Enclosure 2

MFN 09-257

DCD Markups for

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scram. The hydraulic power required for scram is provided by high-pressure water stored in the scram accumulator within the individual HCUs. Each HCU is designed to scram up to two FMCRDs. The HCUs also provide the flow path for purge water to the associated drives during normal operation. The CRD Hydraulic subsystem supplies high pressure demineralized water, which is regulated and distributed to provide charging of the ~~HCU~~ scram accumulators, purge water flow to the FMCRDs, and backup makeup water to the RPV when the feedwater flow is not available.

During power operation, the CRD system controls changes in core reactivity by movement and positioning of the neutron absorbing control rods within the core in fine increments via the FMCRD electric motors, which are operated in response to control signals from the RC&IS.

The CRD system provides rapid control rod insertion (scram) in response to manual or automatic signals from the Reactor Protection System (RPS), so that no fuel damage results from any plant transient.

The FMCRDs are mounted in housings welded into the RPV bottom head. Each FMCRD has a movable hollow piston tube that is coupled at its upper end, inside the reactor vessel, to the bottom of a control rod. The piston is designed such that it can be moved up or down, both in fine increments and continuously over its entire range, by a ball nut and ball screw driven by the electric motor. In response to a scram signal, the piston rapidly inserts the control rod into the core hydraulically using stored energy in the ~~HCU~~ scram accumulator. The scram water is introduced into the drive through a scram inlet connection on the FMCRD housing, and is then discharged directly into the reactor vessel via clearances between FMCRD parts. The FMCRD scram time requirements are provided in the plant-specific Technical Specifications.

The FMCRD design includes an electro-mechanical brake on the motor drive shaft and a ball check valve at the point of connection with the scram inlet line. These features prevent control rod ejection in the event of a failure of the scram insert line. An internal housing support is provided to prevent ejection of the FMCRD and its attached control rod in the event of a housing failure. It uses the outer tube of the drive to provide support. The outer tube, which is welded to the drive middle flange, attaches by a bayonet lock to the base of the control rod guide tube. The flange at the top of the control rod guide tube contacts the core plate and prevents any downward movement of the drive.

The FMCRD is designed to detect separation of the control rod from the drive mechanism. Two redundant and separate safety-related switches detect separation of either the control rod from the hollow piston or the hollow piston from the ball nut. Actuation of either switch causes an immediate rod block and an alarm in the MCR, thereby preventing the occurrence of a rod drop accident. Consequently, a rod drop accident is not considered further for this design. (See Section 4.6.)

Each HCU provides sufficient volume of water stored at high pressure in a pre-charged scram accumulator to scram two FMCRDs at any reactor pressure. Each scram accumulator is connected to its associated FMCRDs by a hydraulic line that includes a normally closed scram valve. The scram valve opens by spring action but is normally held closed by pressurized control air. To cause scram, the RPS provides a de-energizing reactor trip signal to the solenoid-operated pilot valve that vents the control air from the scram valve. The system is “fail safe” in that loss of either electrical power to the solenoid pilot valve or loss of control air pressure causes scram. The HCUs are housed in the Reactor Building at the basemat elevation. This is a Seismic Category I structure, and the HCUs are protected from external natural phenomena such as earthquakes, tornados, hurricanes and floods, as well as from internal postulated accident phenomena. In this area, the HCUs are not subject to conditions such as missiles, pipe whip, or discharging fluids.

The CRD Hydraulic subsystem design provides the pumps, valves, filters, instrumentation, and piping to supply the high-pressure water for charging the HCUs and purging the FMCRDs. Two 100% capacity pumps (one on standby) supply the HCUs with water from the condensate treatment system and/or condensate storage tank for charging the scram accumulators and for supplying FMCRD purge water. The CRD Hydraulic subsystem equipment is housed in the Seismic Category I portion of the Reactor Building to protect the system from floods, tornadoes, and other natural phenomena. The CRD Hydraulic subsystem also has the capability to provide makeup water to the RPV while at high pressure as long as AC power is available.

The CRD system includes MCR indication and alarms to allow for monitoring and control during design basis operational conditions, including system flows, temperatures and pressures, as well as valve position indication and pump on/off status. Safety-related pressure instrumentation is provided on the ~~HCU~~scram accumulator charging water header to monitor header performance. The pressure signals from this instrumentation are provided to the RPS, which initiates a scram if the header pressure degrades to a low-low pressure setpoint. This feature ensures the capability to scram and safely shut down the reactor before ~~HCU~~scram accumulator pressure can degrade to the level where scram performance is adversely affected following the loss of scram accumulator charging water header pressure.

Components of the system that are required for scram (FMCRDs, HCUs and scram piping), are classified Seismic Category I. The balance of the system equipment (pumps, valves, filters, piping, etc.) is classified as Seismic Category II, with the exception of the safety-related scram accumulator charging water header pressure instrumentation, which is Seismic Category I. The major CRD components and their design requirements are provided in Section 4.6.

The CRD system is separated both physically and electrically from the Standby Liquid Control (SLC) system.

1.2.2.2.3 Feedwater Control System

The Feedwater Control System accomplishes both RPV water level control and FW temperature control. RPV water level control is accomplished by manipulating the speed of the FW pumps. FW temperature control is accomplished by manipulating the heating steam flow to the seventh stage FW heaters or directing a portion of the FW flow around the high- pressure FW heaters. The two functions are performed by two sets of triple redundant controllers located in separate cabinets.

The Feedwater Control System (FWCS) provides logic for controlling the supply of feedwater flow to the reactor vessel in response to automatic or operator manual control signals. This control maintains reactor water level within predetermined limits for all operating conditions including startup. A fault-tolerant, triplicated, digital controller uses water level, steam flow and feedwater flow signals to form a three-element control strategy to accomplish this function. Single-element control based only on reactor water level is used when steam flow or feedwater

1.2.2.2.6 Remote Shutdown System

The Remote Shutdown System (RSS) provides the means to safely shut down the reactor from outside the main control room. The RSS provides remote manual control of the systems necessary to:

- achieve and maintain safe (hot) shutdown of the reactor after a scram;
- achieve subsequent cold shutdown of the reactor; and
- maintain safe conditions during shutdown.

The RSS is classified as a safety-related system. The RSS includes control interfaces with safety-related equipment.

1.2.2.2.7 Reactor Protection System

The Reactor Protection System (RPS) initiates an automatic and prompt reactor trip (scram) by means of rapid hydraulic insertion of all control rods whenever selected plant variables exceed preset limits. The primary function is to achieve a reactor shutdown before fuel damage occurs. The RPS also provides reactor status information to other systems, and causes one or more alarms in the MCR whenever selected plant variables exceed the preset limits.

The RPS is a four-division safety-related protection system, differing from a reactor control system or a power generation system. The RPS and its components are safety-related. The RPS and the system electrical equipment are classified as Seismic Category I.

RPS descriptions are provided within Section 7.2.

The RPS initiates reactor trip signals within individual sensor channels when any one or more of the conditions listed below exists during reactor operation. Reactor scram results on any of the following conditions in accordance with the system logic described below.

- Drywell pressure high;
- Reactor power (neutron flux or simulated thermal power) exceeds limit for operating mode;
- Reactor power rapid increase (short period);
- Reactor vessel pressure high;
- Reactor water level low (Level 3);
- Reactor water level high (Level 8);
- Main steam isolation valves closed (Run mode only);
- ~~CRD HCU~~Scram accumulator charging water header pressure – low-low;
- Suppression pool temperature high;
- Turbine stop valve closure and insufficient turbine bypass available;
- Turbine control valve fast closure and insufficient turbine bypass available;
- Main condenser vacuum low;

- The design provides for isolation bypass capability allowing high pressure makeup water injection (HP CRD) into the RPV if GDCS is unsuccessful in injecting water into the RPV.

4.6.1.2 Description

The CRD system is composed of three major elements:

- Electro-hydraulic fine motion control rod drive (FMCRD) mechanisms;
- Hydraulic control units (HCU); and
- Control rod drive hydraulic subsystem ~~(CRDHS)~~.

The FMCRDs provide electric-motor-driven positioning for normal insertion and withdrawal of the control rods and hydraulic-powered rapid insertion (scram) of control rods during abnormal operating conditions.

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

The ~~CRDHS~~CRD Hydraulic Subsystem clean, demineralized water that is regulated and distributed to provide charging of the ~~HCU~~ scram accumulators and purge water flow to the FMCRDs during normal operation. The ~~CRDHS~~CRD Hydraulic Subsystem is also the source of pressurized water for purging the Reactor Water Cleanup/Shutdown Cooling (RWCU/SDC) system pumps and the Nuclear Boiler System (NBS) reactor water level reference leg instrument lines. Additionally, the ~~CRDHS~~CRD Hydraulic Subsystem provides high pressure makeup water to the reactor during events in which the feedwater system is unable to maintain reactor water level. This makeup water is supplied to the reactor via a ~~bypass~~ line off the CRD pump discharge header that connects to the feedwater inlet piping via the RWCU/SDC return piping. During certain LOCA events the makeup water is isolated from the RPV and directed to the CST through the CRD pump minimum flow lines. The high pressure makeup isolation is bypassed, in response to signals indicating unsuccessful GDCS injection, to allow normal high pressure makeup injection to the RPV.

The CRD system performs the following functions:

- Controls changes in core reactivity by positioning neutron-absorbing control rods within the core in response to control signals from the Rod Control and Information System (RC&IS).
- Provides movement and positioning of control rods in increments to enable optimized power control and core power shape in response to control signals from the RC&IS.
- Provides the ability to position large groups of rods simultaneously in response to control signals from the RC&IS.
- Provides rapid control rod insertion (scram) in response to manual or automatic signals from the Reactor Protection System (RPS) so that no fuel damage results from any plant AOO.

The balance of the nonsafety-related hydraulic system equipment (pumps, valves, filters, etc.) is physically separated from the HCUs and housed in a separate room in the reactor building. It is connected to the HCUs by the nonsafety-related FMCRD purge water header, ~~HCU~~scram accumulator charging water header and scram air header. These headers are classified as Seismic Category II so that they will maintain structural integrity during a seismic event and not degrade the functioning of the HCUs.

4.6.1.2.1 Fine Motion Control Rod Drive Mechanism

The FMCRD used for positioning the control rod in the reactor core is a mechanical/hydraulic actuated mechanism (Figures 4.6-1 and 4.6-2). An electric motor-driven ball-nut and ball screw assembly is capable of positioning the drive at both ~~a minimum~~nominal increments of 36.5 mm (1.44 in.) ~~increments~~ and continuously over its entire range at a nominal speed of 28 ~~± 5~~ mm/sec. Hydraulic pressure is used for scrams. The FMCRD penetrates the bottom head of the reactor pressure vessel. The FMCRD does not interfere with refueling and is operative even when the head is removed from the reactor vessel.

The fine motion capability is achieved with a ball-nut and ball screw arrangement driven by an electric motor. The ball-nut is keyed to the guide tube (roller key) to prevent its rotation and traverses axially as the ball screw rotates. A hollow piston rests on the ball-nut, and upward motion of the ball-nut drives this piston and the control rod into the core. The weight of the control rod keeps the hollow piston and ball-nut in contact during withdrawal.

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 control rod into the core. A spring washer buffer assembly stops the hollow piston at the end of its stroke. Departure from the ball-nut releases spring-loaded latches in the hollow piston that engage slots in the guide tube. These latches support the control rod and hollow piston in the inserted position. The control rod cannot be withdrawn until the ball-nut is driven up and engaged with the hollow piston. Stationary fingers on the ball-nut then cam the latches out of the slots and hold them in the retracted position. A scram action is complete when every FMCRD has reached its fully inserted position.

The use of the FMCRD mechanisms in the CRD system provides several features that enhance both the system reliability and plant operations. Some of these features are listed and discussed briefly as follows:

Diverse Means of Rod Insertion — The FMCRDs can be inserted either hydraulically or electrically. In response to a scram signal, the FMCRD is inserted hydraulically via the stored energy in the scram accumulators. A signal is also given simultaneously to insert the FMCRD electrically via its motor drive. This diversity provides a high degree of assurance of rod insertion on demand.

Absence of FMCRD Piston Seals — The FMCRD pistons have no seals and, thus, do not require maintenance.

- The approximate purge flow provided to the NBS reference leg instrument lines is shown in Table 4.6-1. The purge flow maintains the RPV water level reference leg instrument lines filled to address the effects of noncondensible gases in the instrument lines to prevent erroneous reference information after a rapid RPV depressurization event.
- The approximate flow provided to the Process Sampling System (PSS) is shown in Table 4.6-1. The PSS monitors this flow for CRD water conductivity and dissolved oxygen level.
- The minimum flow supplied to the reactor in the high pressure makeup mode of operation is shown in Table 4.6-1. This flow is based on a reactor gauge pressure less than or equal to the reference pressure shown in Table 4.6-1.

CRD Supply Pump

One supply pump pressurizes the system with water from the condensate treatment system and/or condensate storage tanks. One spare pump is provided for standby. A discharge check valve prevents backflow through the non-operating pump. A portion of the pump discharge flow is diverted through a minimum flow ~~bypass~~ line to the Condensate Storage Tank (CST). This flow is controlled by an orifice and is sufficient to prevent pump damage if the pump discharge is inadvertently closed.

Redundant filters in both the pump suction and discharge lines process the system water. A differential pressure indicator and control room alarm monitor each filter element as they collect foreign materials.

For the high pressure makeup mode of operation, the ~~CRDHS~~CRD Hydraulic Subsystem operates with both pumps running simultaneously. The standby pump is initiated automatically by low reactor water level so that the combined flow from both pumps can provide the required high pressure makeup flow to the reactor vessel. The standby pump also starts automatically if loss of discharge header pressure is sensed during normal operation, indicating a failure of the operating pump. This prevents a scram due to low-low scram accumulator charging water header pressure from occurring as result of an inadvertent pump trip.

The pump suction filters are bypassed automatically during two-pump operation to assure that adequate Net Positive Suction Head (NPSH) is available for the pumps. Two bypass lines are provided around the suction filters, each line containing a normally closed motor-operated valve. These valves are signaled to open when the high pressure makeup mode of operation is initiated.

Scram Accumulator Charging Water Header

The scram ~~A~~accumulator charging pressure is established by pre-charging the nitrogen accumulator (gas bottle) to a precisely controlled pressure at known temperature. During scram, the scram valves open and permit the stored energy in the scram accumulators to discharge into the drives. The resulting pressure decrease in the scram accumulator charging water header allows the CRD supply pump to "run out" (that is, flow rate to increase substantially) into the control rod drives via the scram accumulator charging water header. The flow element upstream of the scram accumulator charging water header senses high flow and provides a signal to the manual/auto flow control station which in turn closes the system flow control valve. This action effectively blocks the flow to the purge water header so that the runout flow is confined to the scram accumulator charging water header.

