2.4 Core Cooling Systems

The information in this section of the reference ABWR DCD, including all subsections, tables, and figures, is incorporated by reference with the following departures.

STD DEP T1 2.4-1 (Figure 2.4.1a, Table 2.4.1)

STD DEP T1 2.4-2 (Figure 2.4.3)

STD DEP T1 2.4-3 (Figure 2.4.4a, Table 2.4.4.)

STD DEP T1 2.4-4 (Table 2.4.1, Table 2.4.2, Table 2.4.4)

STD DEP T1 2.14-1 (Figure 2.4.1b, Figure 2.4.1c, Figure 2.4.3)

2.4.1 Residual Heat Removal System

STD DEP T1 2.4-1

STD DEP T1 2.4-4 (Table 2.4.1)

Design Description

The RHR System operates in the following modes:

(6) *Augmented fuel pool cooling, and fuel pool makeup (Divisions* A, *B, and C)*

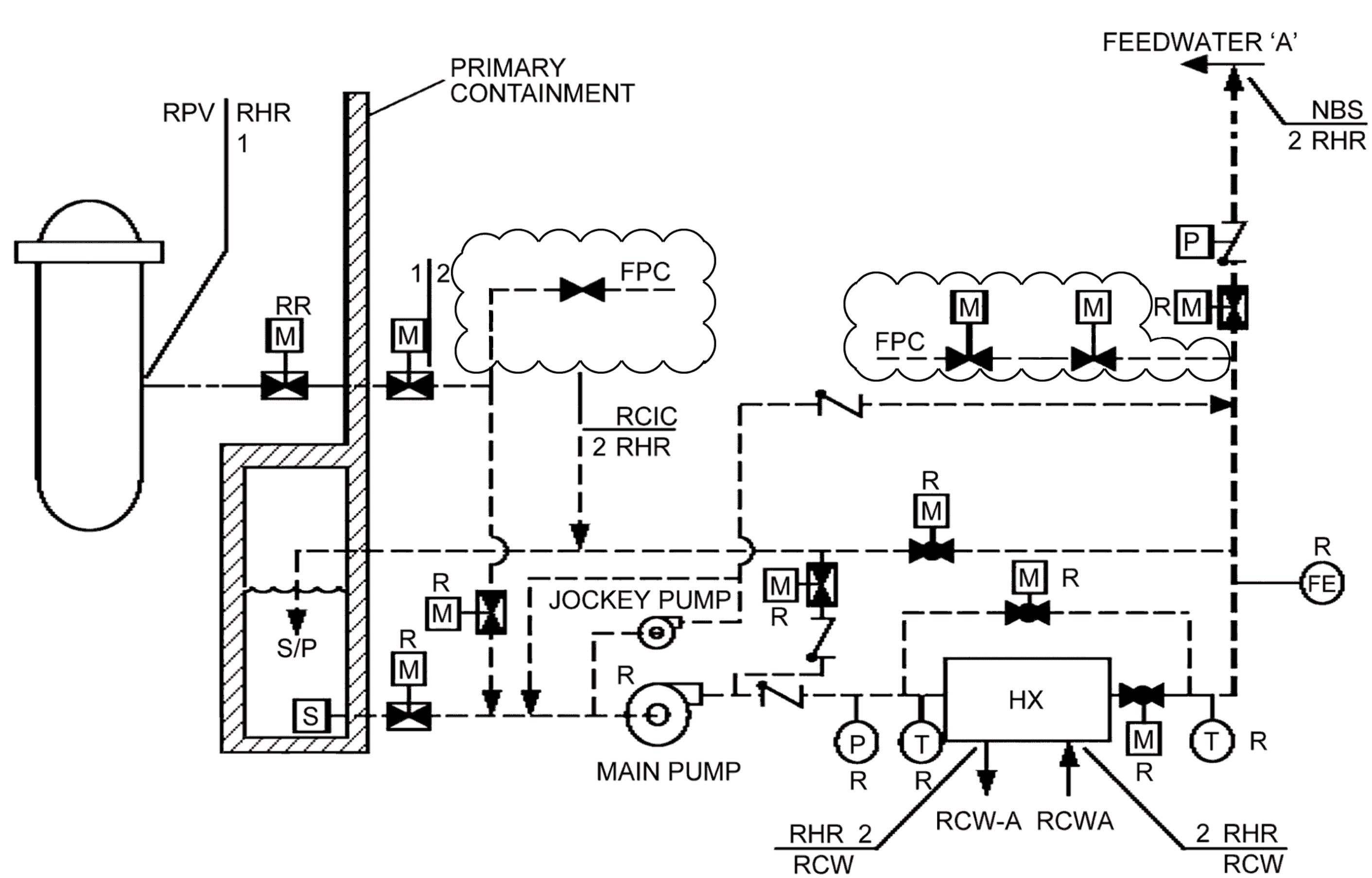
Augmented Fuel Pool Cooling and Fuel Pool Makeup

