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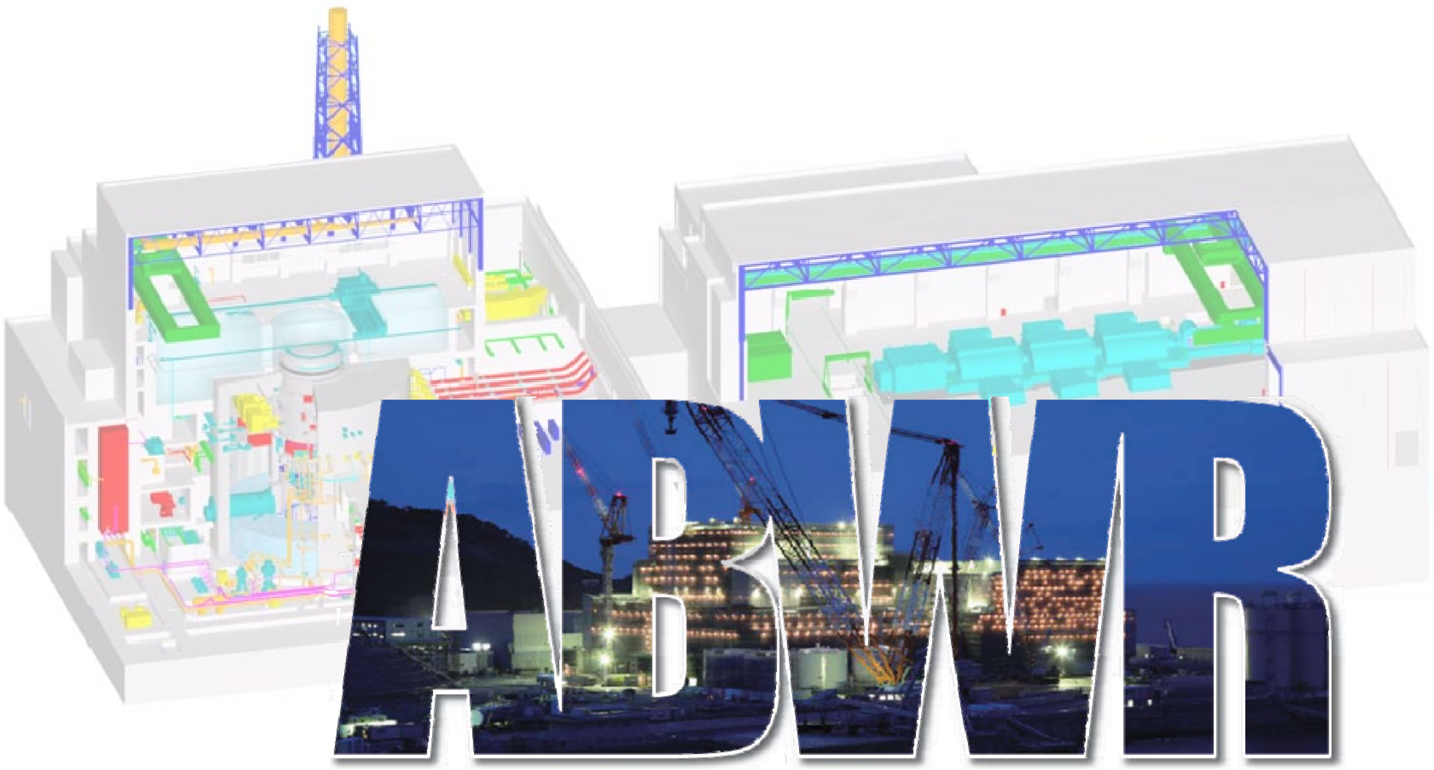
UK ABWR Generic Design Assessment

Generic PCSR Sub-chapter 12.2 : Reactivity Control Systems



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12.2.1 Summary Description of the Reactivity Control Systems

The Reactivity Control Systems consists of the Control Rods (CRs) and the Control Rod Drive System (CRD), and the Standby Liquid Control System (SLC).
The CRD consists of the electro-hydraulic Fine Motion Control Rod Drive mechanisms (FMCRD), the Hydraulic Control Unit (HCU), and the Control Rod Drive Hydraulic System. The Control Rod Drive Hydraulic System is further divided into components such as the CRD Pumps, filters, piping and valves.

The SLC consists of components such as a borated-water storage tank, pumps, a test tank, piping and valves.

As for the reactor shutdown systems, the CRD has the function of shutting down the reactor. The reactor is shut down by inserting the CRs into the core. The CRD inserts the CRs into the core and withdraws them from the core at the speed required for normal operations to control the reactivity of core.
In an emergency, the CRD inserts the CRs into the core rapidly to scram the reactor (to bring the reactor to an emergency shutdown).
In cases where the CRs cannot be inserted, the SLC, as the back-up system of the CRD, injects a liquid neutron absorber into the reactor which inserts negative reactivity and shuts down the reactor.

