2.4 Core Cooling Systems

2.4.1 Residual Heat Removal System

Design Description

The Residual Heat Removal (RHR) System has three separate divisions. The major functions of the RHR System are:

(1) Containment heat removal.

(2) Reactor decay heat removal.

(3) Emergency reactor vessel level makeup and

(4) Augmented fuel pool cooling.

Figures 2.4.1a, 2.4.1b, and 2.4.1c show the basic system configuration and scope. Figure 2.4.1d shows the RHR System control interfaces.

Except for the non-ASME Code components of the alternating current (AC) power source independent water addition feature (Figure 2.4.1c), the entire RHR System shown on Figures 2.4.1a, 2.4.1b, and 2.4.1c is classified as safety-related.

The RHR System operates in the following modes:

(1) Low pressure core flooder (LPFL) (Divisions A, B, and C)

(2) Suppression pool cooling (Divisions A, B, and C)

(3) Wetwell spray (Divisions B, and C)

(4) Drywell spray (Divisions B, and C)

(5) Shutdown cooling (Divisions A, B, and C)

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

(7) AC power source independent water addition (Division C)

(8) Full flow test (Divisions A, B, and C)

(9) Minimum flow bypass (Divisions A, B, and C)

Low Pressure Core Flooder Mode

As shown on Figure 2.4.1d, the RHR System channel measurements are provided to the Safety System Logic and Control (SSLC) for signal processing, setpoint comparisons, and generating trip signals. The RHR System is automatically initiated when either a high drywell pressure or low reactor water level condition exists (i.e., LOCA signal). A RHR initiation signal is provided to the systems as identified on Figure 2.4.1d. The SSLC processors use a two-out-of-four voting logic for RHR System initiation. Each RHR division can also be initiated manually (LPFL mode).

Following receipt of an initiation signal, the RHR System automatically initiates and operates in the LPFL mode to provide emergency makeup to the reactor vessel. The initiation signal starts the pumps, which run in the minimum flow mode until the reactor depressurizes to less than the pump's developed head pressure. A low reactor pressure permissive signal occurs above the pump's developed head pressure, which signals the injection valve to open. As the injection valve opens, the reactor pressure is contained by the testable check valve until the reactor pressure becomes less than the pump's developed head pressure of the minimum flow mode, at which time injection flow begins. This sequence satisfies the response requirements for all potential LOCA pipe breaks when the injection valve opens within 36 seconds after receiving the low reactor pressure permissive signal. The LPFL injection flow for each division begins when the reactor vessel pressure is no less than 1.55 MPa above the drywell pressure. When the reactor vessel pressure is no less than 0.275 MPa greater than the drywell pressure, the LPFL injection flow for each division is 954 m^3/h minimum. The LPFL mode is accomplished by all three divisions of the RHR System by transferring water from the suppression pool to the reactor pressure vessel (RPV), via the RHR heat exchangers. The system automatically aligns to the LPFL mode of operation from the test mode, the suppression pool cooling, or wetwell spray modes upon receipt of an initiation signal. The wetwell spray mode is applicable for Divisions B or C. If a drywell spray valve is open in Division B or C, that RHR division automatically aligns to the LPFL mode in response to the injection valve beginning to open. The RPV injection valve in each division requires a low reactor pressure permissive signal to open, and closes automatically on receipt of a high reactor vessel pressure signal.

Suppression Pool Cooling Mode

The suppression pool cooling mode of the RHR System limits the long-term post-LOCA temperature of the suppression pool, and limits the long-term peak temperatures and pressures within the wetwell and drywell regions of the containment. In this mode, the RHR System circulates water through the RHR heat exchangers and returns it directly to the suppression pool. This mode is manually initiated by control of individual system components. In the suppression pool cooling mode, the total heat removal capacity between the RHR and ultimate heat sink is greater than 0.427 MJ/s·°C for each division. 0.427 MJ/s·°C is the limiting heat removal capacity of all the RHR modes. The heat removal path is the RHR heat exchanger, the Reactor Building Cooling Water (RCW) System, and the Reactor Service Water (RSW) System. In the suppression pool cooling mode, the RHR tube side heat exchanger (Hx) flow rate is 954 m^3/h minimum per division. The RHR pumps have sufficient net positive suction head (NPSH) available at the pump. Suction from the suppression pool is the limiting NPSH condition of all the RHR modes.

Containment Spray Mode

The containment spray mode of the RHR System is available in Divisions B and C, and consists of the wetwell spray and drywell spray operating together. In this mode, the RHR System pumps suppression pool water to a single wetwell spray header and single drywell spray header through the associated RHR heat exchanger. The containment spray mode of the RHR System is initiated manually by control of individual system components. The drywell spray inlet valves can only be opened if a high drywell pressure condition exists and if the injection valves are fully closed. The wetwell spray flow rate for either Division B or C is no less than 114 m^3/h.

Shutdown Cooling Mode

In the shutdown cooling mode of operation, the RHR System removes decay heat from the reactor core, and is used to achieve and maintain a cold shutdown condition by removing decay and sensible heat from the core and reactor vessel. This mode reduces reactor pressure and temperature to cold shutdown conditions. In this mode, each division takes suction from the RPV via its dedicated suction line, pumps the water through its respective heat exchanger tubes, and returns the cooled water to the RPV. Two divisions (B and C) discharge water back to the RPV via dedicated spargers, while the third division (A) utilizes the vessel spargers of one of the two feedwater lines (FW-A). Shutdown cooling is initiated manually once the RPV has been depressurized below the system low pressure permissive. In any division, the shutdown cooling suction valve cannot be opened unless the following valves in that division are closed:

(1) Suppression pool suction valve

(2) Suppression pool return valve

(3) Drywell spray valves

(4) Wetwell spray valve

Each shutdown cooling suction valve automatically closes on low reactor water level. The low pressure portions of the shutdown cooling piping are protected from high reactor pressure by automatic closure of the shutdown cooling suction valves on a high reactor vessel pressure. The shutdown cooling flow rate for any division is no less than 954 m^3/h.

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 A, B or C is no less than 350 m^3/h.

AC Independent Water Addition Mode

Division C of the RHR System also functions in an AC independent water addition (ACIWA) mode. This mode provides a means of injecting emergency makeup water to the reactor by cross connecting the Reactor Building Fire Protection (FP) System header, or alternately utilizing additional sources of water from an external connection just outside the Reactor Building. This makes it independent of the normal safety-related AC power distribution network. This mode is accomplished by manually opening two in-series valves on the cross-connection piping just upstream of the tie-in to the normal RHR piping. This is accomplished by local manual action at the valves. Fire Protection System water can be directed to either the RPV or the drywell spray sparger by local manual opening of the Division C RHR injection valve or the two Division C drywell spray valves. “Local manual” as used in this paragraph means manually operating the valves at the valves.

Full Flow Test Mode

Each division of the RHR System has a full flow test mode to permit pump flow testing during plant operation. In this mode, the system is essentially operated in the suppression pool cooling mode, drawing suction from and discharging back to the suppression pool.

Minimum Flow Bypass Mode

Each division of the RHR System has a minimum flow bypass mode that assures there is always flow in the RHR pumps when they are operating. This is accomplished by monitoring pump discharge flow, and opening a minimum flow valve to the suppression pool when flow falls below the minimum value. The minimum flow valve closes when the pump flow exceeds the minimum value. Minimum flow bypass operation is automatic based on a flow signal opening the minimum flow valve when the flow is low, with a concurrent high pump discharge pressure signal.

Other Provisions

The RHR System is classified as Seismic Category I. Figures 2.4.1a, 2.4.1b, and 2.4.1c show the ASME Code Class for the RHR System. The RHR System is located in the Reactor Building.

Each of the three divisions is powered from the Class 1E division as shown on Figures 2.4.1a, 2.4.1b, 2.4.1c. In the RHR System, independence is provided between Class 1E divisions, and also between the Class 1E divisions and non-Class 1E equipment.

Outside the primary containment, each mechanical division of the RHR System (Divisions A, B, and C) is physically separated from the other divisions.

The RHR System has the following displays and controls in the main control room:

(1) Parameter displays for the instruments shown on Figures 2.4.1a, 2.4.1b, and 2.4.1c.