The augmented fuel pool cooling mode of the RHR System (Divisions A, *B and C) can supplement the Fuel Pool Cooling (FPC) System as follows: (1) directly cooling the fuel pool by circulation fuel pool water through the RHR heat exchanger and returning it to the fuel pool; and (2) while providing shutdown cooling during refueling operations, return the cooled RHR shutdown cooling flow to the fuel pool. Also, this mode provides for fuel pool emergency makeup capability by permitting the RHR pumps (Divisions* A, *B and C) to transfer suppression pool water to the fuel pool. This mode is accomplished manually by control of individual system components. In the augmented fuel pool cooling mode, the RHR tube side heat exchanger flow rate for Division~~s~~* A, *B or C is no less than 350 m^3/h.*

Other Provisions

The piping and components outside the shutdown cooling suction line containment isolation valves and outside the suppression pool containment isolation valves, and upstream of the suction side of the pump with all its branches have a design pressure of 2.82 MPaG for intersystem LOCA (ISLOCA) conditions. Refer to Figures 2.4.1a, 2.4.1b, and 2.4.1c. ~~*For RHR A, the upgraded branch lines from the main pump suction include the path to and including the suppression pool suction valve, the path to the shutdown cooling outboard containment isolation valve, and the path to the jockey pump's discharge check valve including the jockey pump's bypass return line. For RHR B and C, the upgraded branch lines include all the paths listed for RHR A plus the path to (and including the valve) the Fuel Pool Cooling System that branches off*~~