Pressure instrumentation is provided in the scram accumulator charging water header to monitor header performance. The pressure signal from this instrumentation is provided to both the RC&IS and RPS. If the scram accumulator charging water header pressure degrades, the RC&IS initiates a rod block and alarm at a predetermined low pressure setpoint. If pressure degrades even further, the RPS initiates a scram at a predetermined low-low pressure setpoint. This ensures the capability to scram and reactor shutdown before the ~~HCU~~ scram accumulator pressure can degrade to the level where scram performance is adversely affected following the loss of scram accumulator charging water header pressure.

The scram accumulator charging water header contains a check valve and a bladder-~~-~~type accumulator. The accumulator is located downstream of the check valve in the vicinity of the low header pressure instrumentation. It is sized to maintain the header pressure downstream of the check valve above the scram setpoint until the standby CRD pump starts automatically, following a trip or failure of the operating CRD pump. Pressure instrumentation installed on the pump discharge header downstream of the CRD pump drive water filters monitors system pressure and generates the actuation signals for startup of the standby pump if the pressure drops below a predetermined value that indicates a failure of the operating pump.

An air-operated isolation valve is also provided in the scram accumulator charging water header. It closes automatically when the system is initiated into the high pressure makeup mode of operation. It blocks the flow through the header to allow all ~~CRDHS~~CRD Hydraulic Subsystem flow in this mode to be directed to the reactor via the feedwater system. The valve is designed to preferentially fail closed upon loss of control power or instrument air.

Purge Water Header

The purge water header is located downstream from the flow control valve. The flow control valve adjusts automatically to maintain constant flow to the FMCRDs as reactor vessel pressure changes. Because flow is constant, the differential pressure between the reactor vessel and ~~CRDHS~~CRD Hydraulic Subsystem is maintained constant independent of reactor vessel pressure. A flow indicator in the control room monitors system flow. A differential pressure indicator is provided at a local panel to indicate the difference between reactor vessel pressure and purge water pressure.

An air-operated isolation valve is also provided in the purge water header. It closes automatically when the system is initiated into the high pressure makeup mode of operation. It blocks the flow through the header to allow all ~~CRDHS~~CRD Hydraulic Subsystem flow in this mode to be directed to the reactor via the feedwater system. The valve is designed to preferentially fail closed upon loss of control power or instrument air.

High Pressure Makeup Line

The ~~CRDHS~~CRD Hydraulic Subsystem supplies high pressure makeup water to the reactor vessel through piping connecting the discharge lines of the CRD pumps to the RWCU/SDC. The flow is then routed through RWCU/SDC piping to the feedwater system for delivery to the reactor via the feedwater sparger.

Each pump provides half the flow capacity for the high pressure makeup mode of operation. Located downstream of each pump is a flow control station containing the flow instrumentation and the control valve for regulating the pump flow during high pressure makeup. The piping

The purge water header provides the purge water for each drive. The purge water flow control valve automatically regulates the purge water flow to the drive mechanisms. The purge water flow rate is indicated in the control room.

In order to maintain the ability to scram, the scram accumulator charging water header maintains the scram accumulators at a high pressure. The scram valves remain closed except during and after scram, so during normal operation no flow passes through the scram accumulator charging water header. Pressure in the scram accumulator charging water header is monitored continuously. A significant degradation in the scram accumulator charging water header pressure causes a low pressure warning alarm and rod withdrawal block by the RC&IS. Further degradation, if occurring, causes a reactor scram by the RPS.

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 startup of the standby pump is initiated and the system is quickly re-pressurized. A bladder-type accumulator located in the scram accumulator charging water header maintains the pressure in the header above the scram setpoint during the time delay associated with startup of the standby pump. These features protect against a loss of scram accumulator charging water header pressure which may occur as a result of a malfunction of the operating pump, and which could cause the reactor to scram due to a low-low scram accumulator charging water header pressure.

Control Rod Insertion and Withdrawal

The FMCRD design provides the capability to move a control rod in fine steps. Normal control rod movement is under the control of the RC&IS. The RC&IS controls the input of actuation power to the FMCRD motor from the electrical power supply in order to complete a rod motion command. The FMCRD motor rotates a ball screw that, in turn, causes the vertical translation of a ball-nut on the ball screw. This motion is transferred to the control rod via a hollow piston that rests on the ball-nut. Thus, the piston with the control rod is raised or lowered, depending on the direction of rotation of the FMCRD motor and ball screw.

During a control rod insertion, opening the solenoid-operated purge water makeup valve within the associated HCU increases the purge water flow to the drive. The increased flow offsets the volumetric displacement within the drive as the hollow piston is inserted into the core and prevents reactor water from being drawn back into the drive.

Scram

Upon loss of electric power to both scram solenoid pilot valve (SSPV) coils, 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 precharged scram accumulator (the nitrogen-water accumulator having previously been pressurized with charging water from the ~~CRDHS~~CRD Hydraulic Subsystem). Once the hydraulic force is applied, the hollow piston disengages from the ball-nut and inserts the control rod rapidly. The water displaced from the FMCRD is discharged into the reactor vessel. Indication that the scram has been successfully completed (all rods full-in position) is displayed to the operator.

Table 4.6-2 shows the scram performance provided by the CRD system at full power operation, in terms of the maximum elapsed time for each control rod to attain the listed scram position (percent insertion) after loss of signal to the scram solenoid pilot valves (time zero).

The start of motion is the time delay between loss of signal to the scram solenoid pilot valve and actuation of the 0% reed switch.

Simultaneous with the hydraulic scram, each FMCRD motor is started in order to cause electric-driven run-up of the ball-nut until it reengages with the hollow piston at the full-in position. This action is known as the scram follow function. It completes the rod full-in insertion and prepares the drives for subsequent withdrawal to restart the reactor.

After reset of the RPS logic, each scram valve re-closes and allows the ~~CRDHS~~CRD Hydraulic Subsystem to recharge the scram accumulators.

Alternate Rod Insertion

The ARI function of the CRD system provides an alternate means for actuating hydraulic scram that is diverse and independent from the RPS. The ARI is initiated by signals from the DPS ARI ATWS mitigation logic described in Subsection 7.8.1.1.3. Following receipt of an initiation signal, solenoid-operated valves on the scram air header actuate to depressurize the header, allowing the HCU scram valves to open. The FMCRDs then insert the control rods hydraulically in the same manner as the RPS initiated scram. The same signals that initiate ARI simultaneously actuate the FMCRD motors to insert the control rods electrically.

The FMCRDs are capable of inserting the control rods hydraulically during ATWS pressure transients with peak reactor pressures of 10.34 MPaG (1500 psig) or less.

High Pressure Makeup

The high pressure makeup mode of operation initiates on receipt of a low reactor water Level 2 signal. When this occurs, the following actions take place automatically:

- The CRD pump suction filter bypass valves open.
- The standby CRD pump is actuated. Both CRD pumps are operated in parallel in order to deliver the required makeup flow capacity to the reactor.
- The flow control valves in the high pressure makeup lines open to regulate the makeup water flow rate to the reactor. The test valve in the high pressure makeup line to the RWCU/SDC System opens, if it is closed at the start of the event, and the test valve in the return line to the CST closes, if it is open at the start of the event. The pump minimum flow ~~bypass~~ isolation valve closes.
- The isolation valves in the purge water header and scram accumulator charging water header close so that all makeup flow is delivered to the reactor through the high pressure makeup lines.

At high reactor water Level 8, the high pressure makeup flow control valves close to stop flow to the reactor in order to prevent flooding of the Main Steam (MS) lines. Each~~The~~ pump minimum flow ~~bypass~~ valve reopens and both pumps continue to operate in a low flow condition by directing their flow back to the CST through the pump minimum flow lines. Alternately, the operator may choose at this time to manually realign the system into its normal operation mode by shutting down one pump and reopening the scram accumulator charging water header and purge water header isolation valves so that ~~HCU~~scram accumulator charging and FMCRD purge water flow can be reestablished. In either case, the system is reset for an automatic restart of high pressure makeup if a subsequent Level 2 should occur.

During testing of this mode of operation, the high pressure makeup line isolation valve is closed and pump flow is directed back to the CST through the test line. The backpressure in the line is varied by positioning of the throttle valve in the test line to simulate system operation over the full range of reactor pressure.

The high pressure makeup mode of operation is automatically stopped and the high pressure makeup flow to the RPV~~CRD pumps~~ isolated~~tripped~~ by coincident low water level in two of the three GDCS pools or drywell pressure high and drywell level high. The flow is directed to the CST through the pump minimum flow lines. This action prevents a reduction of the containment air space volume and increased containment pressurization ~~that could be~~ caused by injecting water from outside containment during accident conditions. In the event of a GDCS failure (GDCS initiation logic and a time delay to allow for system actuation and a not low signal from two out of three GDCS pools) to successfully inject water into the reactor the HP CRD isolation bypass valves provide a flow path around the HP CRD isolation valves for high pressure makeup water injection to the RPV. Manual inhibit capability exists for the high pressure makeup isolation function and manual initiation capability exists for the isolation bypass function for either GDCS injection failure or loss of air.

4.6.1.2.6 Instrumentation and Control

Instrumentation

The instrumentation for the CRD system includes the following:

- Differential pressure sensors monitor pressure drop across the pump suction filters and drive water filters. High filter differential pressure is alarmed in the control room.
- A pressure sensor is located in the inlet piping to each CRD pump to monitor the suction pressure. A low pressure condition trips the associated pump and is alarmed in the control room.
- Two pressure sensors are located in the common pump discharge line downstream of the drive water filters to monitor system pressure. A low pressure condition indicates a failure of the operating pump. A low pressure signal from either sensor actuates the standby pump.
- Four safety-related pressure sensors are located in the scram~~HCU~~ accumulator charging water header. The output signals from these sensors are provided to the RC&IS logic and RPS logic. A low pressure condition from two-out-of-four sensors causes the RC&IS to generate an all-rod-withdrawal block. A low-low pressure condition causes the RPS to generate a reactor scram.
- A flow sensor is provided in the common pump discharge line downstream of the drive water filters and upstream of the scram accumulator charging water and purge water headers. The flow signal from this sensor provides the control input signal to the purge water flow control valves.

- Each of the two high pressure makeup lines downstream of the CRD pumps contains a flow sensor. The flow control signal from these sensors provides the control input signals to the high pressure makeup flow control valves.
- A pressure sensor is provided in the scram air header piping at a location downstream of the air header dump valves and ARI valves and upstream of the scram valves. Both high and low pressure conditions in the header are alarmed in the control room.
- Status indication for the scram valve position is provided in the control room.

Controls and Interlocks

The controls and interlocks for the CRD system include the following:

- The high pressure makeup mode of operation is initiated by a low reactor water Level 2 signal. On receipt of this signal, the following automatic actions occur:
  - The standby CRD pump is started. Both pumps operate in parallel to deliver the required makeup flow capacity to the reactor.
  - The two pump suction filter bypass valves are opened.
  - The scram accumulator charging water header isolation valve and purge water header isolation valve are closed.
  - The pump minimum flow ~~bypass~~ line isolation valve closes.
  - The flow control valves in the high pressure makeup lines open to regulate the makeup water flow rate to the reactor.
  - The test valve in the high pressure makeup line to the RWCU/SDC system opens if it is closed at the start of the event and the test valve in the return line to the CST closes if it is open at the start of the event.
  - The high pressure makeup flow control valves close to stop flow to the reactor at high reactor water Level 8. Each~~The~~ pump minimum flow ~~bypass~~ line isolation valve opens and both pumps continue to operate in a low flow condition by directing their flow back to the CST through the pump minimum flow lines. The control valves reopen and the pump minimum flow ~~bypass~~ isolation valve closes to restart high pressure makeup flow if a subsequent Level 2 signal should occur.
- The standby CRD pump is started if a low system pressure condition occurs.
- The CRD pump trips upon receipt of a low suction pressure condition. An adjustable time delay is provided in the pump trip logic to protect against transient conditions.
- The CRD pumps are prevented from being started, or are tripped if running, if the pump lube oil pressure is low.

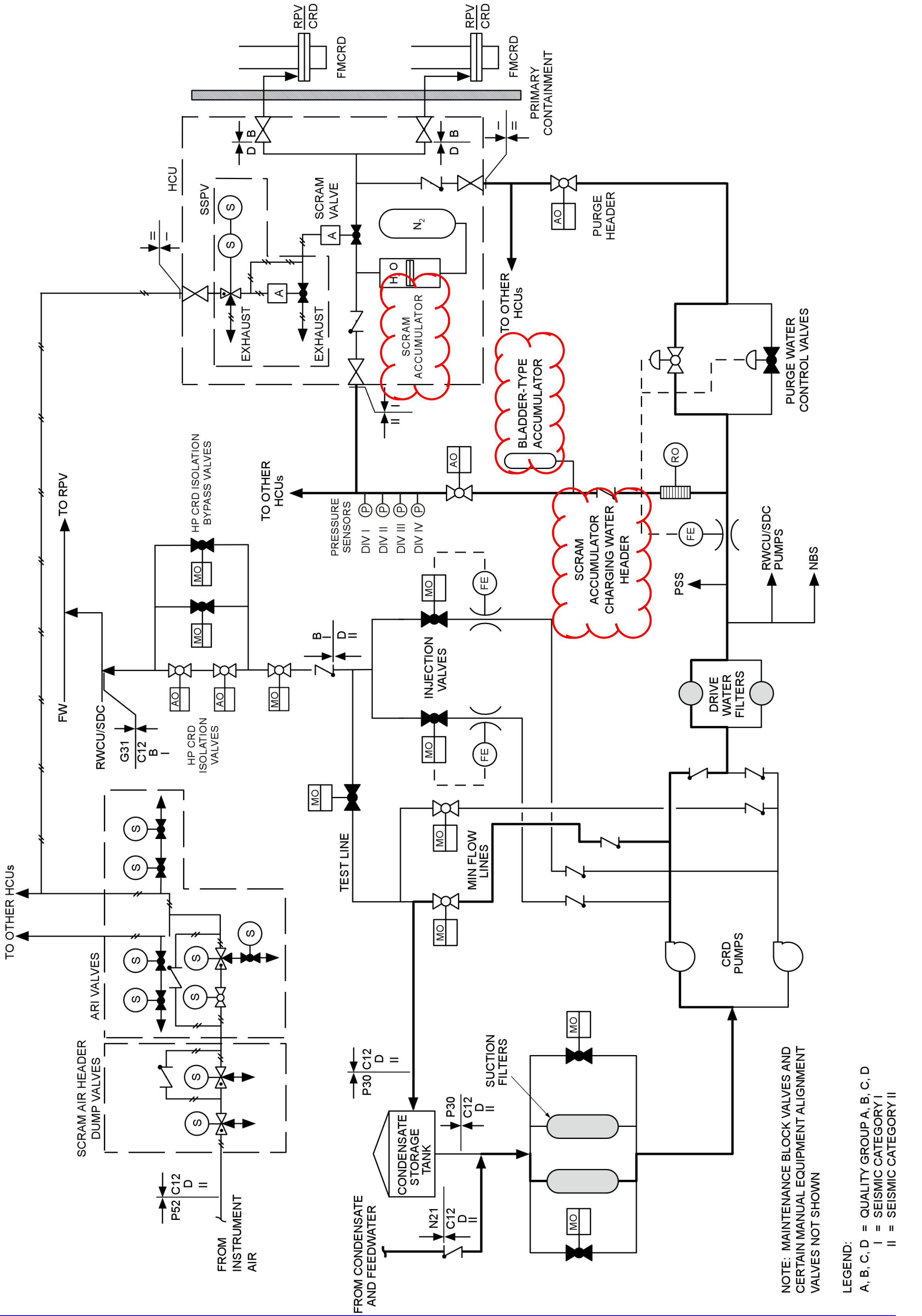
- The RC&IS and the RPS sense the scram accumulator~~CRD~~ charging water header pressure. The following actions occur based on the level of pressure degradation. The actions are based on two-out-of-four logic. A time delay is provided in the RPS to avoid spurious or inadvertent trips.
  - Alarm and all rod withdrawal block due to scram accumulator~~low~~ charging water header pressure - low.
  - Reactor trip due to scram accumulator ~~low low~~ charging water header pressure - low-low.
- Control rod separation detection for any FMCRD causes both annunciation in the control room and a rod withdrawal block.
- The following signals in the CRD system initiate a rod withdrawal block by the RC&IS:
  - Rod separation detection (individual rod block).
  - Scram accumulator charging water header pressure - low (all rods block).
  - Rod gang misalignment (all rods in gang block).
- The high pressure makeup flow control valves are prevented from opening when the inboard feedwater maintenance valve on the feedwater line through which the CRD system delivers flow to the reactor is closed.
- When in the high pressure makeup mode of operation, the high pressure makeup flow to the RPV is~~CRD pumps are tripped~~isolated ~~to terminate CRD system flow~~ on receipt of low water level signals from two-of-the-three GDCS pools or drywell pressure high and drywell level high. The flow is directed to the CST through the pump minimum flow lines.
- When in the high pressure makeup mode of operation and the CRD pumps are isolated due to certain LOCA events and a GDCS failure (GDCS initiation logic and a time delay to allow for system actuation and a not low signal from two out of three GDCS pools) to successfully inject water into the reactor occurs the HP CRD isolation bypass valves open to provide a flow path around the HP CRD isolation valves for high pressure makeup water injection to the RPV. Manual inhibit capability exists for the high pressure makeup isolation function and manual initiation capability exists for the isolation bypass function for either GDCS injection failure or loss of air.