(2) Controls and status indication for the active safety-related components shown on Figures 2.4.1a, 2.4.1b, and 2.4.1c.

(3) Manual system level initiation capability for the following modes:

(a) LPFL initiation

(b) Standby

(c) Shutdown cooling

(d) Suppression pool cooling

(e) Drywell spray

RHR System components with displays and control interfaces with the Remote Shutdown System (RSS) are shown on Figures 2.4.1a and 2.4.1b.

The safety-related electrical equipment shown on Figures 2.4.1a, 2.4.1b, and 2.4.1c located inside the primary containment and the Reactor Building is qualified for a harsh environment.

The motor-operated valves shown on Figures 2.4.1a, 2.4.1b, and 2.4.1c have active safety-related functions and perform these functions to open, close, or both open and close, under differential pressure, fluid flow, and temperature conditions.

The check valves (CVs) shown on Figures 2.4.1a, 2.4.1b, and 2.4.1c (except those in ACIWA lines) have safety-related functions to open, close, or both open and close under system pressure, fluid flow, and temperature conditions.

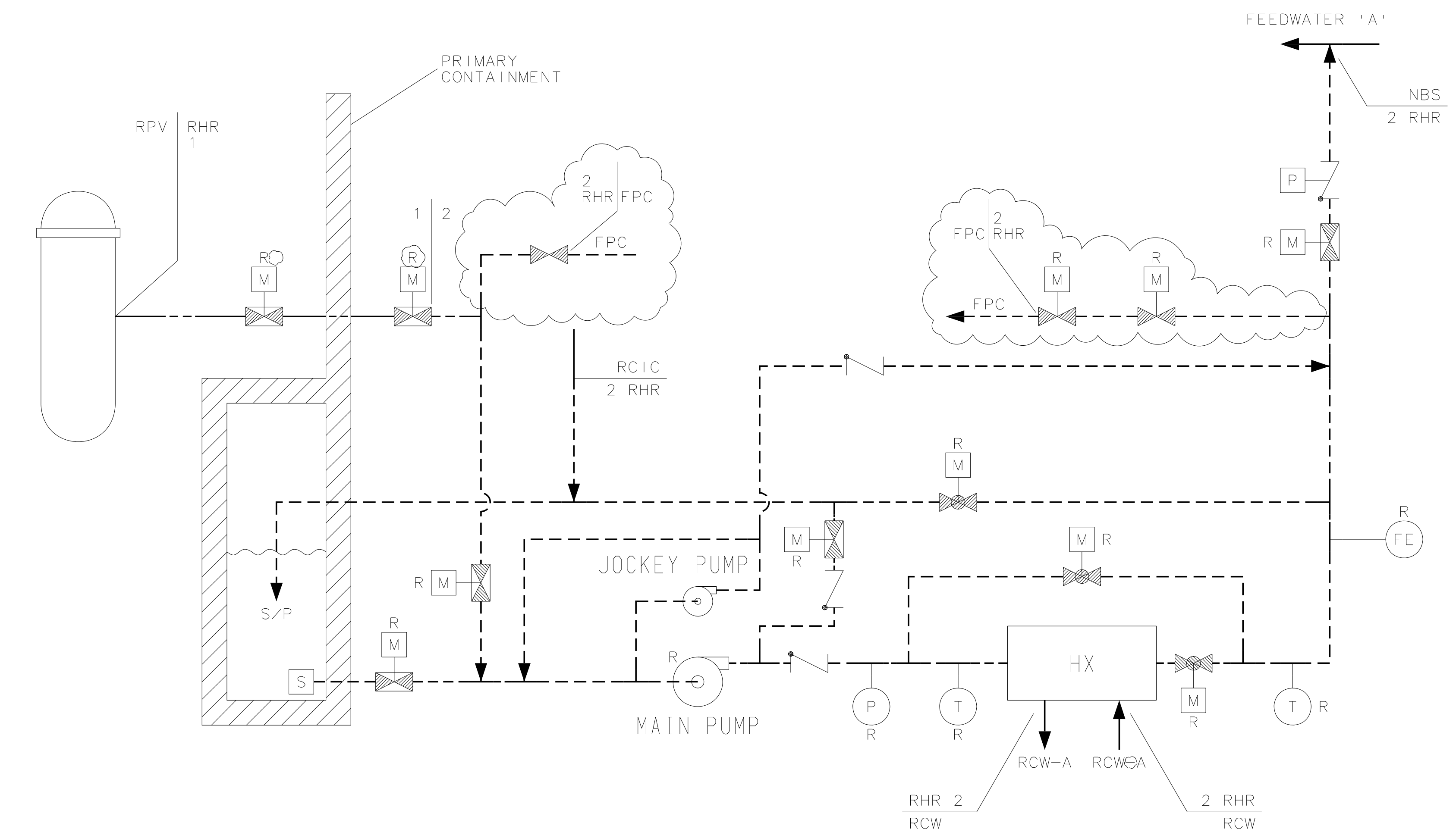
The RHR System main pumps are interlocked to prevent starting with a closed suction path.

Each RHR loop has a continuously running jockey pump to maintain the system piping continuously filled with water. The jockey pump is stopped by an RHR initiation signal or may be stopped or started manually.

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 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 check valve including the jockey pump's bypass line and 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-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”.

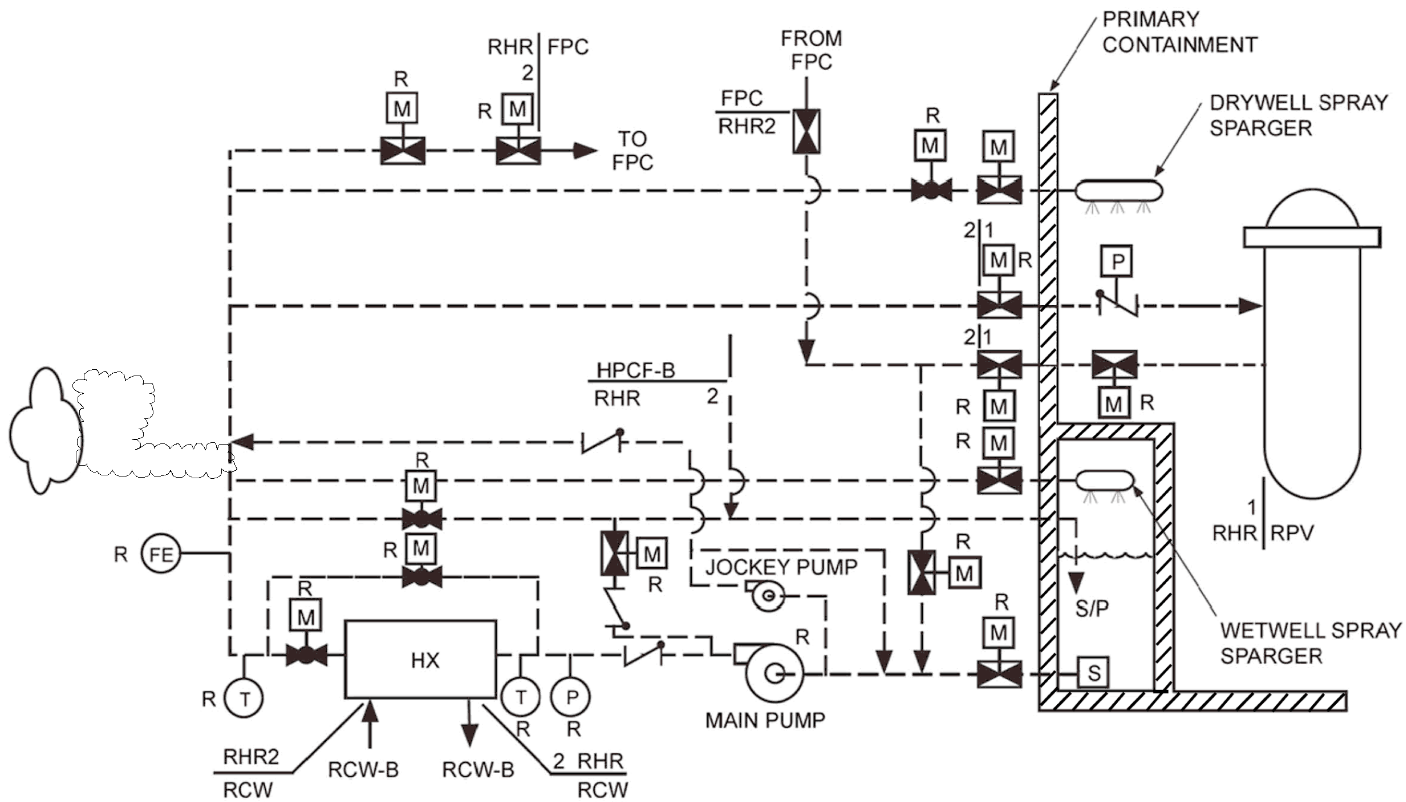
Inspections, Tests, Analyses and Acceptance Criteria

Table 2.4.1 provides a definition of the inspections, test and/or analyses, together with associated acceptance criteria, which will be undertaken for the RHR System.