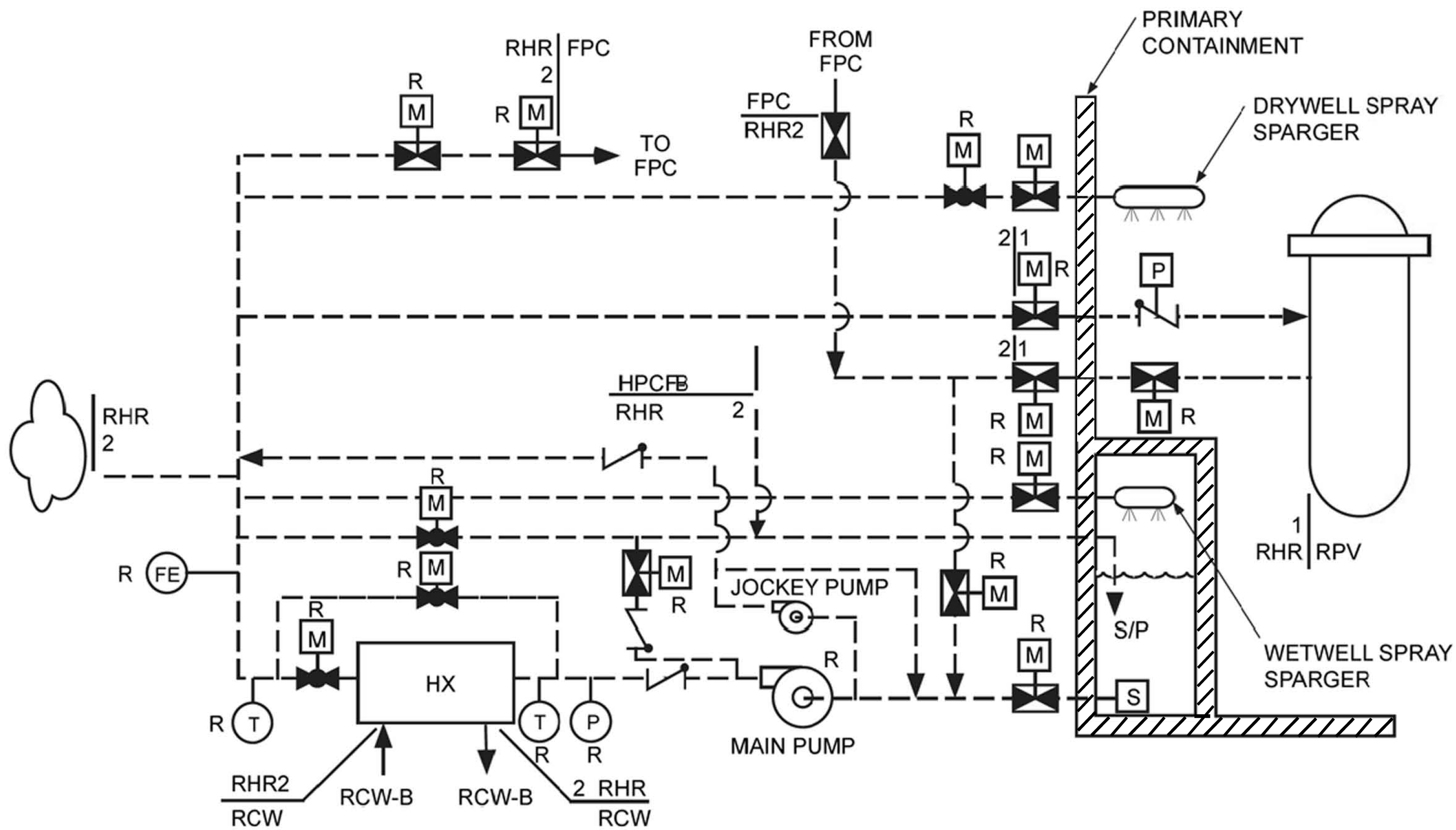
~~*the shutdown cooling suction line, titled "From FPC."*~~ For RHR A and B, the upgraded branch lines from the main pump suction include the path to and including the suppression pool suction valve, the path to the shutdown cooling outboard containment isolation valve, the path to the jockey pump's discharge valve including the jockey pump's bypass line and the path to the (and including the valve) the Fuel Pool Cooling System that branches off the shutdown cooling suction, titled, "From FPC." *For RHR-C, the upgraded branch lines include all the paths listed for RHR-A and B plus the pipeline and valves that are part of the AC independent water addition mode that extends from the noncode boundary indicated by "NNS" to the "external connection" outside the "reactor building" and to the Fire Protection System interface indicated by "FP."*



NOTES:

