establishes a filter's Minimum Efficiency Reporting Value (MERV) and establishes a filter's Average Atmospheric Dust Spot Efficiency. The following ASHRAE filter classifications are MERV specified (with Dust Spot Efficiency in parenthesis) below:

Low Efficiency: MERV 1-4 (Less than 20%)

Medium Efficiency: MERV 5-12 (As least 20% but less than 80%)

High Efficiency: MERV 13-16 (Greater than or equal to 80%)

HEPA filters are specified for various building filtration systems. Filters meet the applicable efficiency rating as stated below.

Filters with efficiency greater than MERV 16 by ASHRAE Standard 52.2 (MERV 17-20) (Reference 9A-45) are usually rated by the dioctylphthalate) test method. This test is based on the ability of a filter to remove an aerosol consisting of 0.3 micrometer (micron) particles of a test challenge. HEPA filters are extended-medium dry-type filters in a rigid frame, having minimum particle-collection efficiency of 99.97% on 0.3-micron particles which meets ASME AG-1, "Code on Nuclear Air and Gas Treatment," Section FC, HEPA Filters (Reference 9A-46).

HEPA filters are constructed, qualified, and tested per Underwriters Laboratory (UL)-586, "High Efficiency, Particulate, Air Filter Units" (Reference 9A-47).

Each of the two SCR Emergency Makeup Filtration Units contains a charcoal filter, located between upstream and downstream banks of HEPA filters. The upstream bank protects the charcoal from clogging. The downstream bank prevents discharging charcoal fines in the SCR.

The purpose of the charcoal bed is to remove potentially radioactive gases from the air stream. The charcoal bed also has properties associated with toxic gas adsorption.

Air Handler Units

Each AHU consists of an inlet area, filters (as specified by the system), electric heating coils, (as required) cooling coils (as required) and the respective fans (supply or exhaust). Bag In/Bag Out AHUs and EFUs are intended for use in units that contain potentially contaminated filters to facilitate filter changeout without the worker or room being exposed to the potentially contaminated filter.

Supply and Exhaust Fans

The various building ventilation systems are provided with supply and exhaust fans, sometimes incorporated into AHUs. These fans are either centrifugal or axial fans depending on the suitability to the specific system. The fans are designed, manufactured, and supplied in accordance with the standards of the Air Movement and Control Association International. Fans in various areas are equipped with Adjustable Speed Drive mechanisms to control airflows for the specific system application.

Heating Coils/Elements

Various AHUs are equipped with electrical heating coils/elements. Electric coils are designed and supplied to the requirements of Underwriters Laboratory, “Heating and Cooling Equipment” (Reference 9A-48).

Cooling Coils

The cooling coils are designed, constructed, and installed in accordance with ASHRAE 33, Methods of Testing Forced Circulation Air-Cooling and Air-Heating Coils (Reference 9A-48) and ANSI/AHRI 410 (Reference 9A-49) and Underwriters Laboratory (Reference 9A-46).

Cooling coil condensate is collected in drain pans within the air handler units with the drain pan discharge (condensate) routed to the Equipment and Floor Drain System (Section 9A.9.3).

9A.5.1.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising irradiation of the plant components, corrodents and mitigating the degradation of materials through material chemistry, heat treatment, contamination, and material processes controls identified in the equipment and purchase specifications.

9A.5.1.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-18 for RB HVS interfaces with other equipment or systems.

9A.5.1.6 System and Equipment and Operation

Normal Operation

The RB lower elevations will normally be provided heated, conditioned, and filtered once-through supply air from one of two operating AHUs located on the CB roof through supply ductwork. AHU cooling is supplemented by cooling provided by chilled water supplied FCUs located in rooms that require extra cooling, with FCUs being controlled by room thermostats. An electric duct heater in the supply duct to each Battery Room and to the SCR is expected to normally be operating as required to maintain SCR habitability and Battery Room temperatures as recommended by the battery manufacturer.

The RB upper elevations, consisting mainly of the fuel handling area operating deck, will normally be provided heated, conditioned, and filtered once-through supply air from one of two operating AHUs located on the RWB roof through supply ductwork. For each of the operating RB upper-level supply AHUs, the second supply AHU will normally be in standby, ready for auto-start should the operating AHU fail.

Air will normally be exhausted from the RB upper and lower levels, including the Battery Rooms, from one of two operating exhaust AHUs discharging ultimately to atmosphere from the PVS.

For each of the RB supply and exhaust AHUs, the second AHU will normally be operational, in standby, ready for auto-start should the operating AHU fail.

Off-Normal Operation

In the event of a SBO, power is lost to the RB exhaust AHUs as well as the upper and lower-level supply AHUs which normally provide heating and air conditioning for the RB, as well as electric duct heaters for the Battery Rooms.

Each Battery Room, normally exhausted via the RB exhaust AHU, continues to be exhausted via one of two 100 percent capacity exhaust fans, powered from its backup power source, for the purpose of being placed into service during loss of power events.

In the event of a loss of the MCR in the CB, the SCR in the RB is activated, and its dedicated HVAC system is placed into service. The emergency pressurisation fans with charcoal radioactive iodine gas filtration, and backed up by battery power, will also be placed into service automatically upon a loss of power to the RB lower-level normal supply AHUs or detection of radiation, at the RB lower-level normal supply AHU intakes.

The SCR pressurisation EFUs and emergency pressurisation fans, including the intake, ductwork, and power supplies are designed to operate for up to seventy-two hours without normal AC power.

In the event of a fuel handling accident on the refueling floor in the Fuel Handling Machine area, a radiation monitor alarm initiates closure of the RB isolation dampers and securing of the RB upper level supply AHUs.

9A.5.1.7 Instrumentation and Control

In general, the following signals are provided as inputs to the control logic to the various Temperature Control Panels (TCPLs) in the HVS:

1) Temperature elements to monitor space, plenum, internal AHU, and duct air temperatures, and to control cooling water control valves or cycle the fans for temperature control. Temperature controls are also used to monitor fan motor winding temperatures.
2) Moisture elements to monitor humidity.
3) Differential pressure transmitters and air flow instruments, as required, to monitor fan operation.
4) Differential pressure transmitters to monitor pressure drop across AHU filters.
5) Intake, exhaust, and return air damper position monitoring.
6) Duct mounted smoke detectors in:
    a. The outside air intake duct to close the intake dampers.
    b. The return air duct to shut down the supply and return/exhaust fans.
    c. Downstream of each AHU to de-energise the associated fan motor and auto-start the standby AHU.

The HVS subsystems have dedicated control panels that regulate the temperature of the spaces to within specified ranges.

Specific system control functions are described in detail in the system design description (Reference 9A-33) for each of the sub-systems. Any Safety Category functions or other required functions happen automatically with notification provided to operators.

9A.5.1.8 Monitoring, Inspection, Testing, and Maintenance

System Level Requirements

Plant-level HVAC inspection and maintenance is conducted in accordance with ASME N511 “In-Service Testing of Nuclear Air – Treatment, Heating, Ventilating, and Air Conditioning Systems” (Reference 9A-50).

Component Level Requirements

Air handlers are field tested as required per ASME N511 (Reference 9A-50).

Charcoal beds used for filtration of radiological effluents support meeting ALARP requirements as discussed in PSR Ch. 12.

Component specific maintenance procedures are outlined in the vendor manuals provided as part of each procurement package.

Personnel and lay-down access are provided around instruments to allow adequate space for maintenance purposes.

HEPA filters conform to the requirements of ASME of AG-1 (Reference 9A-46).

9A.5.1.9 Radiological Aspects

PSR Ch. 12 provides information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.5.1.10 Performance and Safety Evaluation

The RB HVS has sufficient capacity to fulfil its safety function. The RB HVS is designed with redundancy to assure that subsystems are normally available during all modes of plant operation, including startup and shutdown.

The RB HVS ensures that a habitable environment is maintained in the SCR for a minimum of 72 hours following an initiating event. The SCR and supporting Division 1, 2, and 3 Electrical and Switchgear rooms are provided with passive cooling systems powered from the Electrical Distribution System batteries for the required 72 hours. The supplemental passive cooling system also ensures that the SCR temperature does not exceed limiting temperature limits during a postulated design basis accident.

The RB HVS is designed to preclude SCR operators from receiving radiation exposures in excess of 0.05 Sv (5 rem) total effective dose equivalent in a single year by utilising two 100% capacity pressurisation fans which supply filtered outside air to the SCR which pressurises the space relative to adjacent spaces. This design feature protects operators from radiation associated with a Design Basis Accident.

The RB HVS includes supply and exhaust isolation dampers which close automatically in the event of a fuel handling accident, isolating the RB upper levels. These dampers are located at the RB boundary. In addition, the RB HVS provides the capability to isolate ventilation to the SCR. In both cases, the associated controls that provide the isolation signal is supplied from the I&C System.

Tornado dampers are provided for the RB HVS.

The I&C System monitors and provides diagnostic functions relative to RB HVS equipment room temperature.

Battery room exhaust fans are powered from the same bus as the SC1 Electrical Distribution System battery chargers associated with the respective divisional room. This requirement prevents hydrogen production from battery charging operations if the exhaust fans stop working due to a loss in the bus power.

9A.5.2 Control Building Heating, Ventilation and Air Conditioning System

The CB has rooms that contain electrical equipment and associated heat dissipation loads. Other rooms, such as the MCR, Radiation Protection offices, and conference room, contain areas of less heat density. The Battery Rooms, restrooms, break room, and janitor's closet are also low heat density rooms and are served by exhaust fans exhausting to the outdoors. Ductless mini-split systems supply conditioned air for the conference room, and other non-vital areas.

Note the SCR is covered under Section 9A.5.1.

9A.5.2.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

The HVS performs the following Safety Category N function:

- Maintain temperature, quality of air, and pressurisation in other areas of the CB not classified as SC3

Off-Normal Functions (Non-Safety Category)

The CB HVS supports the following HVS functions under Off-Normal conditions:

- The portions of the CB HVS which service control facilities are capable of remote isolation when signaled to do so by instrumentation and control systems.

Normal Functions (Safety Category)

The HVS performs the following Safety Category 2 function:

- Provide ventilation for the equipment room supporting DL4a functions

The HVS performs the following Safety Category 3 functions:

- Maintain temperature, quality of air, and pressurisation in required areas of the CB

Off-Normal Functions (Safety Category)

The HVS performs the following Safety Category 3 functions:

- Provide isolation to the MCR when signaled to do so by I&C systems

9A.5.2.2 Safety Design Bases

The CB HVS performs a range of different Safety Category functions. The majority of components of the CB HVS are SC3, with some components classified as SC2.

The design of the CB HVS meets IAEA requirements specified in IAEA SSR-2/1, Requirement 78 (Reference 9A-4) as related to providing an HVAC system capable of maintaining the required environmental conditions for systems and components important to safety in all states. This is achieved through the following provisions:

1) Preventing unacceptable dispersion of airborne contaminants within the plant by monitoring the normal CB outside air intakes for radioactivity. Upon detection of radioactivity the Control Room Envelope (CRE) goes into isolation mode with normal CB supply and return isolation dampers going closed. CRE-EFU automatically starts, pressurising the CRE with filtered supply air, utilising a mixture of approximately 90% return air from the CRE. The 10% outside air passes through the CRE-EFU with potential radioactive iodine being removed via charcoal filtration.
2) Reducing the concentration of airborne radioactive substances to levels compatible with the need for access to each particular area is achieved by using shielding, ventilation, monitoring instrumentation and ALARP design concepts as discussed in PSR Ch. 12 to ensure the overall design minimises radiation exposure to workers and to the public.
3) Keeping the level of airborne radioactive substances in the plant below prescribed limits. The concentration of radionuclides in the air in areas accessible to personnel for normal plant surveillance and maintenance is below 0.1 the derived air concentration as specified in 10 CFR 20 Appendix B (Reference 9A-44) during normal power operation.

4) Application of ALARP design principles in normal operation as discussed in PSR Ch. 12, Section 12.1.2 (Facility layout general design considerations for maintaining radiation exposures ALARP).

5) Ventilating rooms containing inert or noxious gases without impairing the capability to control radioactive releases by using charcoal filters that have properties for toxic gas adsorption.

9A.5.2.3 Description

Figure 9A-15 depicts the Control Building HVAC Process Flow Diagram.

The CB is a three-story building. Some rooms contain significant quantities of electrical equipment and associated heat dissipation loads. Other rooms, such as the MCR, Radiation Protection offices, and Conference Room, contain areas of less heat density. The Battery Rooms, Restrooms, Break Room, and Janitor's Closet are also low heat density rooms and will be served by exhaust fans exhausting to the outdoors.

The CB is normally air conditioned and heated by 2 x 100% capacity chilled water supplied AHUs located on the CB roof, discharging through supply ductwork and a return plenum. Approximately 10% fresh makeup air is brought into the operating AHU. In addition to the chilled water coils, the AHUs contain electric heating coils, humidification/dehumidification features, filtration, and isolation dampers. Supply ductwork upstream of the MCR and offices is provided with Volume Control Units to vary supply air flow based on thermostatic control. AHU cooling in the high heat load rooms is supplemented by chilled water supplied FCUs with a Train A and a Train B FCU located in each of these rooms.

The Battery Rooms are maintained at the battery manufacturer recommended room temperature. Battery Room temperatures are maintained via Battery Room supply duct electric duct heaters and thermostats located in the rooms.

The outside air intake is instrumented to analyse for toxic gases and for airborne radioactivity as applicable.

To accommodate MCR habitability contingencies the following additional AHUs are provided for the CB:

1) CRE-EFU that operate automatically upon detection of high radiation level at the operating CB supply AHU outside air intake. The CRE goes into isolation mode with normal CB supply and return air dampers going closed. A mixture of approximately 90% return air from the CRE and 10% outside air will pass through the EFU with potential radioactive iodine being removed via charcoal filtration. EFU operation maintains the CRE slightly pressurised. The operating CB normal supply AHU de-energises upon high radiation detection at the intake and auto-start of the standby unit is defeated. Battery Room exhaust fans continue to operate based off timers.

2) CB toxic gas filtration units that operate automatically when toxic gas has been detected at the CB AHU outside air intakes. In this event, normal outside air supply to the operating CB AHU isolates and the toxic gas filtration unit discharge damper opens, allowing the associated toxic gas filtration unit to supply pressurisation air to the CB through the normal CB supply AHU, which continues to operate during a toxic gas event.

Refer to PSR Ch. 6, Section 6.6 for further information pertaining to Control Room habitability

The CB normal supply AHUs are provided ASD to be able to reduce flow as conditions change. CRE isolation and CRE-EFU operation provide a pressurised envelope with respect to adjacent spaces, maintaining CRE habitability during an airborne radiation event. Toxic gas filtration unit operation maintains the entire CB pressurised, maintaining CB habitability during a toxic gas event.

Two smoke exhaust fans are provided for the CB. During recovery from a fire, smoke is exhausted from the CB by operating a CB normal supply AHU in 100% outside air mode in conjunction with operation of two CB smoke exhaust fans.

The CB HVS is provided tornado rated dampers as necessary to withstand high wind events.

Component Description

Refer to Section 9A.5.1.3 for information pertaining to HVS components.

9A.5.2.4 Materials

Refer to Section 9A.5.1.4 for information pertaining to HVS materials.

9A.5.2.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-19 for Control Building HVS interfaces with other equipment or systems.

9A.5.2.6 System and Equipment Operation

Normal Operations

The CB HVS is provided heated, conditioned, and filtered supply air from one of two operating AHUs through supply ductwork, with approximately 90% of the air recirculated back to the units. The second AHU is in standby, ready for auto-start should the operating unit fail. The remaining 10% of the supply air is made up by outside air brought into the operating AHU located on the CB roof. The two exhaust fans provided for each Battery Room are operating based off timers, exhausting to the outdoors. Exhaust fans for the restrooms, break room, and janitors’ closet are all expected to be operating continuously, exhausting to the outdoors. An electric duct heater in the supply duct to each Battery Room is normally operating as required to maintain Battery Room temperatures near the optimal battery temperature as recommended by the battery manufacturer.

Off-Normal Operations

In the event of an SBO, power is lost to the CB AHUs which normally provide heating and air conditioning for the CB, as well as electric duct heaters and cabinet heaters. The restroom, break room, and janitors closet exhaust fans become inoperable. The Battery Room exhaust fans continue to operate off timers using backup power, preventing accumulations of off-gassed hydrogen to the rooms; the timers ensure the exhaust fans only run as needed to eliminate hydrogen buildup. The Control Room operators relocate to the SCR in the RB if the MCR becomes uninhabitable.

In the event of a LOPP, Standby Diesel Generator (SDG) backup power is provided to the CB AHU supply fans. The associated heating coils are not energised. The Restroom, Break Room, and Janitors Closet exhaust fans become inoperable. The Battery Room exhaust fans continue to operate off timers using backup power, preventing accumulations of offgassed hydrogen to the rooms; the timers ensure the exhaust fans only run as needed to eliminate hydrogen buildup. Electric duct and cabinet heaters are de-energised.

In the event of a CB normal outside air intake radiation monitor alarm, the operating normal supply AHU de-energises and any associated toxic gas filtration units also de-energise, and the same train CRE-EFU automatically starts. The CRE isolation dampers close in conjunction with the start of the CRE-EFU. Diesel generator backup power is provided to the CRE-EFU supply fans and associated heating coils. Restroom, break room, and janitors closet exhaust fans become inoperable. The Battery Room exhaust fans continue to operate off timers using backup power, preventing possible accumulations of off-gassed hydrogen to the rooms; the timers ensure the exhaust fans only run as needed to eliminate hydrogen buildup. Electric duct and cabinet heaters are de-energised.

In the event of a CB normal outside air intake toxic gas detection, the operating normal AHU normal outside air intake closes, and the same train toxic gas filtration unit automatically starts and its associated motor control dampers automatically open, providing an alternate source of filtered outside air for CB pressurisation. Diesel Generator backup power is provided to the CB normal supply AHU fans and associated heating coils, as well as the associated Toxic Gas Filtration Unit fan. Restroom, break room, and janitors closet exhaust fans become inoperable. The Battery Room exhaust fans continue to operate off timers using backup power, preventing possible accumulations of off-gassed hydrogen to the rooms; the timers ensure the exhaust fans only run as needed to eliminate hydrogen buildup. Electric duct and cabinet heaters are de-energised. Positive pressure is maintained in the CB by way of providing outside air through the normal supply AHU, the toxic gas filtration unit, or the CRE-EFU.

9A.5.2.7 Instrumentation and Control

Refer to Section 9A.5.1.7 for a general description of the HVS control functions. Specific system control functions are described in detail in the system design description (Reference 9A-33) for each of the sub-systems. Any Safety Category functions or other required functions happen automatically with notification provided to operators.

9A.5.2.8 Monitoring, Inspection, Testing, and Maintenance

Air handlers are field tested per ASME N511 (Reference 9A-50).

Component Level Requirements

Component specific maintenance procedures are outlined in the vendor manuals provided as part of each procurement package.

Personnel and lay-down access are provided around instruments to allow adequate space for maintenance purposes.

Charcoal beds used for filtration of radiological effluents meet ALARP requirements as discussed in PSR Ch. 12.

9A.5.2.9 Radiological Aspects

PSR Ch. 12 (Reference 9A-14) provides information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.5.2.10 Performance and Safety Evaluation

In the event of a LOPP, diesel generator backup power is provided to the CB AHU supply fans. In the event of an SBO, power is lost to the CB AHUs. However, for both the LOPP and SBO cases the Battery Room exhaust fans continue to operate off timers using backup battery power in order to prevent potential accumulations of off-gassed hydrogen to the Battery Rooms. The timers ensure the exhaust fans only run as needed to eliminate hydrogen buildup. In the event the MCR becomes uninhabitable the Control Room operators relocate to the SCR in the RB.

CB HVS design includes:

1) Redundant FCUs which provides cooling to the DL4a room.
2) Redundant FCUs which provides required cooling to the I&C System DL2 Room A and I&C System DL2 Room B.

The RB HVS includes 100% capacity pressurisation fans with emergency filtration units that supply filtered outside air to the SCR needed to pressurise the space relative to adjacent spaces, protecting the operators from hazards such as release of radioactive materials, fire, or smoke in the RB. The pressurisation fans are provided with backup power making them available for use during a LOPP or SBO.

9A.5.3 Radwaste Building Ventilation and Air Conditioning Systems

The RWB contains room-temperature tanks and small to medium-sized pumps. The RWB is not normally occupied. However, plant personnel access and spend time in the Chemistry Lab and dress out areas within the RWB. As such, most of the building to meet habitability requirements.

HEPA filtration is provided to the RWB processing and storage area, the Chemistry Lab fume hood, and sampling areas.

9A.5.3.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

The HVS performs the following Safety Category N function:

- Maintain temperature, quality of air, and pressurisation in all required areas of the RWB.

Off-Normal Functions (Non-Safety Category)

The RWB HVS does not perform any off-normal functions.

Normal Functions (Safety Category)

The RWB HVS includes supply and exhaust isolation dampers for the RWB, which close automatically in the event of a RWB high radiation input from the PREMS.

Off-Normal Functions (Safety Category)

The RWB HVS does not perform any off-normal Safety Category functions.

The RWB HVS is not required to operate during or after a design basis event.

9A.5.3.2 Safety Design Bases

The RWB HVS is SCN.

The design of the RWB HVS meets IAEA requirements specified in IAEA SSR-2/1 Requirement 78 (Reference 9A-4) as related to providing an HVAC system capable of maintaining the required environmental conditions for systems and components important to safety in all states. This is achieved through the following provisions:

1) Preventing unacceptable dispersion of airborne contaminants within the plant through the use of the exhaust AHUs to maintain a negative pressure in clean areas, resulting in air transferring from clean to "dirty" areas.
2) Reducing the concentration of airborne radioactive substances to levels compatible with the need for access to each particular area is achieved by using shielding, ventilation, monitoring instrumentation and ALARP design concepts as discussed in PSR Ch. 12 to ensure the overall design minimises radiation exposure to workers and to the public.
3) Keeping the level of airborne radioactive substances in the plant below prescribed limits. The concentration of radionuclides in the air in areas accessible to personnel for normal plant surveillance and maintenance is below 0.1 the derived air concentration as specified in 10 CFR 20 Appendix B (Reference 9A-44) during normal power operation.
4) Application of ALARP design principles in normal operation as discussed in Section 12.1.2 (Facility layout general design considerations for maintaining radiation exposures ALARP).

5) Ventilating rooms containing inert or noxious gases without impairing the capability to control radioactive releases using HEPA filters. The HEPA filters associated with the RWB HVS exhaust AHUs assist in ensuring radioactive material entrained in gaseous effluent does not exceed the limits specified in appropriate nuclear safety and control regulations for normal operations and anticipated operational occurrences.

9A.5.3.3 Description

Figure 9A-16 depicts the Radwaste Building HVAC Process Flow Diagram.

RWB HVS is comprised of two 100% capacity supply AHUs and two 100% capacity exhaust AHUs with HEPA filtration, functioning in a push-pull manner. In general, clean filtered outside air, heated when needed, is supplied through ductwork to the lobby and Chem Lab, pressurising those areas. The exhaust AHUs take suction on the potentially contaminated tank and pump rooms, creating negative pressures in those spaces, resulting in air transferring from clean to "dirty" areas. ASDs are provided for each of the four AHUs, permitting air flow to be ramped down in the wintertime, saving on heating load.

Fan coil units are provided for the ground and second level general areas. The RWB second floor has three FCUs. Cooling in the Lab and second floor main area is served by one FCU, while the other two FCU are located in the Charcoal Absorber Vault. The Lab is also provided a small Cabinet Heater.

During recovery from a fire, smoke is exhausted from the RWB by operating the normal supply AHUs in 100% outside air mode in conjunction with the RWB exhaust AHUs.

Component Description

Refer to Section 9A.5.1.3 for information pertaining to HVS components.

9A.5.3.4 Materials

Refer to Section 9A.5.1.4 for information pertaining to HVS materials.

9A.5.3.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-20 for Radwaste Building HVS interfaces with other equipment or systems.

9A.5.3.6 System and Equipment Operation

Normal Operations

The RWB will normally be provided heated, filtered once-through supply air from two 50% capacity operating AHUs located on the second elevation of the RWB through supply ductwork. Outside air will be drawn in the RWB supply AHUs through suction ductwork and intake louvers located in the nearby exterior wall.

Air is exhausted from the RWB through two 50% capacity operating exhaust AHUs located on the RWB roof, which discharge to atmosphere from the PVS. AHU cooling provided by ventilation air is supplemented by cooling provided by FCUs. FCUs are controlled by room thermostats. AHU heating is supplemented by electric unit heater.

The RWB Chem Lab is provided an electrical cabinet heater and an FCU to supplement AHU HVAC needs, both are controlled by local thermostats. The Chem Lab fume hood exhausts to RWB exhaust AHU suction, with final discharge to the PVS.

Off-Normal Operations

In the event of a LOPP or SBO, power is lost to all the RWB HVS equipment including the supply and exhaust AHUs, FCUs, electric unit heaters, and the Chem Lab cabinet heater and fume hood.

A radiation monitor alarm in the RWB initiates closure of the RWB isolation dampers and secures the supply and exhaust AHUs. Refer to PSR Ch. 11 for information pertaining to radiation monitoring.

9A.5.3.7 Instrumentation and Control

Refer to Section 9A.5.1.7 for a general description of the HVS control functions. Specific system control functions are described in detail in the system design description (Reference 9A-33) for each of the sub-systems. Any Safety Category functions or other required functions happen automatically with notification provided to operators.

9A.5.3.8 Monitoring, Inspection, Testing, and Maintenance

Air handlers are field tested per ASME N511 (Reference 9A-50).

Component specific maintenance procedures are outlined in the vendor manuals provided as part of each procurement package.

Personnel and lay-down access are provided around instruments to allow adequate space for maintenance purposes.

9A.5.3.9 Radiological Aspects

PSR Ch. 12 (Reference 9A-14) provides information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.5.3.10 Performance and Safety Evaluation

The RWB HVS does not perform any Safety Category functions and therefore requires no nuclear safety evaluation.

The RWB HVS isolates in the event of RWB high radiation input from the PREMS.

Operational failure of any single unit of the RWB HVS does not prevent Safety Class equipment from performing any Safety Category function.

9A.5.4 Turbine Building Heating, Ventilation and Air-Condition System

The TB is a large building with significant cooling loads. It is divided into two main areas:

- The potentially contaminated areas inside the bioshield area, which houses the Main Turbine, Main Condenser, Moisture Separator Reheater, Feedwater Heaters and other significant heat loads.
- Outside the bioshield area includes the Main Generator.

9A.5.4.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

The TB HVS performs the following Safety Category N function:

- Maintain temperature, quality of air, and pressurisation in all required areas of the TB.

Off-Normal Functions (Non-Safety Category)

TB HVS systems continue to operate during off-normal conditions until removed from service either manually or automatically.

Normal Functions (Safety Category)

The TB HVS includes supply and exhaust isolation dampers for the TB, which close automatically in the event of a TB high radiation input from the PREMS.

Off-Normal Functions (Safety Category)

The TB HVS does not perform, ensure, or support any off-normal Safety Category function, and thus, has no safety design bases.

9A.5.4.2 Safety Design Bases

The TB HVS is SCN. The TB HVS is not required to operate during or following a Design Basis Accident.

The design of the TB HVS meets IAEA requirements specified in IAEA SSR-2/1 Requirement 78 (Reference 9A-4) as related to providing an HVAC system capable of maintaining the required environmental conditions for systems and components important to safety in all states. This is achieved through the following provisions:

1) Preventing unacceptable dispersion of all airborne contaminants within the plant using air flow to effect transfer of air from clean areas to potentially contaminated areas.
2) Reducing the concentration of airborne radioactive substances to levels compatible with the need for access to each particular area is achieved by using shielding, ventilation, monitoring instrumentation and ALARP design concepts as discussed in PSR Ch. 12 to ensure the overall design minimises radiation exposure to workers and to the public.
3) Keeping the level of airborne radioactive substances in the plant below prescribed limits. The concentration of radionuclides in the air in areas accessible to personnel for normal plant surveillance and maintenance is below 0.1 the derived air concentration as specified in 10 CFR 20 Appendix B (Reference 9A-44) during normal power operation.
4) Application of ALARP design principles in normal operation as discussed in Section 12.1.2 (Facility layout general design considerations for maintaining radiation exposures ALARP).
5) Ventilating rooms containing inert or noxious gases without impairing the capability to control radioactive releases using HEPA filters. The HEPA filters associated with the TB HVS exhaust AHUs assist in ensuring radioactive material entrained in gaseous effluent does not exceed the limits specified in appropriate nuclear safety and control regulations for normal operations and anticipated operational occurrences.

9A.5.4.3 Description

Figure 9A-17 depicts the Turbine Building HVAC Process Flow Diagram.

The TB is a large building with significant cooling loads. It is divided into two main areas: The potentially contaminated areas inside the shield area, which houses the Main Turbine, Main Condenser, Moisture Separator Reheater, Feedwater Heaters and other significant heat loads. The Main Generator is outside the shield area.

The Main Generator is air-cooled and does not use hydrogen as the coolant. Therefore, there are no special requirements for hydrogen controls in the area.

The TB is supplied with outside air using supply AHUs. These AHUs are provided with electric heating coils to provide a reasonable supply air temperature, and upstream prefilters to keep dirt off the coils, and for building cleanliness. The supply air is distributed through ductwork to areas both inside and outside the shield area. Most floors in the TB consists of metal grating, allowing supply air provided to lower elevations to increase in temperature and elevate naturally. Air is exhausted from the building via four AHUs with HEPA filtration located on the TB roof, taking suction from roof penetrations or suction ductwork. Air flow rates to areas have been chosen to effect transfer air from clean areas outside the shield area to potentially contaminated areas inside the shield area. TB supply and exhaust AHUs are provided AFDs to be able to reduce flow as permitted by plant operation and reduced ambient temperature conditions.

The PVS is located towards the north end of the TB roof. Exhaust air from potentially contaminated areas including the TB, RB, and RWB are filtered using local area HEPA filters before being exhausted to the continuous exhaust air plenum. The continuous exhaust air plenum serves as a large mixing box where potentially contaminated air will be mixed and diluted. During normal operation, up to three continuous exhaust air plenum fans take suction on the plenum and discharge to the nearby PVS. The continuous exhaust air plenum fans are provided ASDs to be able to maintain the continuous exhaust air plenum negatively pressurised relative to the atmosphere. The PVS radiation monitor is addressed in PSR Ch. 11.

The TB Battery Room is ventilated and conditioned by direct expansion type HVS systems. One system is provided backup power from SDG Train A and the other system is provided backup power from SDG Train B. Each system includes an outdoor roof-mounted condenser unit and an indoor wall-mounted AHU, connected by refrigerant piping. Each AHU brings a small amount of filtered, conditioned outside air into the room, maintaining a slight positive pressure in the space. The room is heated by electric unit heaters.

Component Description

Refer to Section 9A.5.1.3 for information pertaining to HVS components.

9A.5.4.4 Materials

Refer to Section 9A.5.1.4 for information pertaining to HVS materials.

9A.5.4.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-21 for Turbine Building HVS interfaces with other equipment or systems.

9A.5.4.6 System and Equipment Operation

Normal Operation

The TB is normally provided heated, filtered once-through supply air from AHUs located on the mezzanine level of the TB, which supply through ductwork to areas both inside and outside the radiological area. Air is exhausted from the same spaces through exhaust AHUs located on the TB low bay roof, taking suction either directly through a TB roof penetration, or through suction ductwork connecting to the TB high bay. These exhaust AHUs discharge to the atmosphere from the PVS. AHU cooling provided by ventilation air is supplemented by cooling provided by FCUs located in areas that require extra cooling, with FCUs being controlled by local thermostats. AHU heating is supplemented by electric unit heaters. Circulating fans are provided and used to mitigate hot spots within the building.

Off-Normal Operation

In the event of an SBO power is lost to all the TB HVAC equipment, Supply and exhaust AHUs and fan, electric unit heaters, FCUs, and all circulating fans.

No cooling will be needed during the SBO event. Hydrogen off-gassing of batteries require exhaust ventilation based on manufacturer's off-gassing rate, operated on a timer.

In the event of a LOPP, power is lost to all the TB HVAC equipment; Supply and exhaust AHUs, electric unit heaters, the FCUs, and all circulating fans.

A radiation monitor alarm in the TB initiates closure of the TB isolation dampers and secures the supply and exhaust AHUs. Refer to PSR Ch. 11 for information pertaining to radiation monitoring.

9A.5.4.7 Instrumentation and Control

Refer to Section 9A.5.1.7 for a general description of the HVS control functions. Specific system control functions are described in detail in the system design description (Reference 9A-33) for each of the sub-systems. Any Safety Category functions or other required functions happen automatically with notification provided to operators.

9A.5.4.8 Monitoring, Inspection, Testing, and Maintenance

The TB HVS provides isolation features to support testing and maintenance.

Air handlers are field tested per ASME N511 (Reference 9A-50).

Component specific maintenance procedures are outlined in the vendor manuals provided as part of each procurement package.

Personnel and lay-down access are provided around instruments to allow adequate space for maintenance purposes.

9A.5.4.9 Radiological Aspects

PSR Ch. 12 provides information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.5.4.10 Performance and Safety Evaluation

The TB HVS is not credited for mitigation of design basis accidents and not required to be operated during off-normal events.

HEPA filters associated with the TB HVS exhaust AHUs assist in ensuring radioactive material entrained in gaseous effluent does not exceed the limits specified in appropriate nuclear safety and control regulations for normal operations and anticipated operational occurrences. The exhaust air from the TB HVS is monitored for radioactivity prior to discharge to the plant vent. Alarms annunciate in the MCR upon detection of high radiation per 006N7938, “Process Radiation and Environmental Monitoring System,” (Reference 9A-51).

The Turbine Building Structure (TBS) HVS isolates in the event of TB high radiation input from the PREMS.

9A.5.5 Service Building and Perimeter Buildings Heating, and Ventilation Systems

The Service Building (SB) consists of three floors. The first floor is designated as a staging area. The second floor consists of maintenance shops, special use areas, and restrooms. The third floor consists of offices, outage centre, and other rooms.

The Perimeter Buildings (Pre-fabricated Equipment Structures) consist of 11 one-story buildings that share a common wall with the TB. The buildings house the Medium Voltage Plant Distribution Centre, Division C Batteries, Feedwater Pump Adjustable Speed Drive Electrical, PPS Service Air Rooms A and B, Reactor and Condensate Storage Tanks, Standby Diesel Generator A, Switchgear A, Standby Diesel Generator B, and Switchgear B rooms.

The Perimeter Buildings are isolated from any source of contamination. The walls of the Division C Battery Room, and each of the two Standby Diesel Generator Rooms share a common wall with the turbine building. The common wall is constructed leak-tight relative to the TB to maintain radioactively clean environments.

The HVS system for these buildings is yet to be defined beyond the system generic requirements and no design detail is specified at this time. The design will be developed along the same principles as the rest of the HVS sub-systems as described within the rest of this chapter.

9A.5.6 Containment Cooling System

The description below of the BWRX-300 CCS aligns with 006N7777 "Containment Cooling System SDD" (Reference 9A-52). The CCS is a closed loop cooling system that recirculates air/nitrogen with no outside air introduced into the system except during outages. The CCS performs the cooling function for the SCCV to maintain the containment bulk average temperature within the Environmental Qualification (EQ) limits of the related equipment located inside containment.

9A.5.6.1 System and Equipment Functions

The CCS supports performance of the following functions during operating conditions through the entire operating range, from startup to full load condition to refueling.

Normal Functions (Non-Safety Category)

The CCS performs the following Non-Safety Category functions during normal operations.

- CCS maintains temperature for plant personnel entering the containment during shutdowns and refueling activities.

Normal Functions (Safety Category)

The CCS performs the following Safety Category 3 functions during normal operations:

- CCS maintains containment bulk average temperature within the EQ limits during Run/ Startup/ shutdown modes of operation.

Off-Normal Functions (Non-Safety Category)

The CCS does not perform any Non-Safety Category functions during off-normal operations.

Off-Normal Functions (Safety Category)

The CCS performs the following Safety Category 3 functions during off-normal operations:

- CCS assists with containment cooldown following a LOPP during the period from hot shutdown to cold shutdown if available.