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.

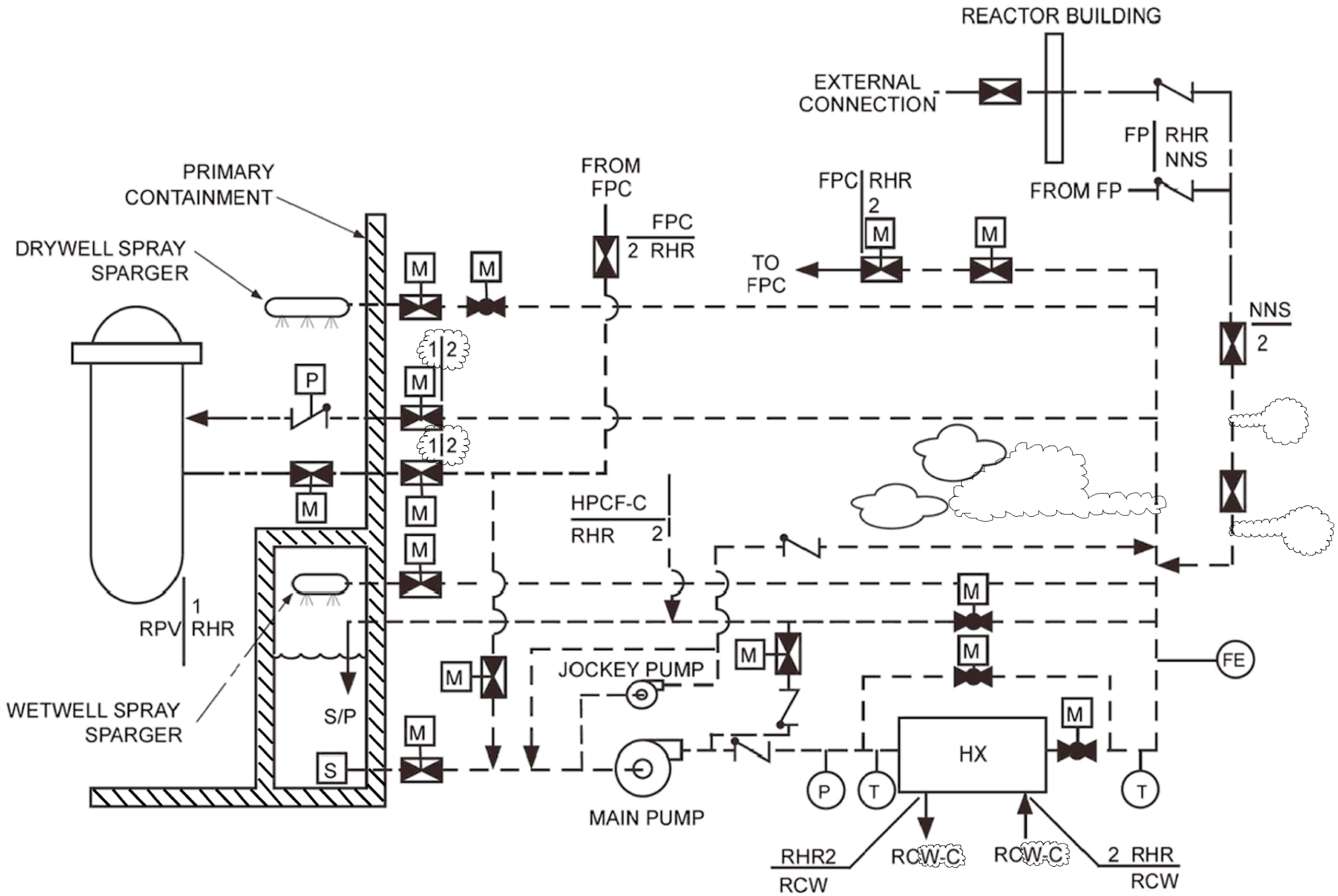
Figure 2.4.1a Residual Heat Removal System (RHR-A)



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.

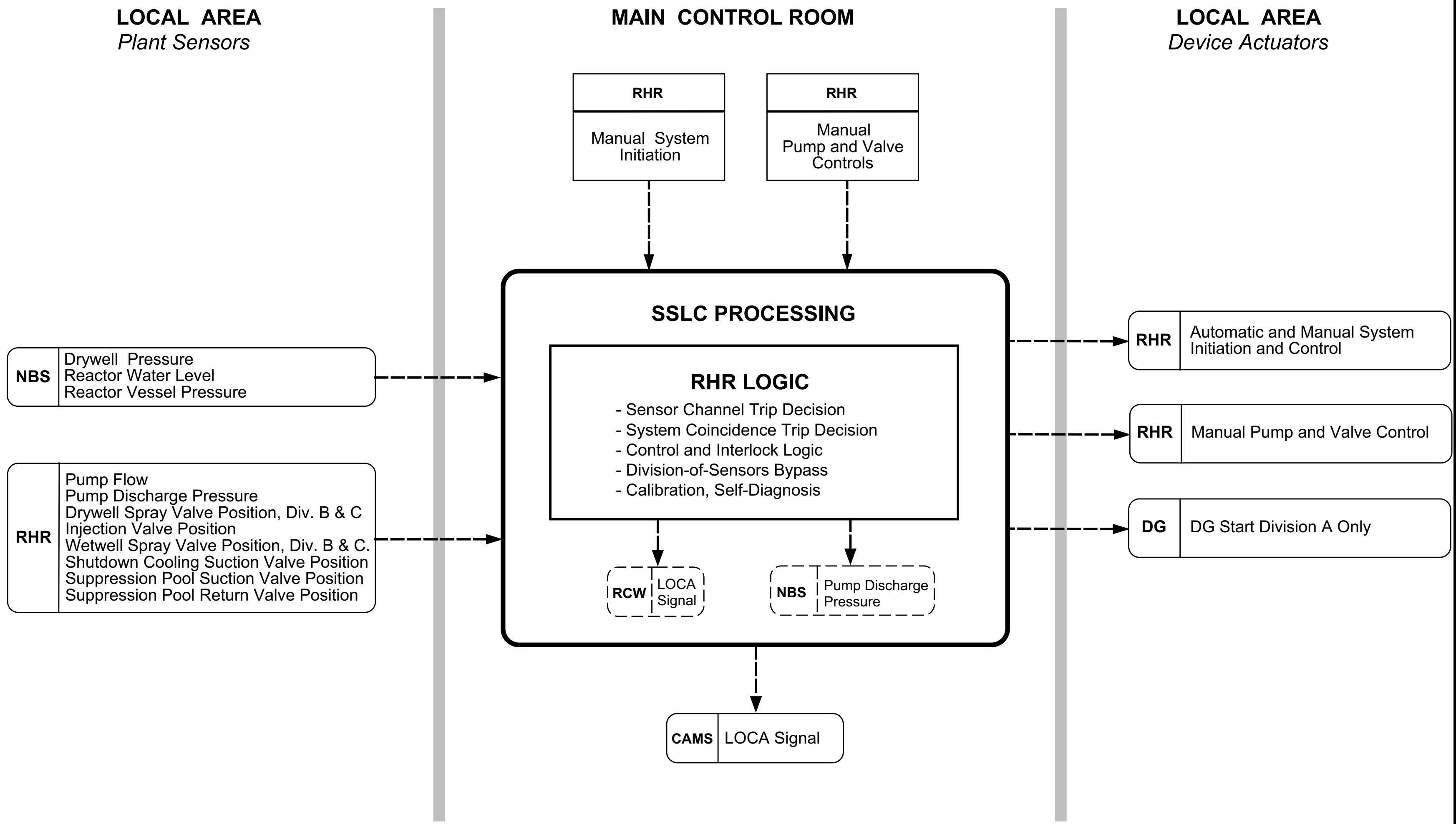
Figure 2.4.1b Residual Heat Removal System (RHR-B)



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 SPARGERS ARE COMMON TO DIVISIONS B AND C.