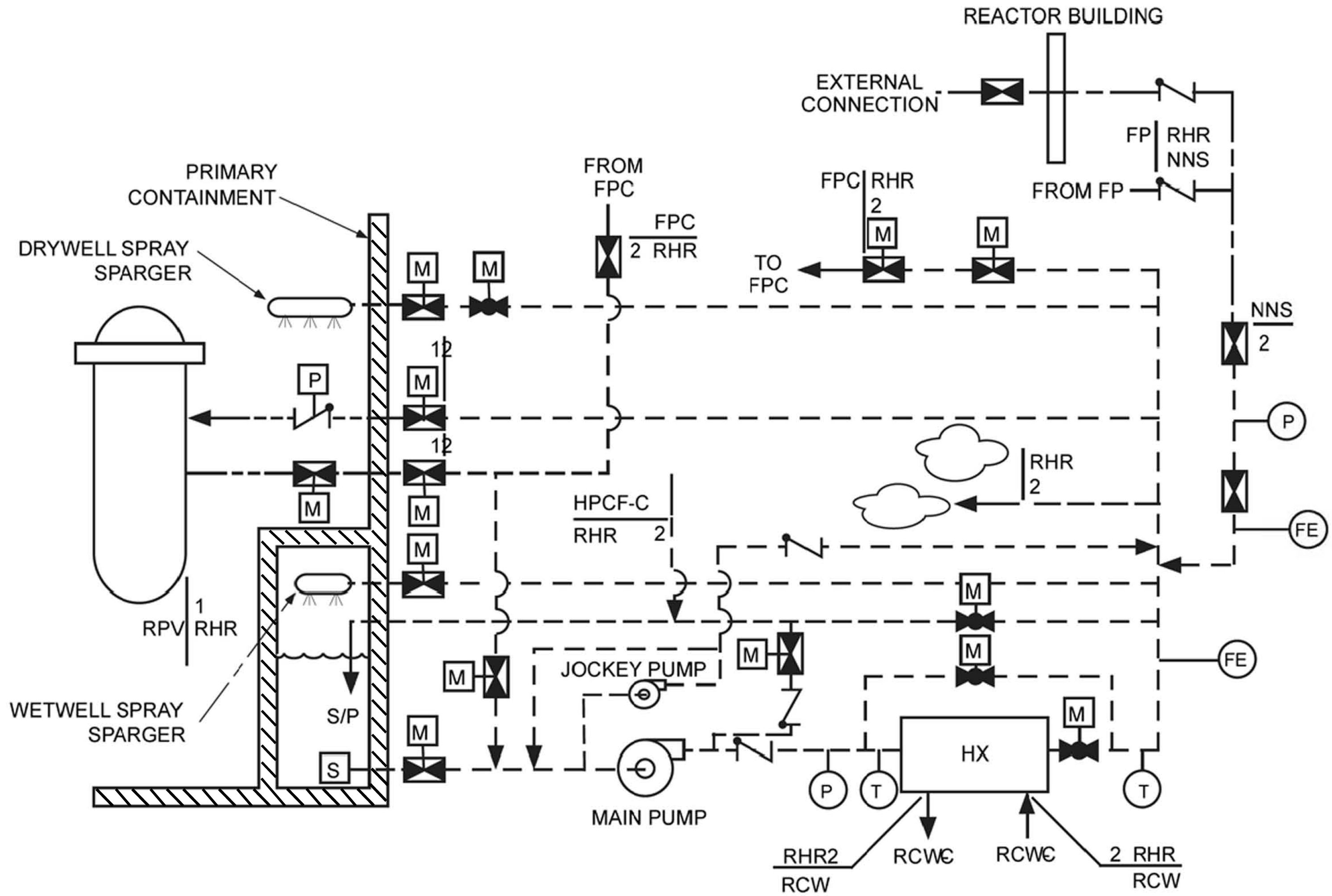
1. ALL ELECTRICAL POWER LOADS FOR THE CLASS 1E COMPONENTS SHOWN ON THIS FIGURE ARE POWERED FROM CLASS 1E DIVISION I EXCEPT FOR THE OUTBOARD CONTAINMENT ISOLATION VALVE OF THE SHUTDOWN COOLING SUCTION LINE, WHICH IS DIVISION II.

Figure 2.4.1a Residual Heat Removal System (RHR-A)



NOTES:
1. ALL ELECTRICAL POWER LOADS FOR THE CLASS 1E COMPONENTS SHOWN ON THIS FIGURE ARE POWERED FROM CLASS 1E DIVISION II EXCEPT FOR THE OUTBOARD CONTAINMENT ISOLATION VALVE OF THE SHUTDOWN COOLING SUCTION LINE, WHICH IS DIVISION III.
2. DRYWELL AND WETWELL SPRAY SPARGERS ARE COMMON TO DIVISIONS B AND C.

Figure 2.4.1b Residual Heat Removal System (RHR-B)



NOTES:

1. ALL ELECTRICAL POWER LOADS FOR THE CLASS 1E COMPONENTS SHOWN ON THIS FIGURE ARE POWERED FROM CLASS 1E DIVISION III EXCEPT FOR THE OUTBOARD CONTAINMENT ISOLATION VALVE OF THE SHUTDOWN COOLING SUCTION LINE, WHICH IS DIVISION I.
2. DRYWELL AND WETWELL SPRAY SPRAGERS ARE COMMON TO DIVISIONS B AND C.