9A.5.6.2 Safety Design Bases

The CCS maintains containment bulk average temperature within required limits, which is regarded as a make-ready support function for DL3, Safety Category 1 function of PCCS. Therefore, the AHUs and other components of the CCS that perform this function are classified as part of DL2 as SC3.

The CCS is regarded as Seismic Category 2 but is designed as a Seismic Interaction as the failure of CCS SSCs during a seismic event could impact other Seismic Category 1A or 1B components.

9A.5.6.3 Description

The CCS provides containment cooling using AHUs with cooling coils that reject heat to the CWE, then the air is forced into a closed loop recirculation inside the SCCV. Any condensed liquids around the cooling coils drains are drained to the bottom of containment then towards the EFS.

Figure 9A-18 presents a simplified process flow diagram for the CCS.

The CCS is comprised of four (4) 50% capacity AHUs and is divided into two trains of two (2) AHUs. Each train is cooled by a corresponding chilled water train so that SCCV cooling is still possible even with loss of one train of CWE or one train of CCS. Each AHU can be powered from one of the standby diesel generators of the SC2 and SC3 Electrical Distribution System.

During normal operation, only one train of CCS is operating while the other is in standby. The train in standby automatically starts upon loss of the lead train or upon temperature exceeding target. All AHUs can be in service at the same time, if needed.

Each AHU has a drain pan. Drain piping is used to drain accumulated condensates in the drain pans around the AHUs cooling coils. Drained condensates are then collected at the bottom of SCCV and drained to the pressurized sump of the EFS (Section 9A.9.3).

The CCS air distribution ductwork is constructed of hot-dipped galvanised sheet metal and uses manual balancing dampers to control the distribution of air to the various containment locations.

Backdraft dampers are provided on each fan suction to prevent reverse rotation of a non-operating fan.

The CCS ductwork and equipment are designed in accordance with “ASHRAE Handbook – Fundamentals” (Reference 9A-53) for the reactor building environment to support the operation and integrity of equipment during normal, startup and shutdown operations.

Component Description

Air Handling Units

The main components of the AHUs include:

- Cooling coils: The cooling coils provide the cooling needed for the containment atmosphere as they are connected to [CWE] piping which provides chilled water with a controlled flowrate. The cooling coils are to be designed, constructed, and installed in manner that facilitates coil cleaning and possible replacement.
- Fans: Supply fans are located downstream of the cooling coils. These fans force air circulation at the desired flowrate for containment cooling. A totally enclosed fan cooled motor is provided for each fan.
- Air filters: Air filter sections are provided upstream of the cooling coil sections to permit installation of temporary filters. The filters are expected to be installed during initial outages, shutdowns, or initial startup and confirmed to be removed prior to containment closure and return to normal operations. The filters are low efficiency air filters.

Ducts and Dampers

The CCS distribution ducts and dampers are constructed of hot-dipped galvanized sheet metal and use manual balancing dampers to control the distribution of air to the various containment locations.

- Ducts: Ducts are used to circulate air or Nitrogen in containment to achieve the desired cooling and maintain bulk average containment temperature within the EQ temperature for the components and instruments located inside containment. Supply air ducts are connected to the AHU outlets distribute the supply air towards the containment and the CRD area. Return air ducts gather the air from upper CRD and upper containment areas and return the air to the [AHU] inlet.

- Dampers: An automatic damper controlled from the MCR is present on inlet to each of the AHUs. Manual flow balancing dampers are installed on ducts, these dampers are adjusted during shutdowns to regulate the flow needed as per relevant EQ temperature limits. A backdraft damper is provided on each fan discharge to prevent reverse rotation of a non-operating fan and serve also for isolation during maintenance. Manual dampers are also installed at the AHUs suction lines for isolation during maintenance. Supply and return dampers are installed in the Air Handling Units, so they are isolable in support of needed repairs and maintenance.

Condensate Drain Piping

Drain piping is used to drain accumulated condensates from the AHUs cooling coils to the pressurized sump of the EFS. Drain piping is equipped with flow sensors to measure the amount of condensate collected around the cooling coils.

9A.5.6.4 Materials

Selection of radiation-resistant materials of construction is included in individual equipment specifications.

Material and equipment selection for CCS components is based on a 60-year plant life, with appropriate provisions for maintenance and replacement. Components which may require periodic replacement and/or maintenance prior to the end of plant life are dampers, damper linkages, AHUs, bearings, and motors.

Materials are selected in accordance with applicable codes, standards, and industry practice for the design, service, and test conditions and expected ambient conditions.

Materials selected are compatible with the internal process and external environmental conditions during normal, abnormal, accident, and beyond design basis accident conditions as appropriate.

9A.5.6.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-22 for CCS interfaces with other equipment or systems.

9A.5.6.6 System and Equipment Operation

The CCS is required to continuously operate in Modes 1-6.

During normal plant operation, the SCCV is inerted with dry nitrogen, thus no air is introduced into the SCCV atmosphere during power operation. Hot nitrogen gas drawn from the upper containment space and the control rod drive area is directed to the AHU coils, to be cooled and discharged by the AHU. The nitrogen is then released into a supply air header and its related ducts that are distributed throughout different locations in containment and the control rod drive area in order to maintain the containment temperature at the target value.

During outages requiring containment entry, the CCS supplies outside air into the containment through containment penetration piping interface to purge the nitrogen out of the SCCV. The CCS supply fans recirculate the air and distribute it throughout the SCCV to maintain a habitable working environment.

Normal Operational Concept

CCS normal plant operation includes startup, power operation, hot shutdown, stable shutdown, cold shutdown, and refueling. In normal operation mode, one (1) of the two (2) trains operates as lead while the other train is in standby. The lead train is initiated remotely from the MCR. The standby train is started automatically with the lead if the bulk temperature in containment exceeds a specific setpoint. The standby train is also automatically started upon tripping of the lead train. The assignment for lead and standby train is switched periodically. Both trains can also operate simultaneously to enhance cooling if required.

Off-Normal Operational Concept

The CCS AHUs and supporting chillers are provided with backup power from the diesel generators. The CCS remains operational during LOPP conditions to keep the containment environment from exceeding design conditions. The CCS assists with containment cooldown following a Loss-of-Offsite Power during the period from hot shutdown to cold shutdown.

9A.5.6.7 Instrumentation and Control

CCS provides the instrumentation to control and monitor system operation remotely from the MCR. The following elements are monitored:

- Temperature elements are provided at the fan discharge to monitor on-line performance of CCS and control CWE flow using CWE temperature control valve to maintain supply air temperature constant.
- Pressure transmitters are installed on supply air ducts to monitor for variation in supply air flow that could be due to AHU fan failure, accumulation of solids in filters during an outage or other causes.
- Flow sensors are placed on the drain lines to measure any associated leak rates inside containment during normal operations.
- Temporary flow indicators can be used during system testing and flow balancing.

9A.5.6.8 Monitoring, Inspection, Testing, and Maintenance

The equipment and components of the CCS are designed for inspection and maintenance accessibility. Pick points for heavy equipment are provided.

Components which may require periodic replacement and/or maintenance prior to the end of plant life include dampers, damper actuators and linkages, cooling coils, instruments, bearings, and motors. Fans, motors, coils, filter section, and dampers and damper actuators can be removed for maintenance and repair. The cooling coils can be accessed for cleaning. Only water can be used for cleaning. No compressed air is allowed. There is no need for duct cleaning because no outside air is introduced during operation.

To minimise maintenance (e.g., changing/adjusting belts) and contribute to ALARP goals, the CCS fans are equipped with a quick disconnect on the motor leads and a motor terminal junction box. The fans are provided with full manual control for testing and maintenance. Ductwork is arranged to facilitate AHU maintenance.

To allow testing and balancing, temporary flow indicators are introduced through ports in the CCS ductwork to take readings with temporary instrumentation. The holes are capped after the testing and balancing is completed.

AHUs are inspected and maintained according to the manufacturer’s requirements.

CCS piping is installed and inspected according to ASME B31.1. CCS ductwork is installed and inspected according to Sheet Metal and Air Conditioning Contractors National Association, Inc.

9A.5.6.9 Radiological Aspects

PSR Ch. 12 (Reference 9A-14) provides information pertaining to ALARP design measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.5.6.10 Performance and Safety Evaluation

The main components of the CCS system are classified as SC3 and Seismic Category 2, Seismic Interaction analysis is required to ensure that in the event CCS SSCs, fail during a seismic event there are no adverse interactions with the ability of any Seismic Category 1A or 1B SSC to accomplish their function.

The CCS is designed with N+1 redundancy for asset protection. In the event of one train failure or shut down for maintenance, the train in standby automatically starts and maintains full operation of the system to protect the EQ equipment inside the SCCV.

9A.6 Fire Protection Systems

Introduction

This section provides information on the BWRX-300 Fire Protection System (FPS) design (006N7785, “BWRX-300 Fire Protection System” (Reference 9A-54)). It also confirms that the design meets the IAEA expectations for fire protection system design. The FPS is part of the Fire Protection Program (FPP) which provides assurance through Defence-in-Depth (D-in-D), that the plant can achieve and maintain a safe shutdown condition in the event of a fire, and that radioactive releases to the environment in the event of a fire are limited. The FPS is described in this section, including the fire detection and fire suppression systems, in accordance with applicable codes and standards.

This section also defines the functions and attributes that the FPS subsystems need to accomplish to meet the intended purpose, consistent with the structure and guidance presented in IAEA SSG-61.

The FPS provides detection, suppression, and notification of smoke and fire incidents within the power block of the BWRX-300. The FPS, in conjunction with the operational plant FPP, works to ensure plant safety and asset protection.

This document addresses the requirements of IAEA SSR-2/1, Safety of Nuclear Power Plants: Design (Reference 9A-4).

This section provides criteria pertaining to the safe design of the BWRX-300. Aspects of the BWRX-300 design are considered, and multiple levels of defence are promoted in design considerations.

Fire Protection Program General Information

The primary objectives of a FPP are to minimise both the probability of occurrence and the consequences of fire. The FPP consists of the integrated effort involving components, procedures, analyses, and personnel used in defining and performing activities of fire protection. It includes system and facility design, administrative controls, fire protection organisation, inspection and maintenance, training and qualification, quality assurance, and testing. The operational FPP will include the concepts of design and layout implemented to prevent or mitigate fires, administrative controls and procedures, and the training of personnel to combat fires.

9A.6.1 System and Equipment Functions

The FPS performs the following functions during normal and off-normal conditions.

Normal Functions (Non-Safety Category)

The FPS performs the following functions during normal and off-normal conditions:

- Fire detection by fire area or fire zone and actuate alarms
- Automatic and manual fire suppression systems
- Firewater supply and distribution of firewater to all suppression systems
- Fire extinguishers for manual suppression

9A.6.2 Safety Design Bases

The FPS is in DL4b and is primarily a SCN system; the portions of the FPS used for FLEX water supply are SC3.

Automatic fire suppression systems: The automatic fire suppression systems are Seismic Category NS (not seismically qualified) except specifically as follows: Seismic Category 2 automatic fire suppression systems are provided in the following areas: seismically qualified access or egress routes; seismically qualified instrumentation rooms; other areas identified in the seismic design basis; and over other seismically qualified SSCs.

Standpipes are Seismic Category NS (not seismically qualified) except specifically as follows: Seismic Category 2 standpipe systems are provided in the following areas: seismically qualified access or egress routes; seismically qualified instrumentation rooms; other areas identified in the seismic design basis; and over other seismically qualified SSCs.

Fire extinguishers are Seismic Category NS (not seismically qualified) except specifically as follows: Fire extinguishers in the following areas are Seismic Category 2 qualified: the secondary control room; seismically qualified access or egress routes; seismically qualified instrumentation rooms; and other areas identified in the seismic design basis.

Fire alarm systems are Seismic Category NS (not seismically qualified) except specifically as follows: Seismic Category 2 fire alarm systems are provided in the following areas: the control room complex; the secondary control room; seismically qualified access or egress routes; seismically qualified instrumentation rooms; the containment structure; other areas identified in the seismic design basis; and over other seismically qualified SSCs.

FHA and Defence-in-Depth

The “BWRX-300 Fire Hazard Assessment Requirements Document – 006N6567” (FHA, Reference 9A-55) provides the minimum fire protection requirements for the design, construction, commissioning, operation, and decommissioning of nuclear power plants, including structures, systems, and components (SSCs) that directly support the plant and the protected area. The FHA is a living document that informs the design process and construction. The document should be reviewed and updated to include any changes occurring during construction and changes occurring during the life of the plant.

The fire protection goals for the plant are to:

- Minimise the risk of radiological releases to the public that are a result of fire.
- Protect plant occupants from death or injury due to fire.
- Minimise economic loss resulting from fire damage to structures, equipment and inventories.
- Minimise the impact of radioactive and hazardous materials on the environment as a result of fire.

The D-in-D principle is used to achieve a high degree of fire protection by providing redundancy, diversity, and a balance in fire protection measures. The elements of the defence in depth principle for the facility design and Fire Hazard Assessment are as follows:

- Prevent Fires - Design measures will be put in place to reduce or eliminate, where practical, combustible materials and ignition sources.
- Fire Detection and Suppression - Means will be provided to quickly detect and extinguish or control fires.
- Limit the Effects of Fire - Fire separations or other measures will be provided to limit the spread of fire and its effects thus minimizing the impact on the plant and its occupants.

A Fire Safe Shutdown Analysis (FSSA) (006N7487 “BWRX-300 Fire Safe Shutdown Requirements and Analysis Report,” Reference 9A-56) established and evaluated distinct fire areas for the RB, RWB, TB, CB, Plant Services Area (PLSA) and Fire Pump Enclosure for the BWRX-300 plant. This assessment will need to be reperformed for a United Kingdom (UK) plant, taking into account any changes in site and/or building layouts. This is captured as a post-GDA FAP item, see Appendix B.

FPS Codes and Standards

FPS Codes and Standards are listed in 006N3441 “BWRX-300 Applicable Codes, Standards, and Regulations List” (Reference 9A-57). The key applicable BWRX-300 Fire Protection (FP) design codes and standards are provided in Table 9A-23.

9A.6.3 Description

Fire detection and fire suppression systems are provided and designed to quickly detect and extinguish or control fires. Fire separation or other measures are provided to limit the spread of fire and its effect.

Total reliance on a single fire suppression method is not used. At least two fire suppression methods are available to suppress a fire in each fire area.

The plant design provides the following types of suppression methods and utilises them in suitable combination for the fire hazard considered:

- Automatic wet-pipe sprinkler system.
- Automatic preaction sprinkler system.
- Automatic dry-pipe sprinkler system.
- Automatic deluge sprinkler or spray system.
- Standpipe and hose stations.
- Portable fire extinguishers.

The plant is protected with the following water-based automatic suppression systems:

- Wet pipe
- Dry pipe
- Preaction
- Deluge

Each sprinkler system consists of an integrated network of piping designed in accordance with fire protection engineering standards and includes a water supply source, a control valve, a waterflow alarm, and a drain.

A Main Fire Alarm Panel (MFAP) located in the MCR, monitors, and receives system actuation, supervisory, and trouble alarm signals from the individual local panels.

Figure 9A-19, presented in Section 9A.6.6, is a simplified single line diagram for the FPS. The FPS includes the following equipment:

- Fire Pumps
- Firewater Supply Piping, Yard Piping, Valves, Sprinklers, and Yard Hydrants
- Fire hydrants
- Manual Suppression Means
- Standpipe and Hose Systems
- Fixed Automatic Fire Suppression Systems
- Wet Pipe Sprinkler Systems
- Preaction Sprinkler Systems
- Deluge Systems

- Water Spray Systems for Charcoal Filters
- Fire Extinguishers
- Fire Detection and Alarm System
- Fire Barriers
- Building Ventilation

Section 9A.6.6 discusses the FPS and equipment operation.

9A.6.4 Materials

Design measures will be put in place to reduce or eliminate, where practical, combustible materials and ignition sources. Non-combustible or limited combustible materials will be used to the extent practical.

Building compartmentalisation is achieved by using passive fire barriers to subdivide the plant into separate areas. The walls, floors, and ceilings have fire resistance ratings of three hours where required based on high combustible loadings in the room (e.g., lubrication oil tank). This also includes fire doors, dampers, and penetration seals. The Fire Hazards Analysis defines the locations of fire areas and fire barriers. Fire areas can be sub-divided into fire zones. A room data sheet is developed for each room in the Power Block identifying information, such as the room number, associated fire area, fire barriers, room contents, fire detection, fire suppression and fire impact (with and without fire protection systems).

Areas or rooms used for the storage or handling of combustible materials or ignitable liquids and solids or gasses will be separated from the remainder of the building by separation having a minimum two-hour resistance rating.

Thermal insulation materials, radiation shielding materials, ventilation duct materials, soundproofing materials, and suspended ceilings, including light diffusers and their supports, will be non-combustible or have limited combustibility.

As a minimum, combustible cable insulation and jacketing material meets the fire and flame test requirements of IEEE 1202, Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies.

FPS detector types are selected on the basis of the nature and burning characteristics of the materials within the room.

9A.6.5 Interfaces with Other Equipment or Systems

Fire Protection interfaces are listed in Table 9A-24.

9A.6.6 System and Equipment Operation

Figure 9A-19 shows the FPS simplified system diagram for the BWRX-300 Standard Plant facilities.

The FPS system is put in service and remains fully functional during all modes (Mode 1, 2, 3, 4, 5, and 6) of plant operation.

FPS systems will be tested and commissioned in accordance with the relevant codes, standards and regulations, see Section 9A.6.2. Upon successful completion of initial testing and commissioning, the systems are put in service.

During normal operations, the FPS systems are in service and in ready conditions. The fire suppression systems are in service and pressurised. The fire alarm systems are monitoring all signalling devices and notification appliances are in service.

In the case of LOPP, fire alarm and releasing panels are maintained by internal battery backup power. All fire alarm panels, to include all subpanels, have batteries capable of providing supervisory functions for not less than 24 hours and 120 minutes of emergency power under full load. All deluge and preaction releasing panels have batteries capable of providing supervisory functions for not less than 24 hours and 120 minutes of emergency power under full load.

In the case of LOPP, fire suppression water supply is maintained in service by standby diesel generator power provided to firewater supply components.

Whenever the FPS is out of service it is considered impaired and requires compensatory measures to be provided in an impairment plan.

9A.6.7 Instrumentation and Control

The fire alarm system and voice communications system is an integrated, supervised, one-way voice communication fire alarm system consisting of fire and smoke detection; fire alarm signal initiation, transmission, notification, and annunciation. This system is designed to prevent, contain, and mitigate the effects of fires to protect personnel, the public, and the plant investment.

The MFAP in the MCR provides the following SCN signals to I&C via a single set of hard contacts:

- Fire Alarm Signal - Alarm
- Fire Alarm Signal - Supervisory
- Fire Alarm Signal – Trouble

Each and every signal recorded on the MFAP is sent to the I&C Historian controller. These signals are transmitted from the MFAP to the I&C Historian via a two redundant ethernet connections.

The Central Alarm and Control Facility is considered to be the MCR in the CB.

The fire alarm system is capable of transferring control from the MCR display and control centre to the SCR display and control centre. The transfer of control is initiated manually from the MCR and incorporated into emergency operating procedures.

The fire alarm system provides a two-stage operation, as follows:

- First stage — an alert signal
- Second stage — an alarm signal

The alert signal is directed to MCR staff and remains silent throughout the balance of the building to suit the requirements of the plant's emergency notification procedures.

On receipt of an alert signal, MCR staff has the capability to immediately provide a voice announcement over the fire alarm system, throughout the protected area and external areas of the BWRX-300 plant with the exception of the main and secondary control rooms.

The alarm signal is activated automatically in the event that MCR staff do not acknowledge the signal within 5 minutes of initial fire alarm system activation. There is no delay in the ability to override the alarm signal and operate the voice communication system.

The MFAP is located in the MCR in the CB. The Secondary Fire Alarm Panel is located in the SCR in the RB. A third Fire Alarm Panel is located in the TB to facilitate testing, maintenance and use by providing an additional panel outside the MCR and SCR.

All Fire Alarm Panels are networked together such that any signal from any area is displayed on each panel, which facilitates efficient operator use.

The MFAP and Secondary Control Panel provide a remote manual actuation capability for the firewater pumps, where installed. Firewater pumps can only be stopped manually from the fire pump controller located inside the fire pump enclosure.

Each preaction and deluge suppression system has a control panel listed for releasing service. If these panels are separate from the MFAP they are monitored by the MFAP.

Fire detectors are installed throughout except as specifically excluded by the FHA. The following types of detectors are utilised:

- Area smoke detectors
- Preaction suppression system smoke detectors
- Area heat detectors
- Very early smoke detection technology
- Line-type heat detection for exterior deluge suppression systems (transformers)
- Duct smoke detectors
- Beam smoke detectors

Duct smoke detectors trigger a supervisory signal at the fire alarm panels.

Smoke detection in ventilation systems is provided to meet NFPA 90A/92 requirements and trigger various HVS actions in ventilation systems.

Area smoke detection triggers various HVS smoke removal and stair pressurisation systems as determined by the HVAC system.

Duct smoke detection is provided in the outside air intake(s) for the MCR ventilation system to enable manual isolation of the control room ventilation system and, thus, prevent smoke from entering the control room.

Smoke detection for elevator equipment located in elevator shafts and lobbies is provided to signal the cranes/hoists/elevators system in order to trigger various elevator recall functions.

Very early air sampling smoke detection systems are installed in the control room complex.

9A.6.8 Monitoring, Inspection, Testing, and Maintenance

Initial Inspections and Testing

Upon installation, all new fire protection systems are preoperationally inspected and tested in accordance with national regulations, ASME B31.1 and applicable National Fire Protection Association (NFPA) standards. Initial testing contained in the following NFPA documents are performed as a minimum as part of the inspection and maintenance requirements for the systems:

- Automatic fire suppression systems are initially tested in accordance with NFPA 13
- Manual Suppression Systems - Standpipes are initially tested in accordance with NFPA 14
- Underground water service mains are initially tested in accordance with NFPA 24
- Fire detection and alarm systems are tested in accordance with NFPA 72
- Fire extinguishers are tested in accordance with NFPA 10

Ongoing Inspections and Testing

Testing contained in applicable national regulations and the following NFPA documents is performed as a minimum as part of the inspection and maintenance requirements for the systems:

- Ongoing inspections and testing for Automatic Fire Suppression Systems are in accordance with NFPA 25
- Ongoing inspections and testing for Manual Suppression Systems - Standpipes are in accordance with NFPA 25
- Ongoing inspections and testing for underground water service mains are in accordance with NFPA 25
- Ongoing inspections and testing for fire detection and alarm systems are tested in accordance with NFPA 72
- Ongoing inspections and testing for fire extinguishers are tested in accordance with NFPA 10

M**aintenance**

The equipment and components of the FPS are designed for easy inspection and maintenance during plant operation, to allow as much inspection/maintenance as possible without shutdown.

System and equipment manuals are supplied that provide instructions and procedures for installation, operation and maintenance, and include identification of recommended tools and spare parts.

Post-Maintenance Testing

Testing contained in applicable national regulations and the following NFPA documents is performed as a minimum as part of the post-maintenance requirements for the systems:

- Automatic Fire Suppression Systems are tested in accordance with NFPA 25
- Manual Suppression Systems - Standpipes are tested in accordance with NFPA 25
- Underground water services mains are tested in accordance with NFPA 25
- Fire detection and alarm systems are tested in accordance with NFPA 72
- Fire extinguishers are tested in accordance with NFPA 10

Post-Modification Testing

Testing contained in applicable national regulations and the following NFPA documents is performed as a minimum as part of the post-modification requirements for the systems:

- Automatic Fire Suppression Systems are tested in accordance with NFPA 25
- Manual Suppression Systems - Standpipes are tested in accordance with NFPA 25
- Underground water services mains are tested in accordance with NFPA 25
- Fire detection and alarm systems are tested in accordance with NFPA 72
- Fire extinguishers are tested in accordance with NFPA 10

9A.6.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.6.10 Performance and Safety Evaluation

The FHA and FSSA are companion documents in demonstrating fire safety adequacy of the BWRX-300 plant design. These two fire safety assessments document a systematic review of the fire hazards for BWRX-300 and the potential consequences of design basis fire events. These documents also identify the fire safety measures provided to meet the fire safety objectives. The FHA and FSSA reports are complemented by a UK-specific conventional fire safety assessment of Power Block building layouts with respect to UK conventional fire safety Relevant Good Practice (RGP).

The FHA and FSSA are both subject to further development in support of future licensing stages. This is discussed further in NEDC-34185P “PSR Ch. 15.7 Deterministic Safety Analyses – Analysis of Internal Hazards” (Reference 9A-58).

Fire Safe Shutdown Analysis

The FSSA report (Reference 9A-56) describes the impacts of a fire on the safe shutdown systems, based on the design maintaining the fire barrier between the three divisions for both mechanical and electrical components.

The BWRX-300 FSSA employs the fire containment approach and assumes fire areas are completely unavailable for safe shutdown. The containment and MCR will require assessment crediting alternate shutdown.

The BWRX-300 has three independent divisions of safety class safe shutdown equipment, separated by fire barriers, and therefore, does not require an analysis for alternate shutdown capability for postulated fires outside the control room and containment. The defence-in-depth principle is used to achieve a high degree of fire protection by providing redundancy, diversity, and balance in fire protection measures.

The conceptual BWRX-300 FSSA report will require future updates to address additional design detail, uncertainties in the plant design, and to include additional fire safe shutdown tasks that are currently addressed only qualitatively, or which are not included in initial revisions of the BWRX-300 FSSA report. Additional details such as fire overlay drawings reflecting room number and fire area numbers and safe shutdown cable routing layouts will be provided as design progresses.

The results of the conceptual FSSA deterministic study show that the BWRX-300 plant is inherently safe with respect to internal fire events. This is due in large part to the passive safety features of the BWRX-300 plant design.

A future Safe Shutdown Circuit Analysis will provide a documented review of the safety class shutdown circuits in each fire area to confirm that the shutdown capability is not impacted by a fire in any single fire area. The Safe Shutdown Circuit Analysis will also consider the potential for hot shorts and spurious actuations and identify those safe shutdown circuits that would require fire wrapping to maintain divisional separation.

Fire Hazard Assessment

The FHA document (Reference 9A-55) describes the fire hazard analysis for the BWRX-300. The FHA reviews the applicable codes and standards, defines necessary acceptance criteria, informs the fire protection design, and reviews the preliminary design of other systems as related to the FHA and confirms suitability. The FHA document is currently preliminary and does not include all the analysis that is necessary for a complete fire hazard assessment. The document will be developed in future as necessary to support site-specific deployments.

The FHA document identifies applicable codes and standards for the fire hazard assessment. In addition, the FHA reviews the prescriptive and performance-based requirements of the applicable codes and standards. Expansion to this document will provide further analysis based on the progression of the design and analyse the fire protection system design against the design criteria. Information directly related to the fire protection system is found in the FPS SDD 006N7785 (Reference 9A-54).

Life safety egress conceptual assessments as well as occupancy classification and travel distance content are provided under building analyses documentation, which are listed in section 4 of the FHA.

UK-Specific Fire Safety Assessments

Specific conventional fire safety assessments of the Power Block buildings have been performed in accordance with UK-specific RGP. This work is summarised within PSR Ch. 24 Conventional Safety and Fire Safety Summary (Reference 9A-59).

The UK-specific conventional fire safety assessment performed the following activities:

- Identified UK regulatory expectations for the required conventional fire safety assessments
- Defined a method that could be used to identify the departures between UK regulatory expectations and what design information was currently available
- Defined a method for assessing the identified departures and determining how these may be addressed, which may include the need to perform further work
- Applied the methods for identifying and assessing departures with respect to UK regulatory expectations to Power Block buildings

Potential departures from UK RGP were identified, for which preliminary optioneering of potential solutions was performed.

It was noted that any future fire safety departure resolution would need to consider risks holistically, trading-off different technical discipline requirements, considering existing design requirements and considering all departures collectively to develop an optimised solution. It was considered that the preliminary optioneering work, performed as part of the workshops, would support such future optioneering studies.

Notwithstanding the departures identified, it was considered that the conventional fire safety risks were low, and that the conventional fire safety measures already incorporated within the BWRX-300 plant design often went beyond what was required by UK RGP.

9A.7 Supporting Systems for Diesel Generators

The description below of the BWRX-300 supporting systems for the SDGs aligns with 006N5115 “BWRX-300 Plant Electrical Systems Architecture Requirements and Design” (Reference 9A-60). The BWRX-300 contains two skid mounted SDGs. These diesel generators provide SC3 electrical power directly supporting DL2 functions. The SDGs backup the SC3 busses which directly power SC1 and SC2 equipment used for DL3 and DL4a functions. Ideally, the SDGs power SC1, SC2, and SC3 loads in the same manner (by providing backup power to the A21 and B21 SC3 busses). Further details are provided in PSR Ch. 8.

The sub systems supporting the SDGs include:

- Diesel Fuel Oil Storage and Transfer System
- Standby Diesel Generator Cooling Water System
- Standby Diesel Generator Starting System
- Standby Diesel Generator Lubrication System
- Standby Diesel Generator Combustion Air Intake and Exhaust System

Except for the Diesel Fuel Oil Storage and Transfer System, these subsystems are provided with the engine skid and do not require auxiliary plant system connections.

The SC3 standby diesel generators are electric start and radiator cooled and do not require plant mechanical support services for operation (such as plant auxiliary cooling or instrument air).

9A.7.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

The Fuel Oil Storage and Transfer System provides bulk fuel oil storage and distribution to the day tanks.

Normal Functions (Safety Category)

The system does not perform any Safety Category functions during normal conditions.

Off-Normal Functions (Non-Safety Category)

The system does not perform any Non-Safety Category functions during off-normal conditions.

Off-Normal Functions (Safety Category)

During a LOPP, fuel oil is transferred from the bulk storage tank to the standby diesel day tanks.

9A.7.2 Safety Design Bases

The SDGs are SC3.

9A.7.3 Description

Diesel Fuel Oil Storage and Transfer System

The Diesel Fuel Oil Storage and Transfer System provides storage and transfer of diesel fuel oil to the day tanks of the SDGs. This subsystem is comprised of one (1) Diesel Fuel Oil Storage Tank, two (2) fully redundant Diesel Fuel Oil Transfer Pumps, and associated piping, valves, and instrumentation. The fuel oil transfer pumps are powered from the Standby Power System to ensure diesel availability. To prevent high viscosity of the fuel, the Fuel Oil Storage Tank is equipped with an immersion heater and a recirculation line from the transfer pumps. A piping tie-in is provided to the Diesel Fuel Oil Storage Tank for EME connections.

The Diesel Fuel Oil Storage Tank is double-walled or provided with a containment berm capable of holding the contents of the tank if a leak develops. The offloading area is bermed to catch the contents of the transport truck if leakage occurs. The bermed area(s) contain(s) a sump pit which can be pumped out following sampling. Provisions are made for sampling of the bermed area(s) for residual oil. The pumps transfer fuel oil underground from the Diesel Fuel Oil Storage Tank to the SDG day tanks located in the diesel generator rooms.

The Diesel Fuel Oil underground piping is constructed using a double wall arrangement, with the ability to detect any leakage from the primary pressure boundary piping.

The Diesel Fuel Oil Transfer Pumps distribute diesel fuel oil from the Diesel Fuel Oil Storage Tank to the SDG day tanks and provides recirculation as appropriate.

Figure 9A-20 provides a simplified schematic of the SDG Fuel Oil Storage and Transfer System.

The Fuel Oil Storage Tank and Transfer Pumps are located outside of the protected area. This allows fuel deliveries without needing to enter the protected area. Additionally, this increases the distance between a potential external combustible source and the plant.

Standby Diesel Generator Cooling Water System

The SDGs are radiator cooled and do not require additional mechanical support for cooling such as an auxiliary cooling water system.

Standby Diesel Generator Starting System

The SDGs are electric start and do not require additional mechanical support for starting such as an air system. SDG starting time is not material to it performing its safety category functions.

The SDGs may be started from the MCR, SCR or a local panel.

Dedicated batteries, mounted inside, are Lead Acid batteries.

Standby Diesel Generator Lubrication System

Each of the SDGs is equipped with a dedicated lubrication system. This system is self-contained on the engine skid-mounted package with no plant auxiliary connections required. All lubricating and fuel handling pumps are API pumps with double seals.

Standby Diesel Generator Combustion Air Intake and Exhaust System

Each of the SDGs is equipped with its own air intake system. Air is supplied from intakes located outside the building containing the SDGs.

The SDG rooms have separate exhausts for radiator heat removal and combustion air removal. The exhaust for combustion air is routed to a safe discharge location.

The exhaust system design is capable to meet occupational requirements for personnel hearing, emissions, and pollution. Refer to 9A.7.11 for additional information on emissions.

9A.7.4 Materials

Materials for the SDGs and fuel system are purchased in accordance with the requirements of SC3.

9A.7.5 Interfaces with Other Equipment or Systems

The SDGs are package skid mounted systems requiring limited interface with other equipment or systems. The SDGs interfaces with plant protective relaying and the DCIS for protection, control, and instrumentation.

The fuel system interfaces with the plant DCIS for control and monitoring.

9A.7.6 System and Equipment Operation

The SDGs are capable of being manually started and aligned to their respective busses via a local control panel or remotely from the Main and (Secondary) control room. During a loss-of-offsite power, the SDGs automatically start and load on their respective bus via the automatic load sequencer.

Once started, the SDGs operate without requiring any plant services other than those required to store and transfer fuel, with the capability of continuous operation for at least one week at rated power without any off-site resources. Diesel fuel oil is supplied by a delivery system from a 7-day storage tank that is monitored periodically to ensure sufficient fuel oil is available. A supply of lubricating oil is available for the SDGs operating for 7-day operation.

9A.7.7 Instrumentation and Control

Sufficient instrumentation and controls are available locally to start and operate the SDGs.

Additionally, control and instrumentation interfaces are provided to the DCIS such that remote control and monitoring from the Main and (Secondary) Control Room is possible.

Indication and alarms for the fuel supply levels in the fuel storage and day tanks are provided.

9A.7.8 Monitoring, Inspection, Testing, and Maintenance

Monitoring, Inspection, Testing, and Maintenance activities are provided to ensure that the SC3 SDGs and fuel system can perform their intended support functions.

The SDGs are also redundant and normally in standby. Any required maintenance can be done online. Specific circumstances of standby diesel generator maintenance are dictated by plant technical specifications and controlled by plant procedures.

9A.7.9 Radiological Aspects

There are no radiological aspects to this system.

9A.7.10 Performance and Safety Evaluation

The SDGs are sized to carry 100% of the required load following an SBO with sufficient fuel to carry the required load for 7 days.

9A.7.11 Diesel Engine Emissions

The exhaust emissions from the SDGs cannot be quantified at this time. Further discussion on combustion emissions and permitting requirements is provided in the Preliminary Environmental Report, Ch. E10: Other Environmental Regulations (Reference 9A-61).

9A.8 Overhead Lifting Equipment (Cranes, Hoists, and Elevators)

The description below of the BWRX-300 Cranes, Hoists, and Elevators (CHE) aligns with the SDD 006N8264, “BWRX-300 Cranes, Hoists and Elevators” (Reference 9A-62). CHE are located throughout the plant and provide the means to lift and lower equipment and materials and move them horizontally along safe load paths. The principal equipment is the Reactor Building Polar Crane, Turbine Building Overhead Bridge Crane and various hoists and monorails. Table 9A-25 identifies the CHE Components.

The Reactor Building Polar Crane is designed to lift heavy loads. A heavy load is defined as a load whose weight is greater than the combined weight of a fuel assembly and the associated handling device. Refer to PSR Ch. 3 [Attachment 1], Section 3.4.4 for additional information pertaining to heavy loads.

The CHE provide a safe and effective means for transporting loads including the handling of new and spent fuel, plant equipment, service tools and spent fuel transfer casks and canisters. Safe handling includes design considerations for maintaining occupational radiation exposure as low as practicable during transportation and handling.

9A.8.1 System and Equipment Functions

The system and equipment functions associated with the lifting of loads includes the following:

Normal Functions (Non-Safety Category)

The CHE system continuously operates during all modes of normal power plant operation, including startup and shutdown, controlling the movement of lifted loads throughout the plant.