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



Notes:
1. Diagram represents one of three RHR divisions, except as noted.
2. See Section 3.4, Figure 3.4b for SSLC Processing.

Figure 2.4.1d Residual Heat Removal System Control Interface Diagram

Table 2.4.1 Residual Heat Removal System

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
1. The basic configuration of the RHR System is shown in Figures 2.4.1a, 2.4.1b, 2.4.1c, and 2.4.1d.	1. Inspections of the as-built system will be conducted.	1. The as-built RHR System conforms with the basic configuration shown in Figures 2.4.1a, 2.4.1b, 2.4.1c, and 2.4.1d.
2. The ASME Code components of the RHR System retain their pressure boundary integrity under internal pressures that will be experienced during service.	2. A hydrostatic test will be conducted on those Code components of the RHR System that are required to be hydrostatically tested by the ASME Code.	2. The results of the hydrostatic test of the ASME Code components of the RHR System conform with the requirements in the ASME Code, Section III.
3.	3.	3.
a. The RHR System is automatically initiated in the LPFL mode when either a high drywell pressure or a low reactor water level condition exists.	a. Tests will be conducted using simulated input signals for each process variable to cause trip conditions in two, three, and four instrument channels of the same process variable.	a. Each division of the RHR System receives an initiation signal.
b. Each RHR division can be initiated manually (LPFL mode).	b. Tests will be conducted by initiating each division manually.	b. Each division of the RHR System receives an initiation signal.

Table 2.4.1 Residual Heat Removal System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
3. continued c. Following receipt of an initiation signal, the RHR System automatically initiates and operates in the LPFL mode to provide emergency makeup to the reactor vessel.	3. continued c. Tests will be conducted on each RHR division using a simulated initiation signal and a simulated low reactor pressure permissive signal.	3. continued c. Upon receipt of a simulated initiation signal, the following occurs: (1) The RHR pump receives a signal to start. (2) The RPV injection valve receives a signal to open provided a low reactor pressure permissive signal is present, and the valve opens within 36 seconds after receiving the low reactor pressure permissive signal. (3) The suppression pool return valve receives a signal to close. (4) The wetwell spray valve receives a signal to close (Divisions B and C only).
d. The LPFL injection flow for each division begins when the RPV dome pressure is no less than 1.55 MPa above the drywell pressure. When the RPV dome pressure is no less than 0.275 MPa greater than the drywell pressure, the LPFL injection flow for each division is 954 m^3/h minimum.	d. Tests will be conducted on the as-built RHR System in the RHR LPFL mode. Analyses will be performed to convert the test results to the conditions of the Design Commitment.	d. The converted RHR flow satisfies the following: The LPFL injection flow for each division begins when the RPV dome pressure is no less than 1.55 MPa above the drywell pressure. When the RPV dome pressure is no less than 0.275 MPa greater than the drywell pressure, the LPFL injection flow for each division is 954 m^3/h minimum.

Table 2.4.1 Residual Heat Removal System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
3. continued	3. continued	3. continued
e. The system automatically aligns to the LPFL mode of operation from the test mode, the suppression pool cooling or wetwell spray modes upon receipt of an initiation signal.	e. Tests will be conducted on each RHR division using simulated LPFL initiation signals.	e. Each division automatically aligns to the LPFL mode of operation from the test mode, the suppression pool cooling or wetwell spray modes upon receiving an initiation signal. The wetwell spray mode is applicable for Divisions B or C.
f. If a drywell spray valve is open in Division B or C, that RHR division automatically reverts to the LPFL mode in response to the injection valve beginning to open.	f. Tests will be conducted on RHR Division B and C drywell spray mode using a simulated injection valve opening signal.	f. Drywell spray valves in a division close on receipt of injection valve not fully closed signal in that division.
g. The RPV injection valve in each division requires a low reactor vessel pressure permissive signal to open and closes automatically on receipt of a high reactor vessel pressure signal.	g. Tests will be conducted on the injection valves in each RHR division using a simulated reactor vessel pressure signal.	g. The RPV injection valve in each division requires a low reactor vessel pressure permissive signal to open and closes automatically on receipt of a high reactor vessel pressure signal.
4.	4.	4.
a. In the suppression pool cooling mode, the total heat removal capacity requirement between the RHR System and ultimate heat sink is greater than 0.427 MJ/s·°C for each division.	a. Inspections and analyses will be performed to determine the heat exchanger's effective heat removal capacity, for each division.	a. In the suppression pool cooling mode, the total heat removal capacity requirements between the RHR System and ultimate heat sink is greater than 0.427 MJ/s·°C for each division.
b. In the suppression pool cooling mode, the RHR tube side heat exchanger flow rate is 954 m^3/h minimum, per division.	b. Tests will be performed on each RHR division.	b. In the suppression pool cooling mode, the RHR tube side heat exchanger flow rate is 954 m^3/h minimum, per division.

Table 2.4.1 Residual Heat Removal System (Continued)

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. – 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.

Table 2.4.1 Residual Heat Removal System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
5.	5.	5.
a. The drywell spray inlet valves can only be opened if a high drywell pressure exists and if the injection valves are fully closed.	a. Tests will be performed of the drywell spray valve interlock logic using simulated drywell pressure and valve position signals.	a. The two in-series drywell spray valves are blocked from being open simultaneously unless signals indicative of the following conditions exist concurrently: (1) Drywell pressure is high. (2) The RPV injection valve is fully closed. (3) The shutdown cooling suction valve is fully closed. The drywell spray valves will automatically close if signals indicative of the following condition exists: (1) The RPV injection valve is not fully closed.
b. The wetwell spray flow rate for either Division B or C is no less than 114 m^3/h.	b. Tests will be conducted on Divisions B and C in the wetwell spray mode.	b. RHR Division B provides wetwell spray flow greater than or equal to 114 m^3/h. RHR Division C provides wetwell spray flow greater than or equal to 114 m^3/h.

Table 2.4.1 Residual Heat Removal System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
6.	6.	6.
a. Shutdown cooling is initiated manually once the RPV has been depressurized below the system low pressure permissive.	a. Tests will be conducted on the RHR shutdown cooling mode for manual initiation, using simulated reactor vessel pressure signals.	a. The RHR shutdown mode operates when reactor vessel pressure is below system low pressure permissive. The RHR shutdown mode is not manually initiated when reactor vessel pressure is not less than the low pressure permissive.
b. In any division, the shutdown cooling suction valve cannot be opened unless the following valves in that division are closed: Suppression pool suction valve. Suppression pool return valve. Drywell spray valves. Wetwell spray valve.	b. Tests will be conducted on each RHR division to open the shutdown cooling suction valve.	b. In any division, the shutdown cooling suction valve cannot be opened unless the following valves in that division are closed: Suppression pool suction valve. Suppression pool return valve. Drywell spray valves. Wetwell spray valve.
c. Each shutdown cooling suction valve automatically closes on low reactor water level.	c. Tests will be conducted on each RHR division using a simulated reactor water level signal.	c. Each shutdown cooling suction valve automatically closes on low reactor water level.
d. The low pressure portions of the shutdown cooling piping are protected from high reactor pressure by automatic closure of the shutdown cooling suction valves on a high reactor vessel pressure signal.	d. Tests will be conducted on the shutdown cooling suction valves in each RHR division using a simulated reactor vessel pressure signal.	d. The shutdown cooling suction valves close when the RHR System receives a simulated high reactor vessel pressure signal.