4.6.1.2.7 Power Supplies

Each of the four divisional HCU charging header pressure sensors is powered from their respective divisional safety-related power supply. Independence is provided between the safety-related divisions for these sensors and between the safety-related and nonsafety-related equipment.

For the FMCRD separation switches, independence is provided between the safety-related divisions and between the safety-related divisions and the non-safety-related equipment.

The Medium Voltage Distribution System (MVD) provides the normal and standby electrical power to the nonsafety-related FMCRD motors.


RPV
CRD
FMCRD
PRIMARY CONTAINMENT
HCU
SSPV
SCRAM VALVE
EXHAUST
EXHAUST
SCRAM ACCUMULATOR
H_2O
N_2
TO OTHER HCUs
PURGE HEADER
BLADDER-TYPE ACCUMULATOR
PURGE WATER CONTROL VALVES
RO
FE
SCRAM ACCUMULATOR CHARGING WATER HEADER
RWCU/SDC PUMPS
NBS
PSS
TO OTHER HCUs
PRESSURE SENSORS
DIV I
DIV II
DIV III
DIV IV
HP CRD ISOLATION BYPASS VALVES
INJECTION VALVES
HP CRD ISOLATION VALVES
TO RPV
FW
RWCU/SDC
G31
C12
B
I
DRIVE WATER FILTERS
TEST LINE
MIN FLOW LINES
CRD PUMPS
TO OTHER HCUs
ARI VALVES
SCRAM AIR HEADER DUMP VALVES
FROM INSTRUMENT AIR
P52
C12
D
II
P30
C12
D
II
CONDENSATE STORAGE TANK
SUCTION FILTERS
N21
C12
D
II
FROM CONDENSATE AND FEEDWATER
NOTE: MAINTENANCE BLOCK VALVES AND CERTAIN MANUAL EQUIPMENT ALIGNMENT VALVES NOT SHOWN
LEGEND:
A, B, C, D = QUALITY GROUP A, B, C, D
I = SEISMIC CATEGORY I
II = SEISMIC CATEGORY II

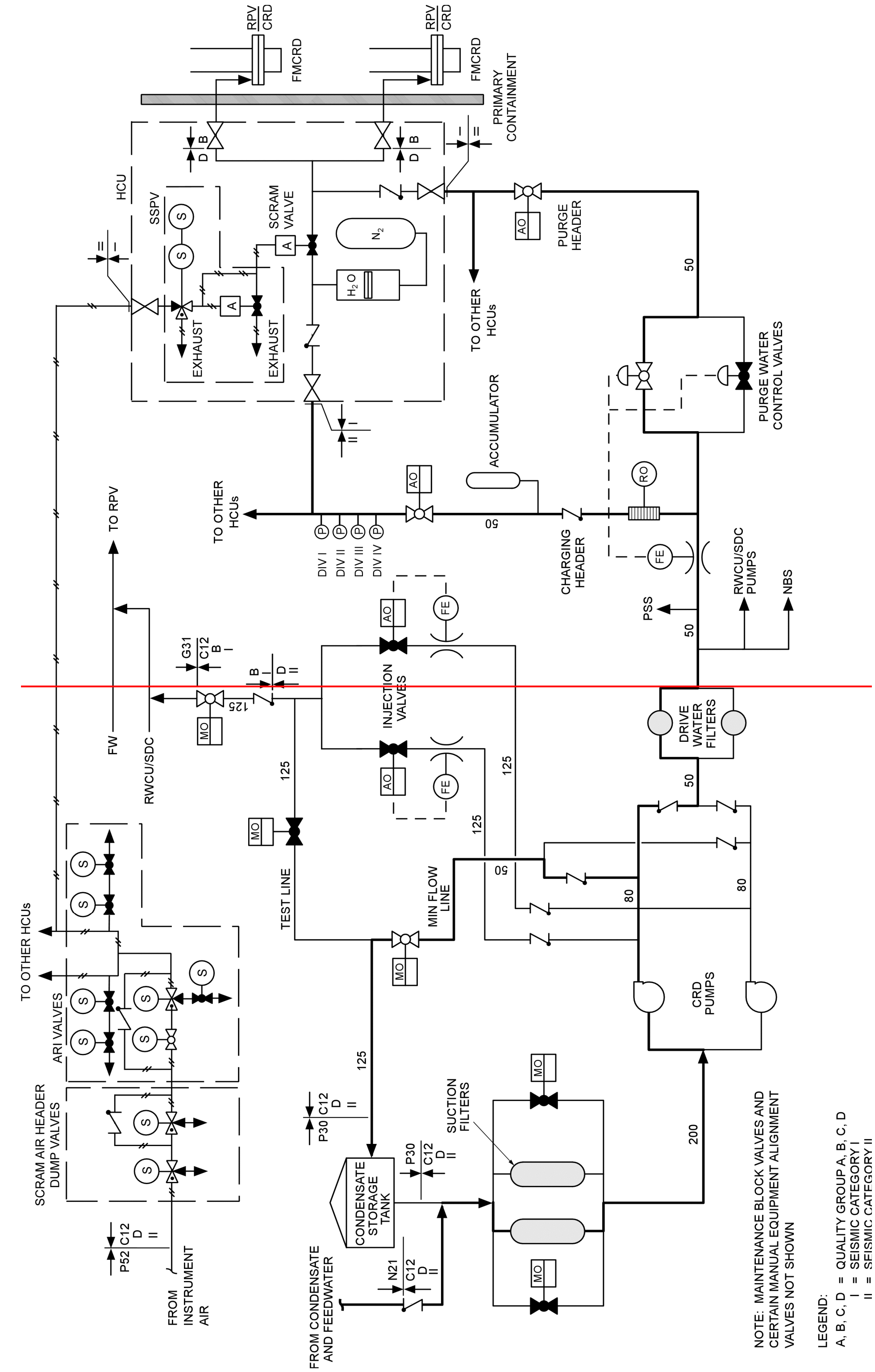


Figure 4.6-8. Control Rod Drive System Simplified Process and Instrumentation Diagram

7.2.1.2.4.2 Initiating Circuits

The RPS logic initiates a reactor scram in the individual sensor channels when any one or more of the conditions listed below exist~~ (IEEE Std. 603, Section 4.1, 4.2 and 4.4)~~. The system monitoring the process condition is indicated in parentheses. These conditions are:

- High drywell pressure (CMS),
- Turbine stop valve (TSV) closure (RPS),
- Turbine control valve (TCV) fast closure (RPS),
- NMS-monitored SRNM and APRM conditions exceed acceptable limits (NMS),
- High reactor pressure (NBS),
- Low reactor pressure vessel (RPV) water level (Level 3) decreasing (NBS),
- High RPV water level (Level 8) increasing (NBS),
- Main steam line isolation valve (MSIV) closure (Run mode only) (NBS),
- ~~Low control rod drive HCU~~Scram accumulator charging water header pressure – low-low (CRDS),
- High suppression pool temperature (CMS),
- High condenser pressure (RPS),
- Power generation bus loss (Loss of all feedwater [FW] flow)(Run mode only) (RPS),
- High simulated thermal power (FW temperature biased) (NBS and NMS),
- Feedwater temperature exceeding allowable simulated thermal power vs. FW temperature domain (NBS),
- Operator-initiated manual scram (RPS), and
- Reactor Mode Switch in Shutdown position (RPS).

With the exception of the NMS outputs, the MSIV closure, TSV closure and TCV fast-closure, loss of all FW flow due to a~~loss of~~ power generation bus loss, main condenser pressure high, and manual scram outputs, systems provide sensor outputs through the ~~RPS~~ RTIF RMU.

The MSIV Closure, TSV closure and TCV fast-closure, loss of power generation bus, manual scram output, and main condenser pressure high signals are provided to the RPS through hardwired connections. The NMS trip signal is provided to the RPS through fiber optic cable. The systems and equipment providing trip and scram initiating inputs to the RPS for these conditions are discussed in the following subsections.

DTM in one of the four RPS divisional sensor channels. The four pressure transmitters and associated instrument lines are components of the NBS.

Reactor Pressure Vessel Water Level: RPV water level is measured by four physically separate level (differential pressure) transmitters mounted on separate divisional local racks in the safety envelope within the RB. Each transmitter is on a separate pair of instrument lines and is associated with a separate RPS electrical division. Each transmitter provides an analog output signal to the ~~RPS~~ RTIF RMU, which digitizes and conditions the signal before sending it to the appropriate DTM in one of the four RPS divisional sensor channels. The four separate level transmitters and associated instrument lines are components of the NBS.

Main Steamline Isolation Valve Closure: Each of the four Main Steam Lines (MSLs) can be isolated by closing either its inboard or outboard isolation valve. Position (limit) switches are mounted on both isolation valves of each MSL. These switches provide output to the appropriate DTM in one of the four RPS divisional trip channels using hard-wired connections. On each MSL, two position switches are mounted on each inboard isolation valve and each outboard isolation valve. Each of the two position switches on any one MSL isolation valve is associated with a different RPS divisional sensor channel. A reactor scram is initiated by either the inboard or outboard valve closure on two or more of the MSLs. The eight MSIVs and the 16 position switches supplied with these valves (for RPS use) are components of the NBS.

Feedwater Temperature Biased Simulated Thermal Power: FW temperature is measured by four separate temperature sensors mounted on each FW line in the MSL tunnel area within the RB. Each sensor is connected to a separate channel and is associated with a separate RPS electrical division. Each sensor provides a temperature signal to the ~~RPS~~ RTIF RMU, which digitizes and conditions the signal before sending it to the appropriate ~~RPS~~ RTIF DTM. The eight temperature sensors (four on each FW line) are components of the NBS. The RPS uses FW temperature from NBS to develop a STP high setpoint that is a function of FW temperature. ~~The RPS initiates a scram when the FW temperature further departs from the area allowed by the thermal power vs. FW temperature domain.~~

Simulated Thermal Power Biased Feedwater Temperature: The RPS uses the STP signal from NMS and feedwater temperature from NBS as described in the paragraph above to generate a high/low feedwater temperature setpoint that is a function of STP. The RPS initiates a scram when the FW temperature further departs from the area allowed by the thermal power vs. FW temperature domain.

Control Rod Drive System

Locally mounted pressure transmitters measure the ~~CRDS~~ scram accumulator charging water header pressure at four physically separate locations. Each transmitter is associated with a separate RPS division and is on a separate instrument line. Each transmitter provides an analog output signal to the RMU, which digitizes and conditions the signal before sending it to the appropriate DTM (in one of the four RPS divisional trip channels). The four pressure transmitters and associated instrument lines are components of the CRDS. This is an anticipatory scram because it initiates a scram before the ~~HCUs~~scram accumulators have time to depressurize ~~the reactor~~.

~~The purpose of a scram~~This is an anticipatory scram on loss of the power generation buses ~~is~~ to mitigate the RPV water level drop to Level 1 following the loss of FW pump function. This scram terminates additional steam production within the RPV before Level 3 is reached.

Manual Scram: Two manual scram switches and the Reactor Mode Switch provide diverse means to initiate manually a reactor scram independent of conditions within the sensor channels, divisions of trip logic, and trip actuators. When the Reactor Mode Switch is placed in the shutdown position, power to the circuits affected by each manual scram pushbutton is interrupted resulting in a full scram. Each of the manual scram switches is associated with one of the two divisions of actuator load power. Both manual scram switches have to be actuated simultaneously to result in a full manual scram. Because the non-software-based manual scram capability of the RPS system operates directly on the scram solenoid power, only Divisions 1 and 2 are involved. If either of those two divisions is out of service (including maintenance), a half-scram results; depressing the other division manual scram pushbutton then results in a full scram. If either of the two divisions is out of service for non-power issues the manual scram capability remains unaffected. The operability of Divisions 3 and 4 has no effect on the RPS manual scram capability.

Manual scram switches also are provided in the remote shutdown (RSS) panels to achieve hot shutdown for the reactor from outside the MCR. There is a separate manual switch in each of the four divisions providing a means to manually trip all actuators in that division. An alternative manual scram can be accomplished by activating any two (or more) of the four manual divisional trip switches.

Reset Logic: A reset switch is provided to reset the manual scram in both (1 and 2) divisions of manual scram controls. A separate manual switch associated with each division of trip actuators provides the means to reset the seal-in at the input of all trip actuators in the same division. The reset does not have any effect if the conditions that caused the division trip have not cleared when a reset is attempted. All manual resets are automatically inhibited for 10 seconds to allow sufficient time for scram completion. The switch used to reset the manual scram circuitry permits resetting of the several scram groups in sequence, so re-energization of only one-half of the scram solenoids is performed at one time.