The CHE system carries out the following functions:

- Lifting and lowering a load and moving it horizontally, with the hoisting mechanism being an integral part of the system.
- Load handling system includes rigging components such as slings, shackles, and eyebolts which connect a load to a lifting device and any lift fixture.
    - The CHE system also includes building elevators for passenger and freight movement.

Normal Functions (Safety Category)

The system does not perform any Safety Category functions during normal conditions.

Off-Normal Functions (Non-Safety Category)

The CHE equipment is capable of operation during all modes of off-normal power plant operation.

Off-Normal Functions (Safety Category)

The system does not perform any Safety Category functions during off-normal conditions.

The design of the CHE meets IAEA requirements specified in IAEA SSR-2/1 Requirement 76 (Reference 9A-4) as related to lifting and handling of large and heavy loads and ensuring design margin exists as well as interlocks to accommodate lifting of loads. Information pertaining to the impact of hard objects upon SSCs is presented in PSR Ch. 3, Section 3.4.4.

9A.8.2 Safety Design Bases

The CHE system is classified as SCN. The Reactor Building Polar Crane is designed, fabricated, erected, and tested to appropriate quality standards such that its failure does not impact the function of other Safety Category function systems.

The Reactor Building Polar Crane is designed to support a critical load (a load that can be a direct or indirect cause of release of radioactivity) following the credible failure of a single component used in normal operation and during a safe shutdown earthquake.

To the extent practicable, heavy loads are not carried over or near safety classified components, including irradiated fuel and safe shutdown components. Safe load paths are designated for heavy load handling.

9A.8.3 Description

A description of the CHE system is provided below. Location, safety class and seismic category for system components are summarised in Table 9A-25.

9A.8.3.1 Reactor Building Lifting Devices

Reactor Building Polar Crane

The Reactor Building Polar Crane is designed according to ASME NOG-1-2020 (Reference 9A-63) for a Type I single failure proof crane. Redundancy and other features ensure that the failure of a single component in the load path does not result in the loss of capability to stop and hold the critical load.

The Reactor Building Polar Crane is composed of an overhead bridge of two deep girders supporting a trolley with a main and auxiliary hook. This rail supports the two girders allowing the crane bridge 360 degrees of rotation. The bridge structure spans the full width of the refueling floor. The crane is classified as Seismic Category 2. Design for both the main and auxiliary hoists is in accordance with ASME NOG-1-2020 which provides a high degree of reliability and safety. Redundancy and other features ensure that the failure of a single component in the load path does not result in the loss of capability to stop and hold a critical load. The principal heavy loads handled by this crane consist of the components associated with reactor vessel refueling, including the reactor head; reactor vessel internals including dryer/separators; fuel assemblies (associated with new fuel receipt), and various containment support components.

During spent fuel handling activities, the cranes maximum load is the combination of the spent fuel cask, transfer cask, and lifting yoke, which weighs less than the cranes overall capacity.

Weight of the spent fuel cask is dependent upon the selected manufacturer. The crane will have access to a truck bay for fuel transfer to spent fuel shipping and/or transfer casks, new fuel assemblies, and replacement components.

Jib Crane

A jib crane is located in the truck bay near the equipment hatch. The jib crane performs rigging services for replacement of components, materials, and supplies to and from the truck bay to the lower levels of the RB.

Load Handling

Overhead pad eyes and rigging beams are located inside containment.

These components are used to manipulate the piping, valves, and equipment at the top of the reactor vessel in the primary containment during outage maintenance activities.

Monorails

In support of maintenance activities, monorails are provided in various locations throughout the plant. The monorails are situated over battery racks, valves, pumps, motors, heat exchangers, and other components as required, to facilitate component maintenance and replacement.

Elevator

A service elevator is provided.

9A.8.3.2 Turbine Building Lifting Devices

Turbine Building Overhead Bridge Crane

The TB Overhead Bridge Crane spans the operating deck above the generator, High Pressure Turbine, Low Pressure Turbines and Condenser. The bridge structure consists of steel girders supporting a trolley with a main hoist and auxiliary hoist. The principal heavy loads handled by this crane consist of components of the turbine-generator system. The heaviest component being the Low Pressure Turbine bladed rotor.

Vertical and horizontal hook travel limits are based on Turbine-Generator equipment requirements as well as the other components located on the operating deck.

Turbine Building Jib Crane

The TB Jib Crane is located at the north end of the operating floor. The TB Jib Crane performs lifts from ground level to the operating deck for maintenance and operation activities such as transport of inspection materials, toolboxes, and other components.

Monorails

Overhead monorails are located above each Diesel Generator and above the circulating water piping elbows directly east of the condenser. The monorails are used for engine maintenance activities.

A monorail system located above battery racks for battery handling during maintenance activities is provided.

Hot Machine Shop Overhead Bridge Crane

An overhead bridge crane is provided in the hot machine shop for maintenance support services.

Elevator

A service elevator is provided.

9A.8.3.3 Radwaste Building Lifting Devices

Tank Filter Monorail

A Tank Filter Monorail hoist is located above concrete hatches adjacent to the concrete tank wall on elevation 13m of the RWB. The Tank Filter Monorail hoist is used to lift concrete hatches above the condensate pre-filter tanks.

Elevator

A service elevator is provided.

9A.8.3.4 Control Building Lifting Devices

Battery room monorails in the CB are provided for battery handling during maintenance activities.

9A.8.3.5 Power Block Pre-Qualified Lift Points

Existing steel or concrete structures throughout the plant have pre-qualified lift points for maintenance activities. The rated load for each lift point is appropriately tagged or stencilled to the building concrete or steel member. Rigging attached to lift points allow for equipment to be moved for repair and/or replacement maintenance activities.

9A.8.3.6 Component Description

This subsection describes CHE components.

Hook

The hook is a device for grabbing and lifting loads by means of a device such as a hoist or crane.

A lifting hook is typically equipped with a safety latch to prevent the disengagement of the lifting wire rope sling, chain or rope to which the load is attached.

The hook is designed to withstand stress imposed under normal operating conditions while handling loads within the rated load. The minimum hook design factor conforms to those specified for the equipment or system in which the hook is a component.

Monorails

Monorails are used for lifting and lowering a load and moving the load horizontally, suspended from a single track. The combined load on all hoists on the monorail do not exceed the rated load of the monorail.

Hoist

A hoist is a suspended machinery unit that is used for lifting or lowering a freely suspended (unguided) load. The hoist and appurtenances are designed to withstand the stresses imposed under normal operating conditions while handling loads within the rated load. Hoists may be hand chain or electric chain operated.

Below-the-Hook Lifting Devices

A below-the-hook lifting device is used for attaching loads to a hoist. The device contains components such as slings, hooks, and rigging hardware. The design of below-the-hook-lifting devices are in accordance with ASME BTH-1 (Reference 9A-64).

9A.8.3.7 Materials

Cranes are fabricated using materials that are designed to meet operating stress limits plus margin. The CHE System equipment and associated structural components are designed to meet the 60-year plant life, with appropriate provisions for maintenance and replacement.

9A.8.3.8 Interfaces with Other Equipment or Systems

Refer to Table 9A-26 for Cranes, Hoists, and Elevators interfaces with other equipment or systems.

9A.8.3.9 System and Equipment Operation

Normal Operations

Crane operators are trained, qualified, and cognizant of the load handling equipment interlocks and protective devices. Interlocks and protective devices are not overridden or bypassed unless authorised by an approved Work Order. Elevators that serve floor elevations above the first floor that are equipped with an automatic emergency recall feature are equipped with smoke detectors installed in the elevator lobbies on the recall level. In-car emergency switches are provided for in all elevator cars.

Off-Normal Operations

Load handling systems are operational unless scheduled for a maintenance.

9A.8.3.10 Instrumentation and Control

Instrumentation

The following information does not pertain to manual or portable hoists in the CHE system.

The Reactor Building Polar Crane and Turbine Building Overhead Crane control circuits are arranged so that tripping of an overload relay or limit switch defeats the permissive to all crane controllers. Overload relay or limit switch operation does not interrupt lighting circuits.

The avoidance of two-blocking for the RB Polar Crane is accomplished using single-failure-proof features and does not rely on any action by the operator. The normal hoist limit switch is supplemented by an independent final hoist limit switch operated by the load block to remove power from the hoist motor and brakes.

The prescribed path for Reactor Building Polar Crane hook travel is enforced by limit switches for hook travel in both vertical and horizontal directions.

Control

The following information does not pertain to manual or portable hoists in the CHE system.

The Reactor Building Polar Crane and Turbine Building Overhead Cranes are controlled by a local master control panel on the crane bridge. Primary control of crane motions is directed from a cab located on the crane bridge and remote control with backup pendant control. The cab, remote and pendant controls provide for bridge, trolley, main hoist, hook rotation (cab and radio control only), and auxiliary hoist motions. Pendant controls are back up for cab/remote and are isolated during normal operation by a transfer switch on the pendant. Remote control utilises lever switch technology.

The Reactor Building Polar Crane electrical system is designed so it is possible for the operator to stop and hold a critical load regardless of the failure of any single component used in normal operation. The operator can stop all motors without a time delay using the emergency stop.

The Reactor Building Polar Crane control system uses a programmable logic controller, housed in a bridge control panel. The programmable logic controller is integral to a restricted zone scheme for the crane which is activated during critical lift evolutions such as movement of the spent fuel cask.

9A.8.3.11 Monitoring, Inspection, Testing, and Maintenance

Elevators are registered in compliance with Technical Standards and Safety Authority.

Surveillances of a load handling system are performed in accordance with plant load handling procedures. The surveillance is a visual check of the overall configuration of the load handling system. Inspections and tests of the load handling system is performed in accordance with Operations and Maintenance Manual requirements as well as load handling procedures.

A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive, and predictive maintenance and operating experience, is established to increase the probability that CHE structures, systems and components function in the required manner over the design life cycle. The program includes procedures which ensure that records are retained, and test and inspection discrepancies are documented and corrected. Any crane, hoist or monorail found in an unsafe operating condition is tagged out and removed from service until repaired. All repairs are made by qualified personnel in accordance with the manufacturers' instructions. Rigging hardware used for load handling systems is maintained in a similar fashion.

Maintenance activities for CHE load handling systems which are either preventive or the result of adverse conditions determined through an inspection program are corrected by adjustment, repair, or replacement of components before continuing the use of the system/component.

Operational testing is performed in accordance with plant procedures.

CHE load handling systems which are altered, repaired, and modified are required to be operationally tested for the functions affected by the alteration, repair, or modification, as determined by a qualified person. In addition, load testing of altered, repaired, and modified load handling systems, may be limited to the functions affected by the alteration, repair, or modification, as determined by a qualified person.

9A.8.3.12 Radiological Aspects

For purposes of meeting radiological protection principles, the Cranes, Hoists and Elevators include hoisting/transport mechanisms to handle parts and components in decontamination areas, in the contaminated storage areas and in the active workshops.

The Cranes, Hoists and Elevators use remotely operated electric hoists where possible for tasks/equipment associated with general area dose rates in excess of 1 mSv/hr.

Refer to PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) for information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP.

9A.8.3.13 Performance and Safety Evaluation

The Reactor Building Polar Crane is designed to be single failure proof to improve operational reliability. The RB Polar Crane electrical system is designed so that it is possible for the operator to stop and hold a critical load regardless of the failure of any single component used in normal operation.

In addition to being designed to meet single-failure-proof criteria, the Reactor Building Polar Crane is designed with a system of interlocks that prevent movement outside safe load paths which is intended to prevent deleterious impacts with SSCs. Physical limits and administrative controls are included to ensure safe handling of loads.

The design of the Reactor Building Polar Crane in conjunction with the designation of safe load paths ensures that the movement of heavy loads in the plant can be performed without affecting plant operations including safe shutdown and cooldown.

9A.8.4 Fuel Building Crane

The BWRX-300 does not have a Fuel Building and as such does not have a Fuel Building Crane. New fuel is received onsite and is brought into the RB through RB hatch. Spent fuel is removed from the Fuel Pool in a cask. Cask loading and transport activities involve use of the Reactor Building Polar Crane located inside of the RB. Refer to Subsections 9A.1.1, 9A.1.2, 9A.1.4, and 9A.8.1 for additional information pertaining to new and spent fuel handling operations.

9A.9 Miscellaneous Auxiliary Systems

9A.9.1 Communication Systems

The description below of the BWRX-300 Communication Systems aligns with the Architecture Requirements and Design document (Reference 9A-60). The Communications Systems provide effective intraplant communications and effective plant-to-offsite communications during normal operation, maintenance, transients, fire, security events, and accident conditions including LOPP.

The Communication Systems are designed to meet emergency plan requirements for DBA conditions, including notification of personnel and implementation of evacuation procedures. This capability includes communications support to both onsite and offsite emergency centers including regulatory agencies. This capability includes at least one onsite and one offsite communications system, each with a backup power source. PSR Ch. 19 presents more information on the Emergency Preparedness and Response program.

Site specific requirements determine the extent of communications subsystems required. The standard plant communications system consists of the following subsystems:

- Private Branch Exchange System.
- Plant Public Address System
- Sound-Powered Telephone System
- Plant Radio System
- Security Communication System

9A.9.1.1 System and Equipment Functions

System and equipment functions associated with the Communication Systems include the following:

Normal Functions (Non-Safety Category)

The Communication Systems provide intraplant and plant-to-offsite communications during normal operation.

Normal Functions (Safety Category)

The Communication Systems provide no Normal Safety Category functions.

Off-Normal Functions (Non-Safety Category)

The Communication Systems provide intraplant and plant-to-offsite communications during transients, fire, accidents, off-normal phenomena, and security-related events.

Off-Normal Functions (Safety Category)

The non-DCIS Communication System provides the following Safety Category 3 function of effective intra-plant and plant-to-offsite communications:

Support the coordination between plant personnel during accident or incident conditions, including transients, fire, security events, and accident conditions including LOPP events, under maximum potential noise levels.

9A.9.1.2 Safety Design Bases

The Communication Systems perform Safety Category 3 functions related to the private branch exchange system, the plant-wide paging system, a sound-powered telephone system which does not require external power, the plant radio system, and secure communication channels from the MCR and SCR to emergency support facilities and off-site emergency response organisations.

The Communication Systems provide diverse methods of communication within the plant and in the immediate vicinity as well as to offsite agencies. In addition, the Communication Systems are designed to provide secure communications channels to emergency support facilities and offsite response organisations.

9A.9.1.3 Description

The Communication Systems provide the means to conveniently and effectively communicate between various plant locations and with offsite locations during normal, maintenance, transient, fire, security events, and accident conditions including LOPP events. The design ensures that effective communication is not impeded by transmission through barriers, high-noise areas, personnel use of protective equipment, inadequate numbers of communications channels, interference between channels or subsystems, or interference from other electronic or electrical equipment.

The Communication Systems support Emergency Preparedness and Response requirements for accident conditions, including provisions in the MCR and SCR for communication with emergency support facilities and offsite emergency report organisations, each with a backup power source. Refer to PSR Ch. 19 for information related to Emergency Preparedness and Response.

The Communication Systems are designed to support the coordination between plant personnel during accident or incident conditions under maximum potential noise levels.

Component Descriptions

Private Branch Exchange System

The private branch exchange system is plant-wide wired telephone system. This system is capable of on-site communication with a connection to the public telephone system. Telephone terminals are located throughout the plant, including in the MCR and SCR. Power for this system is derived from the Preferred Power System with core portions of the system supported by battery backup.

Plant Public Address System

The public address system is a hard-wired system providing voice and plant-wide paging capability. The system is designed to reach all areas of the plant without any dead areas. Sound intensity levels meet standard requirements. Power for the system is derived from the Standby Power System (SDG backed power) with core portions of the system supported by 8-h battery backup.

Sound-Powered System

This is a separate telephone communication system using portable sound-power telephone units independent of the other systems is provided for normal and abnormal conditions. The sound powered phone system is located throughout the plant, including in the MCR and SCR and in areas where critical maintenance activities are expected. The sound-powered phone system does not require an external power source.

Plant Radio System

The plant radio system provides an independent means of normal and emergency communication from the private branch exchange system and plant public address system. This system is a trunked radio system with dedicated talk groups supporting key user groups such as fire protection or emergency preparedness. The system is composed of controllers, antennas, fixed base stations, and portable radios. Amplifiers are installed as needed to ensure acceptable reception across the site. A connection to the private branch exchange system is included to allow users to communicate with off-site organisations. Power for the system is derived from the Standby Power System (SDG backed power) with fixed elements backed by 8-h battery backup.

Security Communication

A typical security communication system utilises the common site private branch exchange, public address, and sound power phone circuits to facilitate a portion of their communications needs.

Security has a dedicated radio system providing two-way communication between alarm stations, security personnel, and local law enforcement. These radio systems are typically powered by the security power system.

9A.9.1.4 Materials

The Communication System is designed using materials suitable for the environment in which they will be installed and operated.

9A.9.1.5 Interfaces with Other Equipment or Systems

The communication system derives its power from the Electrical Distribution System. Refer to PSR Ch. 8, Section 8.1 for information pertaining to the Electrical Distribution System.

9A.9.1.6 System and Equipment Operation

Normal Operation

The Communication Systems operation is checked as part of normal daily usage.

Voice and data communications systems and equipment are provided to support all phases of plant operations and maintenance, including emergency operations.

The Communications Systems function in all ambient noise level environments. The equipment allows communication from high-noise areas consistent with performing other tasks in those areas.

Off-Normal Operation

The Communication Subsystems are designed to be sufficiently redundant and separated from one another, ensuring that diverse methods of communication are available within the Nuclear Power Plant (NPP) and in the immediate vicinity, as well as to offsite agencies, in accordance with the emergency response plan.

9A.9.1.7 Instrumentation and Control

No special instrumentation is required for the Communication System.

9A.9.1.8 Monitoring, Inspection, Testing, and Maintenance

Communication Systems equipment is designed to operate reliably within the environment in which it is installed including environmental conditions such as temperature, humidity, radiation, and noise. Furthermore, the Communication Systems are designed to operate taking into account placement of barriers such as shield walls. Communication System equipment is accessible to personnel for operation, inspection, maintenance, and testing.

The power sources for the Communication Systems are tested separately during the pre-operational and startup test program. Measurements or tests required to identify long-term deterioration are performed on a periodic basis.

9A.9.1.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.9.1.10 Performance and Safety Evaluation

The Communication Systems perform some Category 3 functions. Diverse SC3 power supplies connect to the Communication Systems.

9A.9.2 Lighting and Service Power System

The description below of the BWRX-300 Lighting and Service Power Systems aligns with the Architecture Requirements and Design document (Reference 9A-60). The plant Lighting and Service Power System includes normal and emergency lighting in addition to providing service power throughout the plant. The normal lighting provides illumination during plant operating, maintenance, and test conditions. The emergency lighting provides illumination in areas where emergency operations are performed upon loss of normal lighting.

9A.9.2.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

The Lighting and Service Power System provides illumination throughout the plant as required during normal conditions.

Normal Functions (Safety Category)

The Lighting and Service Power System illuminates control stations and travel areas utilised by operators to perform Safety Category 3 functions (DL2 manual actions).

Off-Normal Functions (Non-Safety Category)

The Lighting and Service Power System provides the same non-safety category functions during Off-Normal conditions as it does during Normal conditions.

Upon loss of the Normal Lighting Subsystem (including loss of power events), the Emergency Lighting Subsystem provides illumination in all areas where emergency operations are performed, including the access and egress routes to and from those areas as required to respond to fires or perform safe shutdown actions.

Off-Normal Functions (Safety Category)

The Lighting and Service Power System performs the following safety category functions during off-normal conditions:

1. Illuminates control stations and travel areas utilised to perform Safety Category 3 functions.
2. Activates emergency lighting as needed to maintain required illumination levels when normal lighting is reduced.

9A.9.2.2 Safety Design Bases

The Lighting and Service Power System provides acceptable levels of normal and emergency lighting, facilitating operators in performance of Safety Category 3 functions.

Emergency lighting supporting egress and safe shutdown is maintained by standby power during LOPP and includes or is supplemented by self-contained battery pack units that provide power for sufficient lighting during egress.

Failure of normal and emergency lighting does not compromise automatic actuation of safety class components or systems that perform a Safety Category function.

9A.9.2.3 Description

The lighting equipment is designed to provide illumination throughout the plant that meet the requirements laid out in EN 12464-1:2021 and EN 12464-2:2014 and meet or exceed the emergency lighting requirements contained in ISO 30061:2007 and IEC 60598-2-22:2021.

Emergency lighting is provided in areas where emergency operations are performed and for personnel safety during a power failure. The individual rooms receive lighting appropriate to their contents. The Lighting and Service Power System is comprised of the following lighting systems:

- Normal Lighting System - The normal lighting system is used to provide illumination in all areas of the plant. The normal lighting system is available under normal plant operating, maintenance, and testing conditions. The normal lighting system does not have a backup power source.
- Control Room Lighting System - Includes lighting for both the MCR and SCR. The CR lighting equipment provides acceptable illumination under both normal and emergency conditions. Power is derived from two divisions of the Emergency Power System which are backed by 72-hour seismically qualified batteries. Lighting supplied by a single division provides acceptable illumination. SCR lighting is designed to provide sufficient lighting for post-accident monitoring following all events.
- Emergency lighting system - Emergency lighting provides acceptable levels of illumination when normal lighting is not available. Emergency lighting is available in areas where emergency operations are performed, including the access and egress routes to and from those areas, in response to a fire, and safe shutdown. All emergency lighting derives power from a source backed by standby power. Lighting supporting egress and safe shutdown is maintained by standby power during LOPP and includes, or is supplemented by, self-contained battery pack units that provide sufficient lighting during a SBO. The self-contained battery pack units are inspected and tested in accordance with manufacturer recommendations. For safe shutdown and access and egress to safe shutdown areas, self-contained 8-h battery pack units are provided; for general egress and life safety purposes to meet building codes, self-contained 90-min battery pack units are provided.

The BWRX-300 uses Light Emitting Diode (LED) lighting that is operated from low voltage power panels where the lighting loads are shared with other loads (e.g., controllers and convenience outlets). These various power panels are powered by three sources:

- Preferred Power System (derived from busses A1 and B1): Normal Lighting
- Standby Power System (derived from busses A21 and B21): Emergency Lighting
- Uninterruptible Power Supplies – Emergency Power System (backed by 72-hour batteries): MCR and SCR Lighting

9A.9.2.4 Materials

The plant lighting is designed using materials suitable for the environment in which they will be installed and operated.

9A.9.2.5 Interfaces with Other Equipment or Systems

The plant lighting derives its power from the Electrical Distribution System (see PSR Ch. 8).

9A.9.2.6 System and Equipment Operation

The plant lighting includes normal, emergency, and control room lighting. The normal lighting provides illumination during all plant operating conditions, including off-normal conditions if preferred power is available. The emergency lighting provides illumination when the normal lighting system is not available. The CR lighting provides illumination for the MCR and SCR under both normal and emergency conditions.

9A.9.2.7 Instrumentation and Control

No special instrumentation is required for the lighting system.

9A.9.2.8 Monitoring, Inspection, Testing, and Maintenance

Pre-operational testing verifies that the normal lighting system provides illumination under normal plant operating, maintenance, and testing conditions, and that the emergency and control room lighting systems provide illumination where required throughout the station, including areas where emergency operations are performed.

System operability is demonstrated by normal use during plant operation.

9A.9.2.9 Radiological Aspects

There are no radiological aspects associated with the design and operation of the lighting system.

9A.9.2.10 Performance and Safety Evaluation

The lighting supports operators in the performance of their Safety Category 3 functions (DL2 manual actions). Failure of normal and emergency lighting does not compromise automatic actuation of safety class components or systems that perform a Safety Category function.

9A.9.3 Equipment and Floor Drainage System

The description below of the BWRX-300 Equipment and Floor Drain System aligns with the SDD 006N7789, “BWRX-300 Equipment and Floor Drain System” (Reference 9A-65). The EFS is designed to collect radioactive or potentially radioactive liquid wastes generated in the BWRX-300 power block and transfer these wastes to an appropriate disposal or collection system. The EFS also collects oily waste from the EHC unit, turbine lube oil skid and diesel generators, and transfers these wastes to a collection barrel.

9A.9.3.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

The EFS collects and stores select non-radioactive liquid waste and oily waste throughout the plant, and transports this waste to an appropriate storage location, typically for transport to a hazardous waste management facility.

Normal Functions (Safety Category)

The EFS performs the Safety Category 3 function of collecting potentially radioactive liquid waste via drainage piping and routing the liquid waste to general sumps located throughout the plant. The sumps are equipped with sump pumps that transfer the waste to a storage location.

Off-Normal Functions (Non-Safety Category)

The system does not perform any Non-Safety Category functions during off-normal conditions. The system is designed to collect spills and leaks via floor drains during off-normal conditions.

Off-Normal Functions (Safety Category)

As part of DL3 and DL4a, the EFS provides containment isolation valves on piping that penetrates the containment boundary. These valves are designed to close upon receiving an isolation signal from the SC1 or SC2 I&C Systems (PSR Ch. 7). The EFS can perform this Safety Category 1 function during and after a Design Basis Event requiring containment isolation.

9A.9.3.2 Safety Design Bases

EFS components are primarily SC3 and categorised as Non-Seismic, except for piping, valves and supports that penetrate the containment boundary which are SC1 and Seismic Category 1A/1B; and oily waste and non-radioactive subsystems which are SCN.

9A.9.3.3 Description

Refer to Figure 9A-21 which depicts a typical drain sump and Figure 9A-*22* which depicts the containment drain sump.

EFS system consists of the drainpipe systems, collection sumps, sump pumps, discharge piping, and instrumentation to facilitate the collection, removal, and measurement of liquid waste in the plant. This system provides this service in the RB, TB, RWB, PLSA, and the SCCV.

General Floor Drains and Sumps

All liquid waste collected in the radioactive drains are treated as High Conductivity Waste (HCW).

Liquid waste is floor drain wastes, equipment drains, and process drains collected throughout the Radioactive Controlled Area. These wastes are collected by drains and drain headers, routed by gravity drainage piping to a sump, and pumped to LWM for processing. All liquid waste is considered HCW in the BWRX-300 with the exception of a small subset of potentially clean drains and sumps that are used to keep chemicals from mixing with radwaste and to reduce the amount of waste sent to processing. Liquid waste testing is utilised in order to test for radioactive contamination among the potentially clean collection samples.

The EFS continuously collects the liquid waste that is generated throughout the plant during all modes of plant operation. The sumps receive and store the liquid wastes until the contents are pumped to the LWM. Each sump has a cover to prevent debris from entering the sump. The sumps are vented to their associated HVAC exhaust systems for control of airborne contamination. The sumps are also provided with flush capability to minimise the solid deposit within the sump and transfer piping. Clean flush water can be added to clean out a sump prior to maintenance activities.

Open drainage lines from areas that are required to maintain an air pressure differential but drain to the system are provided with a water seal.

Oily Wastes Drains and Sump

Dedicated oily waste collection sumps are provided at the base of the Turbine Electro-Hydraulic Control unit, lube oil skid and diesel generators in case of a leak. A temporary pump is required to pump oily waste from the sump pit to a collection barrel for transport to the SWM (PSR Ch. 11) drum evaporator for de-watering and disposal.

Pressurised Containment Sump

Three divisionally separated sumps are included in the basement floor of the RB. One of the sumps is a pressurised containment sump designed to meet the requirements of ASME BPVC Section VIII, Division 1 (Reference 9A-23). The EFS has drain piping in the SCCV floor to drain any leakage or condensation collected in containment to the pressurised sump. The pressurised sump is also used for containment leak detection and measurement. The pressurised sump's upstream piping penetrates the SCCV which requires the use of redundant isolation valves to ensure containment isolation. The isolation valves fail closed and automatically close upon receiving an isolation signal from the SC1 I&C System (PSR Ch. 7).

9A.9.3.3.1 Component Descriptions

Sump Pumps

The sump pumps are vertical, centrifugal types, driven by electric motors. Two parallel 100% capacity pumps (run pump and standby pump) are provided for each sump.

Maintenance valves and flanged connections are provided for sump pumps so that they can be isolated and removed from the sumps for maintenance and repair. Check valves in the pump discharge piping prevent backflow of waste into the sump.

Collection Sumps

The sumps are sized to accommodate the normal anticipated daily inputs without overflow in conjunction with operation of one sump pump.

Collection sumps are lined cavities in the floor slab of their respective building. The sumps have tight fitting, but not gastight, steel plate covers to prevent the entrance of debris as well as to minimise airborne contamination. The sumps have vents that are piped to the building HVAC interfacing exhaust. The sumps are provided with grab sampling connections.

The pressurised containment sump is designed in accordance with ASME Boiler and Pressure Vessel Code Section VIII, Division 1 (Reference 9A-23). The pressurised sump vessel is steel lined and shielded due to its interface with the primary containment. Any leakage from the pressurised sump is contained in the lined cavity, eliminating direct contact with the bare concrete.

A pressurised vessel is used in place of a traditional sump in the RB basement due to its open interface with primary containment during normal operation. The pressurised sump is located outside containment to maintain a dry containment. The pressurised vessel provides an interface for a drain line, flush water, level transmitters and pump connections.

Piping and Valves

All piping is in accordance with the requirements of ASME B31.1 (Reference 9A-25) except for the containment penetration. As part of DL3, the EFS provides containment isolation valves on piping that penetrates the containment boundary. Accordingly, the piping penetrating containment, up to and including both isolation valves, is Safety-Class 1.

The EFS piping penetrating containment is an extension of the containment boundary and is designed to Category 1A/1B; ASME BPVC Section III, Division 1, Class 2 requirements. The arrangement of the isolation valves and connecting piping is such that a single active failure or passive failure in the connecting piping or an outboard valve, cannot prevent isolation of the EFS containment penetrations. The containment isolation valves are classified as Seismic Category 1A/1B.

The floor drain line in containment connects directly to the containment atmosphere, penetrates the primary reactor containment, and is provided with containment isolation valves. There are two containment isolation valves placed in series, located outside the containment vessel, and placed as close to the primary containment wall as practical.

These isolation valves are located to provide accessibility for maintenance, inspection, and testing during all modes of reactor operation.

The pressurised sump system is credited for unidentified leak measurement, so the isolation valves on the EFS containment drain line are designed to be normally open to connect the drain line to the pressurised sump. To ensure a power source availability for the containment isolation valves, the isolation valves are supplied by different power source divisions. The EFS containment isolation valves have provisions to close automatically. Upon loss of actuating power, the automatic isolation valves are designed to fail closed, taking the position that provides greater safety.

All EFS piping is stainless steel to minimise corrosion.

Piping entering the collection sumps is turned down and terminated below the lowest sump fluid level to which the sump pump can draw. This provides a water seal to prevent gas flow and cross-contamination of building areas.

9A.9.3.4 Materials

Material and process control requirements for the BWRX-300 components ensure the reliability of plant operations through its design life by minimising corrodents and mitigating the degradation of materials through material chemistry, heat treatment, material processes controls and periodic inspection. The EFS piping is manufactured from stainless steel and the sumps are manufactured using materials which have a high degree of resistance to effluents treated by the system. Proper selection of radiation-resistant materials of construction is included in individual equipment specifications as all liquid collected is treated as potentially contaminated.

9A.9.3.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-27 for EFS interfaces.

9A.9.3.6 System and Equipment Operation

Normal Operational Concept

The EFS operates automatically in the same manner under all normal operating modes of the plant (startup, power operation, hot shutdown, cold shutdown, and refueling). Liquid wastes generated in the plant are directed into drain fixtures and drain piping. The EFS continually collects these radioactive or potentially radioactive liquid wastes and convey the wastes via gravity drainage piping systems to their respective collection sumps. Each pump is sized to accommodate the normal anticipated daily inputs into the sump. The system is not designed to accommodate fire suppression water. However, the system design features prevent drain or flood water from backing up in the drainage system into areas housing Safety Category function SSC’s.

Dual 100% capacity sump pumps are provided on each sump pump to pump liquid waste to LWM. The second pump automatically starts on sump high-high water level, provides redundancy in the event of sump pump failure, and assists the single pump when abnormally high inputs into the sump occur.

Off-Normal Operational Concept

In the event of a Loss-of-Coolant Accident signal, the containment isolation valves perform a Safety Category function and close, thereby maintaining the integrity of the SCCV. Under Design Basis Event conditions and assuming the unavailability of normal power, the EFS does not operate, nor is it required to be functional. The containment isolation valves fail closed.

All drainage piping whose collapse could result in a loss of function of Safety Category function SSC equipment, is seismically analysed to remain intact following an SSE.

9A.9.3.7 Instrument and Control

Instrumentation

Redundant level sensors and transmitters are provided for each sump. Redundancy is appropriate for ensuring reliability and availability of the I&C systems. Level signals are used to start and stop the sump pumps based on High and Low setpoints. The level transmitters on the pressurised containment sump are also used to detect, measure, and trend leakage inside containment. Pump run timers are provided for each sump pump.

Local pressure transmitters are provided in the discharge piping of each sump pump which display the pressure remotely in the MCR. Additionally, the pressurised sump that penetrates the SCCV is provided with discharge flow transmitters that displays the flow remotely in the MCR.

Isolation diaphragms are installed between all gauges or transmitters and the piping, to avoid contaminating the instrument.

Controls

The following describes the key control features of the EFS.

Sump pump operations automatically maintain the sump level. The lead sump pump starts upon a high level indication and stops on low level indication. When the capacity of one sump pump is exceeded and the sump level rises above the high level, a high-high level setting is reached, and the standby pump starts. Both pumps operate until the low level is reached, causing both pumps to stop. Alarms are annunciated at the high-high level to notify the operator of potential sump overflow and at the low-low level to notify the operator of potential air cross-contamination due to the loss of water seal. Sump pump controls are in the MCR.

Where needed, sumps are provided with remote flush capability to clean out sumps prior to maintenance activities to minimise solid deposits.

The EFS containment isolation valves are controlled via the SC1 I&C System, and close upon receiving an isolation signal. These valves can also be remotely operated from the control rooms.

9A.9.3.8 Monitoring, Inspection, Testing, and Maintenance

The containment isolation valve closure time is measured during the valve operability test and the leakage is measured during the valve leakage test as specified in the containment leakage testing procedures. Each sump in the EFS utilises recirculation lines with a grab sample tap to test/analyse the contents of the sump. Leak detection and inspection for primary containment isolation features comply with the requirements of ASME Boiler and Pressure Vessel Code Section III, Division 1, Class 2 (Reference 9A-34). A test connection is provided between the isolation valves to support local leak rate testing of the primary containment boundary.

9A.9.3.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.9.3.10 Performance and Safety Evaluation

As part of DL3 and DL4a, the EFS performs a containment isolation Safety Category function. The CIVs are designed to close upon receipt of an isolation signal from the SC1 Instrument and Control System. The CIVs are designed to maintain the leak tightness of the containment in the event of an accident and prevent radioactive releases to the environment that exceed prescribed limits.

EFS performed the fundamental safety function of confinement of radioactive material, which it fulfils by draining, collecting, and transporting potentially radioactive liquid waste from the equipment drains and floor drains of the plan.

9A.9.4 Interfacing Water Systems (Potable Water System)

The description below of the BWRX-300 Potable Water System aligns with the SDD 006N7797 “BWRX-300 Water, Gas, and Chemical Pads (WGC)” (Reference 9A-66). The Potable Water

System design is dependent on the site-specific water pathways. The system is designed to supply the required volume of potable water during peak demand periods.

9A.9.4.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

Provides for potable water distribution inside the Power Block. The Potable Water System brings potable water to the Power Block and other on-site buildings from an appropriate water source.

Normal Function (Safety Category)

There are no Safety Category functions related to the Potable Water System.

Off-Normal Functions (Non-Safety Category)

There are no specific off-normal functions related to the Potable Water System.

Off-Normal Functions (Safety Category)

There are no Safety Category functions related to the Potable Water System.

9A.9.4.2 Safety Design Bases

The Potable Water System does not perform, ensure, or support any Safety Category function, and thus has no safety design bases.

9A.9.4.3 Description

The potable water system provides potable water to the Power Block and other on-site buildings. The system includes taps, toilets, showers, and hot water heaters.

Component Description

The Potable Water System components include underground supply lines, isolation valves, and necessary instrumentation. Where required, back flow preventers are installed. Hot water heaters, taps and showers are installed where needed.