Figure 2.4.1c Residual Heat Removal System (RHR-C)

Table 2.4.1 Residual Heat Removal System

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
4. continued c. The RHR pumps have sufficient NPSH.	4. continued c. Inspections, tests and analyses will be performed upon the as-built RHR System. NPSH tests of the pumps will be performed in a test facility. The analyses will consider the effects of: – Pressure losses for pump inlet piping and components. – Suction from the suppression pool with water level at the minimum value. – ~~50% blockage of pump suction strainers~~ **Analytically derived values for blockage of pump suction strainers based upon the as-built system.** – Design basis fluid temperature (100°C) – Containment at atmospheric pressure.	4. continued c. The available NPSH exceeds the NPSH required by the pumps.
7. In the augmented fuel pool cooling mode, the RHR tube side heat exchanger flow rate ~~for Divisions B or C~~ is no less than 350 m^3/h (heat exchanger heat removal capacity in this mode is bounded by suppression pool cooling requirements).	7. Tests will be performed to determine system flow rate through each heat exchanger in the augmented fuel pool cooling mode. Inspections and analyses shall be performed to verify that the augmented fuel pool cooling mode is bounded by suppression pool cooling requirements.	7. The RHR tube side heat exchanger flow rate is greater than or equal to 350 m^3/h in the augmented fuel pool cooling mode. Heat exchanger heat removal capacity in this mode is bounded by suppression pool cooling requirements.

2.4.2 High Pressure Core Flooder System

STD DEP T1 2.4-4 (Table 2.4.2)

Table 2.4-2 High Pressure Core Flooder System

Inspections, Tests, Analyses and Acceptance Criteria		
g. The HPCF pumps have sufficient NPSH available at the pumps.	g. Inspections, tests and analyses will be performed upon the as-built system. NPSH tests of the pumps will be performed in a test facility. The analyses will consider the effects of: – Pressure losses for pump inlet piping and components. – Suction from the suppression pool with water level at the minimum value. – ~~50% minimum blockage of pump suction strainers~~ **Analytically derived values for blockage of pump suction strainers based upon the as-built system.** – Design basis fluid temperature (100°C) – Containment at atmospheric pressure.	g. The available NPSH exceeds the NPSH required by the pumps.

2.4.3 Leak Detection and Isolation System

STD DEP T1 2.4-2 (Leak Detection System) Figure 2.4.3

STD DEP T1 2.4-3 (Reactor Coolant Isolation Cooling System)

STD DEP T1 2.14-1 (FCS, Figure 2.4.3)

Design Description

The following primary and secondary containment isolation and automatic control functions are provided by the LDS using four instrument channels to monitor leakage:

(8) Isolation of the Reactor Core Isolation Cooling (RCIC) System steamline to the RCIC turbine on a signal indicating high steam flow in the RCIC line, low steam pressure in the RCIC line, high RCIC turbine exhaust pressure, or high ambient temperature in the RCIC equipment area.

(9) Isolation of the Suppression Pool Cleanup (SPCU) System on a signal indicating high drywell pressure or low reactor water level.