After a full scram the ~~CRD~~ scram accumulator charging water header pressure drops below the trip setpoint, resulting in a trip initiating input to all four divisions of trip logic. While this condition exists, the four divisions of trip logic cannot be reset until the ~~CRD~~ scram accumulator charging water header pressure trip is manually bypassed in all four divisions, and all other trip-initiating conditions have been cleared.

Containment Monitoring System

Drywell Pressure: Containment (drywell) pressure is measured at four physically separate locations by pressure transmitters located on separate divisional local racks in the safety envelope within the RB. Each transmitter is on a separate instrument line and is associated with a separate RPS electrical division. Each transmitter provides an analog output signal to the RMU, which digitizes and conditions the signal before sending it to the appropriate DTM in the four RPS divisional trip channels. The four pressure transmitters and associated instrument lines are components of the CMS.

Suppression Pool Temperature: Four channels of safety-related divisional suppression pool temperature signals, each formed by the average value of a group of 16 thermocouples installed uniformly (both vertically and azimuthally) inside the suppression pool, provide the suppression pool temperature data for automatic scram initiation. For the suppression pool temperature high signal to be considered valid, 12 of the 16 assigned thermocouples are required to be operable. When the established limits of high temperature are exceeded in two of the four divisions, scram initiation is generated.

Each temperature sensor provides an analog output signal to the RMU, which digitizes and conditions the signal before sending it to the appropriate DTM. The temperature sensors and associated instrument lines are components of the CMS. The suppression pool water level signals also are provided. When water level drops below any of the temperature sensors, the exposed sensors are logically bypassed, so only the sensors below water level are used to determine the averaged temperature signal to the RPS.

7.2.1.2.4.3 Reactor Protection System Outputs to Interfacing Systems

Scram Signals to the CRD System: Reactor trip conditions existing in any two or more of the four RPS automatic trip channels and/or in both RPS manual trip channels cause power to the output circuits of the RPS (normally supplying power to the solenoids of the scram pilot valves of the CRD system) to be disconnected, resulting in insertion of all control rods and reactor shutdown.

When the scram pilot valve solenoids are disconnected from power by the RPS trip signals, the two scram air header dump valves of the CRD system (backup scram valves) are actuated by the RPS trip signals to exhaust the air from the scram air header, resulting in backup scram action.

RPS Status Outputs to the NMS: Two types of RPS status condition signals (four combined signals each, one per division) are provided to the NMS by the RPS. Isolated output signals, indicating that the Reactor Mode Switch is in the Run position, are provided to the four divisions of the NMS whenever the mode switch is in that position. These signals are used by the NMS to bypass the NMS SRNM alarm and trip function, whenever the Reactor Mode Switch is in the Run position.

Scram Follow Signals to the RC&IS: Upon the occurrence of any full reactor scram condition the RPS provides isolated output signals to the RC&IS. This enables automatic rod run-in (scram-follow) logic in the RC&IS to cause full insertion (or "run-in") of the fine motion control rod drives subsequent to scram. The RPS also provides the RC&IS with both scram test switch status, indicating the start of a rod pair scram test and the position of the Reactor Mode Switch.

Rod Block Signals to the RC&IS: Rod withdrawal inhibit signals (one for each channel) are provided by the RPS via isolated output signals sent to the RC&IS whenever there is a "~~Low CRD~~ Scram Accumulator Charging Water Header Pressure - Low" trip signal or when any ~~CRD~~ scram accumulator charging water header pressure trip bypass switch is in the Bypass position.

Outputs to the LD&IS: The Reactor Mode Switch status signals from each division are provided to the LD&IS for RCPB isolation function. The RPS also provides an interlock to the LD&IS for bypassing the MSIV isolation (when the Reactor Mode Switch is not in the Run position) that otherwise would result from high main condenser vacuum-pressure and/or low inlet-pressure to the turbine during startup and shutdown.

Outputs to Main Control Room Panels:

Safety-related status and alarm signals are sent from the RPS to the MCR console.

Displays: Instrument channel sensor checks are capable of being performed at the MCR console. Displays exist for readout and comparison of the current values of the variables or separate processes being monitored for each set of four (one per division). The minimum set of signals included in displays related to RPS scram variables are:

- Reactor vessel pressure,
- RPV water levels,
- Containment drywell pressures,
- ~~CRD HCU~~Scram accumulator charging water header pressures,
- Suppression pool (local or bulk) temperatures,
- Power generation bus voltages,
- FW temperature,
- TSV position,
- Hydraulic Trip System oil pressure,
- MSIV position,
- Main condenser pressure, and
- NMS outputs.

The values of all scram parameters are continuously sent through the required safety-related isolation to the N-DCIS where displays of the scram parameters from all divisions are integrated to allow easy comparison between divisions. Additionally, the PCF and alarm systems alarm if any divisional parameter value differs from the value in the other three divisions by more than a predetermined amount. The intent is that channel sensor checks be performed continuously.

Alarms: Alarms are provided at the MCR console by the trip condition of any of the four sensor trip channels, by the trip condition of each automatic or manual trip system, and when bypassing a scram function. The alarm function is provided through the required safety-related isolation to the PCF.

The provided alarms / indications related to RPS status are:

- RPS NMS trip (generated in NMS),
- Reactor vessel pressure high,

- RPV water level low (≤ Level 3),
- RPV water level high (≥ Level 8),
- Containment (drywell) pressure high,
- MSIV closure trip,
- TSV closure,
- TCV fast closure,
- Main condenser pressure high,
- Power generation bus loss (loss of all FW flow),
- FW temperature biased STP trip,
- ~~CRD HCU~~Scram accumulator~~-~~ charging~~-~~ water header~~-~~ pressure - low,
- Suppression pool temperature high,
- RPS divisional automatic trip (auto-scram) (each of the four: Div. 1, 2, 3, 4 automatic trip),
- RPS divisional manual trip (each of the four: Div. 1, 2, 3, 4 manual trip),
- Manual scram trip (two: both Manual A and Manual B),
- Reactor Mode Switch in Shutdown position,
- Shutdown mode trip bypassed,
- Non-coincident NMS trip mode in effect (in NMS),
- NMS trip mode selection switch still in non-coincident position, with Reactor Mode Switch in Run position (in NMS),
- Division in which channel A (B, C, or D) sensors are bypassed (four),
- Trip conditions in Channel A (B, C, or D) and Channel A (B, C, or D) sensors bypassed (four),
- Division 1 (2, 3, or 4) TLU out-of-service bypass (four),
- ~~CRD~~ Scram accumulator~~-~~ charging~~-~~ water header~~-~~ pressure - low-low trip bypass,
- Any ~~CRD~~ scram accumulator~~-~~ charging~~-~~ water header pressure trip with bypass switch still in bypass position and the Reactor Mode Switch in Startup or Run mode,
- Auto-scram test switch in test mode (manual trip of automatic logic) (four),
- TSV closure trip bypassed,

and location of malfunctioning component to allow for the replacement, adjustment, or repair of the component.

In-service testing of the RPS is performed periodically to verify operability during normal plant operation and to ensure that each tested channel can perform its intended design function. The surveillance tests include: (a) instrument channel checks, (b) functional tests, (c) verification of proper sensor and channel calibration, (d) verification of applicable functions in the division of trip logic and division of actuators, and (e) response time tests.

7.2.1.5 Instrumentation and Control Requirements

7.2.1.5.1 Automatic Scram Variables

Refer to Subsection 7.2.1.2.4.2 for discussions of the automatic scram initiating circuits and the systems that apply to them.

7.2.1.5.2 Automatic and Manual Bypass of Selected Scram Functions

7.2.1.5.2.1 Operational Bypasses

Manual or automatic bypass (take out of service) of certain scram functions permits the selection of suitable plant protection conditions during different conditions of reactor operation~~ (IEEE Std. 603, Sections 6.6 and 7.4)~~. These RPS operational bypasses inhibit actuation of those scram functions not required for a specific state of reactor operation.

The conditions of plant operation requiring automatic or manual bypass of certain reactor trip functions are described below.

- Main steam TSV closure and steam governing TCV fast closure trip bypasses**:** These permit continued reactor operation at low power levels when the TSVs or TCVs are closed. The main steam TSV closure and the steam governing TCV fast closure scram trip functions are automatically bypassed when the APRM simulated thermal power of the NMS is below 40% of the rated thermal power output.

  The TSV closure and TCV fast closure trips are automatically bypassed if a sufficient number of the bypass valves are opened. This bypass occurs if a sufficient number of TBVs open to at least 10% within a preset time limit following the TCV fast closure or TSV closure signal to inhibit reactor trip. The NMS system provides the RPS with an analog simulated thermal power signal used to determine both the low power bypass and the required number of TBV needed to open for a post turbine trip or for full load rejection conditions. The low power bypass is automatically removed and both scram trip functions are enabled at reactor power levels above the bypass setpoint. The bypass permits the RPS to remain in its normal energized state under the specified conditions. This bypass condition is alarmed in the MCR.

- ~~CRD HCU~~Scram accumulator charging water header ~~low~~ pressure - low-low bypass**:** This bypass is allowed only when the Reactor Mode Switch is in either the Shutdown or

Refuel position. If a bypass of a scram trip is required for ~~CRD~~ scram accumulator charging water header ~~low~~ pressure - low-low after a scram has occurred (indicated operational bypass), four administratively controlled trip bypass switches in the MCR permit scram reset.

When the reactor is in the shutdown or refuel mode the ~~low CRD HCU~~scram accumulator charging water header pressure – low-low trip can be bypassed manually in each division of trip logic by separate, manual ~~CRD HCU~~scram accumulator charging water header pressure trip bypass switches. Control of this bypass is achieved through administrative means using manual bypass switches. This bypass allows RPS reset after a scram, while ~~CRD~~ scram accumulator charging water header pressure is below the trip setpoint. The ~~low~~scram accumulator charging water header pressure – low-low condition would persist until the scram valves are re-closed. Each division of trip logic sends a separate rod withdrawal block signal to the RC&IS when this bypass exists in the division. This operational bypass condition is alarmed in the MCR.

The bypass is automatically removed whenever the Reactor Mode Switch is put in either the Startup or Run mode, regardless of whether the ~~CRD~~ scram accumulator charging water header pressure trip bypass switches are in their bypass positions. However, a separate alarm would result in the MCR if any of the switches were left in the bypass position when the Reactor Mode Switch is in either the Startup or Run mode.

- MSIV closure for MSIV bypass (indicated operational bypass)**:** The scram trip for MSIV closure is automatically bypassed in each division whenever the Reactor Mode Switch is in the Shutdown, Refuel, or Startup position - with reactor pressure in the associated sensor channel less than a predetermined setpoint. This bypass condition is alarmed in the MCR and permits plant operation when the MSIVs are closed during low power operation. The bypass is automatically removed if the Reactor Mode Switch is moved to the Run position. This bypass permits the RPS to be placed in its normal energized state for operation at low power levels with the MSIVs either closed or not fully open.

- Special MSIV operational bypass (indicated operational bypass): Four manually-operated bypass switches are made available in the MCR to permit the bypass of trip signals from closed MSIVs on any one of the four main steam lines. This bypass permits continued reactor operation at reduced reactor power and steam flow when one steam line must be isolated for a prolonged period of time. This operational bypass is alarmed in the MCR.

- ~~Loss of p~~Power generation bus loss trip bypass (indicated operational bypass): The ~~Loss of~~ Power Generation Bus Loss (Loss of All Feedwater Flow Event) scram trip function is automatically bypassed whenever the Reactor Mode Switch is in the Shutdown, Refuel, or Startup position. This bypass condition is alarmed in the MCR and is automatically removed if the Reactor Mode Switch is moved to the Run position.

- Reactor Mode Switch in Shutdown position bypass (indicated operational bypass): The RPS scram trip caused by the Reactor Mode Switch being placed in the Shutdown position is automatically bypassed after a time delay of approximately 10 seconds. This

- Reactor Mode Switch operation (results in scram if placed in the Shutdown position),
- Reset of automatic trip systems after trip input signals clear,
- Reset of manual trip systems (preferably after reset of the automatic trip systems),
- Manual bypasses for conditions that are specifically permitted, and
- Manual initiation of selected trip systems or trip actuators using trip logic test switches.

7.2.1.5.4 Reactor Mode Switch

A multi-function, multi-bank, control switch placed on the MCR console provides mode selection for the necessary interlocks associated with the various plant modes: Shutdown, Refuel, Startup, and Run. This Reactor Mode Switch provides both electrical and physical separation between the components associated with each of the four separate divisions. The mode switch positions and their related bypass and trip/reset functions are as follows.

- Shutdown Position:
  - Initiates a reactor scram,
  - Enables NMS non-coincident trips,
  - Enables a manual ~~CRD~~scram accumulator charging water header pressure trip bypass,
  - Enables automatic bypass of the TCV fast closure trip,
  - Enables automatic bypass of the TSV closure trip,
  - Enables automatic bypass of the MSIV closure trip, and
  - Enables automatic bypass of the ~~loss of~~ power generation bus loss (Loss of All FW Flow) trip.
- Refuel Position:
  - Enables NMS non-coincident trips,
  - Enables the manual ~~CRD~~scram accumulator charging water header pressure trip bypass,
  - Enables automatic bypass of the TCV fast closure trip,
  - Enables automatic bypass of the TSV closure trip,
  - Enables automatic bypass of the MSIV closure trip, and
  - Enables automatic bypass of the Power Generation Bus Loss (Loss of All FW Flow) trip.

- Startup Position:
  - Enables NMS non-coincident trips,
  - Disables the manual ~~CRD~~scram accumulator charging water header pressure trip bypass,
  - Enables the automatic bypass of the MSIV closure trip,
  - Enables automatic bypass of the TCV fast closure trip,
  - Enables automatic bypass of the TSV closure trip, and
  - Enables automatic bypass of the ~~loss of~~ power generation bus loss (Loss of All FW Flow) trip.
- Run Position:
  - Disables all trip bypasses enabled by any of the other three modes, and
  - Enables automatic bypass of the NMS SRNM trip.

7.2.1.5.5 Manual Scram Switches

Two manual scram switches permit initiation of a scram, independent of conditions within other RPS equipment (sensor channels, divisions of trip logic, or divisions of trip actuators). Each manual scram switch is associated with one of the two divisions of actuator load power. Both manual scram switches are located on the MCR console and do not require any microprocessor functionality; duplicate switches are included in the RSS panels.

7.2.1.5.6 Manual Divisional Trip Switches

Each of the four RPS automatic trip systems has manual trip capability provided by four divisional trip switches located in positions easily accessible for optional use by the plant operator. Each switch, when momentarily put into its trip position, trips the actuators that normally would be tripped by a scram condition for that division. Momentarily operating any two of the four manual divisional trip switches results in a full reactor scram.