Piping and valves associated with the Potable Water System are designed and manufactured in accordance with applicable codes and standards for the applications involved. These codes and standards include but are not limited to ASME B31.1 “Power Piping” (Reference 9A-25), and American Society for Testing and Materials D3350-14 “Standard Specification for Polyethylene Plastics Pipe and Fittings Material” (Reference 9A-67).

9A.9.4.4 Materials

The Potable Water System provides piping, valves, and other control components to distribute potable water to final use locations. Potable water system component materials are built to the appropriate national standard.

9A.9.4.5 Interfaces with Other Equipment or Systems

The potable water system interfaces with the following other systems:

- Sanitary Sewer – Potable water supplies water to toilets, sinks, showers which drain to the sanitary sewer system.
- Electrical – Low voltage power from the Non-Safety Electrical Distribution System is supplied to components in the system to provide for heating of water.

9A.9.4.6 System and Equipment Operation

The potable water system relies on system pressure being supplied from water source. Hot water heaters are provided where necessary. The hot water heaters temperature is automatically controlled.

The Potable Water System is designed for operation in all modes.

9A.9.4.7 Instrumentation and Control

Instrumentation for the potable water system includes flow meters to track usage of water, back flow preventers where required by code, temperature control thermostats in the hot water heaters, and relief valves in the system where required.

Instrumentation such as valve position switches, pressure gauges, and temperature sensors are located throughout the system.

9A.9.4.8 Monitoring, Inspection, Testing, and Maintenance

The potable water system is tested and commissioned in accordance with the appropriate national plumbing code and procedure. Commissioning includes hydrostatically tested for leak-tightness, disinfection, and flushing of the system.

Periodic testing for water quality is performed in accordance with national requirements.

9A.9.4.9 Radiological Aspects

The Potable Water System has no interconnections to systems with the potential for containing radioactive material.

9A.9.4.10 Performance and Safety Evaluation

There is no potable water piping in the RB. Potable water is limited to Non-Safety Category function areas of the plant. The MCR washroom and kitchen area sinks, and potable water piping are sufficiently remote from the control system to eliminate the potential for interactions.

9A.9.5 Interfacing Water Systems (Demineralised Water Storage and Distribution System)

The description below of the BWRX-300 Demineralised Water Storage and Distribution System aligns with the WGC SDD (Reference 9A-66), as it is WGC subsystem. The Demineralised Water Storage and Distribution System consists of one Demineralised Water Storage Tank, 2X100% Demineralised Transfer Pumps, and associated piping and instrumentation.

The source of demineralised water (on-site demineralisation plant or tankered supply) is a decision for a future operator.

9A.9.5.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

Provides for demineralised water storage and distribution.

Normal Function (Safety Category)

The system does not perform any Safety Category functions during normal conditions.

Off-Normal Functions (Non-Safety Category)

Following a reactor trip with no condenser available, the Demineralised Water Storage and Distribution System provides makeup to the Isolation Condenser pools (PSR Ch. 5).

Off-Normal Functions (Safety Category)

The Demineralised Water Storage and Distribution System provides containment isolation of piping penetrating the SCCV. This isolation is provided by two locked closed manual isolation valves which are SC1 and DL3 – one valve inboard and one valve outboard of the Primary Containment. The containment isolation valves are only open during Mode 5 or 6.

The Demineralised Water Storage and Distribution System is not required to operate during or after a design basis event except for performing the containment isolation function.

9A.9.5.2 Safety Design Bases

The Demineralised Water Storage and Distribution System containment penetration and isolation valves perform the safety function of maintaining containment integrity.

9A.9.5.3 Description

The makeup water supply is sized to provide for normal makeup water needs for the unit as well as additional capacity to refill the ICS pools in a reasonable timeframe following a typical initiation. During certain shutdown/refueling/startup mode evolutions the increases in plant water consumption may require use of a temporary demineralisation subsystem to be used as a supplemental water source.

Demineralised water of the proper water quality specification is supplied to the single demineralised water storage tank located in the site yard. The tank is heated to prevent freezing. Two 100% pumps supply the demineralised water system.

The demineralised water system provides makeup water to: Condensate Storage Tank, Isolation Condenser Pools, Ventilation Humidification, Chilled Water and Plant Cooling Water surge tanks, Boron Injection Tank (Reference 9A-42), and washdown stations on the refuel floor and in containment. Additional demineralised water connections are located where needed for maintenance of systems.

Piping and valves associated with the Demineralised Water Storage and Distribution System are designed and manufactured in accordance with applicable codes and standards for the applications involved.

9A.9.5.4 Materials

Water quality requirements are used in the selection of Demineralised Water Storage and Distribution System components.

The makeup water equipment and associated piping in contact with demineralised water are fabricated from corrosion-resistant materials to prevent contamination of the makeup water.

9A.9.5.5 Interfaces with Other Equipment or Systems

Refer to Table 9A-28 for Demineralised Water Storage and Distribution System interfaces with other systems.

9A.9.5.6 System and Equipment Operation

Filling of the demineralised water storage tank is a batch process that is manually controlled. Level alarms prompt the operator to secure filling when needed.

During normal operations the Makeup Water System provides demineralised water storage and distribution to required systems and equipment in the plant.

The demineralised water in containment is only used when the plant is shutdown. During plant operation both inside and outside manual containment isolation valves are locked closed.

9A.9.5.7 Instrumentation and Control

Level alarms on the demineralised water storage tank alert the operator to high or low level situations.

The storage tank heater as well as heat trace on above ground yard piping is automatically controlled.

9A.9.5.8 Monitoring, Inspection, Testing, and Maintenance

Containment Isolation Valves are periodically tested to validate operability and determine if valve leakage is within acceptable limits. Test and vent connections are provided at the containment isolation valves to verify that the valves meet the local leak rate limits.

Makeup water is monitored and tested to ensure it meets the water quality requirements for interfacing systems.

Periodic and condition-based maintenance are completed for instrumentation, pump vibrations, and other equipment to ensure the proper performance of the system.

9A.9.5.9 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.9.5.10 Performance and Safety Evaluation

The Demineralised Water Storage and Distribution System performs the containment isolation Safety Category function using two manual valves.

9A.9.6 Interfacing Water Systems (Sanitary Water System)

The description below of the BWRX-300 Sanitary Water System aligns with the SDD (Reference 9A-66). The Sanitary Water System collects non-radiologically contaminated sewage water and transfers it off-site.

9A.9.6.1 System and Equipment Functions

Normal Functions (Non-Safety Category)

Provides for sewage water collection and transfers it off-site.

Normal Function (Safety Category)

There are no normal Safety Category functions related to the Sanitary Water System.

Off-Normal Functions (Non-Safety Category)

There are no off-normal functions related to the Sanitary Water System.

Off-Normal Functions (Safety Category)

There are no specific off-normal functions related to the Sanitary Water System.

9A.9.6.2 Safety Design Bases

The Sanitary Water System does not perform, ensure, or support any Safety Category function, and thus, has no safety design bases.

9A.9.6.3 Description

The Sanitary Sewer Collection and Delivery Subsystem collects sewage from the facility washrooms and break areas and transfers the sewage off-site.

The Sanitary Sewage Handling Subsystem is designed to prevent raw sewage overflow in the event of a power outage.

9A.9.6.4 Materials

Piping and valves are designed and manufactured in accordance with applicable codes and standards for the applications involved.

9A.9.6.5 Interfaces with Other Equipment or Systems

The sanitary water system interfaces with the appropriate BWRX-300 waste treatment system.

9A.9.6.6 System and Equipment Operation

The Sanitary Water System is designed for operation in all modes.

9A.9.6.7 Instrumentation and Control

The Sanitary Sewer Handling Subsystem has I&Cs to allow transfer of sewage from the site to the off-site sewage system.

9A.9.6.8 Monitoring, Inspection, Testing, and Maintenance

Inspection and testing are performed in accordance with applicable codes and industry standards. Manholes and access covers are provided where applicable to support maintenance and inspections.

9A.9.6.9 Radiological Aspects

The Sanitary Water System is a non-radiologically contaminated system and only collects sanitary waste from areas outside of any radiologically controlled areas.

9A.9.6.10 Performance and Safety Evaluation

The Sanitary Water System does not perform, ensure, or support any Safety Category function; therefore, a Safety Evaluation is not required.

9A.9.7 Chemistry Systems

Primary Coolant

See Section 9A.9.9, Section 9A.9.10, Section 9A.9.11, and Section 9A.9.12 for details on the Reactor Coolant chemistry systems.

Secondary Coolant

Not Applicable, the terminology “Secondary Coolant” refers to a Pressurised Water Reactor.

9A.9.8 Storage System for Non-Permanent Equipment Used in Design Extension Conditions

The storage system for non-permanent equipment used in Design Extension Conditions is developed based upon EME requirements. The design of the storage system takes into consideration the aggregate set of on-site and off-site resource considerations for the hazards that are applicable to the site as well as final BWRX-300 design considerations.

These factors plus consideration for the following are used as design inputs to size, locate, deploy, and operate the storage system:

- Protection of EME.
- Deployment of EME.
- Procedural Interfaces.
- Utilisation of off-site resources.
- Use of existing site facilities for storage.

9A.9.9 Other Process Media and Other Materials (Hydrogen Water Chemistry)

The description below of the BWRX-300 Hydrogen Water Chemistry System aligns with the SDD 006N8027, “BWRX-300 Hydrogen Water Chemistry System” (Reference 9A-68). The Hydrogen Water Chemistry System adds hydrogen into the feedwater system at the Feedwater Pump suction and oxygen (as a constituent of air) into the Offgas System (OGS)

(PSR Ch. 11, Section 11.3) via the Service Air System (Section 9A.4.1). The Hydrogen Water Chemistry System is included in the BWRX-300 design for the purpose of reducing and mitigating IGSCC in reactor vessel internals.

9A.9.9.1 System and Equipment Functions

System and equipment functions associated with the Hydrogen Water Chemistry System include the following:

Normal Functions (Non-Safety Category)

The Hydrogen Water Chemistry System is responsible for hydrogen injection and process air injection.

Normal Functions (Safety Category)

The system does not perform safety category functions during normal conditions.

Off-Normal Functions (Non-Safety Category)

The system does not perform non-safety category functions during off-normal conditions.

Off-Normal Functions (Safety Category)

The system does not perform safety category functions during off-normal conditions.

9A.9.9.2 Safety Design Bases

The Hydrogen Water Chemistry System does not perform, ensure, or support any Safety Category function, and thus, has no safety design bases.

9A.9.9.3 Description

The Hydrogen Water Chemistry System provides for an established technique for reducing and preventing the growth rates of IGSCC in reactor vessel internals. The mitigation of IGSCC is achieved from the electrochemical reduction of oxygen and other oxidising species (oxidants) in the reactor coolant. This is accomplished by injecting hydrogen into the feedwater at the feedwater pump suction. The injected hydrogen suppresses the radiolytic formation of oxidants in the reactor core. To compensate for any excess hydrogen which may travel downstream and be removed from the main condenser by the OGS, a corresponding amount of oxygen, as a constituent of injected air provided by the Service Air System, is injected into the OGS prior to Offgas Recombiner.

Reduction of oxidants results in a negative shift of the Electrochemical Corrosion Potential, which is the measurement that is used to predict initiation and growth of IGSCC. When the Electrochemical Corrosion Potential achieves an acceptable level, IGSCC crack initiation stops, and crack growth rates are minimised. The BWRX-300 design employs NobleChem^{TM} technology as a means to provide for the injection of noble metal(s) into the reactor to aid in the protection of reactor vessel internals from IGSCC in combination with the addition of hydrogen by the Hydrogen Water Chemistry System. The noble metal deposits in the reactor resulting from NobleChem^{TM} injection act as catalyst sites on the vessel surfaces to facilitate the recombination of free hydrogen and oxygen molecules, which minimises the oxygen available to initiate and encourage IGSCC crack growth. Refer to Section 9A.9.10 for a description of the application of NobleChem^{TM} technology.

Hydrogen addition to the feedwater results in an excess ratio of hydrogen to oxygen at the entrance to the OGS. The Hydrogen Water Chemistry System injects a stoichiometric amount of oxygen (as a constituent of air) upstream of the offgas recombiner to combine with the hydrogen reaching the recombiner. The required air (oxygen) flow is based on the hydrogen flow rate and condenser inleakage rate and is controlled by the Hydrogen Water Chemistry System. The system uses time delays in the air injection controls to ensure that hydrogen and oxygen reach the offgas recombiner in balanced amounts, ensuring that the OGS operates at conditions (pertaining to hydrogen and oxygen concentrations) which resemble conditions without the Hydrogen Water Chemistry System.

The Hydrogen Water Chemistry System consists of a maintenance panel, a hydrogen isolation module (to isolate the hydrogen supply from the power plant buildings if necessary), a hydrogen flow control module, which controls the flow of hydrogen into the FW System, and an air flow control module, which controls air flow to the OGS. Note that Hydrogen Area Monitors are also included in the system which monitor for local hydrogen in the areas of susceptible system equipment.

9A.9.9.4 System and Equipment Operation

Power Operation

The Hydrogen Water Chemistry System can only be operated during power operations. The Hydrogen Water Chemistry System begins operation when the Feedwater Pump is in service and Steam Jet Air Ejectors and OGS are in-service during plant startup.

9A.9.9.5 Instrumentation and Control

Instrumentation is provided to control the injection of hydrogen and the injection of oxygen (as a constituent of air) via the Service Air System. Automatic control features in the Hydrogen Water Chemistry System minimise the need for operator attention and improves performance.

9A.9.9.6 Monitoring, Inspection, Testing, and Maintenance

The Hydrogen Water Chemistry System is demonstrated functional by its use during normal operation.

9A.9.9.7 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.9.9.8 Performance and Safety Evaluation

The Hydrogen Water Chemistry System does not perform a Safety Category function. However, the Hydrogen Water Chemistry System is used, along with other measures, to reduce the likelihood of corrosion failures that would adversely affect plant availability. The means for storing and handling hydrogen utilises the guidelines in Electric Power Research Institute (EPRI) Report “Guidelines for Permanent BWR Hydrogen Water Chemistry Installations” (Reference 9A-69).

9A.9.10 Other Process Media and Other Materials (NobleChem^{TM} Injection)

9A.9.10.1 System and Equipment Functions

The description below of the BWRX-300 On-Line NobleChem^{TM} (OLNC) aligns with the SDD 006N7535 “On-Line NobleChem” (Reference 9A-70). OLNC provides a means for the injection of noble metal salt solution directly into the reactor coolant flow path. The purpose of injecting noble metal into the reactor is to aid in the protection of reactor vessel internals from IGSCC in combination with the addition of hydrogen by the Hydrogen Water Chemistry System (Section 9A.9.9).

9A.9.10.2 Safety Design Bases

The OLNC does not perform, ensure, or support any Safety Category function, and thus, has no safety design bases.

9A.9.10.3 Description

The OLNC application process deposits noble metal salt solution directly into the reactor coolant flow path. The resulting noble metal deposition in the reactor provides a catalyst effect on vessel surfaces to facilitate the recombination of free hydrogen and oxygen molecules to minimise the oxygen available to initiate and encourage IGSCC crack growth. Due to the catalyst effect from noble metal loading, using OLNC in conjunction with the Hydrogen Water Chemistry System results in a much lower amount of injected hydrogen required to establish the Electrochemical Corrosion Potential to mitigate IGSCC initiation and significantly reduce IGSCC crack growth rates than the use of Hydrogen Water Chemistry System alone. This need for less hydrogen to provide mitigation results in lower main steam line dose rates.

OLNC operates in conjunction with the Hydrogen Water Chemistry System although they are both separate systems which have no mechanical or electronic interrelationships. The Hydrogen Water Chemistry System is described in Section 9A.9.9.

The OLNC injection skid is installed as permanent plant equipment in the TB as close as possible to the Feedwater injection tap(s). A direct connection to a supply of demineralised water provides the carrier flow to lessen the residence time of the noble metal solution in the injection line. The effluent from the OLNC injection skid is injected into a tap (or taps) in the Feedwater System at a point that lessens the loss of noble metal prior to entering the reactor.

Once the flow from the injection skid reaches the Feedwater System, the process employs the reactor coolant as the transport medium to deposit noble metal on the surface of all wetted reactor components and inside existing cracks.

9A.9.10.4 System and Equipment Operation

The OLNC injection is designed to be performed only during power operations. The OLNC system is secured during plant startup, all shutdown modes and refueling.

9A.9.10.5 Instrumentation and Control

Instrumentation is provided to monitor and control the injection of a noble metal solution into the reactor coolant flow path at the injection skid.

9A.9.10.6 Monitoring, Inspection, Testing, and Maintenance

Maintenance on the OLNC system occurs prior to each noble metal application, but the skid can also be isolated as needed in the midst of an application to perform unplanned maintenance. Prior to each noble metal application, the demineralised water is checked for purity and then used to prime the skid, the system is calibrated, and electrical components and instrumentation tested, and the system is leak-tested and refurbished as required.

9A.9.10.7 Radiological Aspects

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

The OLNC Injection System should be located in an accessible, low-dose area (such as the Turbine Building) to maintain dose exposure to personnel ALARP.

9A.9.10.8 Performance and Safety Evaluation

OLNC does not perform a Safety Category function. The OLNC Injection System is used, along with the Hydrogen Water Chemistry System to reduce the likelihood of IGSCC.

9A.9.11 Other Process Media and Other Materials (Zinc Injection)

The description below of the BWRX-300 Zinc Injection Passivation System aligns with the SDD 007N4013, “BWRX-300 Zinc Injection Passivation” (Reference 9A-71). The purpose of the Zinc Injection Passivation system is to provide a means for the continuous injections of soluble zinc into the reactor feedwater path to reduce out-of-core shutdown dose rates. The feedwater transports the zinc ion to the reactor, where it is deposited on the surface of the fuel and all wetted reactor components as well as the inner surfaces of external piping.

9A.9.11.1 System and Equipment Functions

The General Electric Zinc Injection Passivation (GEZIP) system continuously injects soluble zinc into the reactor via the feedwater system. A stream of water taken downstream of the feedwater pump common discharge is routed through a dissolution column containing sintered Depleted Zinc Oxide (DZO) pellets. The DZO pellets dissolve to produce soluble ionic zinc in the diverted feedwater stream, which is returned upstream of the feedwater pump common suction and is blended with the main feedwater flow.

9A.9.11.2 Safety Design Bases

The GEZIP system does not perform, ensure, or support any Safety Category function, and thus, has no safety design bases.

9A.9.11.3 Description

The GEZIP system works passively, with no requirement for electrical power, based on the flow of the feedwater and DZO dissolution. The GEZIP system skid consists of a straightening vane, dissolution column, strainer, filter, flow control valve, block and instrumentation valves, and instrumentation to monitor the operation of the skid.

The dissolution column contains a removable basket which holds an inventory of DZO pellets. The column contains the feedwater stream and directs it over the pellets. The straightening vane removes vortices from the flow, which ensures the accuracy of flow measurements at the column orifice.

The strainer is located in the piping spool at the outlet of the dissolution column and prevents large DZO fragments from entering the feedwater stream. Upstream of the heat-up Flow Control Valve (FCV), there is a filter to prevent small DZO pellet fragments or particles which may have passed the strainer from lodging in the heat-up FCV.

The FCV controls the water flow rate through the GEZIP system during normal operation and includes trim for cavitation control. The FCV can control flow over a range of 10 gpm to 100 gpm.

9A.9.11.4 System and Equipment Operation

The GEZIP System is secured in place during pre-startup operations.

The GEZIP system is started from ambient conditions and heated at a set rate to operating temperature, upon reactor feedwater pump startup.

During normal plant operations, GEZIP operates continuously to maintain specified FW Total Zinc values. The flow of feedwater through the GEZIP system is controlled by throttling the FCV, where changes to the feedwater flow rate adjust the feedwater zinc concentration. The GEZIP system is used only during power operation in its normal operating modes.

For system shutdown, the GEZIP system is isolated from the Condensate and Feedwater System and allowed to cool down naturally to ambient temperature. The system may be depressurised while shut down for maintenance and DZO pellet replenishment.

9A.9.11.5 Instrumentation and Control

Temperature, differential pressure, and flow through the GEZIP system is displayed on the system local control panel.

9A.9.11.6 Monitoring, Inspection, Testing, and Maintenance

DZO pellets are replenished in the dissolution column during refueling outages or when desired zinc output is not achievable at the maximum flow rate through the system.

Pre-installation leak tests are performed on the dissolution column, piping, and instrumentation.

The dissolution column itself is pressure tested to ensure conformance to ASME BPVC Section VIII (Reference 9A-23). The entire GEZIP system from inlet to outlet, including the dissolution column, is integrally pressure tested per ASME B31.1 (Reference 9A-25)

9A.9.11.7 Radiological Aspects

The GEZIP system is located in a normally accessible area near the tie-in points to the Condensate and Feedwater System to minimise piping and maintaining dose ALARP.

PSR Ch. 12, Subsections 12.1.1 (Approach to ALARP) and 12.3. (Design Features for Radiation Protection) (Reference 9A-14) provide information pertaining to measures taken to ensure that occupational exposures arising from the operation or maintenance of the equipment or system are ALARP in operational states and in accident or post-accident conditions.

9A.9.11.8 Performance and Safety Evaluation

The GEZIP performs no safety functions. The GEZIP system is designed to operate continuously while feedwater is in service and the reactor is in power operation, and life-limiting components and their materials are selected based on a 60-year design life.

9A.9.12 Other Process Media and Other Materials (Boron Injection System)

The Boron Injection System is described in PSR Ch. 6.

9A.10 Chemical Bases of Water Treatment

Refer to PSR Ch. 13: Conduct of Operations (Reference 9A-72), Section 13.3.1.3 for information pertaining to the Chemistry Control Program.

Table 9A-1: Fuel Pool Cooling and Cleanup System Interfaces

Interfacing System	Interface Description	Interface Boundary
Reactor Building Structure (Fuel Pool, Reactor Cavity, and Equipment Pool)	Overflow from the fuel pool, reactor cavity pool, and equipment pool weirs enters the skimmer surge tanks and is pumped through cleanup and heat removal subsystems, then returned to the bottom of the equipment pool, reactor cavity pool, and fuel pool as required.	Boundary from the Reactor Building exists at overflow from pools to Skimmer Surge Tanks. Boundary at supply exists at sparger nozzle(s) submerged in pools.
Liquid Waste Management System (LWM)	Condensate Storage Tank provides additional coolant inventory or storage volume for overboarding to reduce inventory. LWM also supplies liquid for back wash and flushing of cleanup systems.	Boundary exists at first isolation valve at each connection point.
Solid Waste Management System (SWM)	Repository for spent resin from the demineraliser and backwash of filter elements. Flushed via piping to SWM using LWM inventory.	Boundary exists at first isolation valve at each connection point.
Plant Cooling Water System	PCW supply for heat exchangers.	Boundary exists at first isolation valve at each connection point.
Plant Pneumatics System (PPS)	Air supply to allow mixing of demineraliser resin. Air Operated Valve operation as required.	Boundary exists at first isolation valve at each connection point.
Diverse Protection System	Provides instrumentation and control for SC3 functions of FPC system.	Boundary exists at each rack prior to multiplexer.
Standby Power System	Electricity supplied to pumps, motorised valves, and instrumentation/control throughout system.	Boundary located at individual component sub feed.
Heating Ventilation and Cooling System	Provides ventilation on the pool surface and RB area	Boundary is the interaction with the FPC air space, no physical connection
Fire Protection System	Provides additional coolant inventory and connection point in Off-Normal EME conditions.	Boundary exists at first isolation valve at each connection point.

Interfacing System	Interface Description	Interface Boundary
Yard/ BOP	Although not a standalone system, an external connection is included to provide makeup capacity from remote location.	Boundary at final valve of EME connection point.
Process Radiation and Environmental Monitoring System	Conductivity, sampling, performance monitoring and pool leak detection.	Various locations within the FPC
Primary Containment System	The PCCS exchanges heat with the equipment pool and reactor cavity pools.	Boundary at the connection of the PCCS supply and return lines in the equipment pool and the containment dome with the fuel pool water in the reactor cavity
Containment Inerting System	The Containment Inerting System overpressure protection line discharges through the equipment pool.	Boundary at the connection of the overpressure protection discharge line in the equipment pool
Complementary Control System	Monitors the water level and temperature of the fuel pool.	Level and temperature devices monitor for post-accident monitoring
Refueling Equipment and Servicing	Fuel racks in the fuel pool and various storage racks within the fuel pool for RPV components.	Boundary is the fuel pool liner.

Table 9A-2: Handling System for Fuel Cask Loading Interface

Interfacing System	Interface Description	Interface Boundary
Fuel Pool Cooling and Cleanup System (FPC)	FPC provides water clarity for underwater visibility FPC also provides water cooling to support fuel pool cooling activities.	The Handling System for Fuel Cask Loading equipment is immersed in water treated and cooled by FPC.
Core and Fuel	Supports the transfer of fuel assemblies in and out of the reactor core.	The mast of the Refueling Platform engages the bail handle of the fuel assembly.
Plant Pneumatics System (PPS)	PPS provides pressurised air for powering pneumatic motors and tooling.	Gate seals, nozzle plugs, and tooling.
Non-Safety Electrical Distribution System	Provides electricity to the Handling System for Fuel Cask Loading equipment.	Inspection tooling, underwater lights, refueling platform, auxiliary platform, and tooling.
Grounding and Lightning Protection System	Provides electrical grounding for equipment.	Equipment and inspection equipment.
Cranes, Hoists and Elevators	The RB Polar Crane is used during the disassembly and re-assembly of the Reactor Pressure Vessel.	The Handling System for Fuel Cask Loading equipment couples to RB Polar Crane hook.
Heating Ventilation and Cooling System (HVS)	Provides control of heat and humidity to work areas.	Ambient condition suitable work.
Reactor Building Structure (RBS)	Supports the loads of equipment and provides railing for traversing of the Refueling Platform.	Equipment either rests on the refuel floor or its weight is transmitted to the RB walls through the RB Polar crane.

Table 9A-3: Plant Cooling Water System Interfaces

Interfacing System	Interface Description	Interface Boundary
Safety Class 3 Instrumentation and Control System	Provides SC3 Instrumentation and Control. Pump logics, valve logics, instrumentation (pressure, flow, temperature, level) etc.	Safety Class 3 Instruments
Non-Safety Instrumentation and Control System	Provides SCN Instrumentation and Control Pump logics, valve logics, process variables, etc.	SCN Instruments
Process, Radiation and Environmental Monitoring System	Provides sampling points for chemical analysis	PCW Pump Common header
ICS Pool Cooling and Cleanup System	Provides cooling water to ICS pool heat exchangers from Reactor Component Cooling Water Piping Distribution	ICS Pool Cooler
Shutdown Cooling System	Provides cooling water to SDC heat exchangers from Reactor Component Cooling Water Piping Distribution	SDC Cooler
Fuel Pool Cooling and Cleanup System	Provides cooling water to FPC heat exchangers from Reactor Component Cooling Water Piping Distribution	FPC Cooler
Condensate and Feedwater Heating System (CFS)	Provides cooling water to Condensate and Feedwater Pumps and their Adjustable Speed Drives from Turbine Component Cooling Water Piping Distribution	Condensate and Feedwater Variable Frequency Drive and Motors
Main Turbine Equipment (MTE)	Provides cooling water to Lube Oil and EHC from Turbine Component Cooling Water Piping Distribution	Lube Oil and EHC Coolers
Generator, Exciter, and Isophase Bus Ducts	Provides cooling water to the Generator cooler and Isophase Cooler from the Turbine Component Cooling Water Piping Distribution	Generator and Isophase Coolers
Main Condenser and Auxiliaries	Provides cooling water to the Vacuum Pumps skids from Turbine Component Cooling Water Piping Distribution water loop	Vacuum Pump Skids
Circulating Water System	Heat from the PCW is rejected to the circulating water from the PCW heat exchangers, then towards the heat sink	PCW Heat Exchangers
Plant Pneumatic System	Provides cooling water to the Plant Pneumatics System from Reactor Component Cooling Water Piping Distribution	PPS coolers

Interfacing System	Interface Description	Interface Boundary
	PPS Supplies instrument air to PCW Valves	Valve actuators
Safety Class 2 and SC3 Electrical Distribution System	Provides PCW components low and medium voltage power	SC3 pumps and motors
Equipment and Floor Drain System	Provides drainage and collection for contaminated or potentially contaminated waste	Drain hub
Water, Gas, and Chemical Pads	Water, Gas and Chemical Pads provides demineralised makeup water to the PCW surge tanks	Surge Tank

Table 9A-4: Reactor Water Cleanup System Interfaces

Interfacing System	Interface Description	Interface Boundary
Reactor Coolant System	Locations where flow from the RPV enter the CUW. The RPV isolation valves for reactor water cleanup will fail in the closed position, with valve actuators designed to maintain the valves closed by positive mechanical means	Physical boundary is at the dual RCS reactor isolation valves on two penetrations exiting the RPV
Shutdown Cooling System	Connection from SDC to CUW for overboarding flow at low pressures or flow to the vessel to reduce temperature stratification	The system interface is at the isolation valve between SDC and CUW
Condensate and Feedwater Heating System	Normal CUW flow to Condensate System. All cleanup of CUW injection flow is performed by CFD filters and demineralisers.	Downstream of a Condensate pump prior to filters and demineralisers
	Coolant flow for CUW regenerative heat exchanger from Feedwater	CUW regenerative heat exchanger
Plant Pneumatics System	Provide air or nitrogen to operate air operated valves	The system interface is located at each valve actuator
Safety Class 2 and SC3 Electrical Distribution System	Provide power to CUW instrumentation for system operation and line break detection	The system interface is at each powered component
Safety Class 1 Instrumentation and Control System	CUW instrumentation for leak detection provide input to Safety Class 1 Instrumentation and Control System. Safety Class 1 Instrumentation and Control System is the safety class instrumentation system	The system interface is at the I/O termination cabinets in the DCIS cabinet rooms
Safety Class 2 Instrumentation and Control System	CUW instrumentation for system operation and leak detection provide input to Safety Class 2 Instrumentation and Control System	The system interface is at the I/O termination cabinets in the DCIS cabinet rooms
Liquid Waste Management System	Overboarding to LWM to reduce vessel level if required	The system boundary is after the overboard isolation valve
Main Condenser and Auxiliaries	Overboarding to MCA to reduce vessel level if required	The system boundary is after the overboard isolation valve
Process Radiation and Environmental Monitoring System	Sample line for water chemistry	The system boundary is after the sample line isolation valves

Table 9A-5: Reactor Water Cleanup System Operating Modes

Mode	Title	Reactor Mode Switch Position	CUW System Modes
1	POWER OPERATION (10% - 100% Reactor Power)	RUN	Mode A, B1-A, and B1-B
2	STARTUP	REFUEL(1) or STARTUP	All Modes
3	HOT SHUTDOWN(1)	SHUTDOWN	Mode B1-A, B1-B, B2-A, B2-B, B2-C, and B2-D
4	STABLE SHUTDOWN(1)	SHUTDOWN	Mode B1-A, B1-B, B2-A, B2-B, B2-C, and B2-D
5	COLD SHUTDOWN(1)	SHUTDOWN	Mode B2-A, B2-B, B2-C, and B2-D
6	REFUELING(2)	SHUTDOWN or REFUEL	Mode B2-A, B2-B, B2-C, and B2-D

Notes:

(1) All reactor pressure vessel head closure bolts fully tensioned.

(2) One or more reactor pressure vessel head closure bolts less than fully tensioned.

Table 9A-6: Shutdown Cooling System Interfaces

Interfacing System	Interface Description	Interface Boundary
Environmental Monitoring System	The Shutdown Cooling System provides a sample line to the PREMS for sampling of reactor coolant when SDC is in service.	The systems connect downstream of the SDC isolation valve.
Isolation Condenser System	The Isolation Condenser System provides a suction flow path from the RPV via the condensate return lines to the Shutdown Cooling System for decay heat removal and overboarding.	The systems connect downstream of the ICS containment isolation valves
Control Rod Drive System	The Control Rod Drive system provides water to the Shutdown Cooling System pumps for motor cooling and seal purge flow.	The system interface is on the SDC pump purge water line upstream of SDC isolation valves.
Reactor Water Cleanup System	The Shutdown Cooling System flow can be routed to the Reactor Water Cleanup System for overboarding or into the RPV through the CUW inlet lines for thermal stratification reduction.	The system interface is on the SDC overboard lines at the isolation valve between SDC and CUW.
Liquid Waste Management System	The Shutdown Cooling System can overboard to the Liquid Waste Management System reactor water storage tank if fluid temperature is acceptable.	The systems interface on the SDC overboard lines downstream of the isolation valve between SDC and LWM.
Condensate and Feedwater Heating System	The Shutdown Cooling System discharges into the Condensate and Feedwater Heating System lines A and B which discharge inside the RPV to complete a closed cooling loop.	The system interface is on the upstream side of the isolation valve between CFS and SDC.
Main Condenser and Auxiliaries	The Shutdown Cooling System can overboard to the Main Condenser and Auxiliaries if available for overboard flow.	The system interface on the SDC overboard lines downstream of the isolation valve between SDC and MCA.
Plant Cooling Water System	The Plant Cooling Water System provides cooling water to the Shutdown Cooling System heat exchangers.	The system interface is located at the SDC heat exchanger nozzles.
Plant Pneumatics System	The Plant Pneumatics System provides air or nitrogen to operate the Shutdown Cooling System air operated valves.	The system interface is located at each valve actuator.
Safety Class 2 and SC3 Standby Power System	The Safety Class 2 and SC3 Standby Power System provides power to the Shutdown Cooling System pump.	The system interface is at each powered component.

Interfacing System	Interface Description	Interface Boundary
Reactor Building Structure	The Reactor Building Structure provides structural support to the Shutdown Cooling System SSCs.	The system interface is at each component support.
Safety Class 1 Instrumentation and Control System	The Shutdown Cooling System includes three divisions of SC1 leak detection instrumentation to provide inputs required by the Safety Class 1 Instrumentation and Control System Distributed Control and Information System.	Input/Output termination cabinets in the DCIS cabinet rooms.
Safety Class 3 and Non-Safety Class Instrumentation and Control System	The SC3 and SCN Instrumentation and Control System DCIS interfaces with Shutdown Cooling System instrumented and controlled components.	Input/Output termination cabinets in the DCIS cabinet rooms.
Safety Class 1 Instrumentation and Control System	The Safety Class 1 Instrumentation and Control System DCIS interfaces with instrumentation that is part of the Shutdown Cooling System	Input/Output termination cabinets in the DCIS cabinet rooms.

Table 9A-7: BWRX-300 Shutdown Cooling System Mode Table

Mode	Title	Reactor Mode Switch Position	Shutdown Cooling System Modes
1	POWER OPERATION (10% - 100% Reactor Power) (1)	RUN	NA
2	STARTUP(1)	REFUEL(2) or STARTUP	Modes A1 and/or B1-4, C1
3	HOT SHUTDOWN(1)	SHUTDOWN	Modes A1 and/or B1-4, C1
4	STABLE SHUTDOWN(1)	SHUTDOWN	Modes A1 and/or B1-4, C1
5	COLD SHUTDOWN(1)	SHUTDOWN	Modes A1 and/or B1-4, C1
6	REFUELING(2)	SHUTDOWN or REFUEL	Modes A1 and/or B1-4, C1

Notes:

(1) All reactor pressure vessel head closure bolts fully tensioned.

(2) One or more reactor pressure vessel head closure bolts less than fully tensioned.