12.2.2 Safety Requirements

The safety requirements for Reactivity Control Systems are described within the design bases in the respective sub-sections of each system, separately.

12.2.3 Components and Subsystems

12.2.3.1 Control Rod Drive System

12.2.3.1.1 System Summary Description

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

12.2.3.1.1.1 System Roles

The main roles of the CRD are the following:

(1) The CRD drives the electro-hydraulic FMCRDs through an electric motor and thereby changes the position of the CRs in the core to control the reactivity during normal operation.

(2) During transients of the plant, the FMCRDs can be hydraulically driven by pressurised water from the HCU to rapidly insert all the CRs into the core, in an action known as a Scram, and thereby shut down the reactor safely and quickly.

(3) During normal operation the CRD Pumps supply purge water to the FMCRDs, the Reactor Internal Pumps (RIPs), and the Reactor Water Clean-up System pump (CUW Pump) while continuously maintaining the HCU Accumulators pressurised with water to ensure they are charged at high pressure for possible scrams.

12.2.3.1.1.2 Functions Delivered

The CRD is designed to perform the following functions:

(1) Each CRD, through its electric motor positions the CRs in the core depending on the control signal from the Rod Control and Information System (RC&IS) when performing normal insertion and withdrawal for control of changes in core reactivity.

(2) The CRD through the FMCRDs implements reactor scram operation when receiving the scram signal from the Reactor Protection System (RPS). The FMCRD electric motors are actuated to back up the full insertion of the CRs with the scram follow-in signal from the RPS.

(3) In a scram situation, the CRD opens the scram valves provided on the outlet of each HCU accumulator and thereby the pressurised water stored in the HCU accumulator is supplied to the hollow piston section of the FMCRD in the event that the scram signal was initiated. As a result, the FMCRDs are hydraulically driven and each CR is rapidly inserted into the reactor core to shut down the reactor. Once fully inserted, a latch prevents the CR from moving out of the core.

(4) The Alternative Rod Insertion (ARI) signal, from the Anticipated Transient without Scram System (ATWS), opens solenoid-operated valves on the scram air header to reduce pressure in the header, allowing the HCU scram valves to open, and thus allows the CRs to be hydraulically inserted into the reactor core in case scram could not be performed upon RPS scram signal. At the same time, the CRD actuates the FMCRD electric motors to back up the full insertion of the CRs with the FMCRD run-in signal from the ATWS.

(5) The CRD through the CRD Pumps supplies water to maintain the full pressure required in the HCU accumulators to enable a rapid scram of the reactor.

(6) The CRD through the CRD Pumps supplies purge water to reduce radioactive contamination due to deposition of activated corrosion products contained in the reactor water inside the FMCRDs during plant normal operation.

(7) The CRD through the CRD Pumps supplies purge water to reduce the radioactive contamination due to deposition of activated corrosion products contained in the reactor water within the motor side of the RIPs and the CUW Pumps during plant normal operation.

(8) The CRD is utilised to pressurise the Reactor Pressure Vessel (RPV) when the leakage and hydrostatic test is implemented.

12.2.3.1.1.3 Basic Configuration

The CRD consists of the following main components. Figure 12.2-1 shows an outline of the CRD configuration.

(1) FMCRD
The FMCRDs provide electric-motor-driven positioning for normal insertion and withdrawal of the CRs and hydraulic-powered rapid insertion (scram) of the CRs during abnormal operating conditions. There are a total of 205 FMCRDs mounted in housings welded into the reactor vessel bottom head.
Furthermore, the FMCRD electric motors are actuated to back up the full insertion of the CRs with the scram follow-in signal from the RPS.

(2) HCU
The hydraulic power required for scram is provided by high pressure water stored in 103 individual HCUs. Each HCU contains a nitrogen-water accumulator charged to high pressure and the necessary valves and components to simultaneously fully insert two CRs. In addition, during normal operation, the HCUs provide a flow path for purge water to the associated FMCRDs.

(3) CRD Pumps
Through the CRD Pumps the CRD supplies clean, demineralised water which is regulated and distributed to provide charging of the HCU scram accumulators and purge water flow to the FMCRDs during normal operation. The CRD Pumps also supply pressurised water for purging the RIPs and the CUW Pumps.

(4) CRD Drive Water Heater
This heater is provided to heat CRD water and maintain the scram lines connecting each HCU to its associated FMCRDs at a temperature to avoid condensation on the outside of the lines which helps avoid corrosion of the scram lines.