Table 2.4.1 Residual Heat Removal System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
6. continued e. In the shutdown cooling mode, the RHR tube side heat exchanger flow rate is greater than or equal to 954 m^3 /h.	6. continued e. In the shutdown cooling mode, system functional tests will be performed to determine system flow rate through each heat exchanger. Inspections and analyses shall be performed to verify that the shutdown cooling mode is bounded by suppression pool cooling requirements.	6. continued e. The RHR heat exchangers tube side flow rate is greater than or equal to 954 m^3/h. Heat exchanger removal capacity in this mode is bounded by suppression pool cooling requirements.
7. In the augmented fuel pool cooling mode, the RHR tube side heat exchanger flow rate 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.
8. a. Each division of the RHR has a minimum flow bypass mode that assures there is always flow in the RHR pumps when they are operating.	8. a. Tests will be conducted on the pump minimum flow valve interlock logic using simulated pressure and flow signals.	8. a. The pump minimum flow valve receives a signal to open when signals indicative of the following conditions exist concurrently: (1) Pump discharge pressure is high when the pump starts. (2) Pump flow is low. The pump minimum flow valve receives a signal to close when a signal indicative of the following condition exists: (1) Pump flow exceeds minimum value.

Table 2.4.1 Residual Heat Removal System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
8. continued b. Each division of the RHR System has a minimum flow bypass mode that assures there is always flow in the RHR pumps when they are operating.	8. continued b. Tests and analyses will b e conducted on each division of the RHR System in the minimum flow mode. The tests will quantify pump flow and compare with pump required minimum flow.	8. continued b. The available minimum flow exceeds the required minimum flow.
9. Each of the three RHR divisions is powered from the Class 1E division as shown on Figures 2.4.1a, 2.4.1b and 2.4.1c. In the RHR System, independence is provided between Class 1E divisions, and between Class 1E divisions and non-Class 1E equipment.	9. a. Tests will be performed on the RHR System by providing a test signal to only one Class 1E division at a time.	9. a. The test signal exists only in the Class 1E division under test in the RHR System.
	b. Inspection of the as-installed Class 1E divisions in the RHR System will be performed.	b. In the RHR System, physical separation or electrical isolation exists between Class 1E divisions. Physical separation or electrical isolation exists between these Class 1E divisions and non-Class 1E equipment.
10. Each mechanical division of the RHR System (Divisions A, B, C) is physically separated from the other divisions.	10. Inspections of the as-built RHR System will be performed.	10. Each mechanical division of the RHR System is physically separated from other mechanical divisions of RHR System by structural and/or fire barriers with the exception of components inside primary containment.
11. Main control room displays and controls provided for RHR System are defined in Section 2.4.1.	11. Inspections will be performed on the main control room displays and controls for the RHR System.	11. Displays and controls exist or can be retrieved in the main control room as defined in Section 2.4.1.
12. RSS displays and controls provided for the RHR System are as defined in Section 2.4.1.	12. Inspections will be performed on the RSS displays and controls for the RHR System.	12. Displays and controls exist on the RSS as defined in Section 2.4.1.

Table 2.4.1 Residual Heat Removal System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
13.	13.	13.
a. MOVs designated in Section 2.4.1 as having an active safety function open, close, or both open and close under differential pressure, fluid flow, and temperature conditions.	a. Tests of installed valves for opening, closing or both opening and closing, will be conducted under preoperational differential pressure, fluid flow, and temperature conditions.	a. Upon receipt of the actuating signal, each MOV opens, closes, or both opens and closes, depending upon the valve's safety functions.
b. Check valves (CVs) designated in Section 2.4.1 as having an active safety-related function open, close, or both open and close, under system pressure, fluid flow, and temperature conditions.	b. Tests of installed valves for opening, closing, or both opening and closing, will be conducted under system preoperational pressure, fluid flow, and temperature conditions.	b. Based on the direction of the differential pressure across the valve, each CV opens, closes, or both opens and closes, depending upon the valve's safety functions.
14. The RHR System main pumps are interlocked to prevent starting with a closed suction path.	14. Tests will be conducted on the RHR pump start logic using simulated valve position signals.	14. Each RHR System pump is prevented from starting unless signals indicative of one of the following conditions exists: a. A suction path from the suppression pool is available. (The suppression pool suction valve is fully open.) b. A suction path from the RPV via the shutdown cooling suction line is available. (The shutdown cooling suction valve and inboard and outboard isolation valves are all fully open.)

2.4.2 High Pressure Core Flooder System

Design Description

The High Pressure Core Flooder (HPCF) System is comprised of two separate divisions. The function of the HPCF System is to provide emergency makeup water to the reactor vessel for transient or loss-of-coolant accident (LOCA) events. Each HPCF division consists of a pump, piping, valves and controls and can utilize either of two water sources, the condensate storage tank (CST) or the suppression pool (S/P). The primary source of suction water supply is from the CST. The S/P water is the secondary source of supply. Figure 2.4.2a shows the basic system configuration and scope. Figure 2.4.2b shows the HPCF System control interfaces.

The HPCF System is classified as safety-related.

The HPCF System operates in the following modes:

(1) High pressure flooder.

(2) Full flow test.

(3) Minimum flow bypass.

High Pressure Flooder Mode

As shown on Figure 2.4.2b, the HPCF System channel measurements are provided to the Safety System Logic and Control (SSLC) for signal processing, setpoint comparisons, and generating trip signals. The HPCF System is automatically initiated in the high pressure flooder mode when either a high drywell pressure signal or low reactor water level signal exists. Both divisions of the HPCF System are actuated at a reactor water level below the RCIC actuation level. The SSLC System processors use a two-out-of-four voting logic for system initiation and shutdown. Manual HPCF System initiation can also be performed.

Following receipt of an initiation signal, the HPCF System automatically initiates and operates in the high pressure flooder mode to provide water to the core region of the reactor. The pumps are motor-driven centrifugal pumps that provide flow as a function of reactor vessel pressure. The flow in each division is not less than a value corresponding to a straight line between a flow of 182 m^3/h at a differential pressure of 8.12 MPa and a flow of 727 m^3/h at a differential pressure of 0.69 MPa. The HPCF System has the capability to deliver at least 50% of these flow rates with 171°C water at the pump suction. The differential pressure values represent the difference between the reactor vessel pressure and the pressure of the air space of the source water for the pump. System flow into the reactor vessel is achieved within 16 seconds of receipt of an initiation signal and power available at the emergency busses.

The HPCF pumps have sufficient net positive suction head (NPSH) available at the pumps.

During this mode, pump suction is from the CST. Automatic transfer of pump suction from the CST to the S/P occurs when a low CST water level or high suppression pool water level signal exists. The CST and suppression pool water level signals are processed through the SSLC two-out-of-four voting logic to initiate suction transfer.

When a high water level signal in the reactor pressure vessel exists, the reactor vessel injection valve is automatically closed. When the low reactor water level initiation signal recurs, the injection valve automatically re-opens to reestablish HPCF flow.

Full Flow Test Mode

Each division of the HPCF System has a full flow test mode to permit testing during plant operation. In this mode, water is taken from the suppression pool and returned to the suppression pool via the test return line. The injection valve is kept closed to prevent any vessel injection during the test.

If a system initiation signal occurs during the full flow test mode, each division of the HPCF System automatically aligns to the high pressure flooder mode.

Minimum Flow Bypass Mode

Each division of the HPCF System has a minimum flow bypass mode that assures there is always flow in the HPCF pumps when they are operating. This is accomplished automatically by monitoring pump discharge flow, and opening a minimum flow valve to the suppression pool when flow falls below the minimum value. The minimum flow valve closes when the pump flow exceeds the minimum value. Minimum flow bypass operation is automatic based on a flow signal opening the minimum flow valve when the flow is low, with a concurrent high pump discharge pressure signal.

Other Provisions

The HPCF System is classified as Seismic Category I. Figure 2.4.2a shows the ASME Code Class for the HPCF System. The HPCF System is located both inside the primary containment and within the Reactor Building.

Each of the two HPCF divisions is powered from the respective Class 1E division as shown on Figure 2.4.2a. In the HPCF System, independence is provided between Class 1E divisions, and also between Class 1E divisions and non-Class 1E equipment.

Outside the primary containment, except for piping from the CST, each mechanical division of the HPCF System (Divisions B and C) is physically separated from the other division. Outside the primary containment, except for piping from the CST, both HPCF divisions are physically separated from the Reactor Core Isolation Cooling (RCIC) System.