Table 9A-8: Shutdown Cooling Configuration During Refueling Mode

Reactor Water Level	FPC Assist	SDC System	FPC System
Reactor Cavity Pool Filled	Yes – Gate Removed	SDC normally in service (FPC can be evaluated to perform function as needed)	FPC cooling normally in service (SDC can be evaluated to perform function as needed)
Reactor Cavity Pool Filled	No – Gate Installed	SDC train in service (number of trains in service dependent upon the needed cooldown rate/decay heat)	One FPC cooling train normally in service, one in Standby
Reactor Cavity Pool Drained	No – Gate Installed	SDC train in service (number of trains in service dependent upon the needed cooldown rate/decay heat)	One FPC cooling train normally in service, one in Standby

Table 9A-9: Chilled Water Equipment System Interfaces

Interfacing System	Interface Description	Interface Boundary
SC1 Instrument and Control System	Provides all safety I&C control for containment isolation valve logic	At Input/Output termination
SC3 Instrumentation and Control System	Provides safety I&C controls including pump logics, valve logics, excluding the CIV, instrumentation (pressure, flow, temperature, level) etc.	At Input/Output termination
SCN Instrumentation and Control System	Provides non-safety controls	At Input/Output termination
Offgas System	CWE provides chilled water for the charcoal adsorber vault FCU cooling coils	Isolation valves for the charcoal adsorber vault FCU
Plant Pneumatics System	PPS provides instrument air/nitrogen to pneumatically operated valves	At CWE air operated valves
SC2 and SC3 Electrical Distribution System	Provides power to the CWE chillers and pumps	At CWE equipment
Non-Safety Electrical Distribution System	Provides non-safety low and medium voltage power to CWE equipment	At CWE equipment
Containment System Facility	The liquid connection from the pressure relief valves inside containment discharge to the containment drain	Liquid connection from RB PRV
Containment Cooling System	CWE provides chilled water for containment cooling system chilled water coil loads	CCS AHU flanges
Heating, Ventilation, and Cooling System	CWE provides chilled water for the HVS chilled water cooling coil loads	Isolation valves at AHU and FCU
Equipment and Floor Drain System	The condensate collected from the pump baseplate drain is piped to the EFS sumps.	Drain pipe from chiller pumps and liquid connection from RB PRVs
Water, Gas, Chemicals Pads	Water, Gas, Chemicals System supplies makeup water to the glycol auto-fill unit	Isolation valve at glycol auto-fill unit

Table 9A-10: Normal Heat Sink Interfaces

Interfacing System	Interface Description	Interface Boundary
Circulating Water System	The NHS provides the source of water used as the cooling medium to the CWS pumps and accepts the return flow from the CWS pumps. When required for cold weather operation, CWS is designed to maintain a minimum intake basin temperature through a recirculation line from the CWS discharge line	At the intake and discharge structures

Table 9A-11: Isolation Condenser System Pool Cooling and Cleanup System Interfaces

Interfacing System	Interface Description	Interface Boundary
Reactor Auxiliaries Control System	Provides control logic for initiation and control of the ICC. Receives data signals from ICC instruments for display on MCR and local panels Input to ICC: Control signals to pumps and valves Output from ICC: Instrumentation data	Remote Multiplexer Unit associated with ICC instrument and control equipment
Process Radiation and Environmental Monitoring System	Provides process sampling for water quality to monitor performance of ion-exchange resin and to detect potentially radioactive contaminated Demineraliser resin before discharge to SWM. Monitors air space in IC Inner Pools for radiation levels to detect potential IC tube defects and leakage. Output from ICC: Process water samples for analysis for water quality and monitoring Demineraliser performance.	ICC main Return Pipe Tie-ins IC Inner Pools
Isolation Condenser System	Rejects heat to the IC pools. Input to ICC: Thermal energy to IC pools	Outside wetted surface of ICs
Control Rooms	Provides control logic for initiating operation and control of the ICC. Receives data signals from ICC instruments for display on MCR and local display panel (If necessary). Input to ICC: Control signals to pumps and valves Output from ICC: Instrumentation data.	Remote Multiplexer Unit associated with ICC instrument and control equipment
Solid Waste Management System	Receives discharged demineraliser resin from ICC Demineraliser Output from ICC: Discharge of potentially radioactively contaminated spent resin media from the Demineraliser	ICC Demineraliser Interface is at downstream side of ICC isolation valve
Plant Cooling Water System	Provides cooling water to ICC HXs for heat rejection to UHS Input to ICC: Plant Cooling Water Output from ICC: Heat load from IC Pools	ICC HXs Interface for PCW is at cold side of HXs

Interfacing System	Interface Description	Interface Boundary
Plant Pneumatics System	Provides compressed air for ICC I&C components, AOVs, and Demineraliser Input to ICC: Compressed air service for: ICC I&C; Demineraliser resin media redistribution and exchange evolutions	ICC AOVs ICC Demineraliser Interface for compressed air is at upstream side of ICC isolation valve
Non-Safety Electrical Distribution System	Provides Non-Safety Category AC electrical power to ICC equipment Input to ICC: Non-Safety Category electrical power to equipment electrical loads in ICC	Interface to be located at local breaker box
Non-DCIS Communications Systems	Provides reliable two-way radio communications between the Main Control Room and personnel in the ICC Equipment Room	Interface at ICC Equipment Room
Heat, Ventilation, and Cooling System	Provides HVAC for environmental temperature control of ICC Equipment Room Input to ICC: HVAC air flow Output from ICC: Heat load from ICC equipment	Interface at ICC Equipment Room
Equipment and Floor Drain System	Receives demineraliser water from ICC during maintenance activities requiring evacuation of major equipment and piping segments. Output from ICC: Discharge of potentially radioactively contaminated demineralised water during maintenance and repair activities that require draining ICC components and piping.	Interface at floor drain in ICC Equipment Room
Reactor Building Structure	Provides space, IC pool compartments, structural and infrastructure support, and protection for ICC piping and equipment.	Interfaces at: (1) ICC Equipment Room, (2) ICS piping penetrations, (3) IC pools (vents) (4) IC pools (pipe supports)

Interfacing System	Interface Description	Interface Boundary
Water, Gas, and Chemical Pads	Provides makeup demineralised water for ICS pools during normal reactor operations Input to ICC: Demineralised water to replace routine pool losses due to evaporation	Interface for makeup water is at upstream side of ICC isolation valve
	Provides demineralised water to ICC Demineraliser. Input to ICC: Demineralised water to facilitate Demineraliser resin media exchange evolutions	Demineraliser Interface for demineralised water is at upstream side of ICC isolation valve

Table 9A-12: Isolation Condenser System Pool Cooling and Cleanup System Operating Modes

Mode	Title	Reactor Mode Switch Position	ICC Modes		Description
1	Power Operation(1) (10 – 100% Rated Power)	RUN	A2	A2O(3)	Cooling (A & B Trains Operating)
			A1a	A1aO(3)	Cleanup (A Train Operating)
			A1b	A1bO(3)	Cleanup (B Train Operating)
			A2c	A2cO(3)	Chemical Injection (A & B Trains Operating)
2	Startup(1)	STARTUP or REFUEL(1)	A		All ICC A Operating Modes
3	Hot Shutdown(1)	SHUTDOWN	A		All ICC A Operating Modes
4	Stable Shutdown(1)	SHUTDOWN	A		All ICC A Operating Modes
			B		ICC Shutdown for Maintenance
5	Cold Shutdown(1)	SHUTDOWN	A		All ICC A Operating Modes
			B		ICC Shutdown for Maintenance
6	Refueling(2)	SHUTDOWN or REFUEL	A		All ICC A Operating Modes
			B		ICC Shutdown for Maintenance

Notes:

(1) All RPV head closure bolts fully tensioned.

(2) One or more RPV head closure bolts less than fully tensioned.

(3) Concurrent Outer Pool Sparger operation.

Table 9A-13: Isolation Condenser System Pool Cooling and Cleanup System Instrumentation

Instrument	Location	Function
Level Transmitter (narrow range)	IC Outer Pools IC Cubicle Pools	Control IC Pool Water Level used to control shutoff addition of makeup demineralised water if pools are at maximum level and to shutoff pumps if water level is too low
Level Transmitter (wide range)	IC Cubicle Pools	Post-Accident Monitoring
Temperature Element	ICS Cubicle Pools	Control Temperature of ICS Cubicle Pools used to initiate ICC A2 operation
Temperature Element	Main Suction	Alarm and Monitoring Suction Temperature
Pressure Transmitter	Pump Suction	Alarm and Monitoring Suction Pressure
Pressure Differential Transmitter	Pump Suction	Alarm and Monitoring Pressure Drop across Suction Strainer
Orifice Plate	Pump Minimum Flow Loop	Reduce flow rate in Minimum Flow Loop when loop is active
Pressure Transmitter	Pump Discharge	Alarm and Monitoring Discharge Pressure
Flow Element (Orifice Plate) Pressure Differential Transmitter	Pump Discharge	Control Flow rate in A and Trains Pressure Drop across Flow Element used to control pump speed to adjust Flow Rates in A and B Trains
Temperature Element	HX Inlet	Alarm and Monitoring Temperature of PCW entering HX
Pressure Differential Transmitter	HX Inlet and Outlet	Alarm and Monitoring Pressure Drop across HX
Temperature Element	HX Outlet	Alarm and Monitoring / HX Condition Monitoring
Temperature Element	Main System Return	Control Temperature of HX effluent into Demineraliser
Conductivity Transmitter	Main System Return	Alarm and Monitoring Pre- and post-Demineraliser Conductivity of return fluid

Instrument	Location	Function
Pressure Differential Transmitter	Demineraliser Inlet and Outlet	Alarm and Monitoring Pressure Drop across Demineraliser
Flow Indicator	Dosing Pot	Monitoring (Visual) Flow rate exiting Dosing Pot
Flow Element (Orifice Plate) Pressure Differential Transmitter	Returns to Individual IC Cubicles	Alarm and Monitoring Flow Rate in Return Piping Pressure Drop across Flow Element
Moisture Switch	Return Guard Pipe	Alarm and Monitoring Leak detection
Pressure Transmitter	Makeup Water Line	Alarm and Monitoring Pressure of Makeup Demineralised Water
Flow Element (Orifice Plate) Pressure Differential Transmitter	Makeup Water Supply	Alarm and Monitoring Flow Rate on Makeup Demineralised Water Pressure Drop across Flow Element on Makeup Demineralised Water
Flow Indicator	Outer Pool Dosing Pot	Monitoring (Visual) Flow Rate exiting Dosing Pot
Flow Element (Orifice Plate) Pressure Differential Transmitter	Outer Pool Sparger Supply	Alarm and Monitoring Flow rate in Outer Pool Sparger Supply Pressure Drop across FE in Outer Pool Sparger Supply
Temperature Element	IC Outer Pools	Alarm and Monitoring Temperature of IC Outer Pools used to monitor thermal stratification
Pressure Transmitter	IC Cubicle Pools	Alarm and Monitoring Internal pressure of IC Cubicle Pool compartments
Valve Position Indicators		Alarm and Monitoring Valve Position Indication

Table 9A-14: Process Sampling Subsystem Interfaces

Interfacing System	Interface Description	Interface Boundary
Distributed Control and Information Systems	DCIS Non-Safety Class instrumentation communication	Instrumentation communicates with the SCN DCIS system
Control Rod Drive System	Process sampling for chemistry control	The isolation valve between the system and sample station
ICS Pool Cooling and Cleanup System	Process sampling for radiological analysis, chemistry control and demineraliser performance monitoring	The isolation valve between the system and sample station
Shut Down Cooling System	Process sampling for chemistry control	The isolation valve between the system and sample station
Reactor Water Cleanup System	Process sampling for radiological analysis and chemistry control	The isolation valve between the system and sample station
Fuel Pool Cooling and Cleanup System	Process sampling for radiological analysis and chemistry control	The isolation valve between the system and sample station
Liquid Waste Management System	Process sampling for radiological analysis and chemistry control	The isolation valve between the system and sample station
Solid Waste Management System	Process sampling for radiological analysis, chemistry control, and demineraliser performance monitoring	The isolation valve between the system and sample station
Condensate and Feedwater System	Process sampling for radiological analysis and chemistry control	The isolation valve between the system and sample station
Condensate Filters and Demineralisers System	Process sampling for radiological analysis and chemistry control	The isolation valve between the system and sample station
Main Condenser and Auxiliaries	Process sampling for radiological analysis and chemistry control	The isolation valve between the system and sample station
Plant Cooling Water System	Process sampling for chemistry control	Local grab sampling
Equipment and Floor Drain System	Process sampling for radiological analysis and chemistry control	Local grab sampling

Table 9A-15: Plant Pneumatics System Interfaces

Interfacing System	Interface Description	Interface Boundary
Nuclear Boiler System	PPS provides control and instrument air to AOVs and equipment/components as necessary.	NBS Equipment
Safety Class 1 Instrumentation and Controls System	Safety Class 1 Instrumentation and Controls System de-energises the CIVs solenoids which release the air inside the actuators.	PPS Equipment
Safety Class 2 Instrumentation and Controls Systems	Safety Class 2 Diverse Instrumentation and Controls System de-energises the CIVs solenoids which release the air inside the actuators.	PPS Equipment
Safety Class 3 Instrumentation and Controls Systems	Safety Class 3 Instrumentation and Controls Systems provide signals to SC3 instrumentation and controls in PPS.	PPS Equipment
Non- Safety Instrumentation and Control System	Receive/provide signals to non-safety category instrumentation and controls in PPS.	PPS Equipment
Process Radiation and Environmental Monitoring System	PPS provides control and instrument air to AOVs and equipment/components as necessary. Provides periodic sampling of breathing air quality and instrument air quality.	PREMS AOVs
Isolation Condenser System	PPS provides control and instrument air to AOVs and equipment/components as necessary. including ICS isolation accumulators.	ICS AOVs
Refueling and Servicing Equipment System (RES)	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At RES Equipment
Boron Injection System (BIS) (see 006N7417 “Boron Injection System,” Reference 9A-42)	PPS provides Service Air for periodic storage tank mixing through the in-tank air sparger.	At BIS Equipment
Control Rod Drive System/High Pressure Injection	PPS provides instrument air to the HCU scram valves, and CRD flow control AOVs and Alternate Rod Insertion valves.	CRD Equipment
Isolation Condenser System Pool Cooling and Cleanup System	PPS provides instrument air for ICC I&C components, AOVs, and DMIN to facilitate demineraliser resin conditioning and exchange evolutions.	ICC AOVs and DMIN

Interfacing System	Interface Description	Interface Boundary
Shut Down Cooling System	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At SDC Equipment
Reactor Water Cleanup System	PPS provides control and instrument air or nitrogen to AOVs.	At CUW AOVs
Fuel Pools Cooling and Cleanup	PPS provides control air for mixing of demineraliser resin and instrument-quality air for controlling the FPC AOVs.	At FPC AOVs and demineraliser resin tank
Liquid Waste Management System	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At LWM AOVs
Solid Waste Management System	PPS instrument air to AOVs and dewatering pumps.	At SWM AOVs and SWM dewatering pumps
Offgas System	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At OGS AOVs
Condensate and Feedwater Heating System	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At CFS AOVs
Condensate Filters and Demineralisers System	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At CFD AOVs
Main Turbine Equipment	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At MTE AOVs
Moisture Separator Reheater System (MSR)	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At MSR AOVs
Main Condenser and Auxiliaries	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At MCA AOVs
Circulating Water System	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At CWS AOVs
Chilled Water Equipment	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At CWE AOVs
Plant Cooling Water System	PPS provides control and instrument air to AOVs and equipment/components as necessary. PCW provides cooling water to the air compressors.	At PCW AOVs and compressor cooler isolation valves

Interfacing System	Interface Description	Interface Boundary
Hydrogen Water Chemistry	PPS provides control and instrument air to AOVs and equipment/components as necessary. The PPS also provides air supply for air injection to the OGS.	At Hydrogen Water Chemistry AOVs
Safety Class 2 and SC3 Electrical Distribution System	Safety Class 2 and SC3 Electrical Distribution System provides electrical power to PPS.	At PPS equipment
Primary Containment System	PPS provides CIVs on piping penetrating primary containment, and functions as an extension of the containment boundary.	At containment penetrations
Containment Inerting System	PPS provides control and instrument air to AOVs and equipment/components as necessary. CIS provides nitrogen to components inside of containment through the PPS.	At CIS AOVs
Fire Protection System (FPS)	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At FPS AOV
Equipment and Floor Drain System	PPS provides control and instrument air to AOVs and equipment/components as necessary.	At EFS AOVs
Reactor Building Structure	PPS provides hookups for pneumatic tools throughout the RBS.	At Building Structure
Turbine Building Structure (TBS)	PPS provides hookups for pneumatic tools throughout the TBS.	At Building Structure
Radwaste Building	PPS provides hookups for pneumatic tools throughout the RWB structure.	At Building Structure

Table 9A-16: BWRX-300 Operational Modes

Mode	Title	Reactor Mode Switch Position	CIS Modes
1	Power Operation	Run	Inerting, Make-Up, De-Inerting, or Idle
2	Startup	Refuel or Startup	Inerting, Make-up or Idle
3	Hot Shutdown	Shutdown	Make-Up, De-Inerting or Idle
4	Stable Shutdown	Shutdown	Make-Up, De-Inerting or Idle
5	Cold Shutdown	Shutdown	Make-Up, De-Inerting or Idle
6	Refueling	Shutdown or Refueling	De-Inerting or Idle

Table 9A-17: Containment Inerting System Interfaces

Interfacing System	Interface Description	Interface Boundary
Safety Class 2 and SC3 Instrumentation and Control System	The CIS provides instrument data to the SC2 and SC3 I&C System for system monitoring.	DCIS Instrument Cabinets
	The SC2 I&C System provides an actuation signal to the CIS containment isolation solenoid valves.	Outboard Supply Line CIV Inboard Supply Line CIV Inboard Exhaust Line CIV Outboard Exhaust Line CIV Overpressure Vent Line Isolation Valves
	The SC2 & SC3 I&C System provides a control signal to the CIS solenoid valves.	Nitrogen Supply Isolation Valve Fresh Air Supply Isolation Valve Primary Exhaust Line Control Valve Makeup Exhaust Line Control Valve
Safety Class 1 Instrumentation and Control System	The CIS provides instrument data to the SC1 I&C System for system monitoring.	DCIS Instrument Cabinets
	The Safety Class 1 I&C System provides an actuation signal to the CIS containment isolation solenoid valves.	Outboard Supply Line Containment Isolation Valve Inboard Supply Line Containment Isolation Valve Inboard Exhaust Line Containment Isolation Valve Outboard Exhaust Line Containment Isolation Valve Overpressure Vent Line Isolation Valves
Preferred Power System	The Preferred Power System provides power to the CIS Nitrogen Trim Heater	CIS Trim Heater
Reactor Building Structure	The CIS provides a containment overpressure relief path to the Equipment Pool of the Reactor Building Structure for a beyond design basis accident.	Containment Overpressure Vent Line Sparger
SCCV	The CIS penetrates the SCCV to support containment inerting, de-inerting, and makeup.	Supply Line Containment Mechanical Penetration Exhaust Line Containment Mechanical Penetration

Interfacing System	Interface Description	Interface Boundary
Heating Ventilation and Cooling System	The CIS exhausts containment air to the HVS to support containment inerting and de-inerting.	CIS Exhaust Line to HVS Building Exhaust Line downstream of Exhaust Line Control Valves
	The HVS supplies breathable air to the CIS to support containment de-inerting.	Fresh Air Supply Isolation Valve
Plant Pneumatics System	The Plant Pneumatics System supplies compressed air to the CIS to support actuation of pneumatically operated devices.	Nitrogen Supply Isolation Valve Fresh Air Supply Isolation Valve Primary Exhaust Line Control Valve Makeup Exhaust Line Control Valve Outboard Supply Line CIV Inboard Supply Line CIV Inboard Exhaust Line CIV Outboard Exhaust Line CIV Overpressure Vent Line Isolation Valves
	The CIS supplies nitrogen to the Plant Pneumatics System to support actuation of pneumatically operated valves located inside of containment.	PPS Supply Line Isolation Valve
Process Radiation and Environmental Monitoring System	The Process and Radiation Monitoring System provides inputs of containment pressure and oxygen concentration to support containment inerting and de-inerting. The Process Radiation and Monitoring pressure sensors need to be accurate enough to verify containment pressure is below the set limit	Containment Monitoring pressure sensors

Table 9A-18: Reactor Building Heating, Ventilation and Air Conditioning System Interfaces

Interfacing System	Interface Description	Interface Boundary
SC2 and SC3 I&C System	SC2 and SC3 I&C System provides SC2 control to the RB DCIS fancoil units and provides SC3 control to the RB Battery Room exhaust fans	SC2 Fancoil units
Non-Safety I&C Systems	The Non-Safety Instrumentation and Controls provides distributed control and instrumentation data communication networks	At the HVS equipment
Process Radiation and Environmental Monitoring System	The PREMS provides continuous radiation monitoring of the HVS	At the HVS equipment
Chilled Water Equipment	The CWE provides chilled water for cooling of the HVAC FCUs and AHUs	At the HVS equipment
SC1 Electrical Distribution System	The SC1 Electrical Distribution System provides electrical power to SCR emergency fans and electric duct heaters	At the HVS equipment and heaters
Non-Safety Electrical Distribution System	Non-Safety Electrical Distribution System provides Non-Safety Category electrical power to the HVS Non-Safety Category electrical loads	At the HVS equipment
Equipment and Floor Drain	Provides drains for condensation off AHU/Air Conditioning Unit cooling coils.	At the air handler or fan coil unit flange
SC1 I&C System	SC1 I&C System provides control to the SCR EFUs and associated dampers.	At the RB HVS equipment
SC2 & SC3 Electrical Distribution System	The SC2 and SC3 Electrical Distribution System provides electrical power to SDG Rooms HVS equipment, RB supply and exhaust isolation dampers, TB Supply and exhaust isolation dampers, CRE EFUs.	At the RB HVS equipment
Fire Protection System	Fire Protection System provides start/stop signals to RB HVS to shut down fans.	Fire Protection System contacts to be located within 1 m of the associated temperature control panel
Containment Inerting System	Containment Inerting System discharges containment inerting gases to the Continuous Exhaust Air Plenum /Plant Vent Stack during purging. RB HVS provides outside air supply to CIS for containment de-inerting	At the Containment Inerting System/RB HVS piping interface

Interfacing System	Interface Description	Interface Boundary
Main Control Room Panels	Main Control Room Panels provide the status, alarms, and indications in the control room that are required for system monitoring	At the RB HVS equipment

Table 9A-19: Control Building Heating, Ventilation and Air Conditioning System Interfaces

Interfacing System	Interface Description	Interface Boundary
SC2 and SC3 I&C System	SC2 and SC3 I&C System provides SC2 control to the CB main AHUs, MCR EFUs and MCR envelope dampers	SC2 Fancoil units
Non-Safety Instrumentation and Controls	The Non-Safety Instrumentation and Controls provides distributed control and instrumentation data communication networks.	At the CB HVS equipment
Process Radiation and Environmental Monitoring	The PREMS provides continuous radiation and toxic gas monitoring of the HVS.	At the CB HVS equipment
Chilled Water Equipment	The CWE provides chilled water inside coils for cooling of the HVAC FCUs and AHUs.	At the CB HVS equipment
SC2 & SC3 Electrical Distribution System	The SC2 and SC3 Electrical Distribution System provides electrical power to SDG Rooms HVS equipment, RB supply and exhaust isolation dampers, TB Supply and exhaust isolation dampers, CRE EFUs.	At the CB HVS equipment
Non-Safety Electrical Distribution System	The Non-Safety Electrical Distribution System provides Non-Safety Category electrical power to the HVS Non-Safety Category electrical loads.	At the CB HVS equipment
Water Gas and Chemical Pads	Provides clean water supply used for space humidification if needed. CB AHU & FCU condensate will be collected in drains.	At the CB HVS equipment
Main Control Room Panels	Main Control Room Panels provide the status, alarms, and indications in the control room that are required for system monitoring.	At the CB HVS equipment

Table 9A-20: Radwaste Building Heating, Ventilation and Air Conditioning System Interfaces

Interfacing System	Interface Description	Interface Boundary
Non-Safety Instrumentation and Controls	The Non-Safety Instrumentation and Controls provides distributed control and instrumentation data communication networks.	At the HVS equipment
Process Radiation and Environmental Monitoring	The PREMS provides continuous radiation monitoring of the RWB HVS.	At the HVS equipment
Chilled Water Equipment	The CWE provides chilled water inside coils for cooling of the HVAC FCUs and AHUs.	At the HVS equipment
Non-Safety Electrical Distribution System	The Non-Safety Electrical Distribution System provides Non-Safety Category electrical power to the RWB HVS Non-Safety Category electrical loads.	At the HVS equipment
Equipment and Floor Drain	Provides drains for condensation off AHU/Air Conditioning cooling coils.	At the air handler or fan coil unit flange
Fire Protection System	Fire Protection System provides start/stop signals to RWB HVS to shut down fans.	Fire Protection System contacts to be located within 1 m of the associated temperature control panel
Main Control Room Panels	Main Control Room Panels provide the status, alarms, and indications in the control room that are required for system monitoring.	At the RWB HVS equipment

Table 9A-21: Turbine Building Heating, Ventilation and Air Conditioning System Interfaces

Interfacing System	Interface Description	Interface Boundary
Non-Safety Instrumentation and Controls	Non-Safety Instrumentation and Controls provides distributed control and instrumentation data communication networks.	At the HVS equipment
Process Radiation and Environmental Monitoring	The PREMS provides continuous radiation monitoring of the HVS.	At the HVS equipment
Chilled Water Equipment	The CWE provides chilled water inside coils for cooling of the HVAC FCUs.	At the HVS equipment
Non-Safety Electrical Distribution System	Non-Safety Electrical Distribution System provides Non-Safety Category electrical power to the TB HVS Non-Safety Category electrical loads.	At the equipment
Equipment and Floor Drain	Provides drains for condensation off AHU/Air Conditioning cooling coils.	At the air handler or fan coil unit flange
SC2 & SC3 I&C Systems	Provides SC3 control to RB supply and exhaust isolation dampers, TB supply and exhaust dampers, and CRE EFUs.	At the TB HVS equipment
SC2 & SC3 Electrical Distribution System	The SC2 and SC3 Electrical Distribution System provides electrical power to SDG Rooms HVS equipment, RB supply and exhaust isolation dampers, TB Supply and exhaust isolation dampers, CRE EFUs.	At the TB HVS equipment
Fire Protection System	Fire Protection System provides start/stop signals to TB HVS to shut down fans.	Fire Protection System contacts to be located within 1 m of the associated temperature control panel
Main Control Room Panels	Main Control Room Panels provide the status, alarms, and indications in the control room that are required for system monitoring.	At the TB HVS equipment

Table 9A-22: Containment Cooling System Interfaces

Interfacing System	Interface Description	Interface Boundary
SC 3 I&C System	Provides all SC3 I&C control, logics, and instrumentation (pressure, flow, temperature), etc.	AHUs and instruments
Chilled Water Equipment System	CCS transfers heat to the CWE	Cooling Coils flanges
SC2 and SC3 Electrical Distribution System	Provides power to AHUs	AHUs
Steel-plate Composite Containment Vessel	Contains environment provided by CCS, thereby ensuring that the environmental qualification limits of the Safety Category function related equipment inside of the SCCV are not exceeded	Safety Category function related equipment
Equipment and Floor Drain System	The condensate collected from the AHUs drain pans is routed to the EFS sump located outside of the containment	Drainpipe

Table 9A-23: Applicable BWRX-300 Fire Protection Design Codes and Standards and Key Documents

Item	Applicable Codes, Standards, and Regulatory Guidance
1	American Society of Mechanical Engineers, ASME B31.1, “Power Piping,” ASME Code for Pressure Piping, ASME B31.1, 2022
2	National Fire Protection Association, NFPA 10, Standard for Portable Fire Extinguishers, Quincy, MA, 2018
3	National Fire Protection Association, NFPA 13, Standard for the Installation of Sprinkler Systems, 2022 Edition, Quincy, MA, 2019
4	National Fire Protection Association, NFPA 14, Standard for the Installation of Standpipe and Hose Systems, Quincy, MA, 2024
5	National Fire Protection Association, NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection, 2022 Edition, Quincy, MA, 2022
6	National Fire Protection Association, NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection, Quincy, MA, 2022
7	National Fire Protection Association, NFPA 22, Standard for Water Tanks for Private Fire Protection, Quincy, MA, 2023
8	National Fire Protection Association, NFPA 24, Standard for Installation of Private Fire Service Mains and Their Appurtenances, Quincy, MA, 2022
9	National Fire Protection Association, NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, Quincy, MA, 2023
10	National Fire Protection Association, NFPA 72, National Fire Alarm and Signalling Code, Quincy, MA, 2022
11	National Fire Protection Association, NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems, Quincy, MA, 2024
12	National Fire Protection Association, NFPA 92, Standard for Smoke Control Systems, Quincy, MA, 2024
13	National Fire Protection Association, NFPA 804, Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants, 2020 Edition, Quincy, MA
14	Nuclear Energy Institute (NEI) 00-01, Guidance for Post Fire Safe Shutdown Circuit Analysis, Revision 3, October 2011
15	Regulatory Guide 1.189 – Fire Protection for Nuclear Power Plants, Revision 4, May 2021

Notes:

1. An Alternate Method may be taken to NFPA 804 Section 9.4.11 regarding standpipe water supply. Seismically qualified water supplies to standpipes in areas containing seismically qualified SSCs are not provided. The request and basis for this Alternate Method is to be provided to all regulatory authorities where required, however this is not considered to be an issue in the UK.
2. There is a Codes and Standards FAP item that a future review against the requirements of the UK building regulations and British Standards will be performed in a future licensing phase.
3. In addition to the Codes and Standards and Regulatory guidance documents listed above, there will also be applicable country-specific documents.

Table 9A-24: Fire Protection System Interfaces

Interface	Interface Description	Interface Boundary
Instrumentation and Control System	The FPS Main Fire Alarm Panel (MFAP) in the MCR includes three pairs of hard contacts to output discrete signals to the DCIS: Fire Alarm Signal – Alarm Fire Alarm Signal – Supervisory Fire Alarm Signal – Trouble	At MFAP in MCR.
Instrumentation and Control System	The FPS MFAP in the MCR includes redundant ethernet connections to the DCIS to allow FPS data to be sent to the plant historian.	At MFAP in MCR.
Preferred Power System	The Preferred Power System provides power to FPS loads.	At the location of each fire alarm panel and subpanel.
Cranes, Hoists and Elevators	The FPS provides for elevator emergency functions, i.e., smoke detectors installed in elevator lobbies for auto return.	At the elevator car enclosure
Heating, Ventilation and Cooling System	The FPS provides smoke detection signals to HVS to trigger various actions by the HVS system	Smoke detectors and fire alarm monitoring of smoke detectors are under HVS scope. Locations of duct detectors, fan shutdown or other HVS functions associated with detectors are FPS scope.
Control Rooms	The Control Rooms provide a dedicated space for FPS MFAP and manual fire extinguishers. FPS provides Control Rooms with early fire detection, notification, and suppression of fire, and manual fire extinguishers.	MFAP and fire extinguisher space reservation in MCR.
Fuel Pool Cooling and Cleanup System	FPS is an alternate coolant inventory and connection point for off-normal FLEX/EME conditions.	At first isolation valve at each connection point.
Plant Pneumatics System	Plant Pneumatics System provides dry compressed air to FPS dry-pipe and preaction suppression systems components as necessary.	At air maintenance devices located at each FPS deluge valve.
Freeze and Cathodic Protection System	Freeze and Cathodic Protection System provides EHT Cable that is installed on FPS piping and equipment requiring freeze protection.	Freeze and Cathodic Protection System EHT cables and FPS piping and equipment.

Interface	Interface Description	Interface Boundary
Equipment and Floor Drain System	EFS collects FPS fire protection water during FPS testing and actuation.	No interconnection
FPS (Yard)	FPS (Yard) provides the required water supply to FPS Standard Plant components. FPS (Yard) to supply {13,285 L/min at 8.76 bar (127 psi)} for the most demanding fire suppression system and {4732 L/min at 10.14 bar (147 psi)} for the most demanding standpipe system.	At flanged connection in discharge piping outside the fire pump enclosure.

Table 9A-25: Cranes, Hoists, and Elevators Components

Principal Components	Safety Class	Building	Seismic Category[(1)]
RB Polar Crane – Main Hook	SCN	RB	2
RB Polar Crane – Auxiliary Hook	SCN	RB	2
Jib Crane	SCN	RB	2
Monorails	SCN	RB	2
Elevator	SCN	RB	2
Overhead Bridge Crane Main Hook	SCN	TB	Non-Seismic
Overhead Bridge Crane Auxiliary Hook	SCN	TB	Non-Seismic
Diesel Generator Monorails	SCN	TB	Non-Seismic
Jib Crane	SCN	TB	Non-Seismic
Monorail - Battery Room	SCN	TB	Non-Seismic
Overhead Bridge Crane Hot Machine Shop	SCN	TB	Non-Seismic
Elevator	SCN	TB	Non-Seismic
Monorail - Condenser	SCN	TB	Non-Seismic
Monorail – Filters	SCN	RWB	Non-Seismic
Elevator	SCN	RWB	Non-Seismic
Monorail - Battery Room	SCN	CB	Non-Seismic

Note:

1) Refer to PSR Ch. 3, Section 3.2.3 for information pertaining to seismic classification.