7.2.1.5.7 Trip Reset Switches

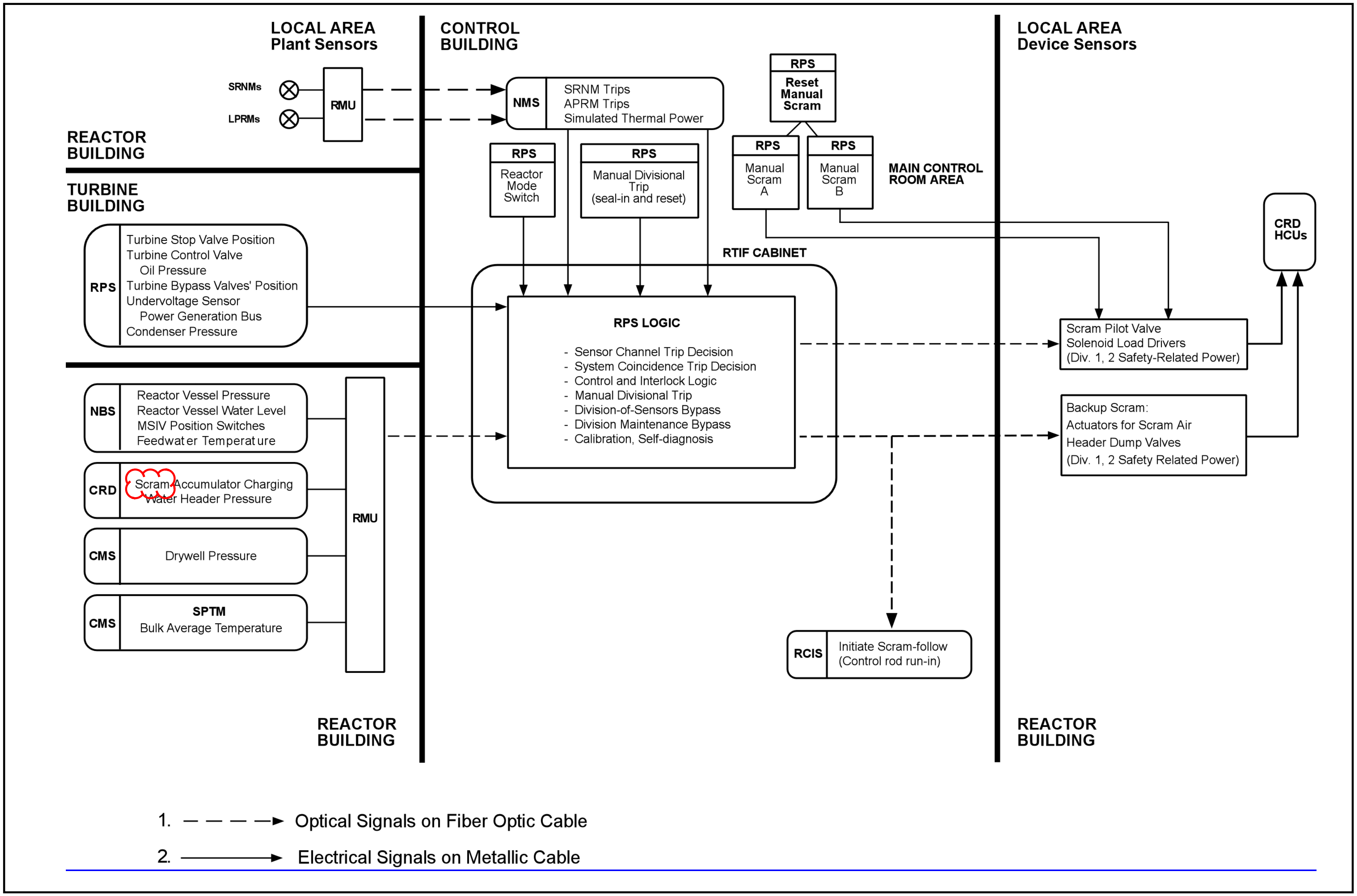
Up to five trip-reset switches will reset any of the four automatic and two manual-scram trip systems that have been tripped and sealed-in, as follows.

- One trip reset switch resets both manual trip systems. The switch circuitry staggers the re-energization of the four groups of scram pilot valve solenoids so only two groups of "A" and "B" solenoids are re-energized simultaneously.
- Four separate switches comprise the trip-reset function for resetting the sealed-in, automatic trip logic outputs in the four divisions. Thus, physical separation of the four electrical divisions is maintained.

Table 7.2-1

Sensors Used in Functional Performance of RPS

Sensor Description	Number of Sensors
NMS (LPRM)	256
NMS (SRNM)	12
NBS reactor vessel pressure	4
Drywell pressure	4
RPV narrow range water level	4
Scram accumulator ~~C~~charging water header pressure ~~to control rod hydraulic unit accumulator~~	4
MSIV position switches	16
TSV position switches	4
TCV hydraulic trip system oil pressure	4
TBV position switches	48
Power generation bus voltage (Loss of All FW flow)	4
Condenser pressure	12
Suppression pool temperature	64
Feedwater temperature	8


LOCAL AREA
Plant Sensors
CONTROL
BUILDING
LOCAL AREA
Device Sensors
SRNMs
LPRMs
RMU
NMS
SRNM Trips
APRM Trips
Simulated Thermal Power
RPS
Reset
Manual
Scram
REACTOR
BUILDING
TURBINE
BUILDING
RPS
Reactor
Mode
Switch
RPS
Manual Divisional
Trip
(seal-in and reset)
RPS
Manual
Scram
A
RPS
Manual
Scram
B
MAIN CONTROL
ROOM AREA
CRD
HCUs
RTIF CABINET
RPS
Turbine Stop Valve Position
Turbine Control Valve
Oil Pressure
Turbine Bypass Valves' Position
Undervoltage Sensor
Power Generation Bus
Condenser Pressure
RPS LOGIC
- Sensor Channel Trip Decision
- System Coincidence Trip Decision
- Control and Interlock Logic
- Manual Divisional Trip
- Division-of-Sensors Bypass
- Division Maintenance Bypass
- Calibration, Self-diagnosis
Scram Pilot Valve
Solenoid Load Drivers
(Div. 1, 2 Safety-Related Power)
NBS
Reactor Vessel Pressure
Reactor Vessel Water Level
MSIV Position Switches
Feedwater Temperature
Backup Scram:
Actuators for Scram Air
Header Dump Valves
(Div. 1, 2 Safety Related Power)
CRD
Scram Accumulator Charging
Water Header Pressure
RMU
CMS
Drywell Pressure
CMS
SPTM
Bulk Average Temperature
RCIS
Initiate Scram-follow
(Control rod run-in)
REACTOR
BUILDING
REACTOR
BUILDING
1. Optical Signals on Fiber Optic Cable
2. Electrical Signals on Metallic Cable

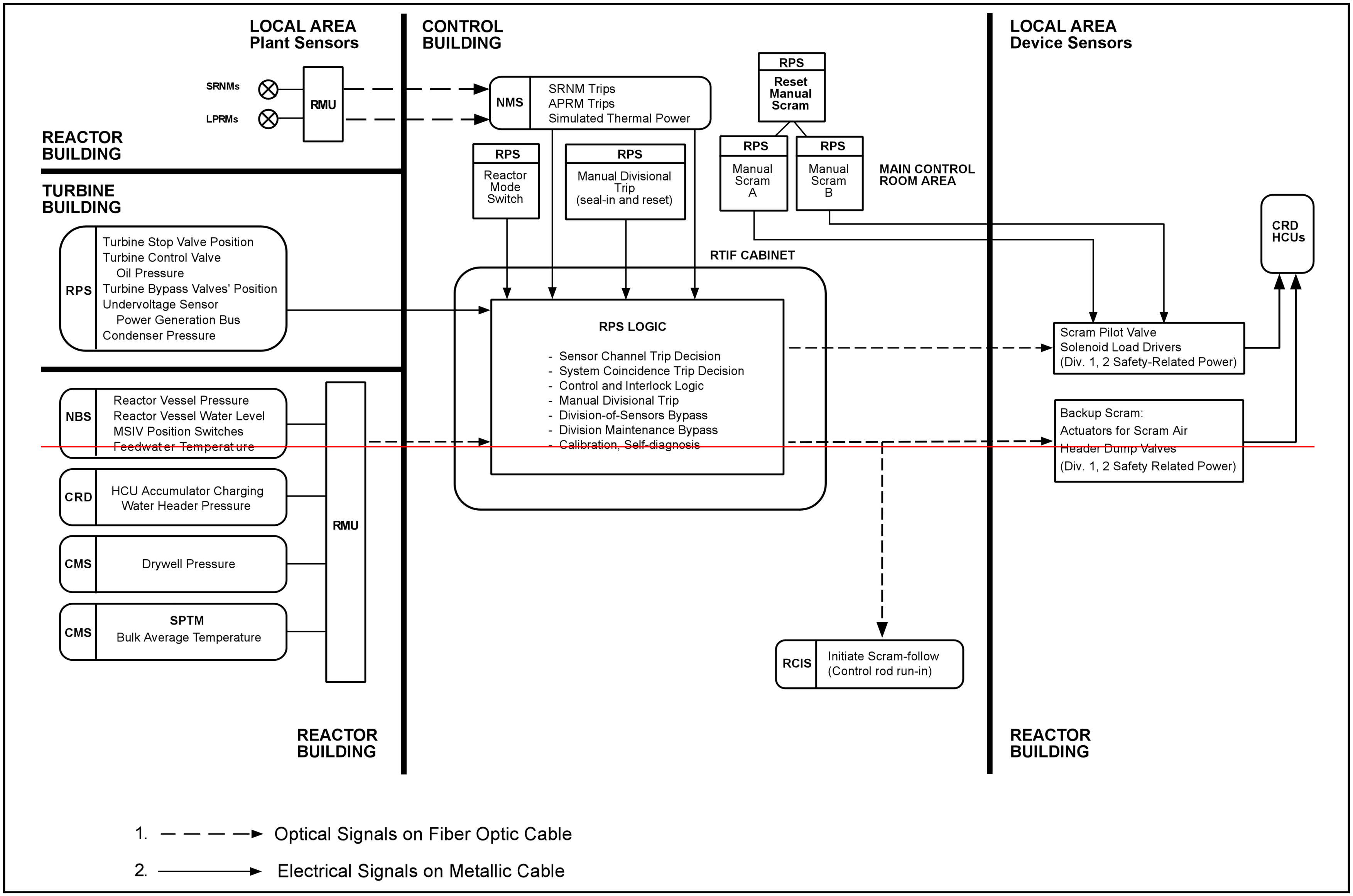
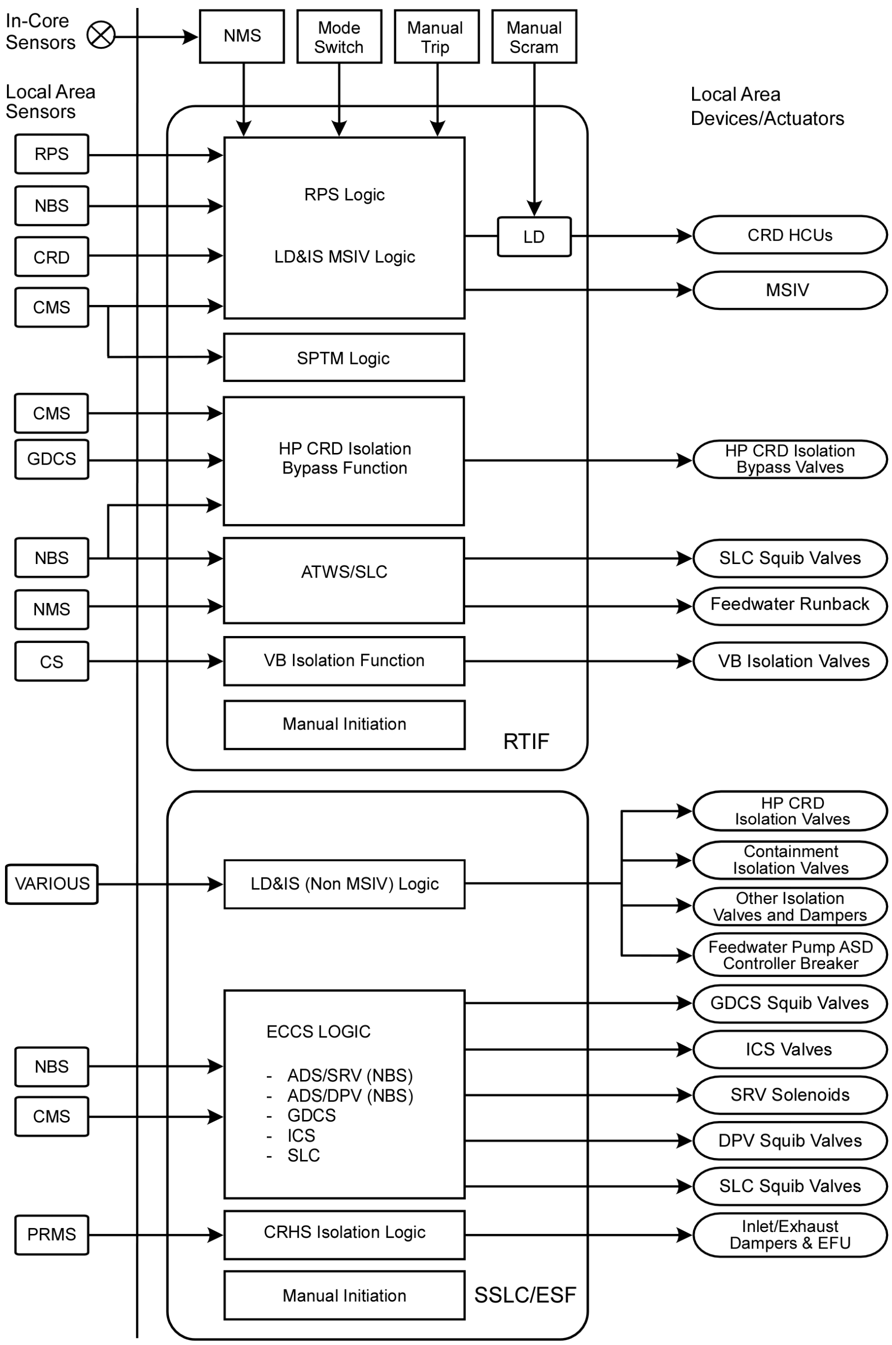


Figure 7.2-2. RPS Interfaces and Boundaries Diagram



Notes: 1) Local area sensors include:

RPS: Turbine stop valve position, turbine CV oil pressure, turbine bypass valve position, main condenser pressure and loss of power generation bus