The HPCF System has the following displays and controls in the main control room:

(1) Parameter displays for the instruments shown on Figure 2.4.2a.

(2) Controls and status indication for the active safety-related components shown on Figure 2.4.2a.

(3) Manual system level initiation capability for the high pressure flooder mode.

HPCF System components with displays and control interfaces with the Remote Shutdown System (RSS) are shown on Figure 2.4.2a

The safety-related electrical equipment shown on Figure 2.4.2a located inside the primary containment and in the Reactor Building is qualified for a harsh environment.

The motor-operated valves (MOVs) shown on Figure 2.4.2a have active safety-related functions to open, close, or both open and close, and perform these functions under differential pressure, fluid flow, and temperature conditions.

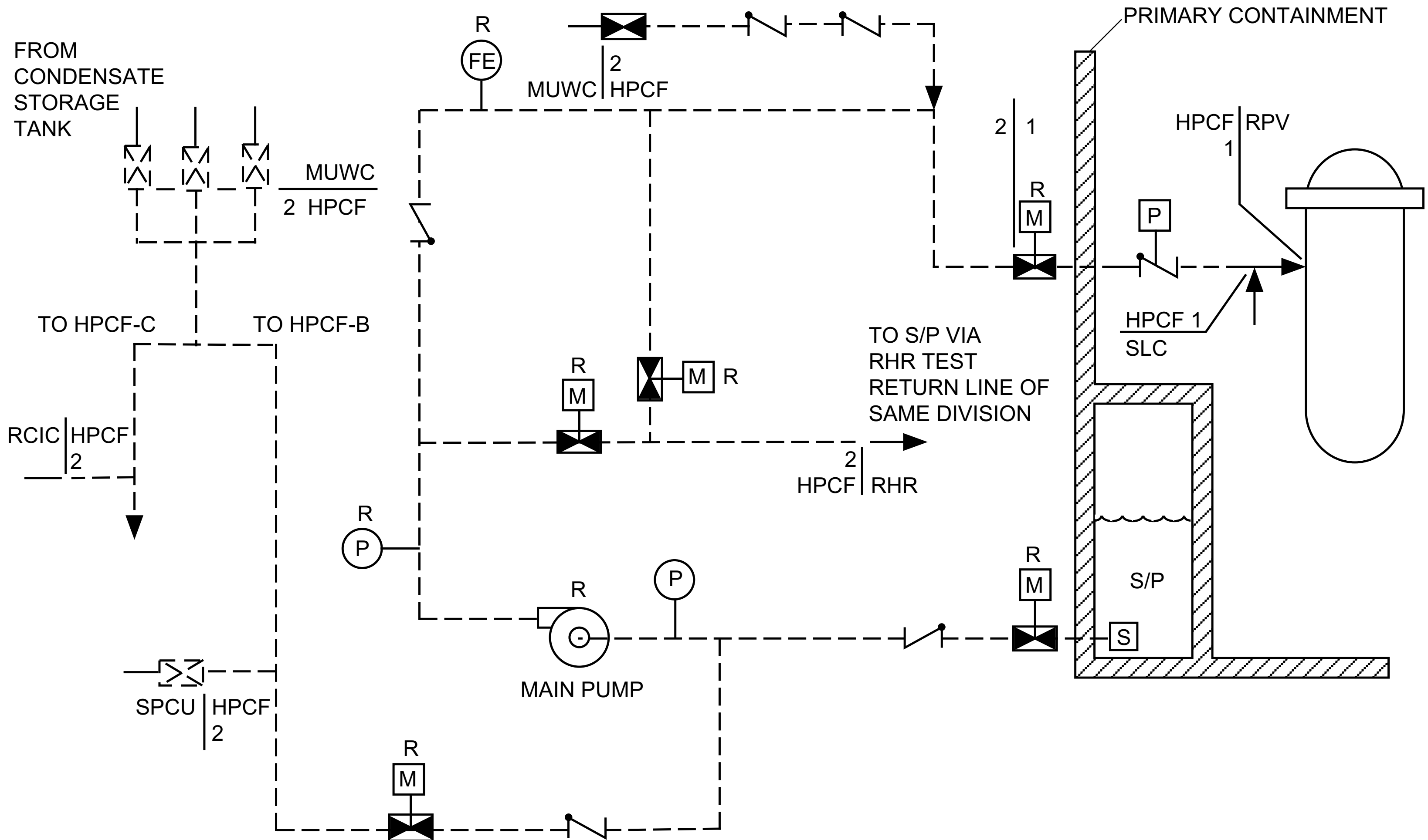
The check valves (CVs) shown on Figure 2.4.2a have safety-related functions to open, close, or both open and close under system pressure, fluid flow, and temperature conditions.

The HPCF System pumps have interlocks which prevent operation if both suction valves are closed.

The HPCF System suction piping and components from the pump suction valves to the pump inlet have a design pressure of 2.82 MPaG for intersystem LOCA (ISLOCA) conditions.

Inspections, Tests, Analyses and Acceptance Criteria

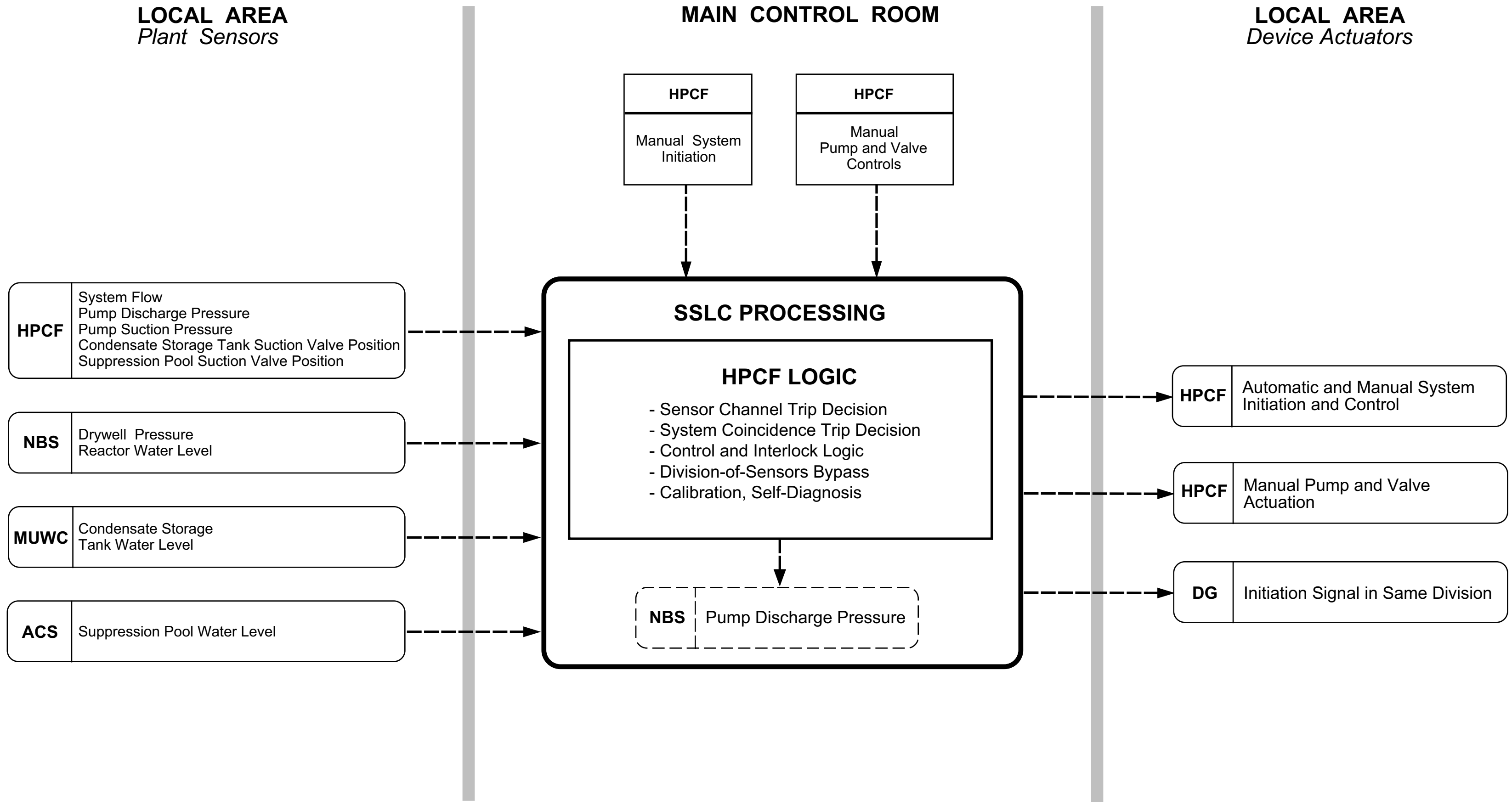
Table 2.4.2 provides a definition of the inspections, test and/or analyses, together with associated acceptance criteria, which will be undertaken for the HPCF System.