(5) CRD Pump Suction Filters
CRD pump suction filters are provided to prevent ingress of debris to the pumps during operation particularly following outage and commissioning.

(6) CRD Drive Water Filters
Filters are provided to ensure no corrosion products or other contamination is present in the water supplied to the FMCRDs, RIPs and CUW system to protect the components downstream the CRD Pump.

(7) CRD Charging Header Accumulator
The charging header accumulator is provided to ensure water pressure is maintained in the event of a CRD pump trip, while the standby pump starts to avoid any spurious reactor scrams due to low charging water pressure.

(8) HCU Nitrogen Gas Charging Equipment
This is required to maintain the nitrogen overpressure in the HCUs.

(9) Valves, piping, instrumentation, and controllers

12.2.3.1.1.4 Modes of Operation

(1) Normal Operation Mode
Normal operation is defined as those periods of time when no control rod drives are in motion. Under this condition, the CRD System provides charging pressure to the HCUs and supplies purge water to the CR drives, RIPs and CUW Pumps.

(2) Control Rod Insertion and Withdrawal Mode
The CRD receives the control signal from the RC&IS and actuates the FMCRD electric motors to drive the CRs according to the specified insertion/withdrawal steps when implementing normal insertion/withdrawal of the CRs for control of changes in core reactivity and normal reactor start-up and shutdown.

(3) Scram Drive Mode
Upon loss of electric power to both scram pilot valve solenoids, the scram valve in the associated HCU opens to apply the hydraulic insert forces to its respective FMCRDs using high pressure water stored within the pre-charged accumulator.
The water is driven by the pressurised nitrogen in the accumulator and nitrogen bottle. The CRs are driven fully into the reactor core inserting adequate negative reactivity to shutdown the reactor.

(4) Scram Completion Mode
The RC&IS transmits the control signal to the FMCRDs after receiving the control signal from the RPS. In consequence the FMCRDs actuate the electric motors in order to initiate the scram follow action.

(5) ARI
The ARI function of the CRD System provides an alternate means for actuating hydraulic scram that is diverse from the RPS. The signals to initiate the ARI are high reactor dome pressure or low reactor vessel water Level 2 or manual operator action. Following receipt of any of these signals, solenoid-operated valves on the scram air header open to reduce pressure in the header, allowing the HCU scram valves to open. The FMCRDs then insert the CRs hydraulically in the same manner as the RPS initiated scram. The same signals that initiate ARI will simultaneously actuate the FMCRD motors to insert the CRs electrically.

12.2.3.1.2 Design Bases

This section describes the design bases for the CRD.

12.2.3.1.2.1 Safety Functions

The CRD has been designed to meet the following safety functions:

(1) Part of the CRD forms the Reactor Coolant Pressure Boundary (RCPB). Therefore, the components within the RCPB ensure the pressure integrity of the boundary and preserve reactor coolant, loss of which would lead to consequences above the BSL. From this perspective, the CRD delivers a Category A safety function (confinement) and the components necessary to deliver this function are classified as Class 1 safety components according to the safety categorisation and classification of UK ABWR.
This safety function is developed and justified in the section 12.1.3 related to the RCPB.

(2) The CR and CRD are the principal means to provide reactor rapid shutdown by performing CR insertion, (an action known as scram), to ensure fuel design margins are not exceeded in the event of frequent faults. Furthermore, the CR and CRD are the principal means to provide scram in the event of infrequent faults requiring reactor shutdown. From this perspective, the CRD delivers a Category A mitigation function, and as a principal means, the components necessary to deliver scram are classified as Class 1 safety components according to the safety categorisation and classification of UK ABWR.
The CR and CRD are the principal means of maintaining core sub-criticality. From this perspective, the CRD delivers a Category A mitigation function, and as a principal means, the components necessary to deliver maintenance of sub-criticality are classified as Class 1 safety components according to the safety categorisation and classification of UK ABWR.

(3) The CR and CRD are the principal means to prevent excessive reactivity insertion due to a CR drop event after reactor shutdown. From this perspective, the CRD delivers a Category A prevention function, and as a principal means, the components necessary to deliver this function are classified as Class 1 safety components according to the safety categorisation and classification of UK ABWR.

(4) Part of the CRD forms the Primary Containment Vessel Boundary (PCV Boundary). Therefore, the components within the PCV boundary form a barrier to maintain the integrity of the boundary and thus prevent the dispersion of radioactive substances. From this perspective, the CRD delivers a Category A safety function (confinement) and the components necessary to deliver this function are classified as Class 1 safety components according to the safety categorisation and classification of UK ABWR.
This safety function is developed and justified in the section related to the Primary Containment in Chapter 13.