PRMS: Process radiation - control room inlet ventilation

NBS: MSIV position (for RTIF only), RPV pressure, water level

CRD: Scram accumulator charging water header pressure

CMS: Drywell pressure, drywell level, suppression pool temperature

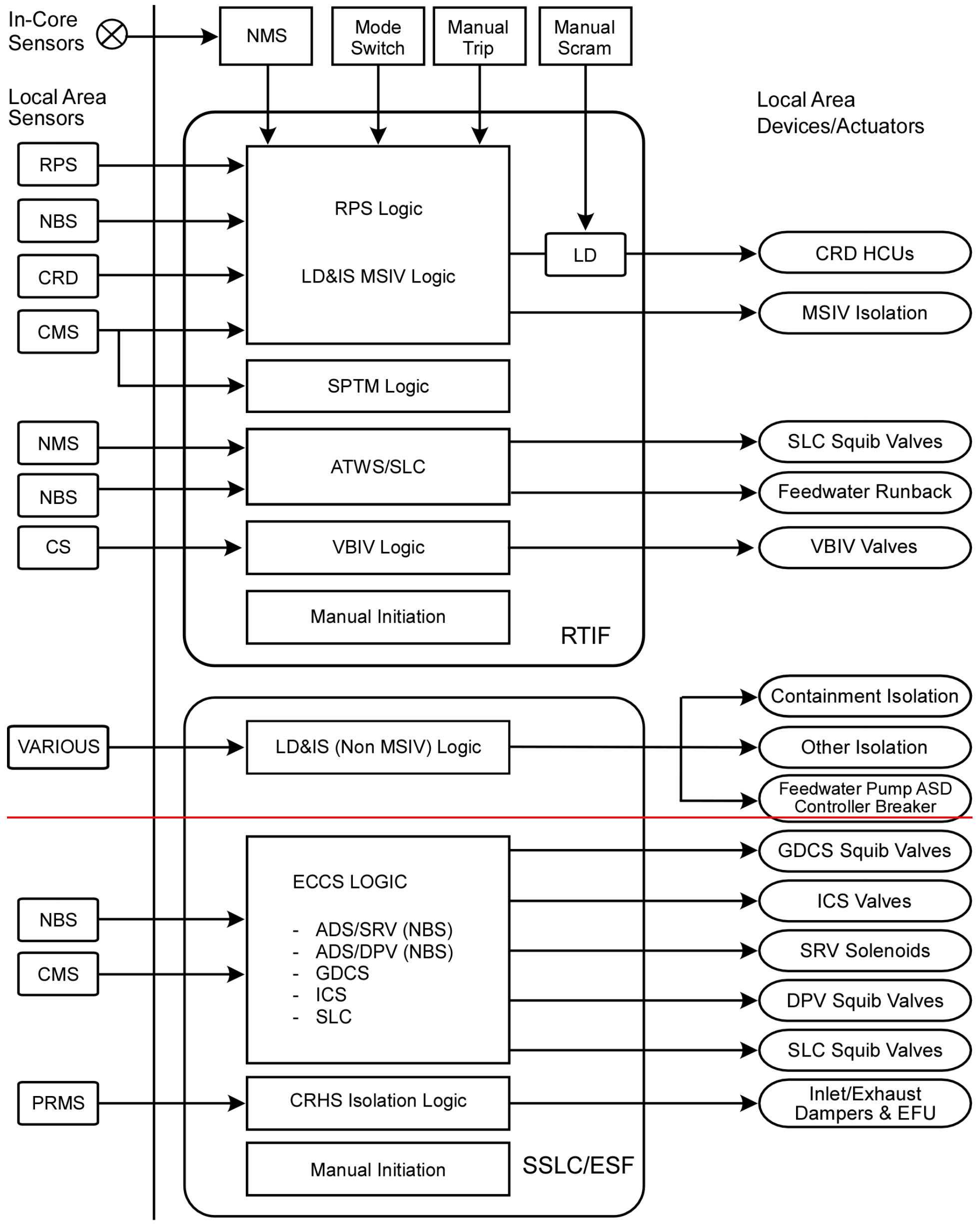
HP CRD High Pressure Control Rod Drive System

CS: (Containment System) wetwell and drywell temperature, Vacuum Breaker (VB) and VB isolation valve position

2) Manual scram interrupts power to the LD circuit

3) LD&IS MSIV isolation logic shares RTIF sensors. LD&IS non-MSIV isolation logic shares SSLC/ESF sensors.

4) The various LD&IS sensors and functions are depicted on Figure 7.3-3.



Note:
1) Local area sensors include:
   - RPS: Turbine stop valve position, turbine CV oil pressure, turbine bypass valve position, main condenser pressure and loss of power generation bus
   - PRMS: Process Radiation Monitoring - control room inlet ventilation
   - NBS: MSIV position (for RTIF only), RPV pressure, water level
   - CRD: HCU accumulator charging water header pressure
   - CMS: Drywell pressure, drywell level, suppression pool temperature
   - CS: (Containment System) Wetwell and drywell temperature sensors
2) Manual Scram interrupts power to the LD circuit
3) LD&IS MSIV isolation logic shares RTIF sensors. LD&IS non-MSIV isolation logic shares SSLC/ESF sensors.
4) The various LD&IS sensors and functions are depicted on Figure 7.3-3.

Figure 7.3-5. SSLC/ESF System Interface Diagram

from the N-DCIS (that indicate a ARI function or automatic SCRRI function is active) or by input signals from the two manual SCRRI pushbuttons on the Main Control Room Panel (MCRP).

Emergency Rod Insertion Panels

The emergency rod insertion panels (ERIP) are located in the RB and provide discrete output signals to the IMCs in the IMCCs. The discrete output signals are activated by input signals received from the ERICP that indicate the scram-follow function, the ARI function or the SCRRI function is active.

Scram Time Recording Panels

The Scram Time Recording Panels (STRPs), located in the RB, monitor the FMCRD position reed switch status using Reed Switch Sensor Modules (RSSMs). They communicate this information to the RAPI through the RC&IS multiplexing network. Also, the STRPs automatically record and time tag FMCRD scram timing position reed switch status changes. This is done either after initiation of an individual HCU scram test at the RPS Scram Time Test Panel or after a full-core reactor scram has been initiated. The recorded scram timing data can be transmitted to the scram time recording and analysis panel (STRAP) in the MCR back-panel area.

Scram Time Recording and Analysis Panel

The STRAP receives scram timing position information from the STRPs and performs scram timing performance analysis. The recorded performance information can also be transmitted to the N-DCIS equipment for further data analysis and archiving.

RAPI Auxiliary Panels

RAPI Auxiliary Panels, located in the RB, provide output signals to open a purge water valve whenever either FMCRD associated with the corresponding HCU receives an insertion command from the RAPI subsystem. These panels also monitor scram valve position status as well as whether the ~~HCU~~scram accumulator water pressure and level status are normal or abnormal. Communication of this information to and from the RAPI subsystem is achieved through the N-DCIS equipment. Two or more of the nonsafety-related remote multiplexing unit (RMU) cabinets of the N-DCIS equipment are used as the RAPI auxiliary panels that are physically not part of the RC&IS equipment, even though they provide the RC&IS related functions described above.

7.7.2.2.2 Multiplexing Network

The RC&IS multiplexing network consists of two separate channels that use fiber optic communication links. The first channel handles communication between the RACS and the RSPCs in the remote communication cabinets (through the FCMs), and communication between the STRPs and the RACS. The second channel handles communication between the STRPs and the STRAP. Communication between the RAPI auxiliary panels, for HCU purge water valve control and HCU status monitoring, and the RAPI channels is achieved by the N-DCIS equipment, not the RC&IS multiplexing network.

- ~~CRD~~ Scram accumulator charging water header ~~low~~ pressure - low (rod withdrawal block for all control rods);
- ~~CRD~~ Scram accumulator charging water header ~~low~~ pressure - low-low trip bypass (rod withdrawal block for all control rods);
- RWM withdrawal block (rod withdrawal block for all control rods, applicable below the Low Power Setpoint);
- RWM insert block (rod insertion block for all control rods, applicable below the low power setpoint);
- ATLM withdrawal block (rod withdrawal block for all control rods, not applicable below the ATLM enable setpoint);
- MRBM withdrawal block (rod withdrawal block for all control rods, not applicable below the ATLM enable setpoint);
- Gang large deviation (for example, gang misalignment) withdrawal block (rod withdrawal block for all operable control rods of the selected gang, applicable when RC&IS Gang mode selection is active);
- Refuel mode withdrawal block (rod withdrawal block for all control rods, applicable when the RPS Reactor Mode Switch is in the Refuel position if a fuel bundle is being handled by the refueling platform while positioned over the RPV);
- Startup mode withdrawal block (rod withdrawal block for all control rods, applicable when the RPS Reactor Mode Switch is in the Startup position if the refueling platform is positioned over the reactor pressure vessel);
- RAPI trouble (rod withdrawal block and rod insertion block for all control rods);
- RAPI SIU trouble (rod withdrawal block for all control rods); and
- Electrical group power abnormal (rod withdrawal block and rod insertion block for all control rods);

The RC&IS enforces all rod blocks until the rod block condition is cleared. The bypass capabilities of the RC&IS permit clearing certain rod block conditions that are caused by failures or problems that exist in only one channel of the logic.

7.7.2.2.7.5 RC&IS Reliability

The RC&IS has a high reliability and availability due to its dual channel configuration design. The design allows its continued operation, when practicable, in the presence of component hardware failures. This is achieved because the operator is able to reconfigure the operation of the RC&IS through bypass capabilities while the failures are being repaired.

The expected system availability during its 60-year life exceeds 0.99. The expected reliability is based upon the expected frequency of an inadvertent movement of more than one control rod,

Table 15.2-23

Instrument Response Time Limits for RPS, ECCS, MSIV, ICS, CRHAVS and Isolation Functions

Process Variable	Initiating System	Response Function	Sensor Time Constant / Delay	Total Initiation Delay[1]	Control Logic Delay	Actuation Time Delay	Actuation Time Response
SRNM (Neutron Flux-High)	NMS	Scram	0.03 sec	0.09 sec	---	---~~0.05 sec[4]~~	Tables 15.2-2 and 15.2-3[2]
SRNM (Neutron Flux - Short Period)	NMS	Scram	0.03 sec	0.09 sec	---	---~~0.05 sec[4]~~	Tables 15.2-2 and 15.2-3[2]
APRM (Fixed Neutron Flux-High, Setdown)	NMS	Scram	0.03 sec	0.09 sec	---	---~~0.05 sec[4]~~	Tables 15.2-2 and 15.2-3[2]
APRM (Simulated Thermal Power – High)	NMS	Scram	7.0 sec	7.09 sec	---	---~~0.05 sec[4]~~	Tables 15.2-2 and 15.2-3[2]
APRM (Fixed Neutron Flux – High)	NMS	Scram	0.03 sec	0.09 sec	---	---~~0.05 sec[4]~~	Tables 15.2-2 and 15.2-3[2]
OPRM - Upscale	NMS	Scram	0.03 sec	0.09 sec	---	---~~0.05 sec[4]~~	Tables 15.2-2 and 15.2-3[2]
~~CRD~~ Scram Accumulator Charging Water Header Pressure – Low-Low[3]	RPS	Scram	---	---	---	---	Tables 15.2-2 and 15.2-3[2]

Table 16.0-1-A (page 7 of 10)
COL - Applicant Open Items

COL Item	Description	Reviewer's Note
3.8.3-3	Battery Cell Parameters	Provide battery cell parameters consistent with manufacturer specifications.
3.8.3-4	Battery margin for aging factor and state of charge uncertainty.	Provide battery margin including aging factor and state of charge uncertainty.
3.9.5-1	Minimum ~~CRD~~ scram accumulator pressure	Provide minimum ~~CRD~~ scram accumulator pressure that supports maximum scram time assumption.
4.1-1	Plant-specific description of site location.	The plant specific description of site location. The intent of the description is to convey the exclusion area as defined by 10CFR Part 100. A Figure is an acceptable option.
5.2.2-1	Non-licensed operator manning requirements	Applicant to determine if unit will be on a multi-unit site. Two unit sites with both units shutdown or defueled require a total of three non-licensed operators for the two units.
5.3.1-1	Unit staff qualifications requirements	Minimum qualifications for members of the unit staff shall be specified by use of an overall qualification statement referencing an ANSI Standard acceptable to the NRC staff or by specifying individual position qualifications. Generally, the first method is preferable; however, the second method is adaptable to those unit staffs requiring special qualification statements because of unique organizational structures.
5.4.1-1	Guidance documents for written procedures	Applicant to provide appropriate guidance documents for operating procedures
5.4.1-2	Guidance documents for emergency operating procedures	Applicant to provide appropriate guidance document for EOPs to implement the requirements of NUREG-0737 and to NUREG-0737, Supplement 1.
5.5.6-1	Outdoor Liquid Storage Tank Radioactivity Monitoring Program	Applicants incorporating unprotected outdoor liquid radioactive waste storage tanks in their design must incorporate the bracketed requirements and surveillance program for unprotected outdoor storage tanks.
5.5.9-1	Containment Leakage Rate Testing Program exceptions to Regulatory Guide 1.163	Applicants are to determine if additional exception(s) to Regulatory Guide 1.163 are applicable and describe the additional exception(s).
5.5.10-1	Battery Cell Parameters	Provide battery cell parameters consistent with manufacturer specifications.

BASES

LCO	The OPERABILITY of the control rod scram accumulators is required to ensure that adequate scram insertion capability exists when needed over the entire range of reactor pressures. The OPERABILITY of the scram accumulators is based on maintaining adequate accumulator pressure.
APPLICABILITY	In MODES 1 and 2, the scram function is required for mitigation of DBAs and transients and, therefore, the scram accumulators must be OPERABLE to support the scram function. In MODES 3, 4, and 5, control rods are not able to be withdrawn since the reactor mode switch is in shutdown and a control rod block is applied. This provides adequate requirements for control rod scram accumulator OPERABILITY under these conditions. Requirements for scram accumulators in MODE 6 are contained in LCO 3.9.5, "Control Rod OPERABILITY - Refueling."
ACTIONS	The ACTIONS Table is modified by a Note indicating that a separate Condition entry is allowed for each control rod scram accumulator. This is acceptable since the Required Actions for each Condition provide appropriate compensatory action for each inoperable control rod scram accumulator. Complying with the Required Actions may allow for continued operation and subsequent inoperable accumulators governed by subsequent Condition entry and application of associated Required Actions. A.1 With one control rod scram accumulator inoperable, the scram function could become severely degraded because the accumulator is the primary source of scram force for the associated control rod or rod pair at all reactor pressures. In this event, the associated control rod or rod pair is declared inoperable and LCO 3.1.3 entered. This would result in requiring the affected control rod or rod pair to be fully inserted and disarmed, thereby satisfying its intended function in accordance with ACTIONS of LCO 3.1.3. The allowed Completion Time of 8 hours is considered reasonable, based on the large number of control rods available to provide the scram function. Additionally, an automatic reactor scram function is provided on sensed low pressure in the ~~CRD~~ scram

Table 3.3.1.1-1 (page 1 of 3)
Reactor Protection System Instrumentation

~~COL 16.0-2-H 3.3.1.1-1~~ FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	CONDITIONS REFERENCED FROM REQUIRED ACTION B.1	SURVEILLANCE REQUIREMENTS	~~ALLOWABLE VALUE~~
1. Neutron Monitor System Input - Startup Range Neutron Monitors	2	F	SR 3.3.1.1.1 SR 3.3.1.1.2	~~NA~~
	6(a)	G	SR 3.3.1.1.1 SR 3.3.1.1.2	~~NA~~
2. Neutron Monitor System Input - Average Power Range Monitors / Oscillation Power Range Monitors	1,2	F	SR 3.3.1.1.1 SR 3.3.1.1.2	~~NA~~
3. ~~Control Rod Drive~~ Scram Accumulator Charging Water Header Pressure - Low-Low	1,2	F	SR 3.3.1.1.1 SR 3.3.1.1.2 SR 3.3.1.1.3	~~≥ [MPaG (psig)]~~
	6(a)	G	SR 3.3.1.1.1 SR 3.3.1.1.2 SR 3.3.1.1.3	~~≥ [MPaG (psig)]~~
4. Reactor Vessel Steam Dome Pressure - High	1,2	F	SR 3.3.1.1.1 SR 3.3.1.1.2 SR 3.3.1.1.3 SR 3.3.1.1.4	~~≤ [MPaG (psig)]~~
5. Reactor Vessel Water Level - Low, Level 3	1,2	F	SR 3.3.1.1.1 SR 3.3.1.1.2 SR 3.3.1.1.3 SR 3.3.1.1.4	~~≥ [m (inches)]~~
6. Reactor Vessel Water Level - High, Level 8	≥ 25% RTP	D	SR 3.3.1.1.1 SR 3.3.1.1.2 SR 3.3.1.1.3 SR 3.3.1.1.4	~~≤ [m (inches)]~~

(a) With any control rod withdrawn from a core cell containing one or more fuel assemblies.