NOTES:

1. DIVISION B SHOWN, DIVISION C IDENTICAL EXCEPT INTERFACE CONNECTIONS WITH RSS AND SLC ON DIVISION B ONLY.
2. ALL ELECTRICAL POWER LOADS FOR THE CLASS 1E COMPONENTS SHOWN ON THIS FIGURE ARE POWERED FROM CLASS 1E DIVISION II (DIVISION C POWERED FROM CLASS 1E DIVISION III).

Figure 2.4.2a High Pressure Core Flooder System



Notes:
1. Diagram represents one of two HPCF divisions.
2. See Section 3.4, Figure 3.4b for SSLC Processing.
3. HPCF Division C has manual initiation and monitoring capability which is diverse from SSLC (see Section 3.4).

Figure 2.4.2b High Pressure Core Flooder System Control Interface Diagram

Table 2.4.2 High Pressure Core Flooder System

Inspections, Tests, Analyses and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. The basic configuration of the HPCF System is as shown on Figures 2.4.2a and 2.4.2b.	1. Inspections of the as-built system will be conducted.	1. The as-built HPCF System conforms with the basic configuration shown on Figures 2.4.2a and 2.4.2b.
2. The ASME Code components of the HPCF System retain their pressure boundary integrity under internal pressures that will be experienced during service.	2. A hydrostatic test will be conducted on those Code components of the HPCF System required to be hydrostatically tested by the ASME Code.	2. The results of the hydrostatic test of the ASME Code components of the HPCF System conform with the requirements in the ASME Code, Section III.
3.	3.	3.
a. The HPCF System is automatically initiated in the high pressure flooder mode when either a high drywell pressure signal or a low reactor water level signal exists.	a. Tests will be conducted using simulated input signals for each process variable to cause trip conditions in two, three, and four instrument channels of the same process variable.	a. Each division of the HPCF System receives an initiation signal.
b. Manual HPCF System initiation can be performed in the high pressure flooder mode.	b. Tests will be conducted by manually initiating each HPCF division.	b. Each division of the HPCF System receives an initiation signal.
c. Following receipt of an initiation signal, the HPCF System automatically initiates and operates in the high pressure flooder mode to provide water to the core region of the reactor.	c. Tests will be conducted on each HPCF division using a simulated initiation signal.	c. Upon receipt of a simulated initiation signal, the following occurs: – The HPCF pump receives a signal to start. – The RPV injection valve receives a signal to open. – The condensate storage tank suction valve receives a signal to open. – The test line return valve receives a signal to close.

Table 2.4.2 High Pressure Core Flooder System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
d. The HPCF System flow in each division is not less than a value corresponding to a straight line between a flow of 182 m^3/h at a differential pressure of 8.12 MPa and a flow of 727 m^3/h at a differential pressure of 0.69 MPa.	d. Tests will be conducted on each division of the as-built HPCF System in the HPCF high pressure flooder mode. Analyses will be performed to convert the test results to the conditions of the Design Commitment.	d. The converted HPCF flow satisfies the following: The HPCF System flow in each division is not less than a value corresponding to a straight line between a flow of 182 m^3/h at a differential pressure of 8.12 MPa and a flow of 727 m^3/h at a differential pressure of 0.69 MPa.
e. The HPCF System has the capability to deliver at least 50% of the flow rates in item 3d with 171°C water at the pump suction.	e. Analyses will be performed of the as-built HPCF System to assess the system flow capability with 171°C water at the pump suction.	e. The HPCF System has the capability to deliver at least 50% of the flow rates in item 3d with 171°C water at the pump suction.
f. System flow into the reactor vessel is achieved within 16 seconds of receipt of an initiation signal and power available at the emergency busses.	f. Tests will be conducted on each HPCF division using simulated initiation signals.	f. The HPCF System flow is achieved within 16 seconds of receipt of a simulated initiation signal.
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. – Analytically derived values for blockage of pump suction strainers based upon the as-built system.	g. The available NPSH exceeds the NPSH required by the pumps.

Table 2.4.2 High Pressure Core Flooder System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
g. (continued)	g. (continued) – Design basis fluid temperature (100°C). – Containment at atmospheric pressure.	g. (continued)
h. Automatic transfer of pump suction from the CST to the suppression pool occurs when a low CST water level or high suppression pool water level signal exists.	h. Tests will be conducted on each HPCF division using simulated input signals for each process variable to cause trip conditions in two, three, and four instrument channels of the same process variable.	h. HPCF System receives suction transfer initiation signal.
i. Following receipt of a suction transfer initiation signal, the HPCF System automatically switches pump suction.	i. Test will be conducted on each HPCF division using simulated suction transfer initiation signals.	i. Upon receipt of a simulated suction transfer initiation signal, the following occurs: – Suppression pool suction valve opens. – CST suction valve closes.
j. When a high water level signal in the reactor pressure vessel exists, the reactor vessel injection valve is automatically closed.	j. Tests will be conducted on each HPCF division using simulated high reactor water level signals to cause trip conditions in two, three, and four instrument channels of water level variable.	j. The HPCF System receives a signal to close the reactor vessel injection valve.
k. Following receipt of an injection valve closure signal, the HPCF System automatically closes the vessel injection valve.	k. Tests will be conducted on each HPCF division using a simulated injection valve closure signal.	k. Upon receipt of a simulated injection valve closure signal, the reactor vessel injection valve closes.

Table 2.4.2 High Pressure Core Flooder System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
l. Following HPCF System injection valve closure on a high reactor water level signal, when the low water level initiation signal recurs, the vessel injection valve automatically re-opens to re-establish HPCF flow.	l. Tests will be conducted on each HPCF division using a simulated low reactor water level signal.	l. Upon receipt of a simulated low reactor water level signal, the vessel injection valve opens.
m. Each division of the HPCF System has a full flow test mode to permit testing during plant operation.	m. Tests will be conducted on each as-built HPCF division, using installed controls, power supplies and other auxiliaries. Water will be pumped in the test flow mode with system head equivalent to a pressure differential of at least 8.12 MPa between the RPV and the air space of the source water for the pump.	m. Water is pumped at a flow rate of not less than 182 m^3/h in the test flow mode.
n. If a system initiation signal occurs during the full flow test mode, each division of the HPCF System automatically aligns to the high pressure flooder mode.	n. Tests will be performed on each HPCF division using simulated initiation signals.	n. Upon receipt of a simulated initiation signal, each HPCF division automatically aligns to the high pressure flooder mode of operation from the test mode.

Table 2.4.2 High Pressure Core Flooder System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
o. Each division of the HPCF System has a minimum flow bypass mode that assures there is always flow in the HPCF pumps when they are operating.	o. Tests will be conducted on the pump minimum flow valve interlock logic using simulated pressure and flow signals.	o. The pump minimum flow valve receives a signal to open when signals indicative of the following conditions exist concurrently: – Pump discharge pressure is high when the pump starts and, – Pump flow is low. The pump minimum flow valve receives a signal to close when a signal indicative of the following condition exists: – Pump flow exceeds the minimum value.
p. Each division of the HPCF System has a minimum flow bypass mode that assures there is always flow in the HPCF pumps when they are operating.	p. Tests and analyses will be conducted on each division of the HPCF System in the minimum flow mode. The tests will quantify pump flow and compare with pump required minimum flow.	p. The available minimum flow exceeds the required minimum flow.
4. Each of the two HPCF divisions is powered from the respective Class 1E division as shown on Figure 2.4.2a. In the HPCF System, independence is provided between Class 1E divisions, and between Class 1E divisions and non-Class 1E equipment.	4. a. Tests will be performed on the HPCF System by providing a test signal in one Class 1E division at a time. b. Inspection of the as-built Class 1E divisions in the HPCF System will be performed.	4. a. The test signal exists only in the Class 1E division under test in the HPCF System. b. In the HPCF System, physical separation or electrical isolation exists between Class 1E divisions. Physical separation or electrical isolation exists between these Class 1E divisions and non-Class 1E equipment.