Table 9A-26: Cranes, Hoists and Elevators System Interfaces

Interfacing System	Interface Description	Interface Boundary
Non-Safety Electrical Distribution System	Non-Safety Electrical Distribution System provides power	Crane bridge or Elevator control panel
	The Turbine Building Overhead crane and the Reactor Building Polar Crane are supplied with an A or B train electrical power transfer switch	Crane bridge
	Communications to elevators	Elevator car enclosure
Reactor Building Structure	The Reactor Building provides shelter and structural support to the components of the Cranes, Hoists and Elevators System	Runway for crane or monorail, Elevator supporting steel or concrete structure
Turbine Building Structure	The Turbine Building provides shelter and structural support to the components of the Cranes, Hoists and Elevators System	Runway for crane or monorail, Elevator supporting steel or concrete structure
Control Building Structure	The Control Building provides shelter and structural support to the components of the Cranes, Hoists and Elevators System	Runway for monorail
Radwaste Building Structure	The Radwaste Building provides shelter and structural support to the components of the Cranes, Hoists and Elevators System	Runway for monorail, Elevator supporting steel or concrete structure
Fire Protection System	The Fire Protection System provides for elevator emergency functions, i.e., smoke detectors installed in elevator lobbies for auto return	Elevator car enclosure

Table 9A-27: Equipment and Floor Drain System Interfaces

Interfacing System	Interface Description	Interface Boundary
Nuclear Boiler System	EFS provides a drain path from the NBS to the EFS sumps. EFS containment sump is the quench tank for the NBS head vent discharge.	Floor Drain
Safety Class 1 Instrumentation and Control System	Provides all Safety Class 1 I&C control (Containment Isolation Valves).	Primary Containment Isolation Valves
Safety Class 3 Instrumentation and Control System	Receive/provide signals from/to instrumentation and controls in the EFS.	Instruments
Non-Safety Class Instrumentation and Control System	Receive/provide signals from/to the Non-Safety Class I&C control in the PPS.	Valve solenoids and instruments
Process Radiation and Environmental Monitoring System	Provides sampling for EFS sumps and radiation monitoring for the PPS condensate tank. EFS containment sump level transmitters provide signal/information for containment leak detection and monitoring.	Sampling locations
Control Rod Drive System	Provides drain piping for CRD pumps and the Hydraulic Control Unit room.	Floor Drain
Isolation Condenser System Pool Cleaning and Cleanup System	EFS provides a drain path from the ICC to the EFS sumps	Floor Drain
Shutdown Cooling System	EFS provides a drain path from the SDC to the EFS sumps	Floor Drain
Water Cleanup System	EFS provides a drain path from the CUW to the EFS sumps	Floor Drain
Fuel Pool Cooling and Cleanup System	EFS provides a drain path from the FPC to the EFS sumps	Floor Drain
Liquid Waste Management System	General sump pumps discharge effluent to LWM for processing (LWM collection tank). LWM provides seal water and flushing water for sumps.	Collection Tank

Interfacing System	Interface Description	Interface Boundary
Solid Waste Management System	Oily waste is collected and transferred to SWM drum evaporator for dewatering and disposal. EFS collects liquid waste from SWM.	Drum Evaporator
Condensate and Feedwater Heating System	Provides drain piping from CFS to EFS.	Floor Drain
Condensate Filters and Demineralisers System	Provides drain piping from CFD to EFS.	Floor Drain
Main Turbine Equipment	Provides drain piping from MTE to EFS.	Floor Drain
Moisture Separator Reheater System	Provides drain piping from MSR to EFS.	Floor Drain
Main Condenser and Auxiliaries System	Provides drain piping from MCA to EFS.	Floor Drain
Chilled Water Equipment	Provides drain piping from CWE to EFS. Provides drain path from chiller PRVs inside containment to a dedicated glycol storage tank.	Floor Drain
Plant Cooling Water	Dedicated clean sump for PCW system. The PCW dedicated sump discharges the collected water back to the makeup water surge tank.	Floor Drain
Plant Pneumatics System	Dedicated above ground storage tank for PPS condensate. PPS provides air to EFS Air Operated Valves.	PPS Tank/Air Operated Valves
Standby Power System - Safety Class 2 and SC3 Electrical Distribution System	EFS provides diesel generator oil catching from Standby Power System diesel generators. Standby Power System provides Safety Class 3 low voltage power to EFS pump motors and instrumentation.	Oily Waste Sump Pump motors and Instrumentation
Primary Containment Vessel System	EFS provides piping that penetrates the SCCV to drain containment, as well as a drain path from the PCCS to a general sump.	Primary containment wall penetration and EFS piping embedded in containment floor

Interfacing System	Interface Description	Interface Boundary
Heating Ventilation and Cooling System	The collection sumps are vented to Heating, Ventilation and Air Conditioning ductwork. EFS provides a drain path for the condensation off AHU and FCU cooling coils.	Sump vent duct
Fire Protection System	EFS collects FPS water.	Collection Sumps
Reactor Building Structure	EFS Sump and drain piping embedded in RBS.	Reactor Building structure and floor
Turbine Building Structure	EFS Sump and drain piping embedded in TBS concrete floor.	Sump pit
Radwaste Building Structure	EFS Sump and drain piping embedded in RWS concrete floor.	Slab on grade concrete floor
Yard/Balance of Plant	EFS discharges verified clean water to the yard storm water drain.	Yard

Table 9A-28: Demineralised Water Storage and Distribution System Interfaces

Interfacing System	Interface Description	Interface Boundary
Non-Safety Instrumentation and Control System	Provides all SCN Instrumentation and Control for the demineralised water equipment, potable water, sewage treatment, and hydrogen subsystems	Non-Safety Class Instruments
Non-Safety Electrical Distribution System	Provides power to demineralised water transfer pumps and tank/piping heating	SCN Pumps and heater, and controls
Process Radiation and Environmental Monitoring System	Provides demineralised water to Process and Radiation Monitoring for process sampling	Sampling points and RWB chemical Laboratory
ICS Pool Cooling and Cleanup System	Provides Demineralised water to the IC pools through the ICS Cooling and Cleanup system	Interface valve
Boron Injection System	Provides demineralised water to the Boron Injection Sodium Pentaborate Storage Tank for filling	Interface valve
Plant Cooling Water System	Provides demineralised water to the surge tanks	Interface valve
Chilled Water Equipment System	Provides demineralised water to the glycol auto fill unit	Interface valve
Heating, Ventilation and Cooling System	Provides demineralised water to CB AHUs used for space humidification	AHUs
Liquid Waste Management System	Provides demineralised water to the Condensate storage tank	Interface valve
Refueling Equipment and Servicing	Provides demineralised water connections on the refueling floor for use during outages	Interface valve
Main Condenser and Auxiliaries	Provides fill and makeup water to the condenser vacuum skids for seal water separators	Interface valve
Demineralised Water System	System is supplied demineralised water from the Demineralised Water System	Yard demineralised water tie-point connection

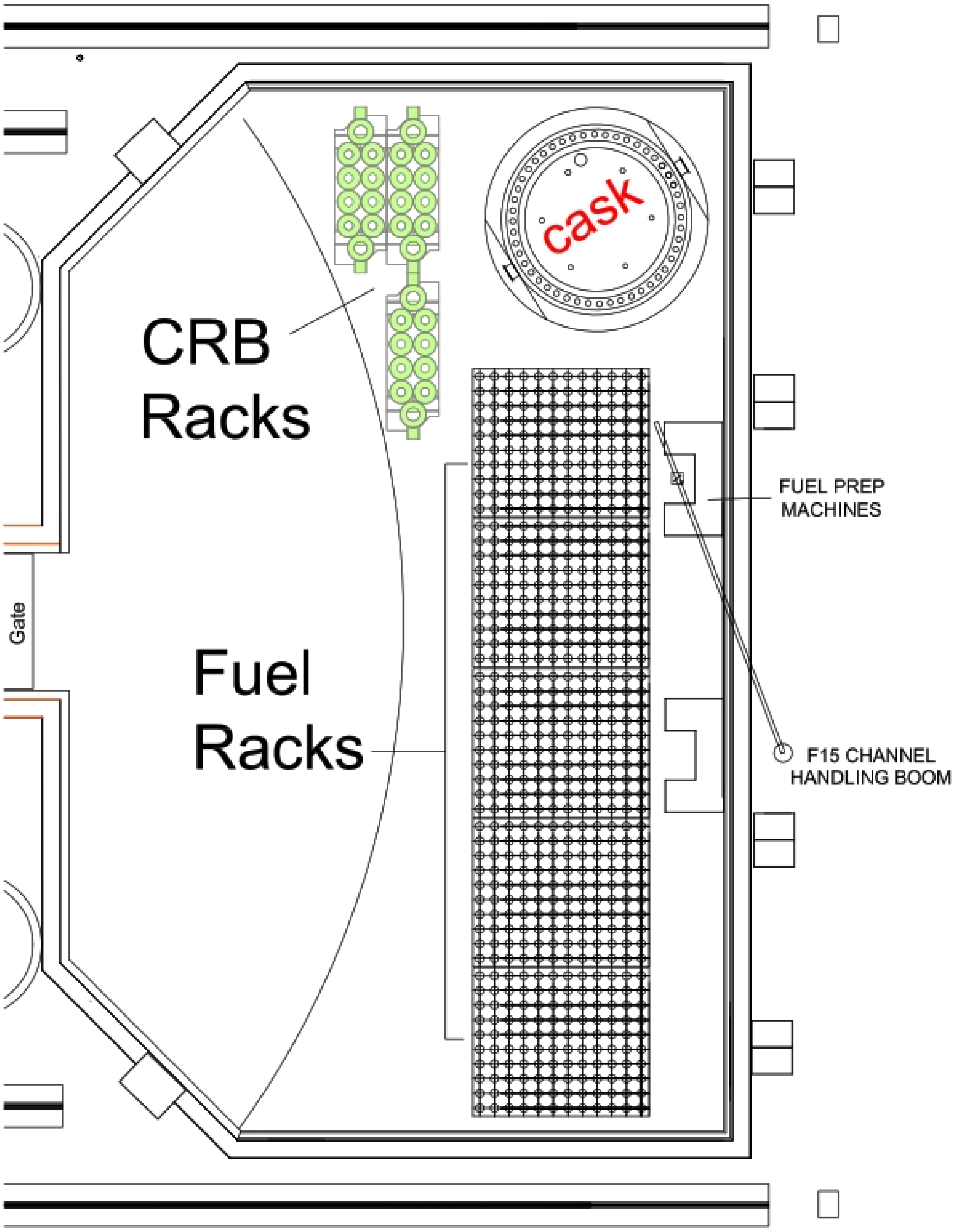


Figure 9A-1: Fuel Pool Arrangement

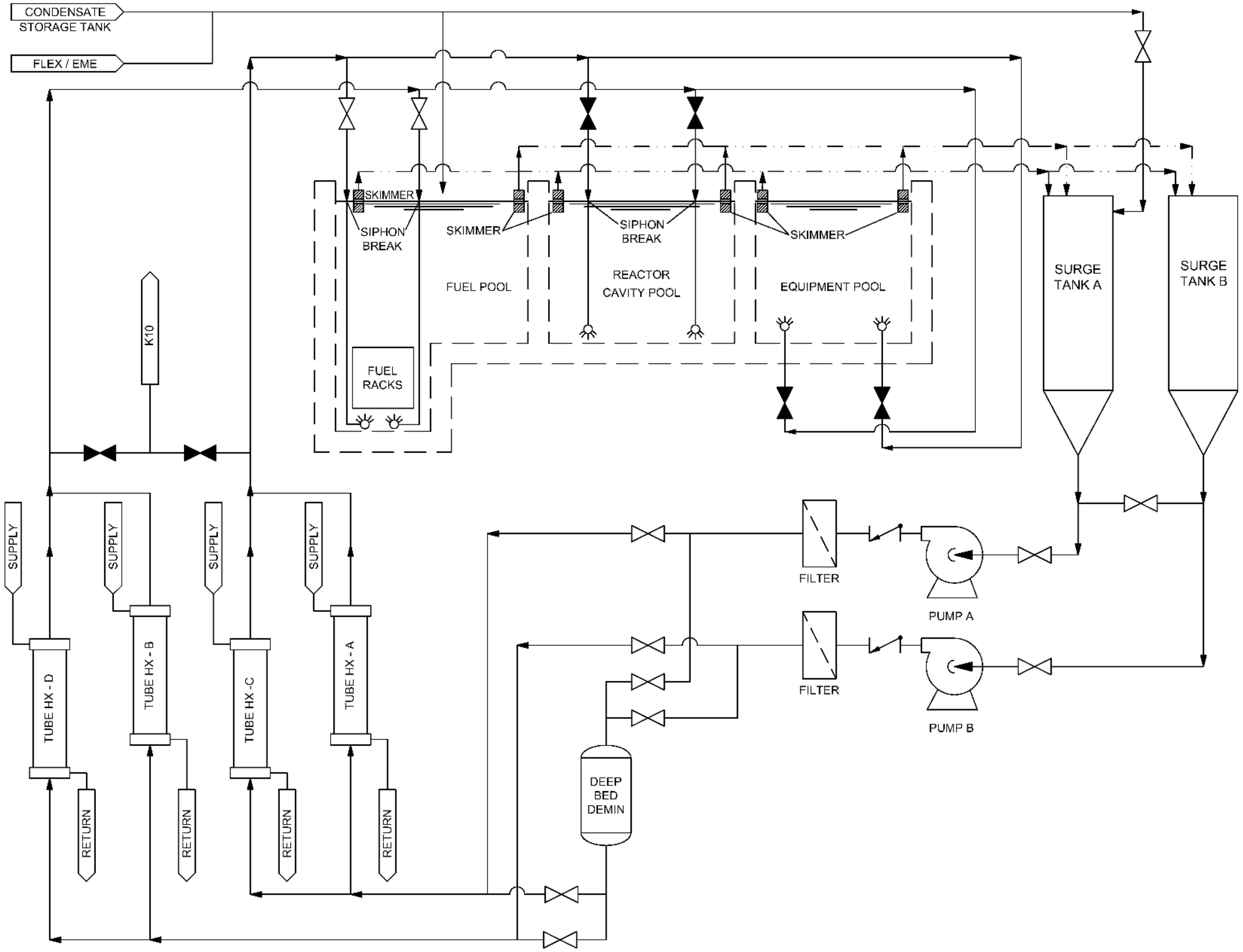


Figure 9A-2: Fuel Pool Cooling and Cleanup System

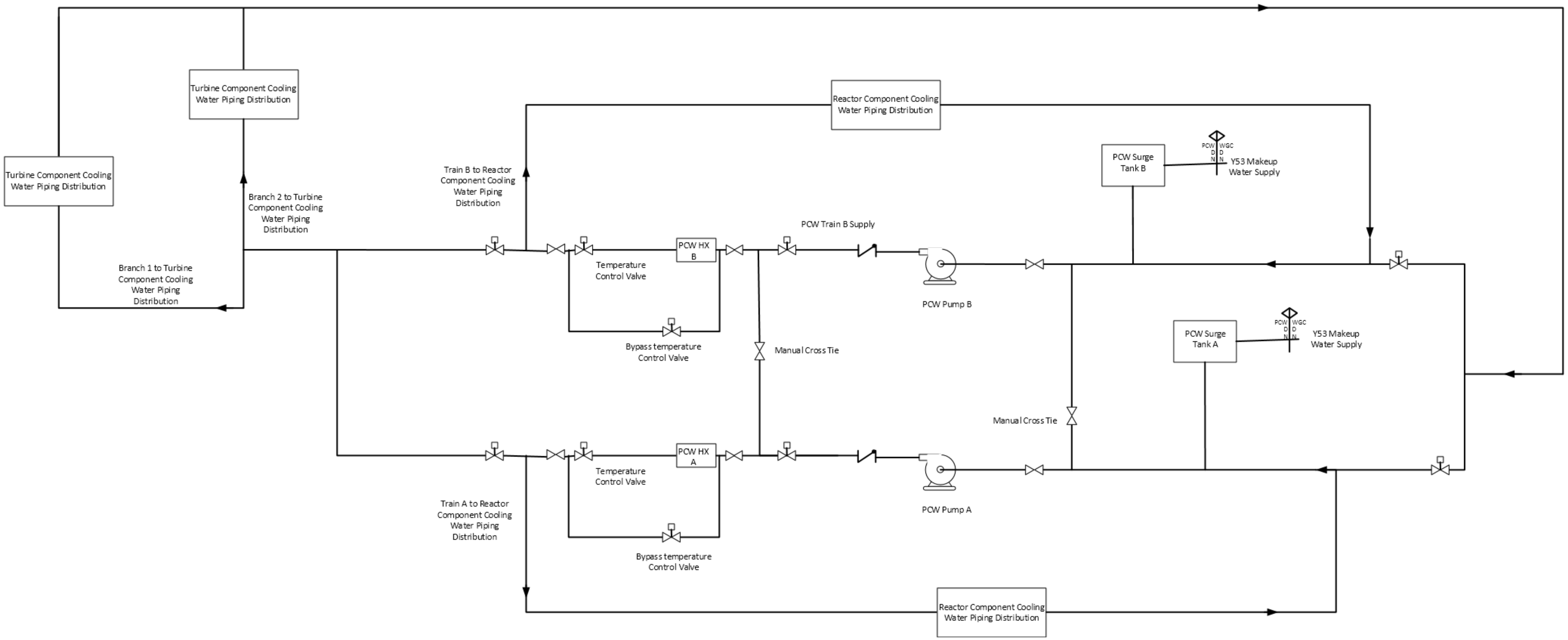
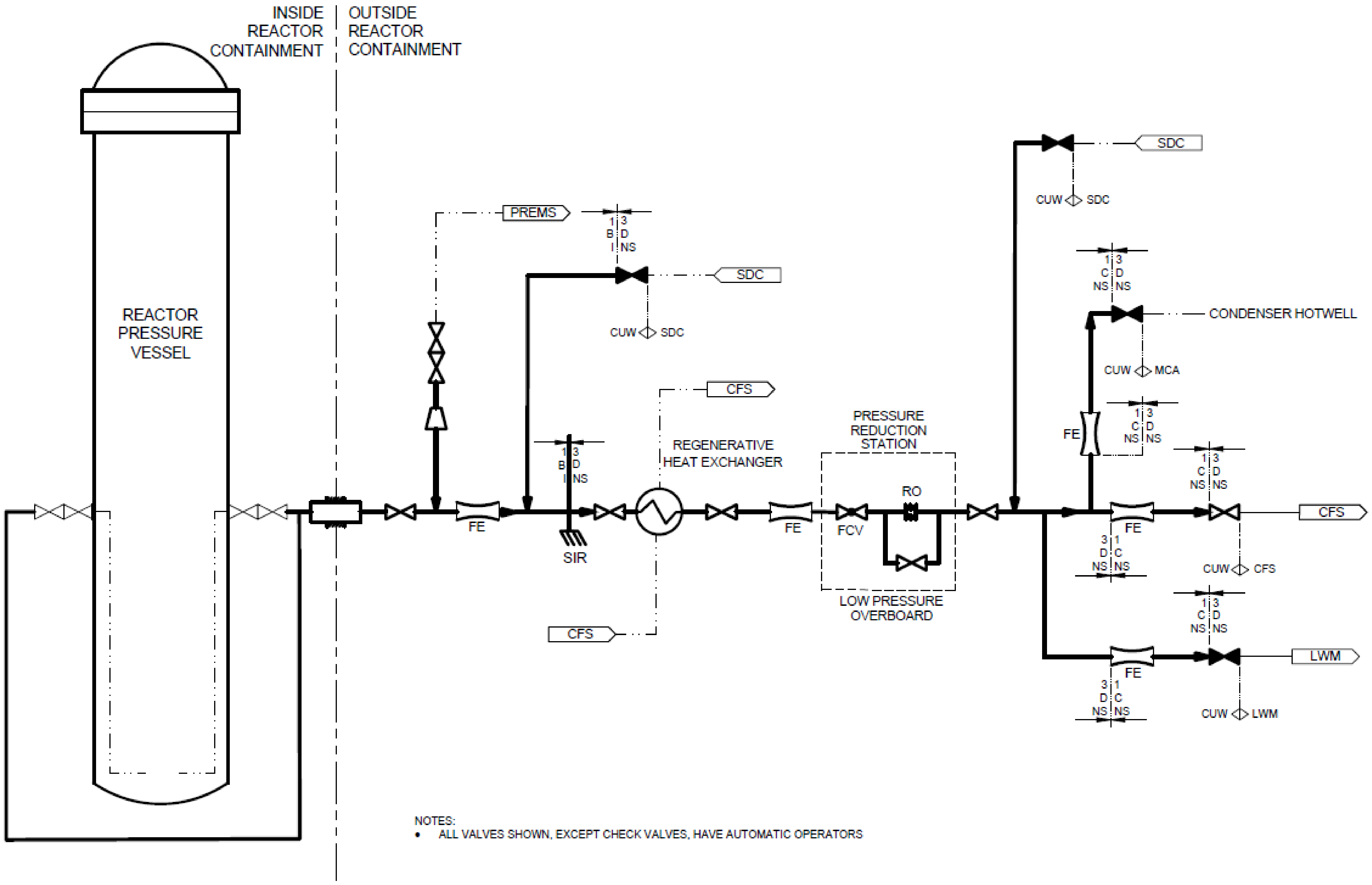