12.2.3.1.2.2 Design Bases for Power Generation

From the power generation perspective, the CRD meets the following design bases, though no safety requirements are put on the system from this perspective:

(1) The CRD is designed to control changes in core reactivity by positioning neutron-absorbing CRs within the core.

(2) The CRD is designed to move and position CRs in increments to enable optimised power control and core power shaping.

12.2.3.1.3 System Design

This section describes the design of the CRD to satisfy the design bases.

12.2.3.1.3.1 Overall Design and Operation

(1) Normal Operation Mode

Normal operation is defined as those periods of time when no control rod drives are in motion. Under this condition, the CRD provides charging pressure to the HCUs to maintain them at high pressure standby conditions for eventual scram.

Two CRD Pumps installed in parallel (normally one in operation and the other on standby) supply the system with water from the Condensate and Feed Water System (CFDW) and/or the Condensate Storage Tank (CST) depending on the operational conditions of the reactor.

(a) Water is provided by the condenser spill over water from the CFDW during reactor normal operation.

(b) Water is supplied from the CST during reactor shutdown or start-up.

The system water is processed by redundant filters in both the pump suction and discharge lines. In order to maintain the ability to scram, the charging water line maintains the accumulators at high pressure. The scram valves remain closed except during and after scram, so during normal operation no flow passes through the charging water header. Pressure in the charging water header is monitored continuously. A significant degradation in the charging header pressure causes a low pressure warning alarm and rod withdrawal block by the RC&IS. If further degradation in pressure occurs, the RPS causes a reactor scram.

Pressure in the pump discharge header downstream of the drive water filters is also monitored continuously. Low pressure in this line is used to indicate that the operating pump has failed or tripped. If it should occur, automatic start-up of the standby pump is initiated and the system is quickly repressurised. This prevents the malfunctioning of the operating pump from causing a spurious reactor scram on low charging water header pressure, an event which would otherwise be a direct consequence of the malfunction.

The CRD Charging Header Accumulator and the check valves installed in the charge water line are capable of maintaining the line pressurised until the standby CRD Pump starts up and provides sufficient pressure.

(2) Scram Drive Mode

Upon loss of electric power to both scram pilot valve solenoids, the scram inlet valve in the associated HCU opens to apply the hydraulic insert forces to its respective FMCRDs using high pressure water stored within the previously charged HCU Accumulator (the nitrogen-water accumulator previously having been pressurised with charging water from the CRD Pumps). Once the hydraulic force is applied, the hollow piston disengages from the ball-nut and inserts the CR rapidly to deliver reactor shutdown and maintenance of core sub-criticality. The water displaced from the drive is discharged into the RPV. Indication that the scram has been successfully completed (all rods full-in position) is displayed to the operator.

12.2.3.1.3.2 Equipment Design and Operation

(1) FMCRD

(a) Configuration

There are a total of 205 FMCRDs, one for each CR. The FMCRD penetrates the bottom head of the RPV. The FMCRD consists of the components enclosed inside the CRD housing mounted on the bottom head of the RPV.

The FMCRD used for positioning the CR in the reactor core is a mechanical/hydraulic actuated mechanism. An electric motor-driven ball-nut and ball screw is capable of positioning the drive during normal operation according to the signals from the RC&IS. On the other hand, hydraulic pressure is used for scrams after receiving the scram signal from the RPS or the ARI signal.

During fault conditions, a single HCU powers the scram action of two FMCRDs. Upon scram valve initiation, high pressure nitrogen from the HCU raises the piston within the accumulator, forcing water through the scram piping. This water is directed to each FMCRD connected to the HCU. Inside each FMCRD, high-pressure water lifts the hollow piston off the ball-nut and drives the CR into the core. Departure from the ball-nut automatically releases spring-loaded latches in the hollow piston that engage slots in the guide tube. These latches are redundant and support the CR in the inserted position to prevent excessive reactivity insertion due to an eventual drop of the CR. The CR cannot be withdrawn until the ball-nut is driven up and engaged with the hollow piston.

A bayonet coupling is located between the CR and the FMCRD to engage them. . Once locked, the drive and rod form an integral unit that can only be unlocked manually by specific procedures before the components can be separated.

(b) Performance

The FMCRD components for scram are designed to be hydraulically actuated by the HCU and thus fully insert the CRs to deliver reactor rapid shutdown and maintenance of core sub-criticality within approximately 2.8 seconds.

(2) HCU

(a) Configuration

Each HCU furnishes pressurised water for scram, on signal from the RPS, to the two associated FMCRDs. There are 103 HCUs in total, of which 102 units actuate two FMCRDs and one unit actuates one FMCRD. Additionally, each HCU provides the capability to adjust purge flow to the two associated FMCRDs.