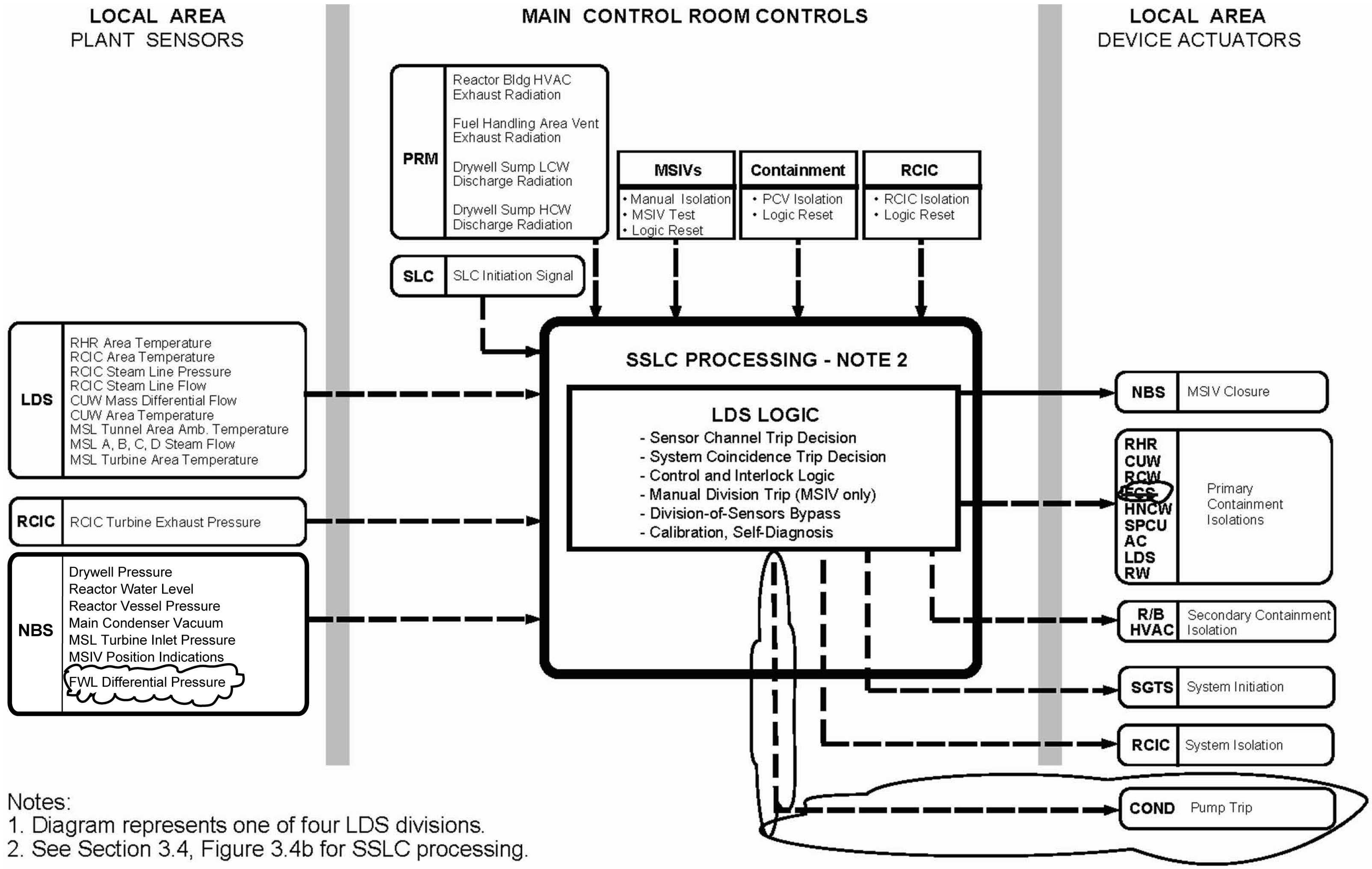
~~*(10) Isolation of the Flammability Control System (FCS) on a signal indicating high drywell pressure or low reactor water level.*~~

(10) ~~(11)~~ Isolation of the drywell sump low conductivity waste (LCW) and high conductivity waste (HCW) discharge lines on a signal indicating high drywell pressure or low reactor water level. Also, each discharge line is individually isolated on a signal indicating high radioactivity in the discharged liquid waste; only one channel is used for this function.

(11) ~~(12)~~ Isolation of the LDS fission products monitor drywell sample and return lines on a signal indicating high drywell pressure or low reactor water level.

(12) ~~(13)~~ The LDS provides to the neutron monitoring system a signal indicating a high drywell pressure or low reactor water level.

(13) The LDS provides a trip of the condensate pumps on signals that indicate high drywell pressure and high differential pressure between the feedwater lines.



Notes:
1. Diagram represents one of four LDS divisions.
2. See Section 3.4, Figure 3.4b for SSLC processing.

Figure 2.4.2 Leak Detection and Isolation System Interface Diagram

2.4.4 Reactor Core Isolation Cooling System

STD DEP T1 2.4-3

STD DEP T1 2.4-4 (Table 2.4.4)

The RCIC System has the following displays and controls in the main control room (MCR):

(1) Parameter displays for the instruments shown on Figure 2.4.4a.

(2) Controls and status indication for the active safety-related components shown on Figure 2.4.4a.

(3) Manual system level initiation capability for RPV water makeup mode.

(4) Manual override of the automatic CST to S/P suction transfer.

The safety-related electrical components (including instrumentation and control) shown on 2.4.4a located inside primary containment and in the Reactor Building are qualified for a harsh environment.

The motor-operated valves (MOVs) shown on Figure 2.4.4a have active safety-related functions to open, close, or both open and close, and performs these functions under differential pressure, fluid flow, and temperature conditions.