Figure 9A-3: Plant Cooling Water



NOTES:
- ALL VALVES SHOWN, EXCEPT CHECK VALVES, HAVE AUTOMATIC OPERATORS

Figure 9A-4: Reactor Water Cleanup System

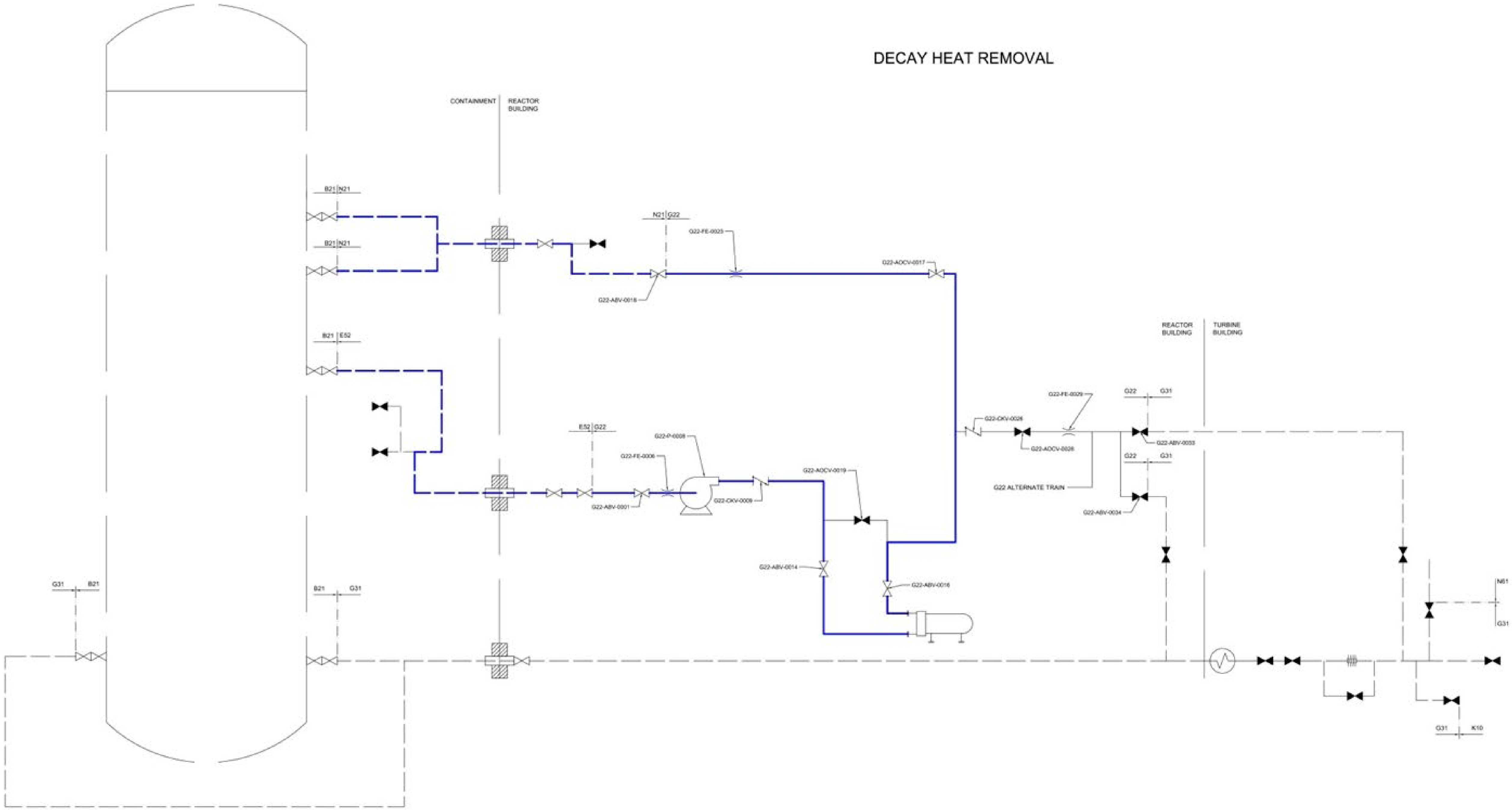


Figure 9A-5: Decay Heat Removal Subsystem

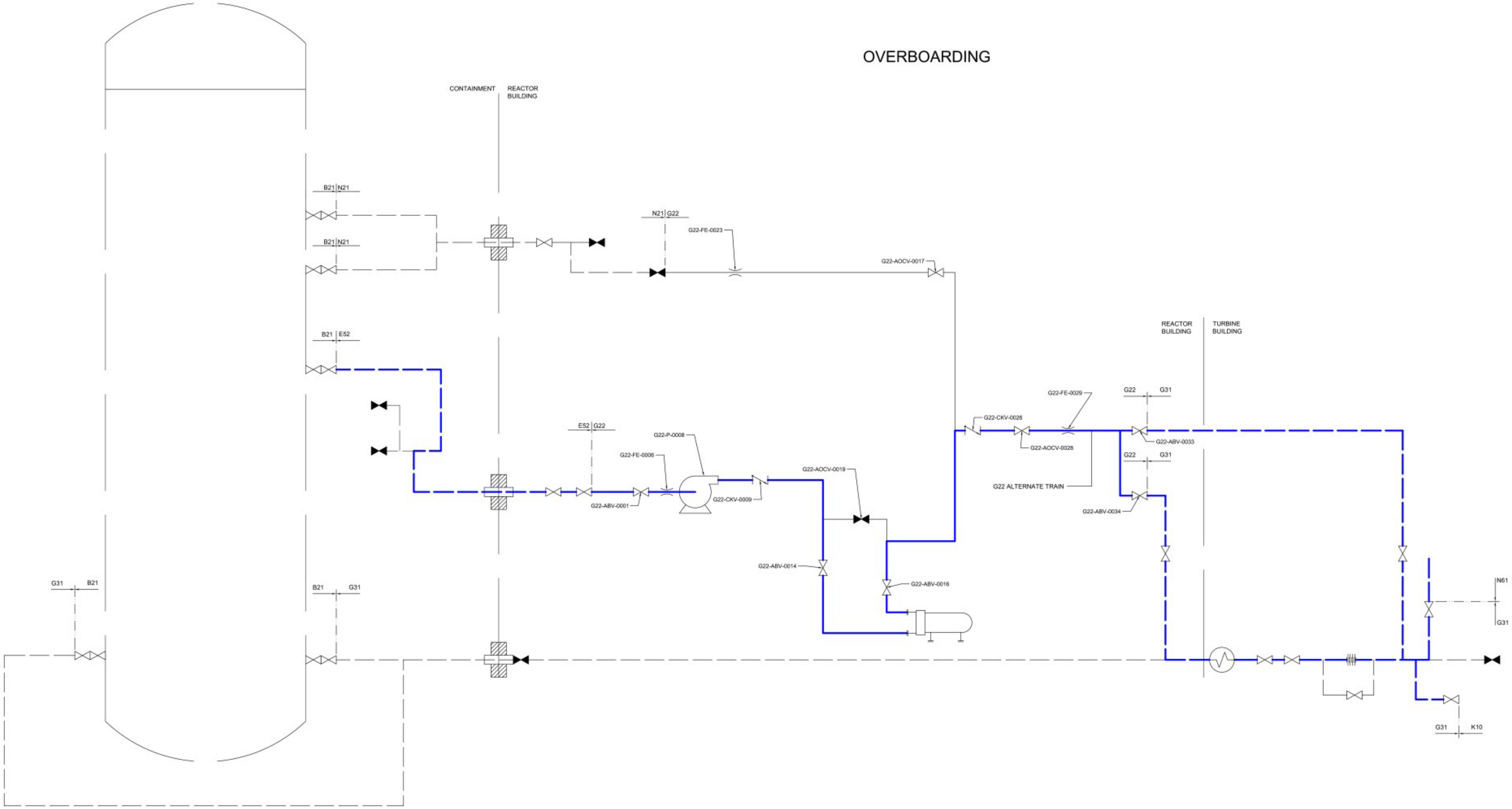


Figure 9A-6: Overboard Subsystem

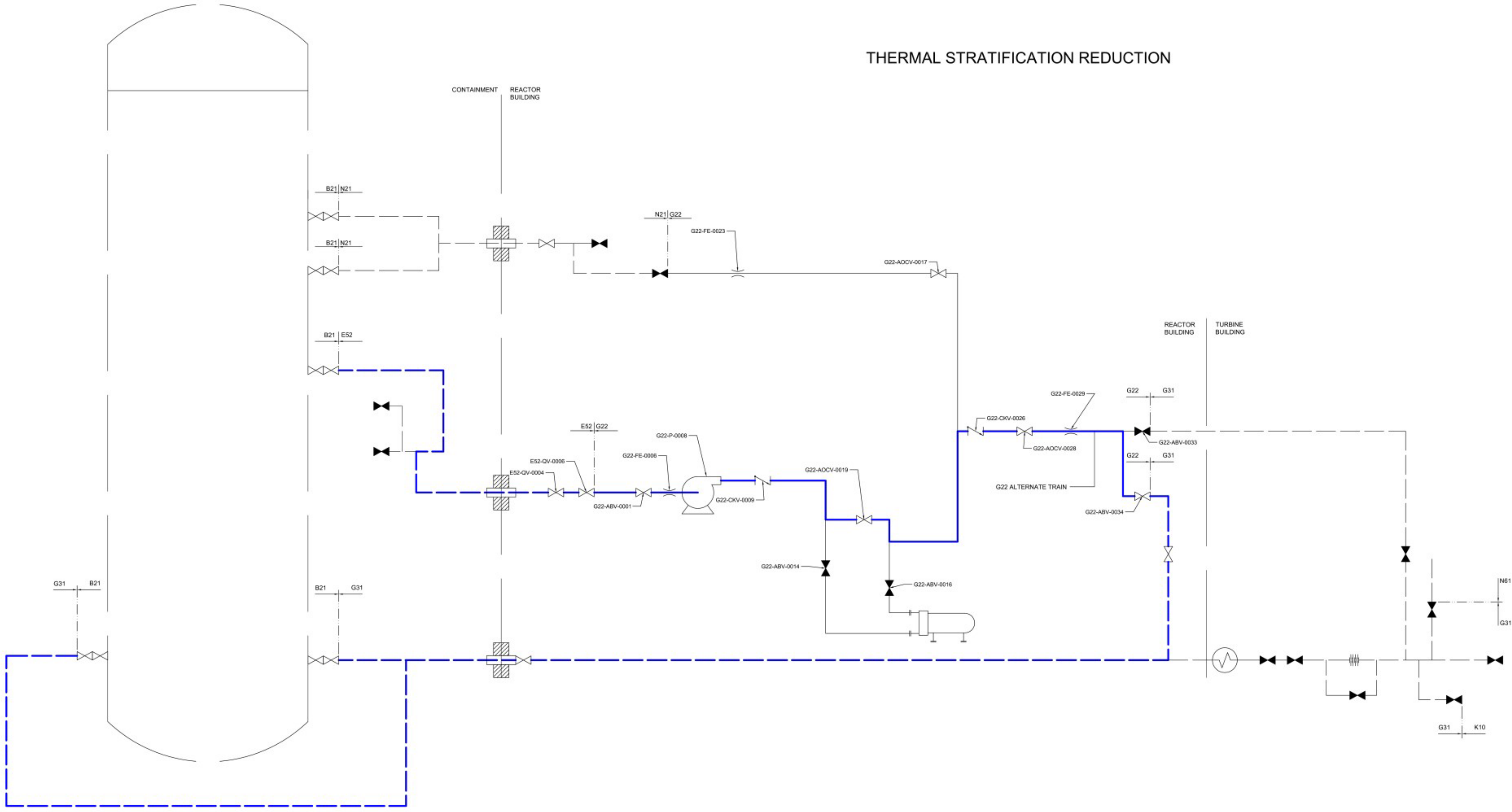


Figure 9A-7: Thermal Stratification Reduction Subsystem

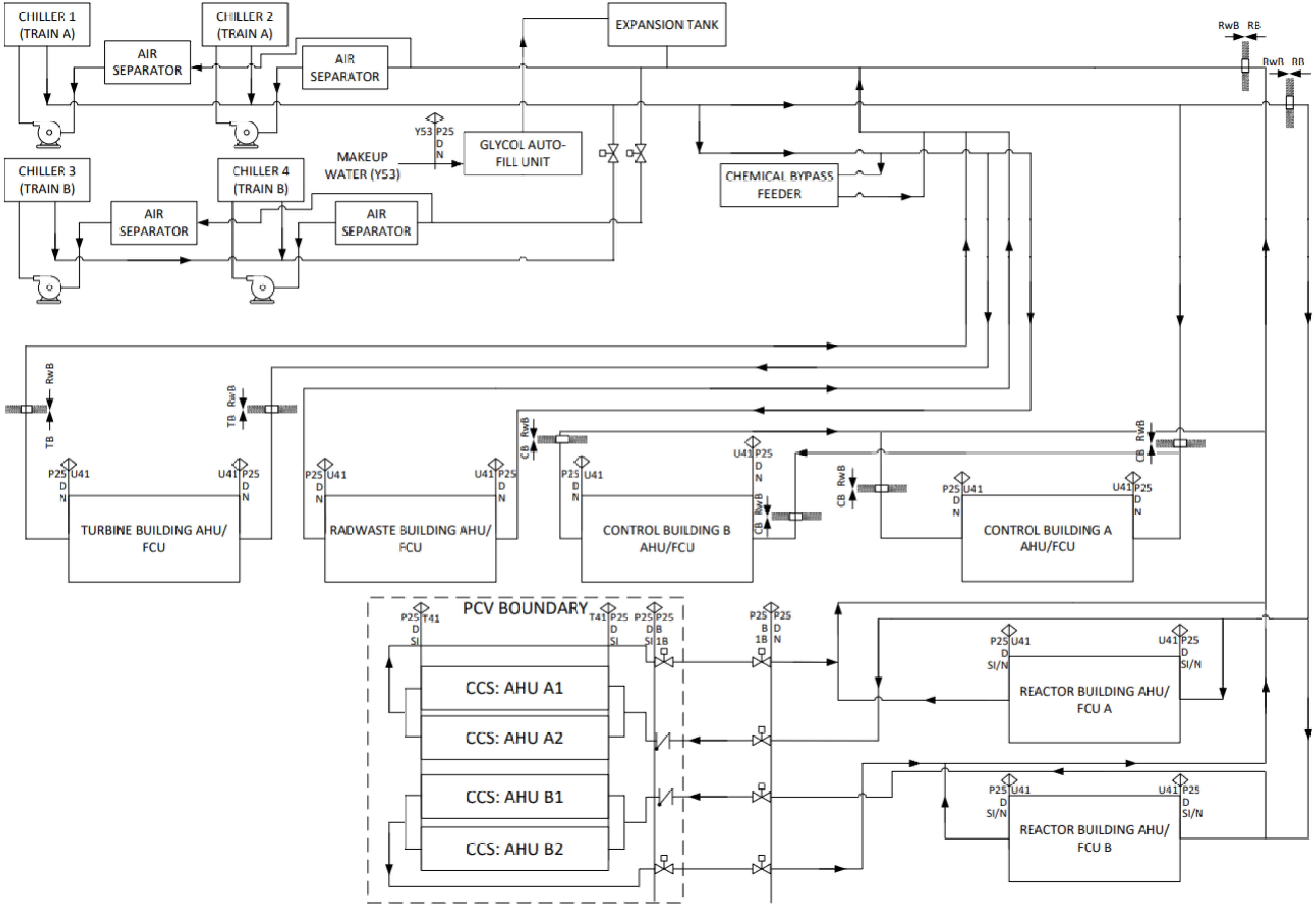


Figure 9A-8: Chilled Water Equipment

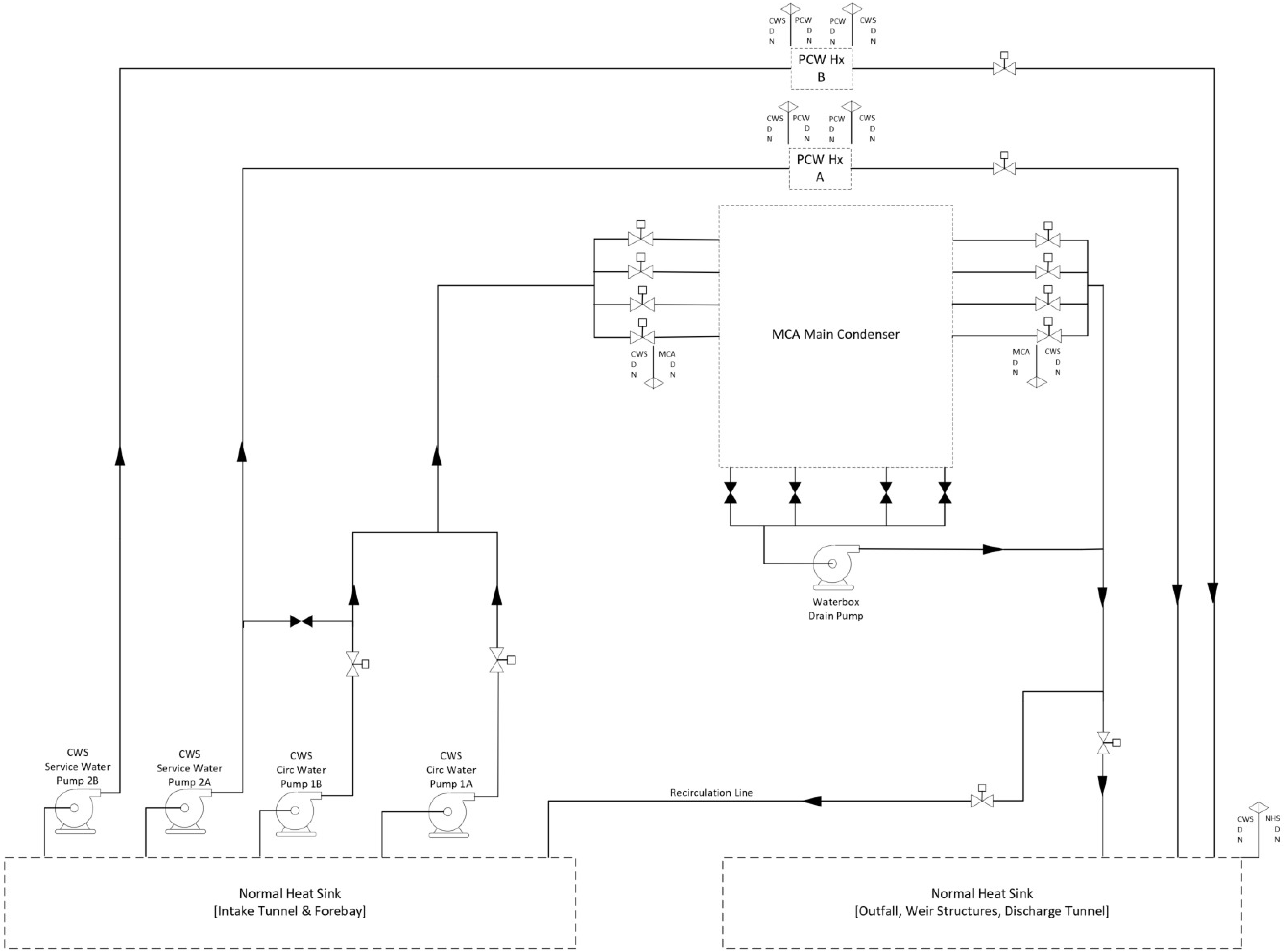


Figure 9A-9: CWS Simplified Single Line Diagram

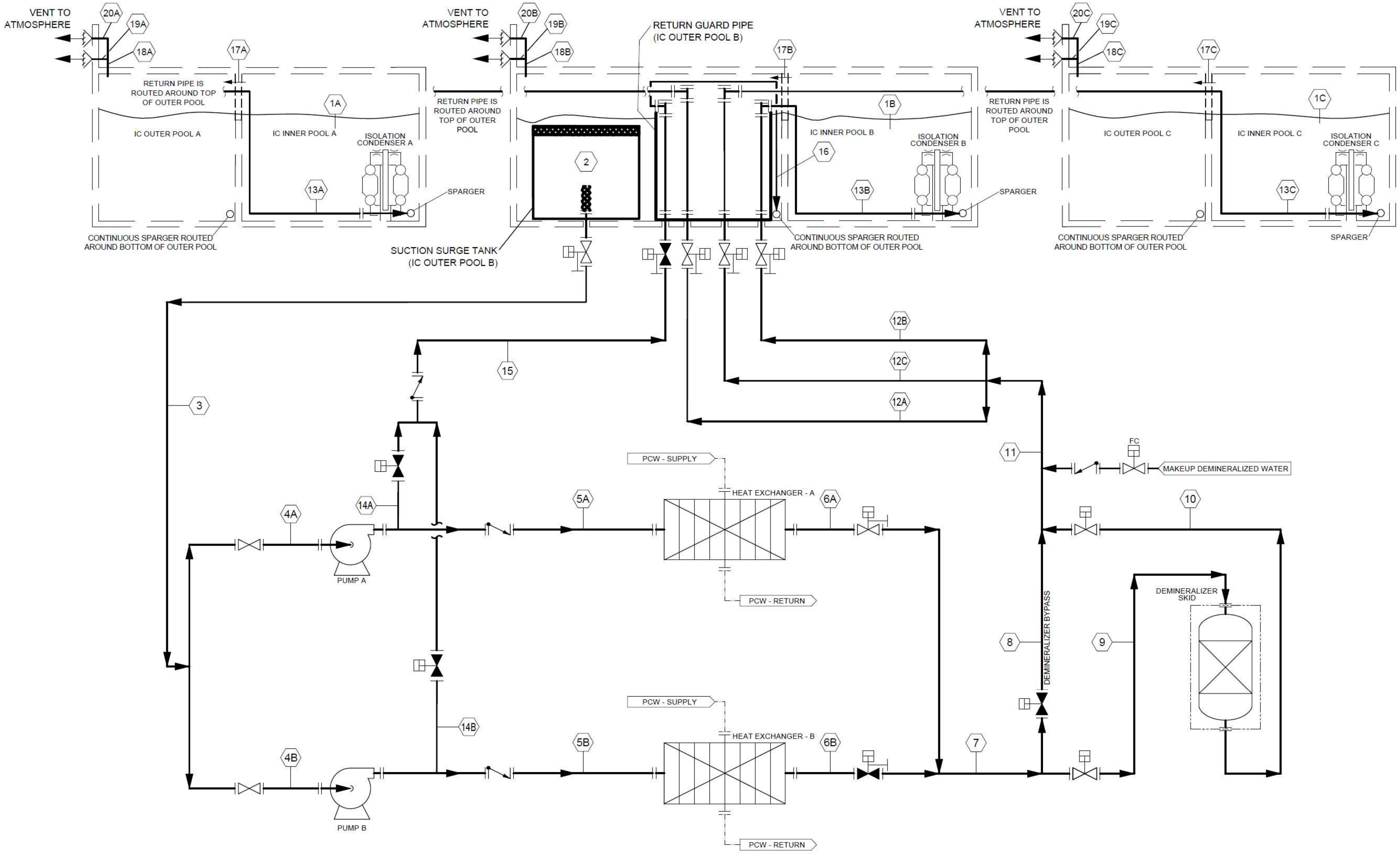


Figure 9A-10: Isolation Condenser System Pool Cooling and Cleanup System

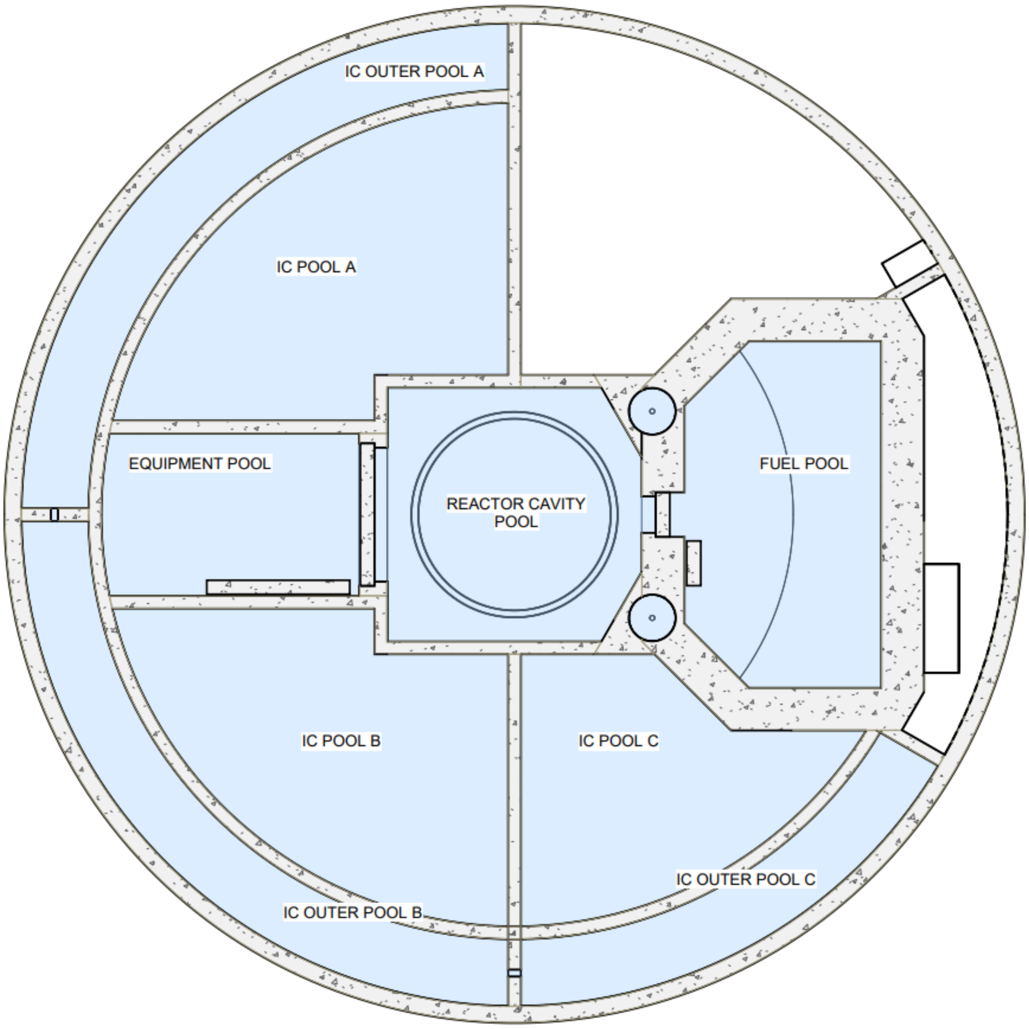


Figure 9A-11: Ultimate Heat Sink Pools Simplified Diagram

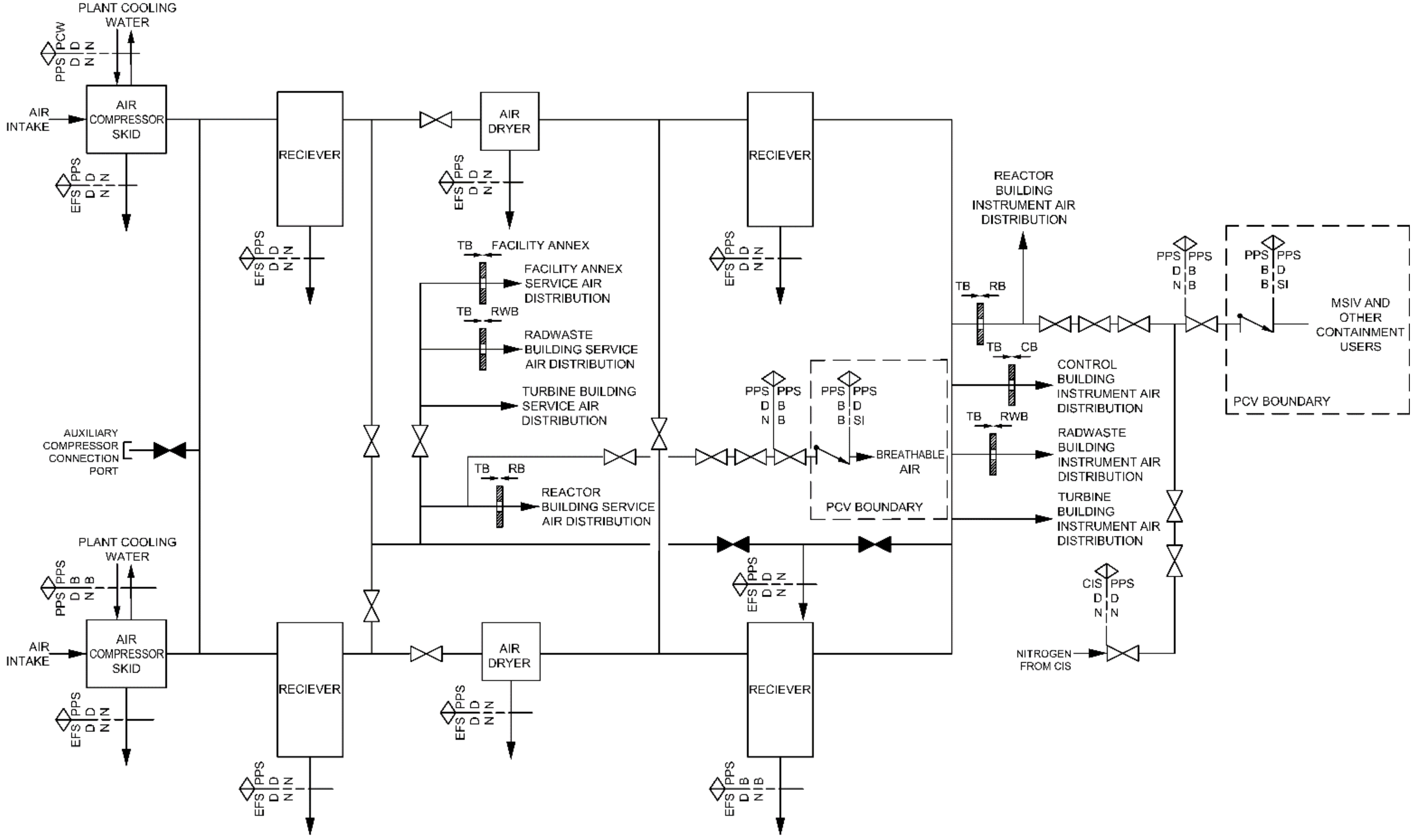


Figure 9A-12: Plant Pneumatic System

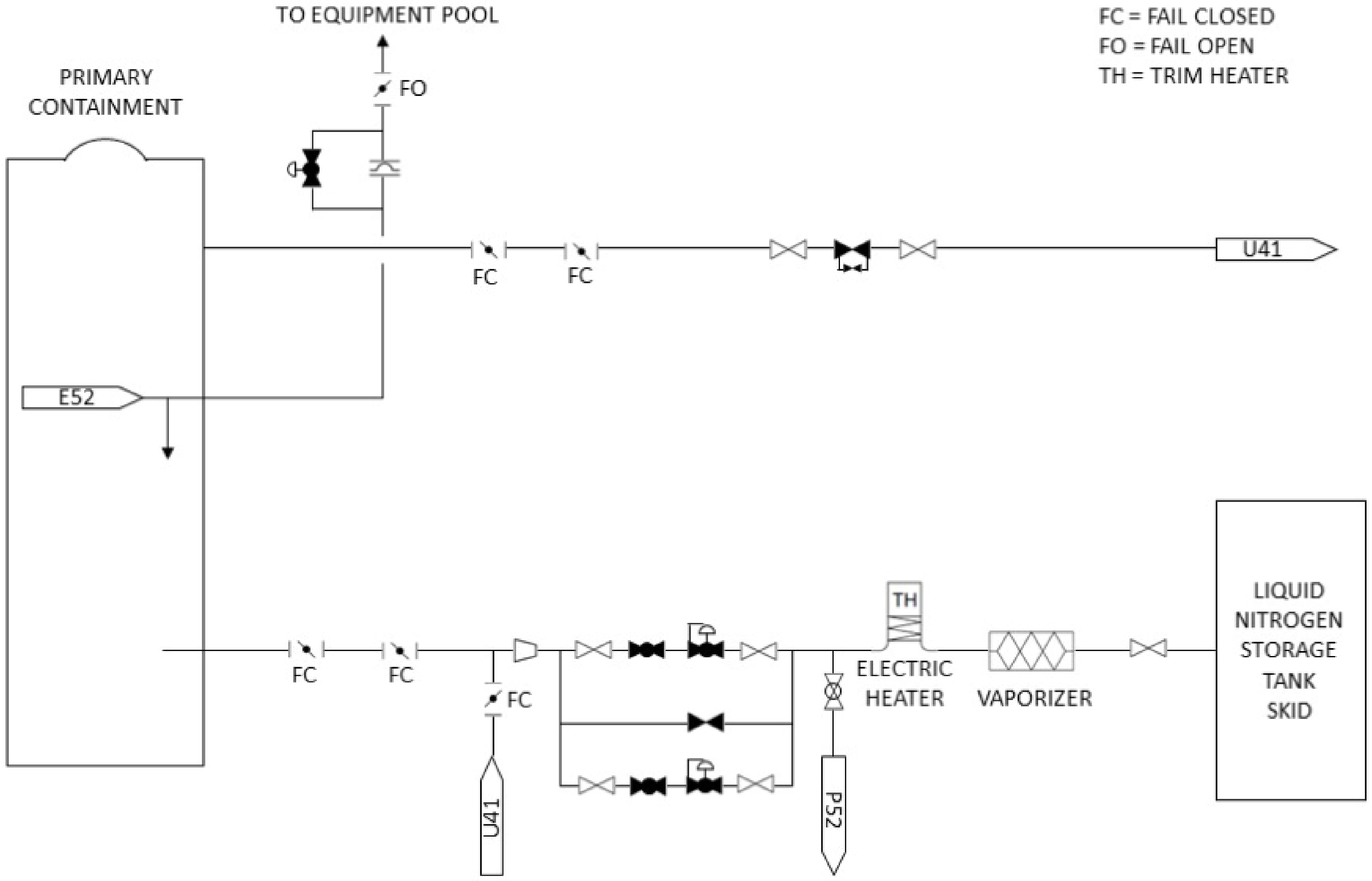


Figure 9A-13: Containment Inerting System

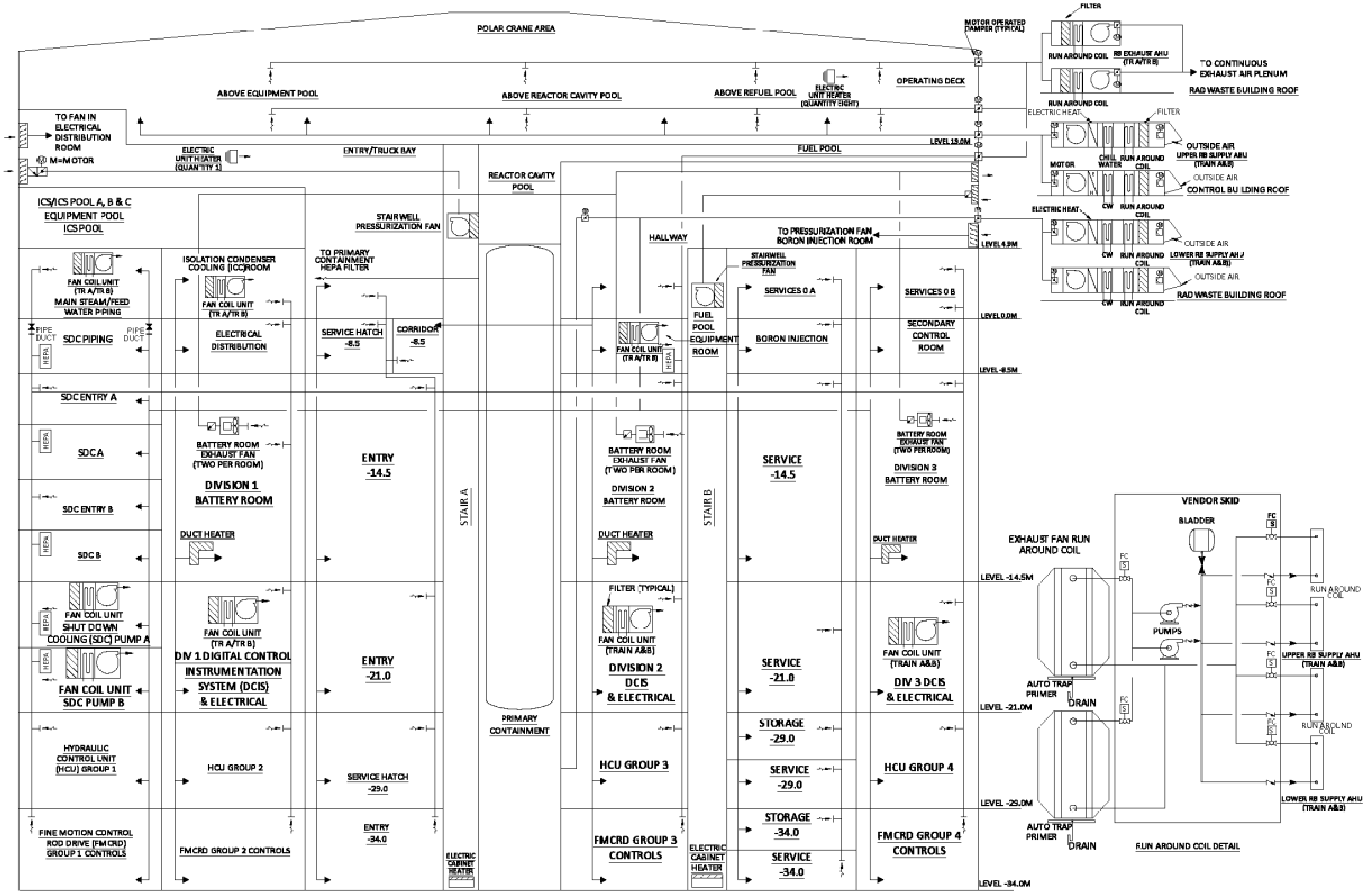


Figure 9A-14: Reactor Building HVAC

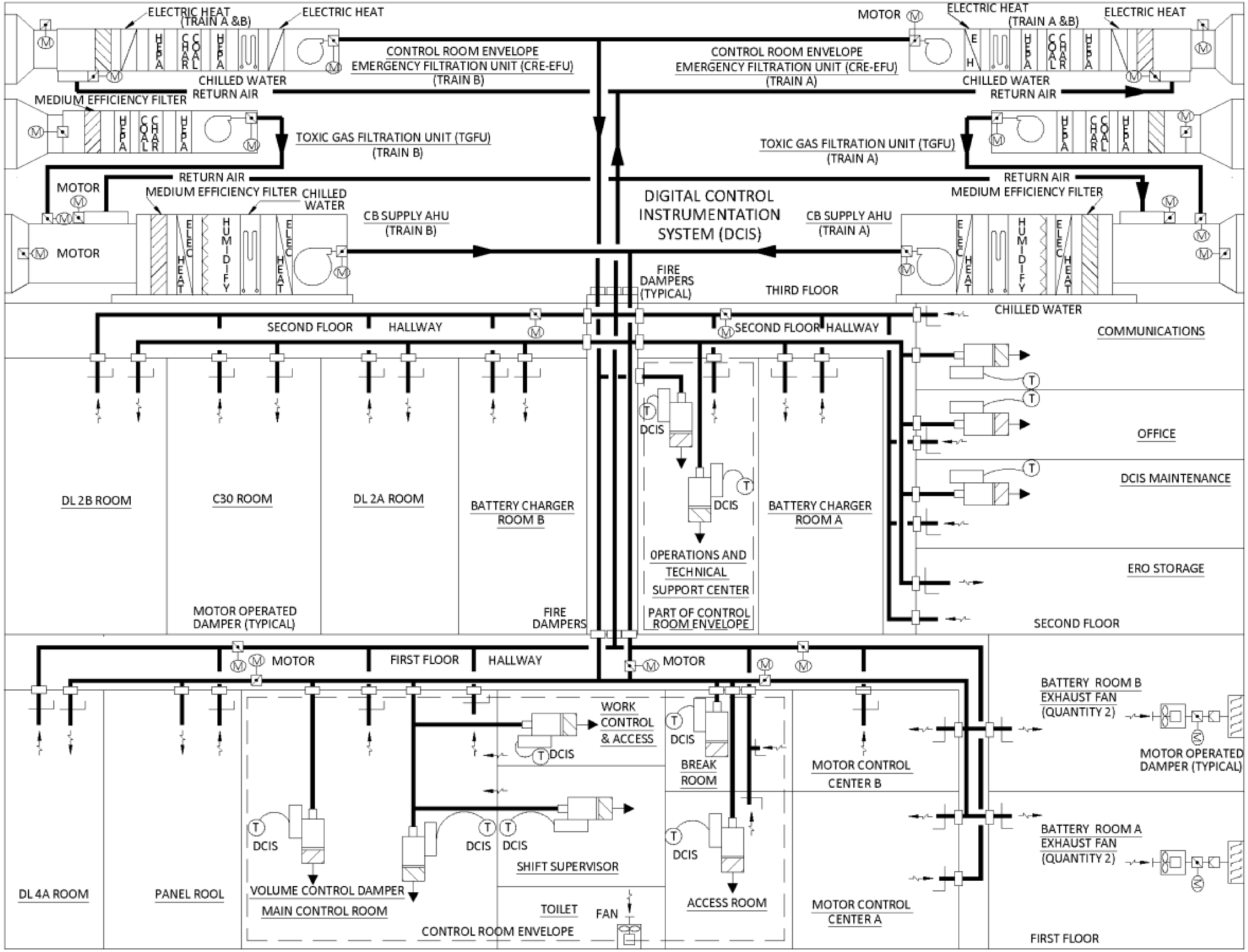


Figure 9A-15: Control Building HVAC

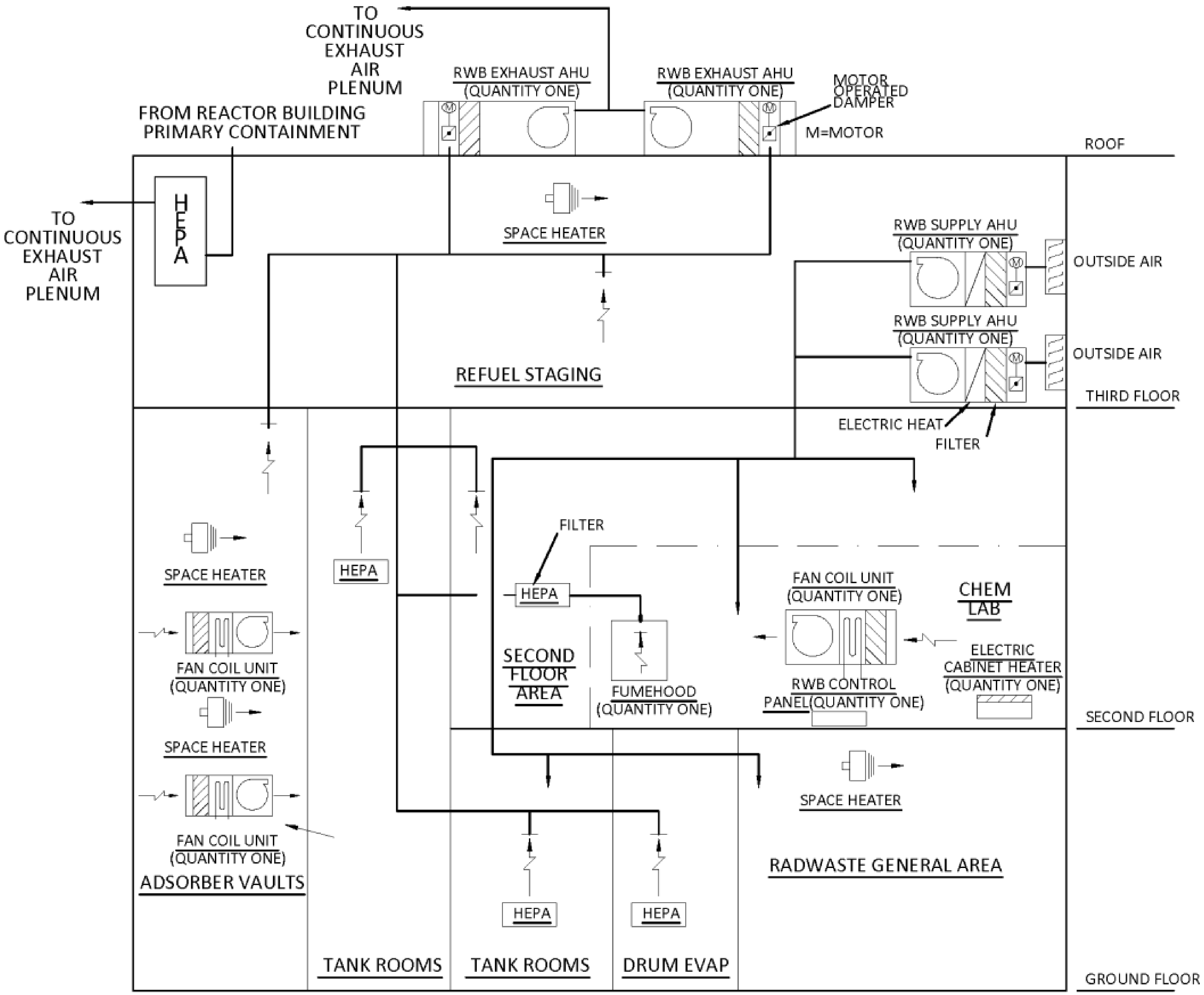


Figure 9A-16: Radwaste Building HVAC

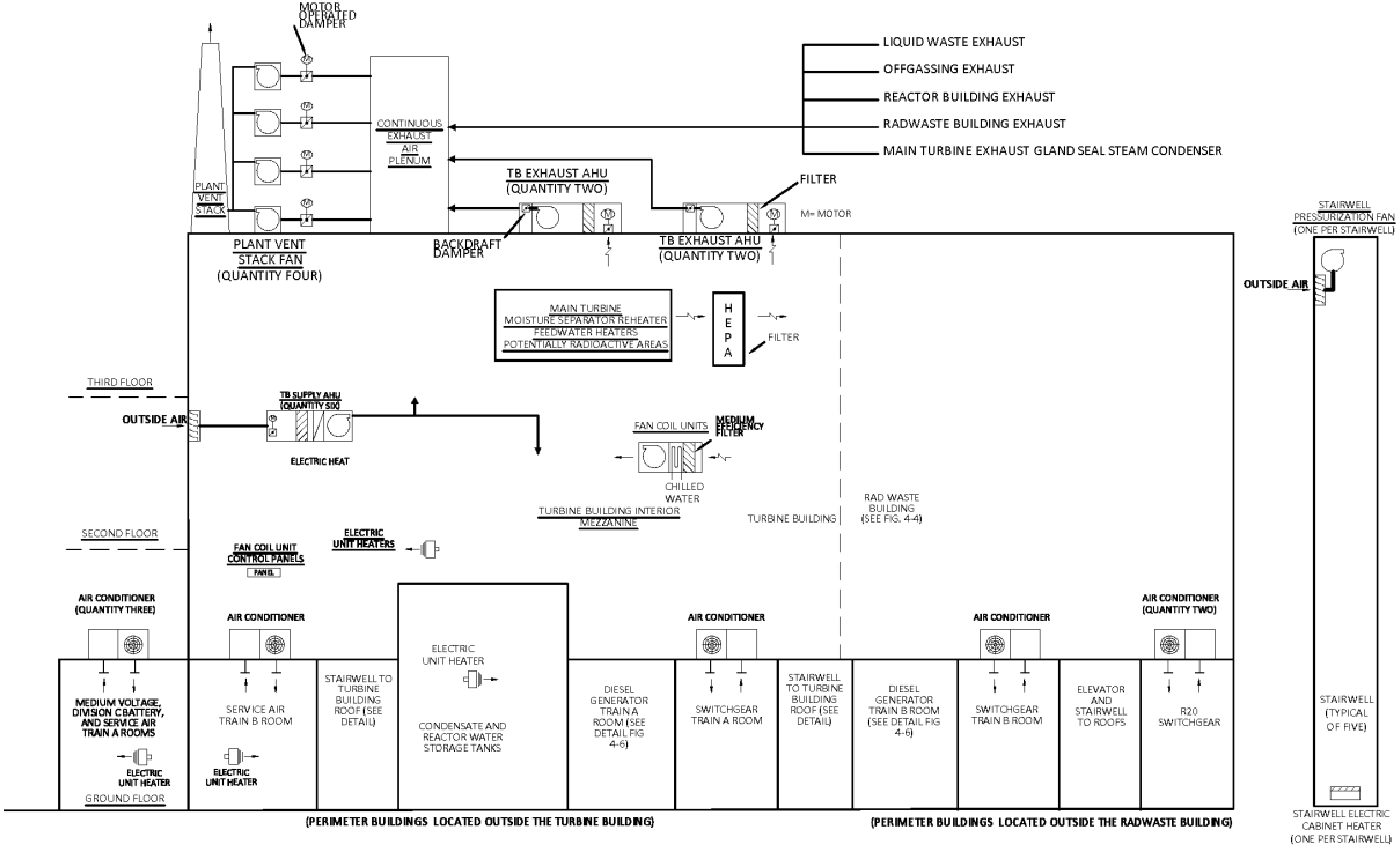


Figure 9A-17: Turbine Building HVAC

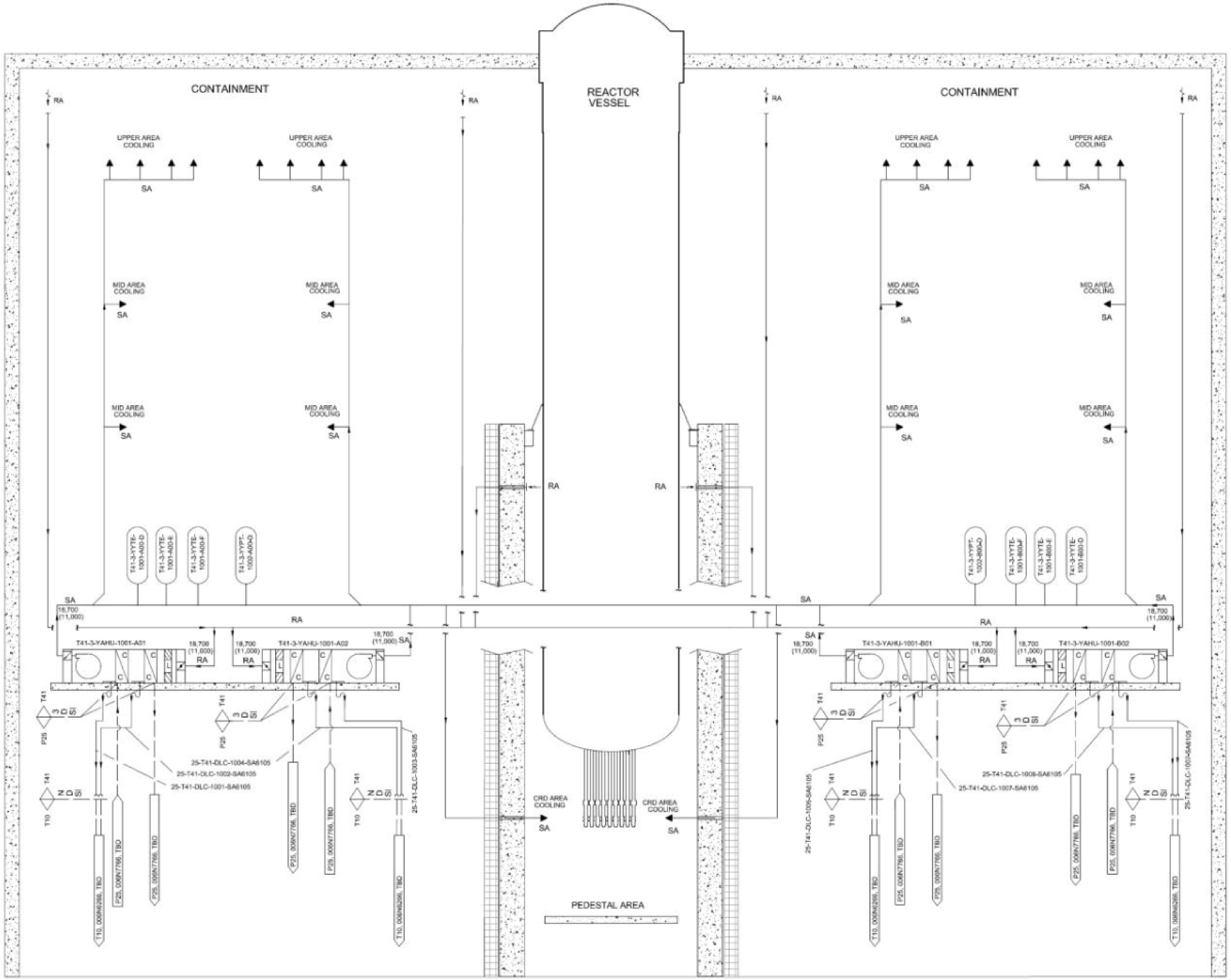


Figure 9A-18: Containment Cooling System

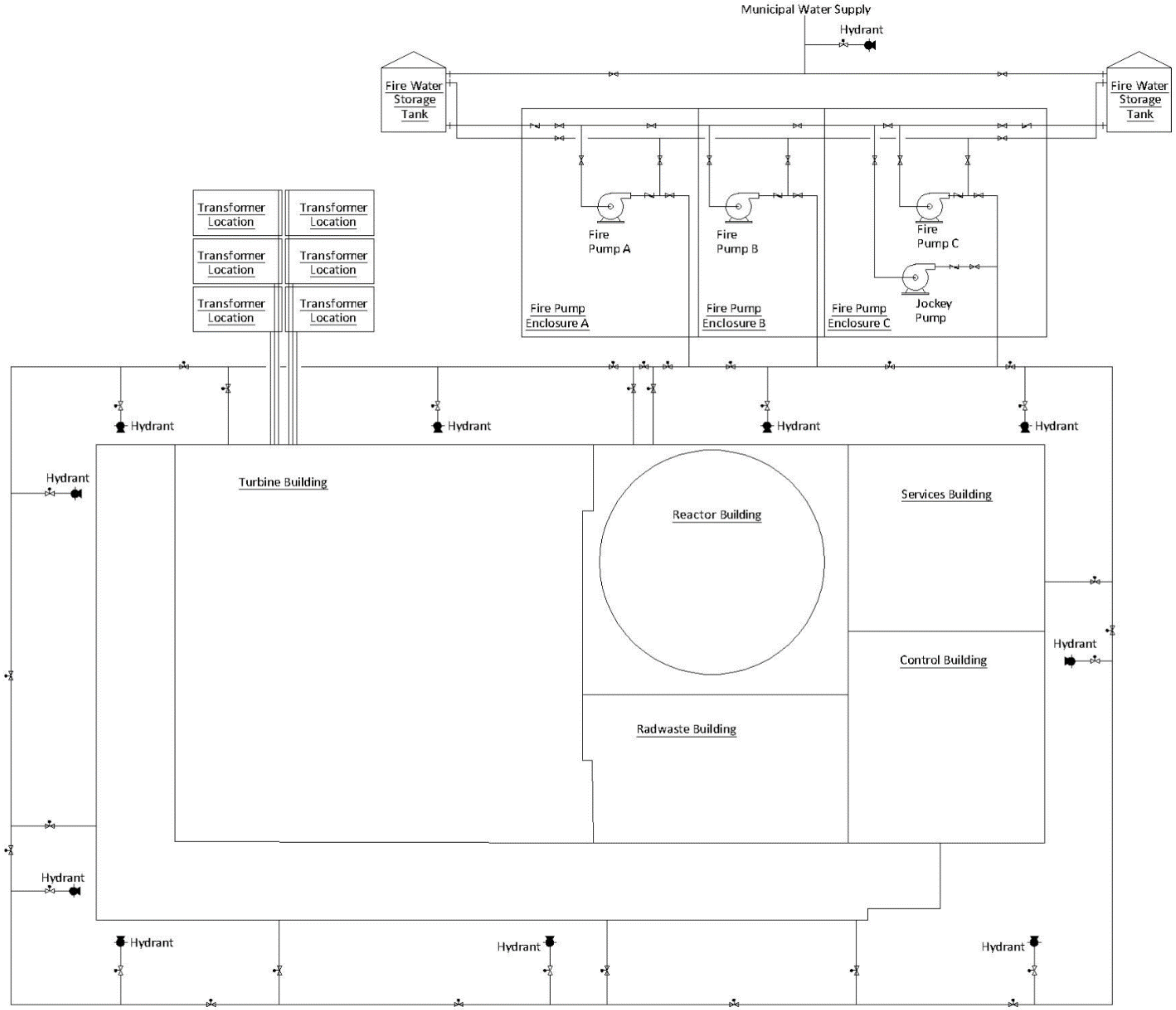


Figure 9A-19: BWRX-300 Fire Protection System Schematic

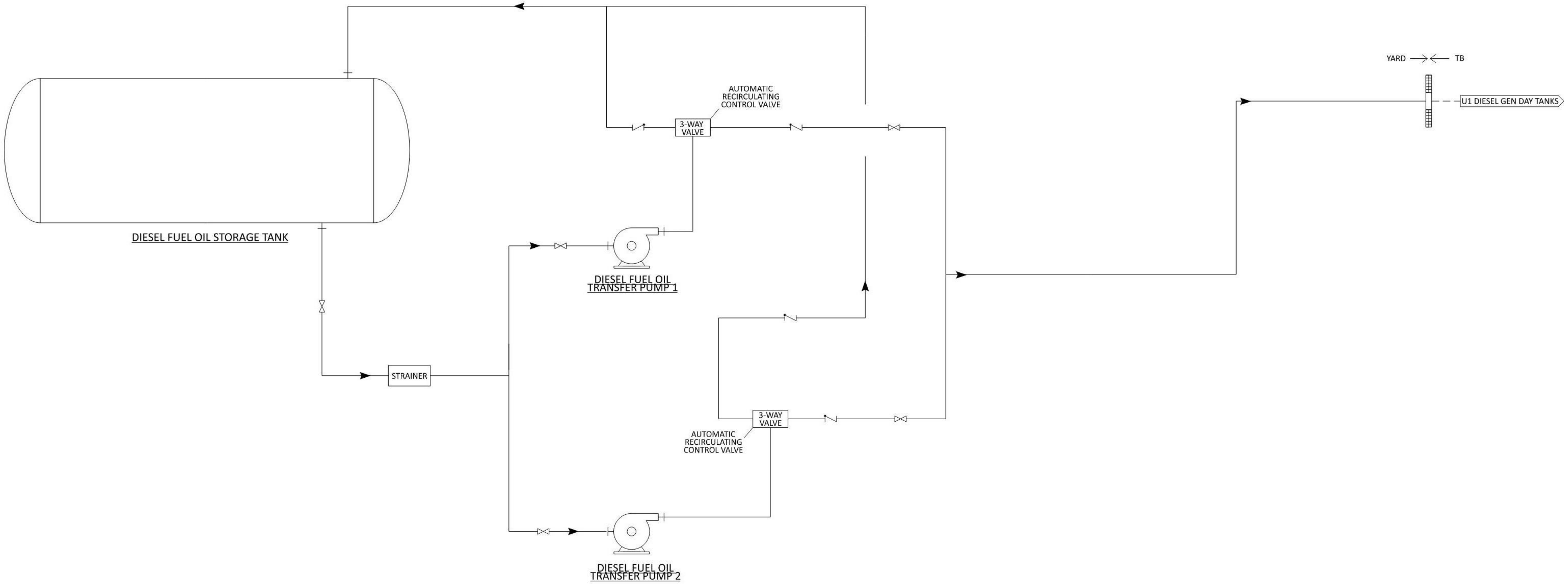


Figure 9A-20: Diesel Fuel Oil Storage and Transfer System Schematic

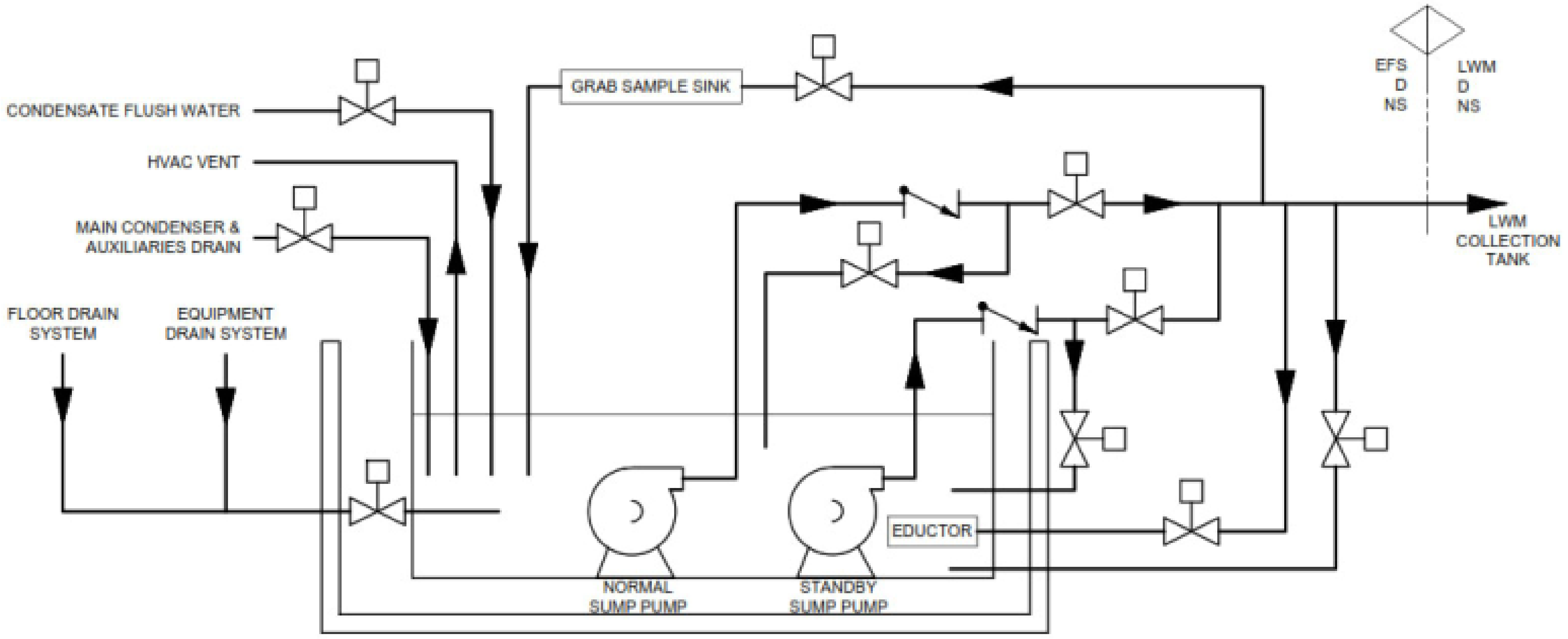


Figure 9A-21: Floor Drain System Drain Sump (Typical)

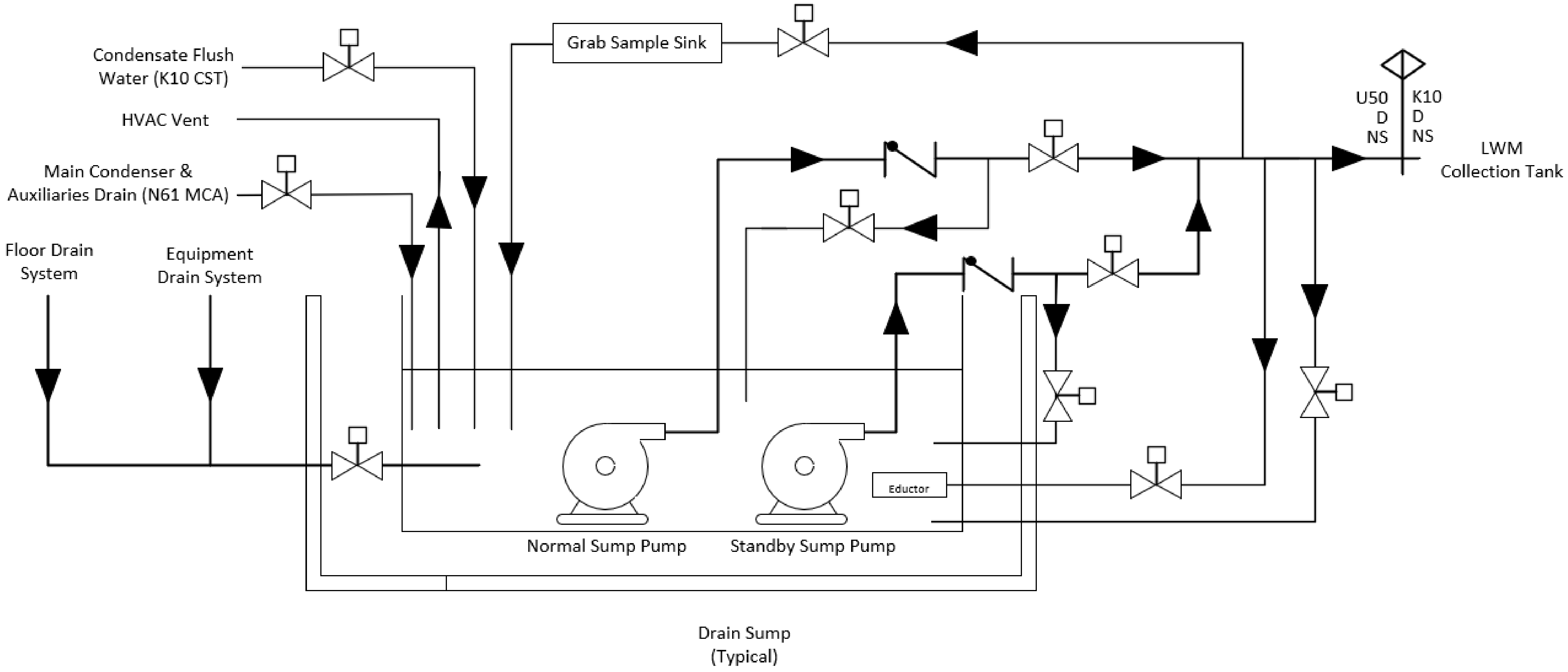


Figure 9A-22: Floor Drain System Containment Drain Sump (Pressurised)

9A.11 References

9A-1 NEDC-34172P, "BWRX-300 UK GDA PSR Ch. 9B: Civil Structures," Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-2 NEDC-34165P, “BWRX-300 UK GDA PSR Ch. 3: Safety Objectives and Design Rules for SSCs,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-3 006N5377, “BWRX-300 Refueling and Servicing Equipment,” Rev 2, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-4 IAEA SSR-2/1, “Safety of Nuclear Power Plants: Design,” International Atomic Energy Agency, IAEA Safety Standards Series No. SSR-2/1, 2012.

9A-5 NEDC-34200P, “BWRX-300 UK GDA PSR Ch. 28: Safeguards Annex,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-6 NEDC-34166P, “BWRX-300 UK GDA PSR Ch. 4: Reactor (Fuel and Core),” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-7 NEDO-33926, "BWRX-300 Steel-Plate Composite Containment Vessel (SCCV) and Reactor,” Rev 2, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-8 005N9341, “BWRX-300 General Civil Structural Design Criteria,” Rev 2, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-9 NEDC-34179P through NEDC-341487P, “BWRX-300 UK GDA PSR Ch. 15: Safety Analysis,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-10 007N1897, “BWRX-300 Refueling Platform Design Specification,” Rev 0, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-11 NEDC-34174P, “BWRX-300 UK GDA PSR Ch. 11: Management of Radioactive Waste,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-12 ANSI 57.1, “Design Requirements for Light Water Reactor Fuel Handling System,” American National Standards Institute.

9A-13 NEDC-34193P, “BWRX-300 UK GDA PSR Ch. 21: Decommissioning and End of Life Aspects,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-14 NEDC-34175P, “BWRX-300 UK GDA PSR Ch. 12: Radiation Protection,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-15 006N7941, “BWRX-300 Fuel Pool Cooling and Cleanup System,” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-16 NEDC-34188P, “BWRX-300 UK GDA PSR Ch. 16: Operational Limits and Conditions,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-17 NEDC-34174P, “BWRX-300 UK GDA PSR Ch. 10: Steam and Power Conversion Systems,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-18 NEDC-34168P, “BWRX-300 UK GDA PSR Ch. 6: Engineered Safety Features,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-19 006N7769, “BWRX-300 Plant Cooling Water (PCW) System SDD P40,” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-20 006N7761, “Circulating Water System SDD (N71),” Rev 0, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-21 IAEA SSG-30, "Safety Classification of Structures, Systems and Components in Nuclear Power Plants," International Atomic Energy Agency, IAEA Safety Standards, Specific Safety Guide No. SSG-30.

9A-22 ANSI/HI 1.3, “Rotodynamic Centrifugal Pumps for Design and Application,” Hydraulic Institute.

9A-23 ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, “Rules for Construction of Pressure Vessels Division 1,” American Society of Mechanical Engineers.

9A-24 AWWA D100, “Welded Carbon Steel Tanks for Water Storage,” American Water Works Association.

9A-25 ASME B31.1, “Power Piping,” American Society of Mechanical Engineers.

9A-26 006N7609, “Reactor Water Cleanup System,” Rev 2, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-27 006N7729, “BWRX-300 Liquid Waste Management System (LWM) (K10),” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-28 NEDC-34163P, “BWRX-300 UK GDA PSR Ch. 1: Introduction," Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-29 NEDC-34167P, “BWRX-300 UK GDA PSR Ch. 5: Reactor Coolant System and Associated Systems,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-30 NEDC-34169P, “BWRX-300 UK GDA PSR Ch. 7: Instrumentation and Control,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-31 006N7765, “BWRX-300 Chilled Water Equipment (CWE) SDD (P25),” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-32 ASHRAE Standard 15, “Safety Standard for Refrigeration Systems.”

9A-33 006N7781, “Heating, Ventilation and Cooling System (HVS),” Rev 4, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-34 ASME BPVC-III NF, “BPVC Section III – Rules for Construction of Nuclear Facility Components – Division 1 – Subsection NF – Supports,” American Society of Mechanical Engineers.

9A-35 006N7345, “Isolation Condenser Pools Cooling and Cleanup System,” Rev 2, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-36 AMSE B31.5, "Refrigeration piping and heat transfer components," American Society of Mechanical Engineers, 2001.

9A-37 ASME B16.34, “Valves – Flanged, Threaded, and Welding End,” American Society of Mechanical Engineers.

9A-38 NEDC-34177P, “BWRX-300 UK GDA PSR Ch. 14: Plant Construction and Commissioning,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-39 IAEA SSG-12, "Licensing Process for Nuclear Installations," International Atomic Energy Agency, IAEA Safety Standards Series No. SSG-12, 2010.

9A-40 NEDO-32991-A, “Regulatory Relaxation for BWR Post-Accident Sampling Stations (PASS),” GE-Hitachi Nuclear Energy, Americas, LLC.

9A-41 006N7773, “Plant Pneumatic System (PPS),” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-42 006N7417, “Boron Injection System,” Rev 2, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-43 006N7948, “Containment Inerting System,” Rev 2, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-44 10 CFR 20 Appendix B, “Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentration for Release to Sewerage.”

9A-45 ANSI/ASHRAE 52.2, “Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.”

9A-46 ASME AG-1, “Code on Nuclear Air and Gas Treatment,” Section FC, “HEPA Filters,” American Society of Mechanical Engineers.

9A-47 UL-586, “High Efficiency, Particulate, Air Filter Units,” Underwriters Laboratory.

9A-48 UL 1995, “Heating and Cooling Equipment,” Underwriters Laboratory.

9A-49 AHRI Standard 410, “Forced Circulation Air-Cooling and Air-Heating Coils,” Air Conditioning, Heating, and Refrigeration Institute.

9A-50 ASME N511, “In-Service Testing of Nuclear Air – Treatment, Heating, Ventilating, and Air Conditioning Systems,” American Society of Mechanical Engineers.

9A-51 006N7938, “Process Radiation and Environmental Monitoring System,” Rev 2, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-52 006N7777, “Containment Cooling System (CCS),” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-53 “ASHRAE Handbook– Fundamentals,” ASHRAE.

9A-54 006N7785, “BWRX-300 Fire Protection System (FPS) - U43,” Rev 4, GE-Hitachi Nuclear Energy, Americas, LLC, April 2024.

9A-55 006N6567, “BWRX-300 Fire Hazard Assessment Requirements Document,” Rev 2, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-56 006N7487, “BWRX-300 Fire Safe Shutdown Requirements and Analysis Report,” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-57 006N3441, “BWRX-300 Applicable Codes, Standards, and Regulations List,” GE-Hitachi Nuclear Energy, Revision 3

9A-58 NEDC-34185P, “BWRX-300 UK GDA PSR Ch. 15.7: Deterministic Safety Analyses – Analysis of Internal Hazards,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-59 NEDC-34196P, “BWRX-300 UK GDA PSR Ch. 24: Conventional Safety and Fire Safety Summary Report,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-60 006N5115, “BWRX-300 Plant Electrical Systems Architecture Requirements and Design,” Rev 5, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-61 NEDC-34227P, “BWRX-300 UK GDA Preliminary Environmental Report Ch. E10: Other Environmental Regulations,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-62 006N8264, “BWRX-300 Cranes, Hoists and Elevators,” Rev 3, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-63 ASME NOG-1, “Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder),” American Society of Mechanical Engineers.

9A-64 ASME BTH-1 “Design of Below-the-Hook Lifting Devices,” American Society of Mechanical Engineers.

9A-65 006N7789, “BWRX-300 Equipment and Floor Drain System,” Rev 3, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-66 006N7797, “BWRX-300 Water, Gas and Chemical Pads (WGC),” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-67 American Society for Testing and Materials D3350-14, “Standard Specification for Polyethylene Plastics Pipe and Fittings Material.”

9A-68 006N8027, “BWRX-300 Hydrogen Water Chemistry System (HWC),” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-69 EPRI Report NP-5283-SR-A, “Guidelines for Permanent BWR Hydrogen Water Chemistry Installations,” Electric Power Research Institute.

9A-70 006N7535, “On-Line NobleChem (OLNC),” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-71 007N4013, “BWRX-300 Zinc Injection Passivation,” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-72 NEDC-34176P, “BWRX-300 UK GDA PSR Ch. 13: Conduct of Operations,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-73 "Safety Assessment Principles (SAPs)," Office for Nuclear Regulation, 2014 edition (Revision 1, 2020).

9A-74 NEDC-34140P, “BWRX-300 GDA Safety Case Development Strategy,” Rev 0, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-75 NEDC-34137P, “BWRX-300 Design Evolution,” Rev 0, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-76 NEDC-34139P, “BWRX-300 UK GDA Step 1 Codes and Standards Report,” Rev 1, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-77 006N5064, “BWRX-300 Safety Strategy,” Rev 6, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-78 005N9751, “BWRX-300 General Description,” Rev F, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-79 0066822, “BWRX-300 System Functional Requirements (A11),” Rev 4, GE-Hitachi Nuclear Energy, Americas, LLC, DBR-Revision 4.

9A-80 006N8706, “BWRX-300 Construction Strategy Report,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-81 006N3139, “BWRX-300 Design Plan,” Rev 5, GE-Hitachi Nuclear Energy, Americas, LLC.

9A-82 NEDC-34198P, “BWRX-300 UK GDA PSR Ch. 26: Interim Storage of Spent Fuel,” Rev A, GE-Hitachi Nuclear Energy, Americas, LLC.

APPENDIX A CLAIMS, ARGUMENTS AND EVIDENCE AND ALARP

Claims, Argument, Evidence

The ONR "Safety Assessment Principles (SAPs)" 2014 (Reference 9A-73) identify ONR's expectation that a safety case should clearly set out the trail from safety claims, through arguments to evidence. The Claims, Argument, Evidence (CAE) approach can be explained as follows:

1. Claims (assertions) are statements that indicate why a facility is safe.
2. Arguments (reasoning) explain the approaches to satisfying the claims.
3. Evidence (facts) supports and forms the basis (justification) of the arguments.

The GDA CAE structure is defined within the "Safety Case Development Strategy (SCDS)" (NEDC-34140P, "BWRX-300 GDA Safety Case Development Strategy" (Reference 9A-74)) and is a logical breakdown of an overall claim that:

> *"The BWRX-300 is capable of being constructed, operated and decommissioned in accordance with the standards of environmental, safety, security and safeguard protection required in the UK."*

This overall claim is broken down into Level 1 claims relating to environment, safety, security and safeguards, which are then broken down again into Level 2 area related sub-claims and then finally into Level 3 (chapter level) sub-claims.

The Level 3 sub-claims that this chapter demonstrates compliance against are identified within the SCDS (Reference 9A-74) and are as follows:

> *2.1.2: The design of the system/structure has been substantiated to achieve the safety functions in all relevant operating modes.*
>
> *2.1.3: The system/structure design has been undertaken in accordance with relevant design codes and standards (RGP) and design safety principles and taking account of Operating Experience to support reducing risks As Low As Reasonably Practicable (ALARP).*
>
> *2.1.4: System/structure performance will be validated by suitable testing throughout manufacturing, construction and commissioning.*
>
> *2.1.5: Ageing and degradation mechanisms will be identified and assessed in the design. Suitable examination, inspection, maintenance and testing will be specified to maintain systems/structures fit-for-purpose through-life.*
>
> *2.1.6: The BWRX-300 will be designed so that it can be decommissioned safely, using current available technologies, and with minimal impact on the environment and people.*
>
> *2.4.1: Relevant Good Practice (RGP) has been taken into account across all disciplines.*
>
> *2.4.2: Operational Experience (OPEX) and Learning from Experience (LfE) has been taken into account across all disciplines.*
>