The HCU basically consists of a purge water solenoid valve, a scram pilot valve, a scram valve, the accumulator and the nitrogen gas bottle. Each HCU (except for the one driving only one FMCRD) is capable of storing the energy required to force the scram of two FMCRDs.

The scram pilot valve is operated by the signal from the RPS. The scram pilot valve consists of two three-way solenoid valves to control the scram valve. The scram pilot valve is solenoid-operated and is normally energised. Upon loss of electrical signal to the solenoids (loss of power supply), the inlet port closes and the exhaust port opens to assure fail-safe condition. The scram pilot valve is designed so that so that both solenoids must be de-energised before air pressure can be discharged from the scram valve actuator. This prevents the inadvertent scram of both drives associated with a given HCU in the event of a failure of one of the pilot valve solenoids.

The scram valves are provided in order to assure a reliable scram when required. The scram valve opens to supply pressurised water to the bottom of the hollow piston. This valve is operated by an internal spring and air pressure. The scram valves are kept closed by the effect of the air pressure during normal operation. The scram valves are designed such that in the event of loss of electric power of the scram pilot valve or air supply, the actuator discharges the pressurised air and the valves open to perform scram (fail-safe design). The scram valves are opened by the pressurised air discharge from the actuator upon any of the following events:

(i) Both of the scram pilot valve solenoids stop being energised

(ii) The scram pilot valve air line is depressurised by the backup scram pilot valves or the ARI electromagnetic valves.

The scram accumulator stores sufficient energy to fully insert two CRs. The accumulator is a cylinder with a free-floating piston. The piston separates the water on top from the nitrogen below. A check valve in the accumulator charging header prevents loss of water pressure in the event that supply pressure is lost.. In order to ensure that the accumulator is always available to perform scram, instrumentation is installed in the HCU to confirm the nitrogen gas is maintained at high pressure and there is no water leakage.

(b) Performance

The HCU accumulators are designed as follows in order to deliver the performance required for scram.

Table 12.2-1 : HCU Accumulator

Capacity:	
Accumulator	approx. 66L (water side capacity)
Nitrogen Gas Bottle	approx. 200L
Charging Water Pressure	approx. 15MPa [gauge]

The capacity of water side and nitrogen side of the HCU accumulators is the necessary to insert the two CRs of each HCU within the required time.

(3) CRD Pump

(a) Configuration

One supply pump pressurises the CRD with water from the CFDW or the CST while the spare pump is on standby.

(b) Performance

The pumps are designed as indicated below such that they can supply the rated flow and head required for pressurising the HCU Accumulators (approx. 15MPa [gauge]) during normal operation and after scram completion. The pumps are operated continuously at the rated flow and pressure for purging during normal plant operation.

Table 12.2-2 : CRD Pump

Capacity for HCU Accumulator Charge	approx. 46m^3/h
Head for HCU Accumulator Charge	Head: ≥1,420m (approx.)

12.2.3.1.3.3 Main Support Systems

(1) Instrumentation and Control
  (a) Instrumentation
  Instrumentation is provided to measure and monitor the operating conditions of the CRD components necessary for the delivery of the safety functions. The status, measurements and alarms of the components and valves to be remotely operated are generally displayed in the Main Control Room (MCR). The main provisions for instrumentation are described as follows.
    (i) Charging water header inlet pressure (start-up of standby CRD Pump if low)
    (ii) Charging water header pressure (CR withdrawal block if low, reactor scram if low-low)
    (iii) Scram pilot valve air header inlet pressure
    (iv) HCU accumulator pressure
  (b) Control
  The main control provisions related to the delivery of the safety functions are described as follows.
    (i) The HCU scram pilot valve is actuated (discharge) by the scram signal from the RPS and thereby the scram valve is opened to implement scram.
    (ii) The CRD Pump on standby is automatically started up if the charging water header inlet pressure decreases in order to maintain the line pressure at an equal or higher level than the scram trip set value to prevent spurious scram.
    (iii) The charging water header low-low pressure signal is transmitted to the RPS for implementing the reactor scram before the scram function is lost.

(2) Power Supply System
  The design is fail-safe and therefore, power supply is not required for the delivery of the safety functions.