The check valves (CV's) shown on Figure 2.4.4a have active safety-related functions to open, close, or both open and close under system pressure, fluid flow, and temperature conditions.

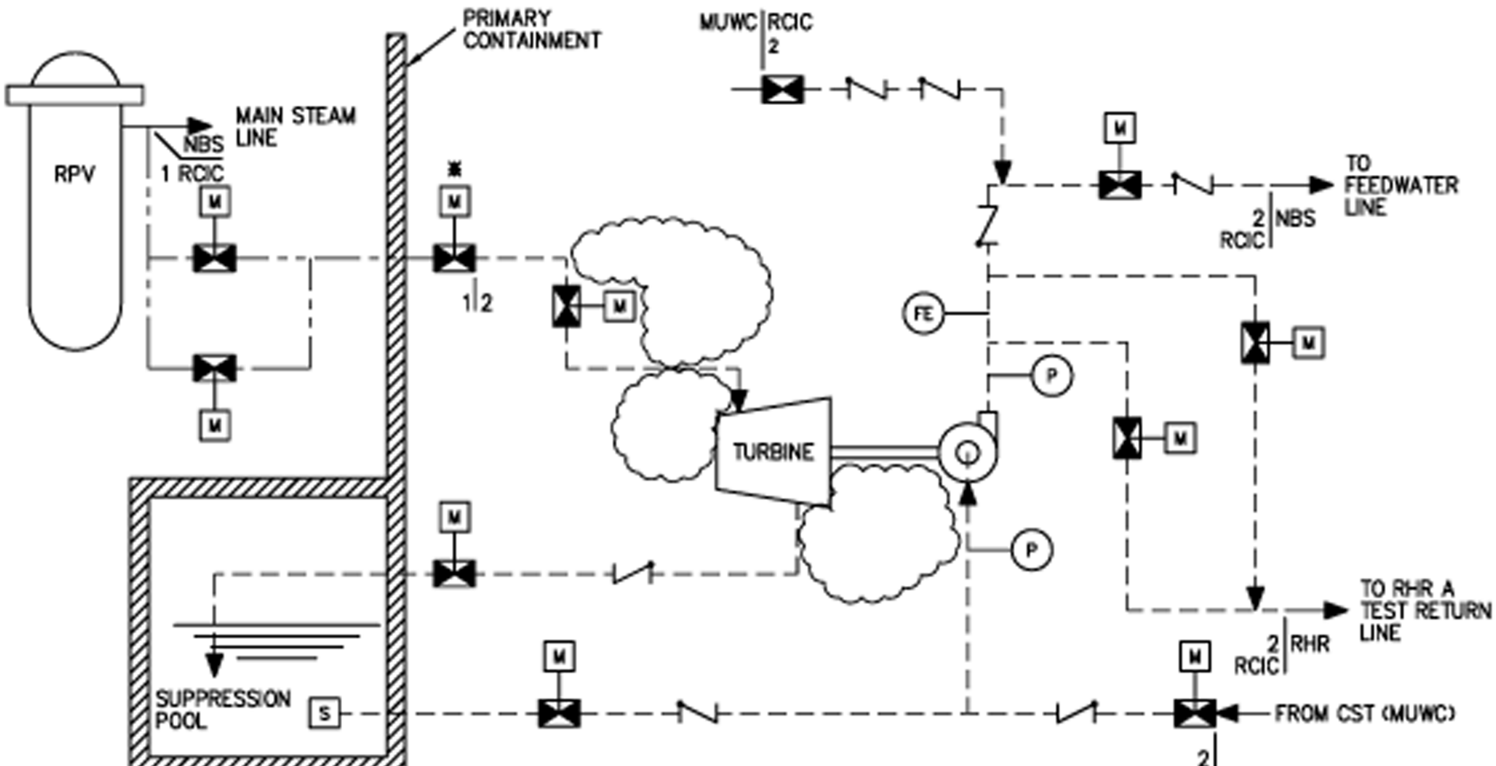
The RCIC turbine is tripped if a low pump suction pressure condition is present.

The following RCIC System component:

(1) Piping and component from the pump suction MOV's up to the pump inlet,

~~*(2) Barometric condenser and associated equipment.*~~

have a design pressure of 2.82 MPaG for intersystem loss-of-coolant accident (ISLOCA) conditions.