BASES

BACKGROUND (continued)

(MSIV) position, drywell pressure, ~~control rod drive~~scram accumulator charging water header pressure, turbine stop valve position, turbine control valve closure, main condenser vacuum, bus voltage, and suppression pool temperature, as well as reactor mode switch in shutdown position and manual scram signals. The reactor mode switch in shutdown position and manual scram signal inputs to the scram logic are addressed in LCO 3.3.1.3.

All average power range monitors (APRM)/oscillation power range monitors (OPRM) and startup range neutron monitors (SRNM) trip decisions are made within the Neutron Monitoring System (NMS). This is done on a divisional basis and the results then sent directly to the RPS TLUs. Thus, each NMS division sends only two inputs to the RPS divisional TLUs, one for APRM/OPRM trip/no-trip and one for SRNM trip/no-trip. A divisional APRM/OPRM or SRNM may be tripped due to any of the monitored variables exceeding its trip setpoint. The RPS two-out-of-four trip decision is then made, not on a per variable basis, but on an APRM/OPRM tripped or SRNM tripped basis, by looking at the four divisions of APRM/OPRM and four divisions of SRNM. All bypasses of the SRNMs and APRMs/OPRMs are performed within and by the NMS. Refer to LCO 3.3.1.4, "Neutron Monitoring System (NMS) Instrumentation," and LCO 3.3.1.5, "Neutron Monitoring System (NMS) Actuation," for the NMS specifications.

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

The actions of the RPS are assumed in the safety analyses of Reference 2. The RPS initiates a reactor scram when monitored parameter values exceed predetermined values specified in the SCP to preserve the integrity of the fuel cladding, preserve the integrity of the reactor coolant pressure boundary, and preserve the integrity of the containment by minimizing the energy that must be absorbed following a LOCA.

RPS Instrumentation satisfies the requirements of Selection Criterion 3 of 10 CFR 50.36(d)(2)(ii). Functions not specifically credited in the accident analysis are retained for the overall redundancy and diversity of the RPS as required by the NRC approved licensing basis.

The OPERABILITY of the RPS is dependent on the OPERABILITY of the individual RPS instrumentation Functions specified in Table 3.3.1.1-1. Each Function must have the required number of OPERABLE channels,

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY (continued)

2. Neutron Monitor System Input - Average Power Range Monitors /Oscillation Power Range Monitors (OPRMs)

The APRMs and OPRMs are a part of the NMS. The NMS Functions associated with the APRMs and OPRMs are described in the Bases of LCO 3.3.1.4.

Three channels of NMS inputs from the NMS (APRMs/OPRMs) arranged in a two-out-of-four logic are required to be OPERABLE to ensure no single instrument failure will preclude a scram from this Function on a valid signal.

This Function is required to be OPERABLE in the MODES where the APRM and OPRM Functions are required (LCO 3.3.1.4).

3. ~~Control Rod Drive~~ Scram Accumulator Charging Water Header Pressure - Low-Low

To maintain the continuous ability to scram, the scram accumulator charging water header maintains the hydraulic scram accumulators at a high pressure. The scram valves under this condition remain closed, so that no flow passes through the scram accumulator charging water header. Pressure in the scram accumulator charging water header is monitored. The ~~Control Rod Drive~~Scram Accumulator Charging Water Header Pressure - Low-Low Function initiates a scram if a significant degradation in the scram accumulator charging water header pressure occurs. During a scram, the water discharge from the accumulators goes into the reactor, and thus against reactor pressure. Therefore, fully charged hydraulic control units (HCUs) are essential for assuring reactor scram. After a reactor scram, this Function can be bypassed from the operator's console to reset the RPS, allowing the scram valves to close and the HCUs to be re-pressurized.

Low-Low scram accumulator charging water header pressure signals are initiated from four pressure sensors located at the scram accumulator charging water header. The ~~Control Rod Drive~~Scram Accumulator Charging Water Header Pressure - Low-Low Allowable Value is chosen to provide sufficient margin to the capability to scram.

Three channels of ~~Control Rod Drive~~Scram Accumulator Charging Water Header Pressure - Low-Low Function are required to be OPERABLE to ensure no single instrument failure will preclude a scram from this Function on a valid signal. The Function is required to be OPERABLE

BASES

SURVEILLANCE REQUIREMENTS

SR 3.9.5.1 and SR 3.9.5.2

During MODE 6, the OPERABILITY of control rods is primarily required to ensure that a withdrawn control rod will automatically insert if a signal requiring a reactor shutdown occurs. Because no explicit safety analysis exists for automatic shutdown during refueling, the shutdown function is satisfied if the withdrawn control rod is capable of automatic insertion and the associated ~~CRD~~ scram accumulator pressure is ≥ [12.76 MpaG (1850 psig)].

COL 16.0-~~2-H~~1-A 3.9.5-1

The 7 day Frequency considers equipment reliability, procedural controls over the scram accumulators, and control room alarms and indicating lights, which indicate low accumulator charge pressures.

SR 3.9.5.1 is modified by a Note that allows 7 days after withdrawal of the control rod to perform the Surveillance. This acknowledges that the control rod must first be withdrawn before performance of the Surveillance, and therefore avoids potential conflicts with SR 3.0.1.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 26.
2. Section 15.3.7.

B 3.10 SPECIAL OPERATIONS

B 3.10.2 Reactor Mode Switch Interlock Testing

BASES

BACKGROUND

The purpose of this Special Operations LCO is to permit operation of the reactor mode switch from one position to another to confirm certain aspects of associated interlocks during periodic tests and calibrations in MODES 3, 4, 5, and 6.

The reactor mode switch is a conveniently located, multi-function, multi-bank, control switch provided to select the necessary scram functions for various plant conditions (Ref. 1). The Reactor Protection System (RPS) selects and bypasses the appropriate trip functions based on the position of the reactor mode switch. For the average power range monitor (APRM), oscillation power range monitor (OPRM), and startup range neutron monitor (SRNM) trip functions the Neutron Monitoring System (NMS) selects and bypasses the functions, not the RPS. The mode switch positions and related scram interlock functions are summarized in Reference 1.

The reactor mode switch also provides interlocks for such functions as control rod blocks, ~~low CRD~~scram accumulator charging water header pressure trip bypass enable, refueling interlocks, and main steam isolation valve isolations.

APPLICABLE SAFETY ANALYSES

The acceptance criterion for reactor mode switch interlock testing is to preclude fuel failure by precluding reactivity excursions or core criticality.

The interlock functions of the shutdown and refuel positions of the reactor mode switch in MODES 3, 4, 5, and 6 are provided to preclude reactivity excursions which could potentially result in fuel failure. Interlock testing which requires moving the reactor mode switch to other positions (run, or startup) while in MODES 3, 4, 5, or 6, requires administratively maintaining all control rods inserted in core cells containing 1 or more fuel assemblies and no CORE ALTERATIONS in progress. There are no credible mechanisms for unacceptable reactivity excursions during the planned interlock testing.

Table 2.2.1-2

RC&IS Major Functional Groups

Major Functional Group	Functions
Scram Time Recording Panels (STRPs)	Monitors the ~~CRDS~~ FMCRD position switch status Automatically records and time tags ~~CRDS~~ FMCRD scram timing position switch status changes Transmits recorded scram timing data to the scram time recording and analysis panel (STRAP) Communicates with the RAPI
Scram Time Recording and Analysis Panel (STRAP)	Performs scram timing performance analysis
RAPI Auxiliary Panels	Open ~~CRDS~~ HCU purge water valve. Monitor scram valve position. Monitor ~~CRDS HCU~~ scram accumulator water pressure. Monitor ~~CRDS HCU~~scram accumulator water level. Send data to RAPI subsystem.

Table 2.2.1-3

RC&IS Automatic Functions, Initiators, and Associated Interfacing Systems

Function	Initiator	Interfacing System
Initiate Rod Block and Terminate Rod Withdrawal (See Table 2.2.1-4 for a complete list of rod blocks.)	ATLM Operating Limit Minimum Critical Power Ratio (OLMCPR) parameter greater than or equal to setpoint.	NMS
	ATLM Operating Limit Maximum Linear Heat Generation Rate (OLMLHGR) parameter greater than or equal to setpoint.	NMS
	SRNM period greater than or equal to setpoint.	NMS
	RWM function sequence error.	NMS
	Refueling platform over core and fuel on hoist.	The RB refueling machine
	Reactor Mode Switch (RMS) in SHUTDOWN position	RPS
	~~CRD~~ Scram accumulator charging water ~~low~~ header pressure - low	CRD System
	~~CRD~~ Scram accumulator charging water ~~low~~ header pressure - low-low trip bypass	CRD System
	RWM function parameter greater than or equal to setpoint.	NMS
	Large deviation of CR positions from RRPS in selected gang.	-
	Any attempt to withdraw an additional rod beyond the original control rod pair.	-
	RAPI trouble	-
	RAPI Signal Interface Unit trouble	-
SCRRI	Generator load rejection signal.	TGCS

Table 2.2.1-4

RC&IS Rod Block Functions

Rod Block	Permissive Condition	Description
Rod separation detection	RMS: STARTUP or RUN	Rod withdrawal block only for those selected rod(s) for which the separation condition is detected and are not in the Inoperable Bypass condition.
RMS in SHUTDOWN position	RMS: SHUTDOWN	Rod withdrawal block for all control rods.
SRNM withdrawal block	RMS: SHUTDOWN, REFUEL, or STARTUP	Rod withdrawal block for all control rods.
APRM withdrawal block	None	Rod withdrawal block for all control rods.
~~CRD~~Scram accumulator charging water ~~low~~header pressure - low	None	Rod withdrawal block for all control rods.
~~CRD~~Scram accumulator charging water ~~low~~ header pressure – low-low trip bypass	None	Rod withdrawal block for all control rods.
RWM withdrawal block	Reactor power less than setpoint	Rod withdrawal block for all control rods.
RWM insert block	Reactor power less than setpoint	Rod insertion block for all control rods.
ATLM withdrawal block	Reactor power greater than setpoint	Rod withdrawal block for all control rods.
MRBM withdrawal block	Reactor power greater than setpoint	Rod withdrawal block for all control rods.
Gang large deviation	RC&IS Mode Switch: GANG:	Rod withdrawal block for all operable control rods of the selected gang upon detection of: – Large deviation of CR positions from RRPS in selected gang.

Table 2.2.2-1

CRDS Functional Arrangement

FMCRDs, including the equipment defined in Table 2.2.2-5 and 2.2.2-6, are safety-related, Seismic Category I.
FMCRDs are capable of rapid hydraulic insertion of the CRs during ATWS peak reactor pressure transient.
FMCRDs are capable of maintaining RCPB continuously at the RPV design pressure and briefly during the ATWS peak reactor pressure transient.
FMCRDs have continuous CR position indication sensors that detect CR position based on motor rotation.
FMCRDs have scram position indication switches that detect intermediate and scram completion CR positions.
FMCRDs have a bayonet CR coupling mechanism that requires a minimum rotation to decouple.
FMCRD rotation, sufficient to decouple the CR, is precluded when fuel bundles are present.
FMCRDs have spring-loaded latches in the hollow piston that engage slots in the guide tube to prevent rotation of the bayonet coupling except at predefined positions.
FMCRDs have redundant safety-related rod separation switches that detect separation of the FMCRD from the CR.
FMCRDs have a magnetic coupling that provides seal-less, leak-free operation of the CRD mechanism.
FMCRDs have safety-related holding brakes that engage on loss of power.
FMCRDs~~d~~ have safety-related scram inlet port check valves that close under reverse flow.
FMCRD have passive safety-related integral internal blowout support that prevents ejection of the FMCRD and the attached control rod.
FMCRD hydraulic scram feature moves a CR pair (except for one single CR) to defined scram positions, starting from loss of signal to the scram solenoid pilot valves in the HCUs, using only the stored energy in the ~~CRDS~~ ~~HCU~~ scram accumulators, in time spans equal to or less than the times defined in Table 2.2.2-2.
HCUs are safety-related, Seismic Category I.
HCUs are located in four dedicated rooms in the Reactor Building (RB).

Table 2.2.2-1

CRDS Functional Arrangement

~~HCU s~~Scram accumlator charging water header pressure instrumentation is safety-related, Seismic Category I.
HCU scram pilot solenoid valves transfer open to vent on loss of power to both solenoids.
HCU air header dump valves transfer open to vent on loss of power.
HCU ARI solenoid valves are closed on loss of power and transfer open to vent when energized.
Each HCU contains a nitrogen-water scram accumulator charged to a sufficiently high pressure and with the necessary valves and components to fully insert two CRs.
HCUs provide a flow path for purge water to the associated FMCRDs during normal operation.
~~HCU s~~Scram accumulators are continuously monitored for water leakage by level instruments.
HCU have a test port to allow connection of temporary test equipment for the conduct of FMCRD ball check valve testing and drive friction testing.
~~CRDHS~~ FMCRD purge water header, ~~HCU~~ scram accumulator charging water header, and scram air header, are classified Seismic Category II.
Divisional safety-related power supplies power safety-related FMCRD and HCU equipment.

Table 2.2.2-4

CRD System Controls and Interlocks

Parameter	Description
Control	Manual start (CRD pumps)
Interlock	High ~~-~~pressure makeup mode (RPV water level low [~~(~~Level 2]~~)~~) • The standby CRD pump is started. Both pumps operate in parallel to deliver the required makeup flow capacity to the reactor. • The two pump suction filter bypass valves are opened. • The scram accumulator charging water header isolation valve and purge water header isolation valve are closed. • ~~The~~ Each pump minimum flow ~~bypass~~ line isolation valve closes. • The flow control valves in the high~~-~~ pressure makeup lines open to regulate the makeup water flow rate to the reactor. • The test valve in the high ~~-~~pressure makeup line to the RWCU/SDC system opens if it is closed at the start of the event and the test valve in the return line to the CST closes if it is open at the start of the event. • The high ~~-~~pressure makeup flow control valves close to stop flow to the reactor at high reactor water Level 8. • ~~The~~ Each pump minimum flow ~~bypass~~ line isolation valve opens and both pumps continue to operate in a low flow condition by directing their flow back to the CST through the pump minimum flow lines.