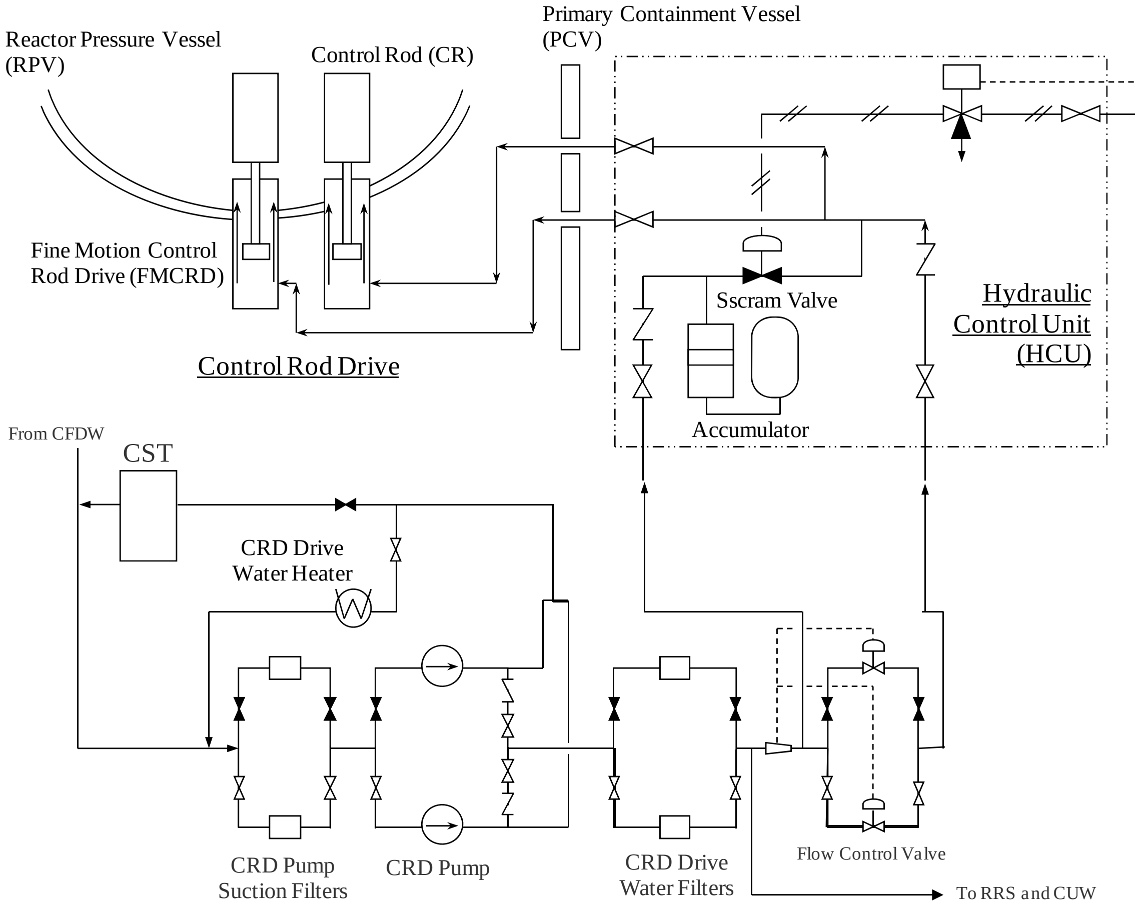

Figure 12.2-1 : Outline of the CRD

12.2.3.2 Standby Liquid Control System

12.2.3.2.1 System Summary Description

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

12.2.3.2.1.1 System Roles

The SLC is the secondary means to provide the reactor shutdown and maintain sub-criticality if the reactor cannot be shut down by scram action in an event known as ATWS.

12.2.3.2.1.2 Functions Delivered

The main role of the SLC is to inject sufficient negative reactivity into the core to shut down the reactor in a safe manner from full power operation to cold shutdown conditions in the unlikely event that CRs insertion is not available. Sodium pentaborate solution (boric-acid solution) is used as a neutron absorber.

12.2.3.2.1.3 Basic Configuration

The SLC injects the neutron absorber into the core from the SLC Storage Tank through the High Pressure Core Flooder System (HPCF) flooder sparger.
The SLC consists of the following components:

(1)	SLC Storage Tank	1 unit
(2)	SLC Test Tank	1 unit
(3)	SLC Pump	2 units
(4)	Motor-operated injection valve	2 units
(5)	Piping and Valves	1 set
(6)	Instruments and Control Components	1 set

Figure 12.2-2 shows an outline of the SLC.

12.2.3.2.1.4 Modes of Operation

The SLC performs the following three operating modes:

(1) Standby Mode
During normal plant operation, the SLC lines are in a standby condition with the motor-operated valves in their normally open or normally closed positions. In this mode, the lines from the SLC Storage Tank outlet valves to the motor-operated injection valves are filled with water from the Makeup Water Purified System (MUWP).

(2) Reactor Injection Mode
This mode is actuated by signal from the MCR in the case that the reactor cannot be shut down by the CRs. The sodium pentaborate solution is injected from the SLC Storage Tank through the SLC Pump, the injection motor operated valve, and the HPCF sparger into the core.