NOTES:

1. RCIC TURBINE IS ~~NOT~~ COVERED BY ASME CODE SECTION III ~~BUT IS DESIGNED, FABRICATED, AND INSTALLED TO SAFETY RELATED STANDARDS AND IS CONSISTENT WITH THE ASME CODE SECTION III REQUIREMENTS. THE TURBINE INCLUDES THE TURBINE TRIP AND THROTTLE VALVE.~~
2. ALL RCIC SYSTEM COMPONENTS SHOWN ON THIS FIGURE ARE POWERED FROM CLASS 1E DIVISION I EXCEPT FOR THE OUTBOARD CONTAINMENT ISOLATION VALVE (*) WHICH IS CLASS 1E DIVISION II.
3. ALL RCIC SYSTEM COMPONENTS SHOWN ON THIS FIGURE EXCEPT THE INBOARD CONTAINMENT ISOLATION VALVES, ARE POWERED FROM DC SOURCES.

Figure 2.4.4a Reactor Core Isolation Cooling System

Table 2.4.4 Reactor Core Isolation Cooling System

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
3. c. Following receipt of an initiation signal, the RCIC System automatically initiates and operates in the RPV water makeup mode.	3. c. Tests will be conducted on the RCIC System using simulated initiation signal.	3. c. Upon receipt of a simulated initiation signal, the following occurs: ~~(1) Steam supply bypass valve receives open signal.~~ ~~(2)~~**(1)** Test return valves receive close signal. ~~(3)~~**(2)** CST suction valve receives open signal. ~~(4)~~**(3)** Injection valve receives open signal .~~after a 10-second delay.~~ ~~(5)~~**(4)** Steam admission valve receives open signal. ~~after a 10-second time delay.~~
e.Following receipt of shutdown signal, the RCIC System automatically terminates the RPV water makeup mode.	e.Tests will be conducted on RCIC System using simulated shutdown signal.	e.Upon receipt of simulated shutdown signals, the following occurs: ~~(1)Steam supply bypass valve receives close signal.~~ ~~(2)~~**(1)** RCIC initiation logic resets. ~~(3)~~**(2)** Injection valve receives close signal. ~~(4)~~**(3)** Steam admission valve receives close signal.

Table 2.4.4 Reactor Core Isolation Cooling System

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
f. Following RCIC shutdown on high reactor water level signal, the RCIC System automatically restarts to provide RPV water makeup if low water level signal recurs.	f. Tests will be conducted using simulated low reactor water level signals.	f. Upon receipt of simulated low reactor water level signals, the following occurs: ~~*(1) Steam supply bypass valve receives open signal.*~~ ~~*(2)*~~**(1)** Test return valves receive close signal. ~~*(3)*~~**(2)** CST suction valve receives open signal. ~~*(4)*~~**(3)** Injection valve receives open signal. ~~*after a 10 second delay.*~~ ~~*(5)*~~**(4)** Steam admission valve receives open signal. ~~*after a 10 second time delay.*~~

Table 2.4.4 Reactor Core Isolation Cooling System

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
i. In the RPV water makeup mode, the RCIC pump delivers a flow rate of at least 182 m^3/h against a maximum differential pressure (between the RPV and the pump suction) of 8.12 MPa.	i. Tests will be conducted in a test facility on the RCIC System pump and turbine.	i. (1) The RCIC pump delivers a flow rate of at least 182 m^3/h against a maximum differential pressure (between the RPV and the pump suction of 8.12 MPa. (2) The RCIC turbine delivers the speed ~~*and torque*~~ required by the pump at the above conditions.
j. The RCIC System pump has sufficient NPSH.	j. Inspections, tests and analyses will be performed based upon the as-built system. NPSH tests of the pump will be performed at a test facility. The analyses will consider the effects of: (1) Pressure losses for pump inlet piping and components. (2) Suction from the suppression pool with water level at the minimum value. (3) ~~*50% blockage of pump suction strainers*~~ **Analytically derived values for blockage of pump suction strainers based upon the as-built system.** (4) Design basis fluid temperature (77°C) (5) Containment at atmospheric pressure.	j. The available NPSH exceeds the NPSH required by the pump.