Table 2.2.2-4(Continued)

CRD System Controls and Interlocks

Parameter	Description
	• The control valves reopen and the pump minimum flow ~~bypass~~ isolation valve closes to restart high ~~-~~pressure makeup flow if a subsequent Level 2 signal should occur. Normal operation mode (CRD common pump discharge line pressure low) • Start standby CRD pump. Normal operation mode (CRD pump inlet pressure low) • Trip running CRD pump after expiration of an adjustable time delay. Normal operation mode (pump lube oil pressure low) • Trip running CRD pumps and remove CRD pump start permissive condition. Normal operation mode (rod separation detection) • Send individual rod block initiate signal to RC&IS. Normal operation mode (scram accumulator charging water header pressure - low) • Send all rods block initiate signal to RC&IS. Normal operation mode (rod gang misalignment) • Send all rods in gang block initiate signal to RC&IS. High ~~-~~pressure makeup mode (inboard FW maintenance valve closed) • Inhibit opening (hp makeup water) injection valves. High ~~-~~pressure makeup mode (at least 2 GDCS pool levels low or Drywell pressure high and Drywell level high) • ~~Trip~~ Isolate CRD pumps to allow both pumps to operate in a low flow condition by directing their flow back to the CST through the pump minimum flow lines.

Table 2.2.2-5

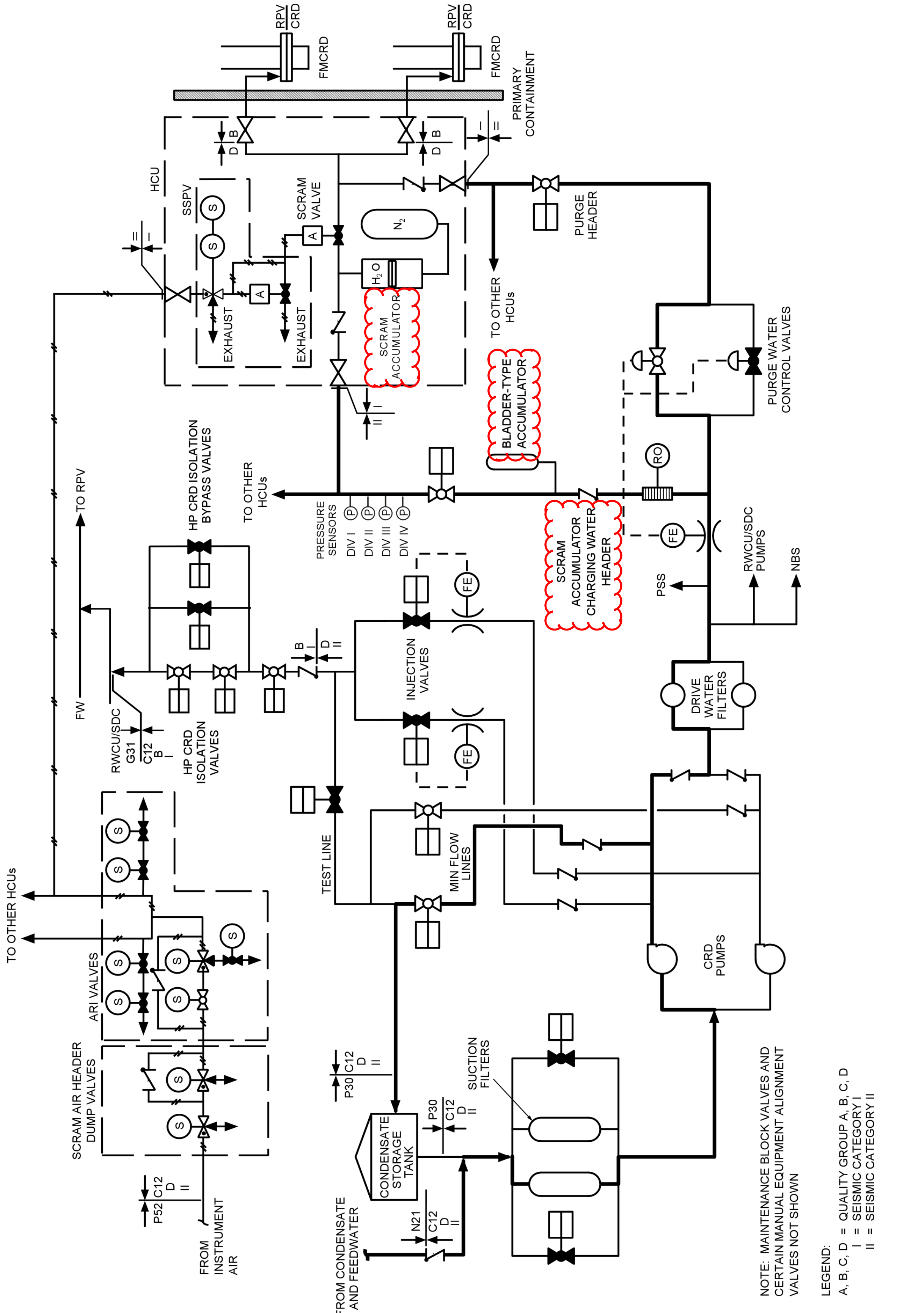
Control Rod Drive System Mechanical Equipment

Equipment Name (Description)	Equipment Identifier See Figure 2.2.2-1	ASME Code Section III	Seismic Cat. I	RCPB Component	Functional Capability Required	MCR Alarms
FMCRD components required for scram	FMCRD	No	Yes	No	Active	-
FMCRD reactor coolant primary pressure boundary components	FMCRD	Yes	Yes	Yes	-	-
HCU components required for scram	HCU	No	Yes	No	Active	1. ~~HCU~~ Scram accumulator gas pressure low 2. ~~HCU~~ Scram accumulator leakage high
Scram inlet piping	-	Yes	Yes	No	-	-
Internal drive housing supports	-	-	Yes	No	-	-
FMCRD magnetic coupling	FMCRD	-	Yes	No	Passive	-
FMCRD ball check valves	FMCRD	-	Yes	No	Active	-
HCU charging water supply line check valve	HCU	Yes	Yes	No	Active	-
HCU purge water supply line	HCU	Yes	Yes	No	Active	-

Table 2.2.2-6

Control Rod Drive System Electrical Equipment

Equipment Name (Description)	Equipment Identifier See Figure 2.2.2-1	Control Q-DCIS/DPS See Note 1	Seismic Category I	Safety-Related	Safety-Related Display	Active Safety Function	Loss of Motive Power Position	Remotely Operated Valve
HCU scram solenoid pilot valves	SSPV	Yes	Yes	Yes	Associated scram valve position status	Energize to apply air to HCU scram valve	Vent HCU scram valve	By RPS system logic
FMCRD passive holding brakes	FMCRD	No	Yes	Yes	Yes	Release brake	Apply brake	-
~~HCU~~ Scram accumulator charging water header pressure transmitters	Div 1-4	Yes	Yes	Yes	MCR alarm	-	-	-
FMCRD separation switches	FMCRD	Yes	Yes	Yes	MCR alarm	-	-	-
High pressure makeup isolation valves	HP CRD Isolation valves	Yes	Yes	Yes	MCR valve position	Close	Close	Yes
High pressure makeup isolation bypass valves (not including valve operator)	HP CRD Isolation Bypass valves	Yes	Yes	Yes	MCR valve position	-	As-Is	Yes


RPV
CRD
FMCRD
PRIMARY CONTAINMENT
HCU
SSPV
SCRAM VALVE
EXHAUST
SCRAM ACCUMULATOR
TO OTHER HCUs
PURGE HEADER
BLADDER-TYPE ACCUMULATOR
PURGE WATER CONTROL VALVES
HP CRD ISOLATION BYPASS VALVES
TO RPV
PRESSURE SENSORS
DIV I
DIV II
DIV III
DIV IV
SCRAM ACCUMULATOR CHARGING WATER HEADER
RO
FE
RWCU/SDC PUMPS
PSS
NBS
INJECTION VALVES
DRIVE WATER FILTERS
FW
RWCU/SDC
G31
C12
HP CRD ISOLATION VALVES
TEST LINE
MIN FLOW LINES
CRD PUMPS
ARI VALVES
SCRAM AIR HEADER DUMP VALVES
P52
FROM INSTRUMENT AIR
P30
CONDENSATE STORAGE TANK
SUCTION FILTERS
N21
FROM CONDENSATE AND FEEDWATER
NOTE: MAINTENANCE BLOCK VALVES AND CERTAIN MANUAL EQUIPMENT ALIGNMENT VALVES NOT SHOWN
LEGEND:
A, B, C, D = QUALITY GROUP A, B, C, D
I = SEISMIC CATEGORY I
II = SEISMIC CATEGORY II

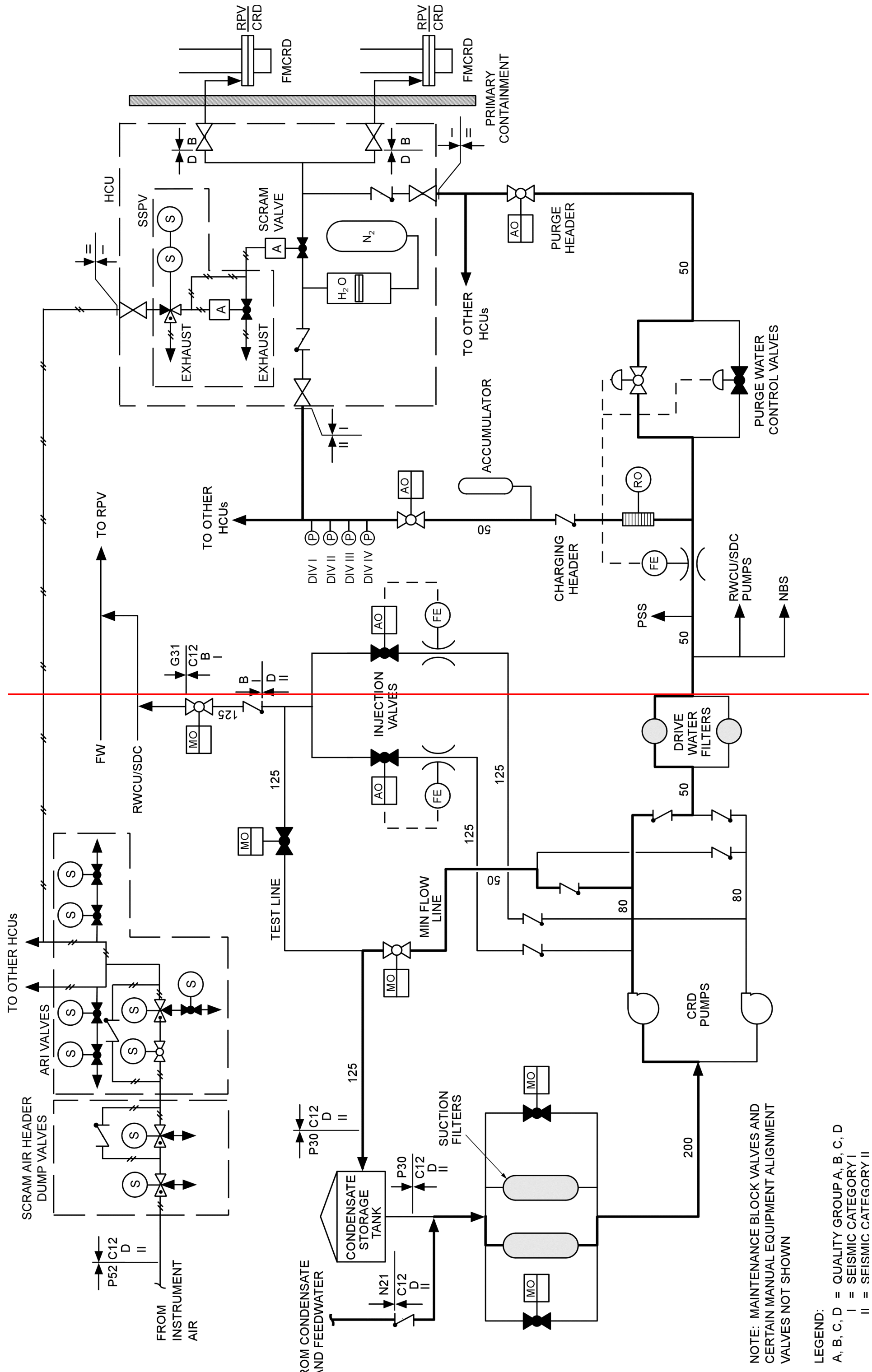


Figure 2.2.2-1. Control Rod Drive System

Table 2.2.7-2

RPS Automatic Functions, Initiators, and Associated Interfacing Systems

Function	Initiator	Interfacing System
Reactor scram	NMS PRNM trip condition	NMS
	NMS SRNM trip condition	NMS
	~~CRD~~ Scram accumulator charging water header pressure – low-low	CRDS
	Turbine stop valve closed position	-
	Turbine control valve control oil pressure low	-
	Condenser pressure high	-
	Power Generation Bus Loss (Loss of all feedwater flow event)	-
	MSIV closed position	NBS
	Reactor Pressure high	NBS
	RPV reactor level low (Level 3)	NBS
	RPV reactor level high (Level 8)	NBS
	DW pressure high	CMS
	Suppression pool average temperature high	CMS
	High simulated thermal power (feedwater temperature biased)	NBS, NMS
	Feedwater temperature exceeding allowable simulated thermal power vs. FW temperature domain.	NBS, NMS

Table 2.2.7-3

RPS Controls, Interlocks (System Interfaces), and Bypasses

Parameter	Description
Control	Manual divisional trip switches Manual scram trip switches Reactor Mode Switch Divisional actuator trip manual switches RPS trip reset manual switches RPS scram test switch (to RC&IS)
Interlock (System Interface)	RPS full scram condition (to RC&IS, CRDS) Turbine bypass valves open position indication APRM Simulated Thermal Power (to NMS) Reactor Mode Switch positions: -RUN (to NMS, ICS, PAS, LD&IS) -STARTUP (to PAS, NMS) -SHUTDOWN (to CRDS) -REFUEL (to CRDS, PAS, NMS) Reactor Mode Switch in the SHUTDOWN position automatic bypass after a time delay ~~CRD~~ Scram accumulator charging water header pressure signal (to RC&IS) MSIV closure bypass (to LD&IS)
Bypass	Special MSIV operational bypass switches Reactor Mode Switch in Shutdown scram manual bypass switches ~~CRD HCU~~ Scram accumulator charging water header pressure trip manual bypass switches (to RC&IS) MSIV closure trip signals manual bypass switches (to LD&IS) RPS division of logic (TLU output) manual divisional bypass switches RPS Division of sensors (DTM output) manual divisional bypass switches