(3) Test Mode
   (a) The pump functional test is carried out by re-circulating demineralised water from SLC Test Tank through the SLC Pump to the SLC Test Tank during normal operation and shutdown of the plant.

(b) The system test is carried out by actuating the pump and the injection motor-operated valve to inject pure water into the reactor during the plant shutdown. Demineralised water is injected from the test tank through the injection motor operated valve into the reactor. The system injection test is implemented only during plant shutdown.

12.2.3.2.2 Design Bases

(1) Part of the SLC forms the RCPB. Therefore, the components within the RCPB ensure the pressure integrity of the boundary and preserve reactor coolant, loss of which would lead to consequences above the BSL. From this perspective, the SLC delivers a Category A preventive function and the components necessary to deliver this function are classified as Class 1 safety components according to the safety categorisation and classification of UK ABWR.
(2) The SLC is the secondary means to provide reactor shutdown without CRs insertion, from full power operation during cycle equilibrium to cold sub-critical condition by injecting the neutron absorbing solution into the reactor core and keeping it under such conditions. From this perspective, the SLC delivers a Category A mitigation function, and, as secondary means, the components necessary to deliver reactor shutdown and maintenance of sub-criticality function are classified as Class 2 safety components according to the safety categorisation and classification of UK ABWR.
This function is developed and justified in section 12.1.3 related to the RCPB.

12.2.3.2.3 System Design

12.2.3.2.3.1 Overall Design and Operation

The SLC is a redundant, independent reactor shutdown system to operate as a back-up of the CRD.

The SLC injects the neutron absorber into the core from the SLC Storage Tank.

Two trains of the dynamic equipments (pumps, motor-operated injection valves) are provided to assure sufficient redundancy. The system is designed such that the specific functions can be implemented with either of the trains operating.

12.2.3.2.3.2 Equipment Design and Operation

(1) Storage Tank
   (a) Configuration
      (i) The SLC Storage Tank is a vertical cylindrical type of tank provided with a hatch and suitable access arrangements to load the sodium pentaborate solution.
      (ii) Auxiliary equipment including electric heaters, air spargers, and various nozzles are mounted.
      (iii) The electric heaters are installed inside the Storage Tank. The heater is designed to be capable of independently maintaining an adequate tank temperature to prevent any precipitation of sodium pentaborate solution.
      (iv) The tank solution outlet connections are mounted on the tank surface side to assure that the outlet will not be plugged by any foreign material that may inadvertently be added into the tank.
      (v) Stainless steel is applied to welded components.

(b) Performance

The SLC Storage Tank is designed to perform as follows in order to satisfy the safety function.

The capacity of the SLC Storage Tank is set up based on the boron concentration necessary to maintain the sub-critical condition of the reactor plus margins. The storage capacity of the SLC is determined as the necessary quantity of the sodium pentaborate solution, which contains the boron quantity required to achieve the necessary boron concentration mentioned before when distributed in water of the capacity of the RPV, in the saturated boron solution at 15°C.

(i) Number: 1 unit
(ii) Type: Vertical cylindrical type
(iii) Capacity: (later)

(2) SLC Pumps

(a) Configuration

(i) The SLC is provided with two 100% flow capacity injection pumps in parallel. The pumps are triplex plunge type.
(ii) The SLC Pumps start with a certain delay after lubricant pressure reaches the established set point.
(iii) The suction and discharge connections of the pumps are flange connection type.

(b) Performance

The SLC Pump is designed to perform as follows in order to satisfy the safety function.

The flow rate of the SLC Pump is set up such that the boron concentration variation rate in the reactor water satisfies the minimum reactivity insertion rate of the reactor plus margins. The SLC Pump is designed to inject the sodium pentaborate solution in SLC Storage Tank within the time necessary satisfy the required boron concentration variation rate in the reactor water mentioned before.

Each pump is capable of pumping the rated injection flow into the reactor at all reactor operating pressures ranging from 0MPa [gauge] to the maximum pressure required for this system.

(i) Number: 2 units
(ii) Pump Type: Reciprocating
(iii) Capacity: (later)

(3) SLC Test Tank

(a) The test tank has sufficient capacity so that the SLC can be operated at rated flow for a minimum of three minutes during injection test mode.
(b) Stainless steel is applied to welded components.

12.2.3.2.3.3 Main Support Systems

(1) Instrumentation and Control

(a) Instrumentation

(i) All important equipment and valve conditions, measured parameters and alarms are indicated in the MCR.
(ii) The manual valves (test valve, Test Tank outlet valve) position during functional test mode is indicated in the MCR, so as to be capable of confirming the open/closed state of the valves.
(iii) The monitored items are shown in Table 12.2-3.