> *2.4.3: Optioneering (all reasonably practicable measures have been implemented to reduce risk).*

In order to facilitate compliance demonstration against the above Level 3 sub-claims, this PSR chapter has derived a suite of arguments that comprehensively explain how their applicable Level 3 sub-claims are met (see Table A-1 below).

It is not the intention to generate a comprehensive suite of evidence to support the derived arguments, as this is beyond the scope of GDA Step 2. However, where evidence sources are available, examples are provided.

Risk Reduction As Low As Reasonably Practicable

It is important to note that nuclear safety risks cannot be demonstrated to have been reduced ALARP within the scope of a 2-Step GDA. It is considered that the most that can be realistically achieved is to provide a reasoned justification that the BWRX-300 SMR design aspects will effectively contribute to the development of a future ALARP statement. In this respect, this chapter contributes to the overall future ALARP case by demonstrating that:

- The chapter-specific arguments derived may be supported by existing and future planned evidence sources covering the following topics:
    - Relevant Good Practice (RGP) has demonstrably been followed.
    - OPEX has been taken into account within the design process.
    - All reasonably practicable options to reduce risk have been incorporated within the design.
- It supports its applicable level 3 sub-claims, defined within the SCDS (Reference 9A-74).

Probabilistic safety aspects of the ALARP argument are addressed within PSR Ch. 15.

In terms of supporting a future ALARP statement, the BWRX-300 approach to the auxiliary systems is to replicate designs previously used for the Advanced Boiling Water Reactor (ABWR). This is because the designs have been proven to be effective, supported by many years of OPEX and few further practicable design improvements have been identified. As the designs for the auxiliary systems have been previously licensed internationally, they comply with relevant IAEA and USNRC requirements. RGP has been followed for fuel handling processes by minimising drop heights and the travel distance between set down points. The operations deck of the BWRX-300 is at a lower elevation above ground than that of the ABWR, reducing the potential drop height of fuel casks leaving the RB.

Table A-1: Claims, Arguments, Evidence Route Map

L3 No.	Level 3 Chapter Claim	Chapter 6 Arguments	Sub-sections and/or Reports that Evidence the Arguments
2.1: The functions of systems and structures have been derived and substantiated taking into account RGP and OPEX, and processes are in place to maintain these through-life. (Engineering Analysis)			
2.1.2	The design of the system/structure has been substantiated to achieve the safety functions in all relevant operating modes.	Safety functions associated with the relevant SSC have been substantiated during normal operating conditions (including design codes and standards compliance)	9A.2.1 Plant Cooling Water System 9A.2.2 Reactor Water Clean-up System 9A.5.1 Reactor Building Heating, Ventilation and Air Conditioning System 9A.6.6 Fire Protection System and Equipment Operation 9A.7 Supporting Systems for Diesel Generators 9A.9.5 Makeup Water System
		A record of safe Boiling Water Reactor (BWR) plant operation and continuous improvement demonstrates a well-founded design	NEDC-34137P, “BWRX-300 Design Evolution,” (Reference 9A-75).
		Safety functions associated with the relevant SSC have been substantiated during hazard and fault conditions	Safety function will be identified in Chapters 3 & 15. Means of substantiation will be included in PSR Ch. 9A. The BWRX-300 approach to classifying of SSC is discussed in PSR Ch. 3, Section 3.2.
		Any shortfalls in safety function substantiation have been identified and assessed to identify any reasonably practicable means to reduce risk	This argument is out of the scope of a 2-Step GDA and will be addressed during a site specific stage (when evidence is developed).
2.1.3	The system/structure design has been undertaken in accordance with relevant design codes and standards (RGP)	Design evolutions to SSC have been considered taking into account relevant BWR OPEX, and any reasonably practicable changes to reduce risk have been implemented	The BWRX-300 approach to classifying of SSC is discussed in PSR Ch. 3, Section 3.2. OPEX on BWRX-300 (Indicated by Text): 9A.1.2 Fuel Storage and Handling System 9A.1.3 Fuel Pool Cooling and Cleanup System

L3 No.	Level 3 Chapter Claim	Chapter 6 Arguments	Sub-sections and/or Reports that Evidence the Arguments
	and design safety principles, and taking account of Operating Experience to support reducing risks ALARP		9A.2.1 Plant Cooling Water System 9A.2.2 Reactor Water Cleanup System 9A.2.3 Shutdown Cooling System 9A.2.5 Normal Heat Sink System 9A.4.2 Containment Inerting System 9A.8.1 Cranes, Hoists and Elevators BWRX-300 Fuel Pool Cooling and Cleanup System, System Design Description, 006N7941, Revision 1 relate to the following section: 9A.1.3 Fuel Pool Cooling and Cleanup System BWRX-300 Plant Cooling Water (PCW) System, System Design Description, 006N7769, Revision 1 relate to the following section: 9A.2.1 Plant Cooling Water System BWRX-300 Design Evolution (Reference 9A-75) OPEX & ALARP approach alignment which relate to the following section: 9A.2.2 Reactor Water Clean-up System (Section 4.9)
		The SSC have been designed in accordance with relevant codes and standards (RGP)	The BWRX-300 approach to classifying of SSC is discussed in PSR Ch. 3, Section 3.2. BWRX-300 Applicable Codes, Standards, and Regulations List (Reference 9A-57). NEDC-34139P, “BWRX-300 UK GDA Step 1 Codes and Standards Report,” (Reference 9A-76). This PSR chapter also discusses the C&S to which it has been designed.
		The SSC have been designed in accordance with an appropriate suite of design safety principles	The BWRX-300 approach to classifying of SSC is discussed in PSR Ch. 3, Section 3.2.

L3 No.	Level 3 Chapter Claim	Chapter 6 Arguments	Sub-sections and/or Reports that Evidence the Arguments
			The GEH Safety and Design Principles are documented in the BWRX-300 Safety Strategy, supplemented by the BWRX-300 General Description. These principles are also be presented within PSR Ch. 3 • 006N5064, BWRX-300 Safety Strategy, Revision 6 (Reference 9A-77) • 005N9751, BWRX-300 General Description, Revision F (Reference 9A-78)
2.1.4	System/structure performance will be validated by suitable testing throughout manufacturing, construction and commissioning.	SSC pre-commissioning tests (e.g., NDT) validate the relevant performance requirements	The BWRX-300 approach to classifying of SSC is discussed in PSR Ch. 3, Section 3.2. ASME V Pre-Service Inspection
		SSC commissioning tests (e.g., system level pressure and leak tests) validate the relevant performance requirements	The BWRX-300 approach to classifying of SSC is discussed in PSR Ch. 3, Section 3.2.
		SSC are manufactured, constructed and commissioned in accordance with QA arrangements appropriate to their safety classification	0066822, “BWRX-300 System Functional Requirements (A11),” (Reference 9A-79) describes how safety categorisation and SSC classification are linked to quality group (QA arrangement) definition. 006N8706, “BWRX-300 Construction Strategy Report,” (Reference 9A-80) describes the high-level construction quality assurance and quality control arrangements and responsibilities. PSR Ch. 3 defines this approach. ASME B31.1: S9.2.1; S9.2.6; S9.9.3; S9.9.4; & S9.9.5 ASME III NF: S9.2.6 ASME II NC Class 2: S9.9.3 ASME NOG-1: S9.8.1 ANSI MH27.1 & MH27.2: S9.8.1 ANSI 57.1: S9.1.2 ANSI/HI 1.3: S9.2.1

L3 No.	Level 3 Chapter Claim	Chapter 6 Arguments	Sub-sections and/or Reports that Evidence the Arguments
2.1.5	Ageing and degradation mechanisms will be identified and assessed in the design. Suitable examination, inspection, maintenance and testing will be specified to maintain systems/structures fit-for-purpose through-life	SSC ageing and degradation mechanisms will be identified during SSC design. Mitigation measures, such as material selection, will reduce the likelihood of SSC failure to ALARP.	NEDC-34137P, BWRX-300 Design Evolution (Reference 9A-75)
		Appropriate Examination, Maintenance, Inspection and Testing (EMIT) arrangements will be specified taking into account SSC ageing and degradation mechanisms	EMIT Supporting evidence (not currently referenced) includes: 006N4360, BWRX-300 Reliability, Availability, Maintainability, and Inspectability (RAMI) Program 006N4294, BWRX-300 Design Reliability Assurance Program 006N5377, BWRX-300 Outage Plan 006N6378, BWRX-300 In-Service Testing Program 006N6279, BWRX-300 In-Service Inspection Requirements 006N2829, BWRX-300 Human Factors Engineering Design Requirement Document
		Ageing and degradation OPEX will be considered as part of the design stage component/materials selection process in order to mitigate SSC failure risk	BWRX 300 Decommissioning planning (PSR Ch. 21). OPEX demonstrates that decommissioning of reactor facilities is facilitated if considered during the design phase: 1) Materials are selected to minimise the quantities of radioactive waste and assisting decontamination. 2) Plant layout is designed to facilitate access for decommissioning or dismantling activities. 3) Future potential requirements for storage of radioactive waste. NEDC-34137P, BWRX-300 Design Evolution (Reference 9A-75)

L3 No.	Level 3 Chapter Claim	Chapter 6 Arguments	Sub-sections and/or Reports that Evidence the Arguments
2.1.6	The BWRX will be designed so that it can be decommissioned safely, using current available technologies, and with minimal impact on the environment and people	SSC decommissioning is considered at the design stage to ensure that safe decommissioning may take place	BWRX 300 Decommissioning planning (PSR Ch. 21). OPEX demonstrates that decommissioning of reactor facilities is facilitated if considered during the design phase: 1) Materials are selected to minimise the quantities of radioactive waste and assisting decontamination. 2) Plant layout is designed to facilitate access for decommissioning or dismantling activities. 3) Future potential requirements for storage of radioactive waste.
		SSC are designed in order to minimise impacts on people and the environment during decommissioning	BWRX 300 Decommissioning planning, PSR Ch. 21.
2.4 Safety risks have been reduced as low as reasonably practicable			
2.4.1	Relevant Good Practice (RGP) has been taken into account across all disciplines	Relevant SSC codes and standards (RGP) are identified	BWRX-300 Applicable Codes, Standards, and Regulations List (Reference 9A-57). BWRX-300 UK GDA Step 1 Codes and Standards Report (Reference 9A-76). This PSR chapter also discusses the C&S to which it has been designed.
		SSC have been designed in accordance with relevant codes and standards (RGP)	BWRX-300 Applicable Codes, Standards, and Regulations List (Reference 9A-57). BWRX-300 UK GDA Step 1 Codes and Standards Report (Reference 9A-76). This PSR chapter also discusses the C&S to which it has been designed.
		Any shortfalls in codes and standards compliance are identified and assessed to reduce risks ALARP	This argument is out of two step GDA scope and will be addressed during site specific stage.

L3 No.	Level 3 Chapter Claim	Chapter 6 Arguments	Sub-sections and/or Reports that Evidence the Arguments
2.4.2	OPEX and Learning from Experience (LfE) has been taken into account across all disciplines	Design improvements to SSC have been identified considering relevant OPEX and LfE	NEDC-34137P, BWRX-300 Design Evolution (Reference 9A-75).
		Any reasonably practicable design changes to reduce risk have been implemented	NEDC-34137P, BWRX-300 Design Evolution (Reference 9A-75).
2.4.3	Optioneering (all reasonably practicable measures have been implemented to reduce risk)	Design optioneering has been performed in accordance with an approved process	006N3139, “BWRX-300 Design Plan,” (Reference 9A-81).
		Design optioneering has considered all reasonably practicable measures	006N3139 (Reference 9A-81) NEDC-34137P, BWRX-300 Design Evolution (Reference 9A-75).
		Any reasonably practicable design changes to reduce risk have been implemented	NEDC-34137P, BWRX-300 Design Evolution (Reference 9A-75).

APPENDIX B FORWARD ACTION PLAN ITEMS

The FAP is not required to capture the ‘normal business’ of Safety, Security, Safeguards and Environmental case development as the design progresses from concept to design for construction and commissioning. FAP items can arise from several sources:

- Assumptions and commitments made in the GDA submissions that will require future verification/ implementation, for example, by the future constructor and/or plant operator.
- A gap in the underpinning of the GDA submissions currently under development,
- A potential gap in a future phase of submissions if additional work is not performed or
- A gap identified by the regulators and communicated to the Requesting Party (RP) through a Regulatory Query or Regulatory Observation.

Table B-1: Auxiliary Systems Forward Action Plan Items

FAP No.	Section	Finding	Forward Action Plan Item	Delivery Phase
PSR9A-293	9A.6.1	From PSR Ch. 9A, Section 9A.6.1: A Fire Safe Shutdown Assessment (FSSA) established and evaluated distinct fire areas for the Reactor Building, Radwaste Building, Turbine Building, Control Building, PLSA and Fire Pump Enclosure for the standard BWRX-300 plant. A UK-specific FSSA will be required to confirm and/or amend these fire areas.	A UK-specific Fire Safe Shutdown Assessment (FSSA) will need to be performed for a UK plant, taking into account any changes in site and/or building layouts, in order to define distinct fire areas within the various Power Block buildings.	For PCSR / PCER
PSR9A-294	9A.6.10	From PSR Ch. 9A, Section 9A.6.10: It is a general conclusion of the Fire Safe Shutdown Analysis (FSSA) that the plant has the capability to safely shutdown the operating unit in the event of a fire. A UK-specific FSSA will be required.	A UK-specific Fire Safe Shutdown Assessment (FSSA) will need to be performed for a UK plant, taking into account any changes in site and/or building layouts, in order to demonstrate that the plant may be shutdown safely in the event of a fire.	For PCSR / PCER