Table 12.2-3 : Monitored Items of SLC

No.	Items	Indicator	Alarm	Control
1	Water Level of SLC Storage Tank	MCR Local	High/Low	-
2	Temperature in SLC Storage Tank	Local	High/Low	Heater on/off control
3	Discharge Pressure of SLC Pump	MCR Local	-	

(b) Interlocks

(i) The SLC Pumps, SLC sodium pentaborate solution injection valves and Storage Tank outlet valves are operated such that the operation can be controlled from the MCR.

(ii) The CUW is isolated from the Nuclear Boiler System (NB) by closure of isolation valves when the SLC is in operation.

(iii) The SLC Pump can be shut off and the SLC Storage Tank outlet valves and injection valves can be closed when the SLC Storage Tank solution level reaches zero level by turning the manual switch to stop position.

(iv) The SLC Pumps, SLC Storage Tank outlet valves and the SLC injection valves are designed such that they can be locally operated for functional test. The SLC Pumps discharge pressure is indicated in the local panel to confirm their operating conditions. Moreover, the SLC injection valves and the SLC Storage Tank outlet valves are interlocked so as not to open simultaneously when carrying out local opening/closing tests to prevent an inadvertent injection of sodium pentaborate solution into the reactor.

(v) The heater provided inside the SLC Storage Tank prevents precipitation of sodium pentaborate in the tank and the solution temperature is controlled.

(2) Power Supply System

The system is designed such that it can operate even upon loss of normal power supply (LOOP). The power supplies required for the pumps, solution injection valve, Storage Tank outlet valve, electric heaters and control and instrumentation are provided from the emergency power sources.

(3) Makeup Water Purified System (MUWP)

Water filling equipment is provided for sealing the system between the SLC Storage Tank outlet valve and the injection valve with water from the MUWP, and maintain it filled at all times during system standby mode. It minimises the time delay to fill the pump discharge line with water, prevents water hammer at the system start-up, and prevents pentaborate solution leakage from the SLC Storage Tank outlet valve into the system.

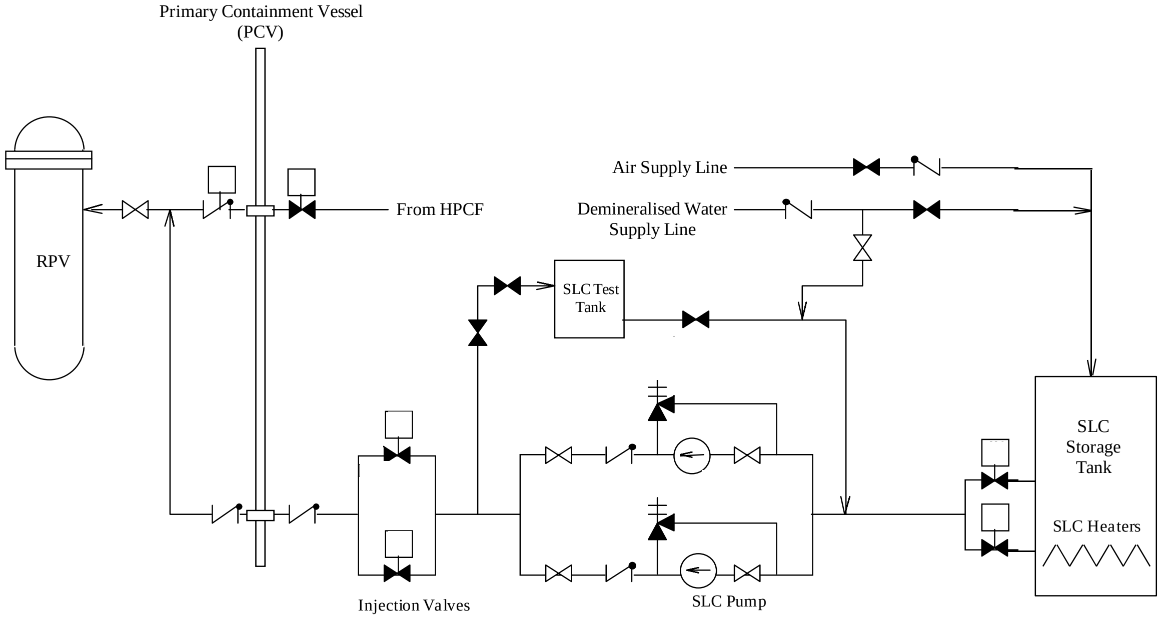

Figure 12.2-2 : Outline of the SLC

12.2.4 References

[Ref-1] GA91-9201-0002-00013 Rev.0 Basis of Safety Cases on Control Rod Drive System, Hitachi-GE.