Table 2.4.2 High Pressure Core Flooder System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
5. Outside the primary containment, except for piping from the CST, each mechanical division of the HPCF System (Divisions B and C) is physically separated from the other division. Except for piping from the CST, both HPCF divisions are physically separated from the RCIC System.	5. Inspections of the as-built HPCF System will be performed.	5. Outside the primary containment, except for piping from the CST, each mechanical division of the HPCF System is physically separated from the other mechanical division of the HPCF System, and both HPCF divisions are separated from the RCIC System by structural and/or fire barriers.
6. Main control room displays and controls provided for the HPCF System are as defined in Section 2.4.2.	6. Inspections will be performed on the main control room displays and controls for the HPCF System.	6. Displays and controls exist or can be retrieved in the main control room as defined in Section 2.4.2.
7. RSS displays and controls provided for the HPCF System are as defined in Section 2.4.2.	7. Inspections will be performed on the RSS displays and controls for the HPCF System.	7. Displays and controls exist on the RSS as defined in Section 2.4.2.
8. MOVs designated in Section 2.4.2 as having an active safety-related function open, close, or both open and close under differential pressure, fluid flow, and temperature conditions.	8. Tests of installed valves for opening, closing or both opening and closing, will be conducted under preoperational differential pressure, fluid flow, and temperature conditions.	8. Upon receipt of the actuation signal, each MOV opens, closes, or both opens and closes, depending upon the valve's safety functions. The following valve opens in the following time limit: <u>Valve</u> — <u>Time (s)</u> Injection valve — ≤16 open
9. CVs designated in Section 2.4.2 as having an active safety-related function open, close, or both open and close, under system pressure, fluid flow, and temperature conditions.	9. Tests of installed valves for opening, closing, or both opening and closing, will be conducted under system preoperational pressure, fluid flow, and temperature conditions.	9. Based on the direction of the differential pressure across the valve, each CV opens, closes, or both opens and closes, depending upon the valve's safety functions.

Table 2.4.2 High Pressure Core Flooder System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
10. The HPCF System pumps have interlocks which prevent operation if both suction valves are closed.	10. Tests will be conducted on each HPCF System pump start logic using simulated valve position signals.	10. Each HPCF System pump is prevented from operating unless signals indicative of one of the following conditions exists: a. A suction path from the S/P is available (the S/P suction valve is fully open). b. A suction path from the condensate storage tank is available (the CST suction valve is fully open).

2.4.3 Leak Detection and Isolation System

Design Description

The Leak Detection and Isolation System (LDS) is a control and instrumentation system whose function is to detect and monitor leakage from the reactor coolant pressure boundary and initiate isolation of the leakage source. The system is designed to initiate automatic isolation of the process lines that penetrate the containment by closing the isolation valves. The functions of the LDS include: isolation of the main steamlines, the primary and secondary containment, and individual system process lines; activation of the Standby Gas Treatment System (SGTS); monitoring of leakages inside and outside the primary containment; and providing the monitored leakage parameters in the main control room.

The LDS is classified as a Class 1E safety-related system.

The LDS logic design uses four instrument channels to monitor each leakage parameter that initiates an isolation function on a two-out-of-four channel trip.

As shown on Figure 2.4.3, the LDS safety-related channel measurements are provided as inputs to the Safety System Logic and Control (SSLC) for signal processing, setpoint comparisons, and generation of the trip signals that initiate the isolation functions. The LDS isolation logic consists of safety-related sensors, redundant instrument channels and logic processors that initiate the automatic isolation functions. Once isolation is initiated, the logic seals in the isolation signal, and operator action is required to reset the logic to its normal state.

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

(1) Closure of the main steamline isolation valves (MSIVs) and main steamline (MSL) drain valves on a signal indicating low reactor water level, high main steamline flow in any main steamline, high ambient temperature in the MSL tunnel area or in the Turbine Building along the MSLs, low main condenser vacuum, or low steam inlet pressure to the main turbine.

(2) Isolation of the Reactor Water Cleanup (CUW) System process lines on a signal indicating low reactor water level, high ambient MSL tunnel area temperature, high mass differential flow, high ambient temperature in the CUW areas, or when the Standby Liquid Control (SLC) System is activated.

(3) Initiation of the SGTS on a signal indicating high drywell pressure, low reactor water level, high radiation in the secondary containment or high radiation in the fuel handling area.

(4) Isolation of Reactor Building Heating, Ventilating and Air Conditioning (HVAC) System on a signal indicating high drywell pressure, low reactor water level, high radiation in the secondary containment or high radiation in the fuel handling area.

(5) Isolation of containment purge and vent lines on a signal indicating high drywell pressure, low reactor water level, high radiation in the secondary containment or high radiation in the fuel handling area.

(6) Isolation of the Reactor Building Cooling Water (RCW) System and of the HVAC Normal Cooling Water (HNCW) System lines on a signal indicating high drywell pressure or low reactor water level.

(7) Isolation of the Residual Heat Removal (RHR) System shutdown cooling system loops on a signal indicating high reactor pressure or low reactor water level. Also, each RHR shutdown cooling division is individually isolated on a signal indicating high ambient temperature in its respective equipment area.

(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) Not Used

(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.

(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.

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

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

Separate manual controls in the control room are provided in LDS design for logic reset, MSIV operational control, MSIV partial closure tests, and for manual isolation of primary and secondary containment.

Each MSIV has three pilot solenoid valves; two are used for operational control and the third is used to test the MSIV for partial closure. Each MSIV pilot solenoid valve is controlled separately by the LDS as follows:

(1) Two of the three pilot solenoid valves of the MSIV are each provided with four divisional control signals to open the valve. MSIV closure occurs on loss of any two of the four divisional signals.

(2) The third MSIV pilot solenoid valve is provided with one-out-of-two manual control signals to test the MSIV for partial closure. Division I or III manual signal is used to close the outboard MSIV, while Division II or IV manual signal is used to close the inboard MSIV.

Except for MSIVs, the LDS provides three separate divisional isolation signals (Divisions I, II and III) for automatic closure of the primary and secondary containment isolation valves. Each LDS divisional isolation signal initiates closure of the isolation valves that are assigned in the same division.

The LDS design includes the following manual controls for separate isolation of the RCIC System, and closure of the MSIVs and the primary and secondary containment isolation valves:

(1) Four MSIV isolation switches–one per Divisions I, II, III, and IV.

Closure of all the MSIVs requires the actuation of any two of the four divisional MSIV isolation switches.

(2) Three primary and secondary containment isolation switches–one per Divisions I, II and III.

Each isolation switch closes its respective divisional isolation valves in the primary and secondary containment, except for the MSIVs and RCIC.

(3) Two RCIC isolation switches–one per Divisions I and II.

Either isolation switch isolates the steamline to the RCIC turbine and causes turbine trip. Division I switch closes the inboard, while Division II switch closes the outboard isolation valves.

Manual reset controls are provided at the divisional level to initialize the logic and to reset the logic after isolation has cleared. Separate reset functions are provided in the LDS logic design for the MSIVs, the RCIC, and the containment isolation.

The LDS design uses redundant channels and is fail-safe in the event of loss of electrical power to one division of LDS logic.

Each of the four LDS divisional logic channels and associated sensors is powered from its respective divisional Class 1E power supply. In the LDS, independence is provided between Class 1E divisions, and also between the Class 1E divisions and non-Class 1E equipment.

The LDS sensors are located in the Reactor Building and Turbine Building; the logic processors are located in the Control Building.

The LDS has the following displays and controls in the main control room:

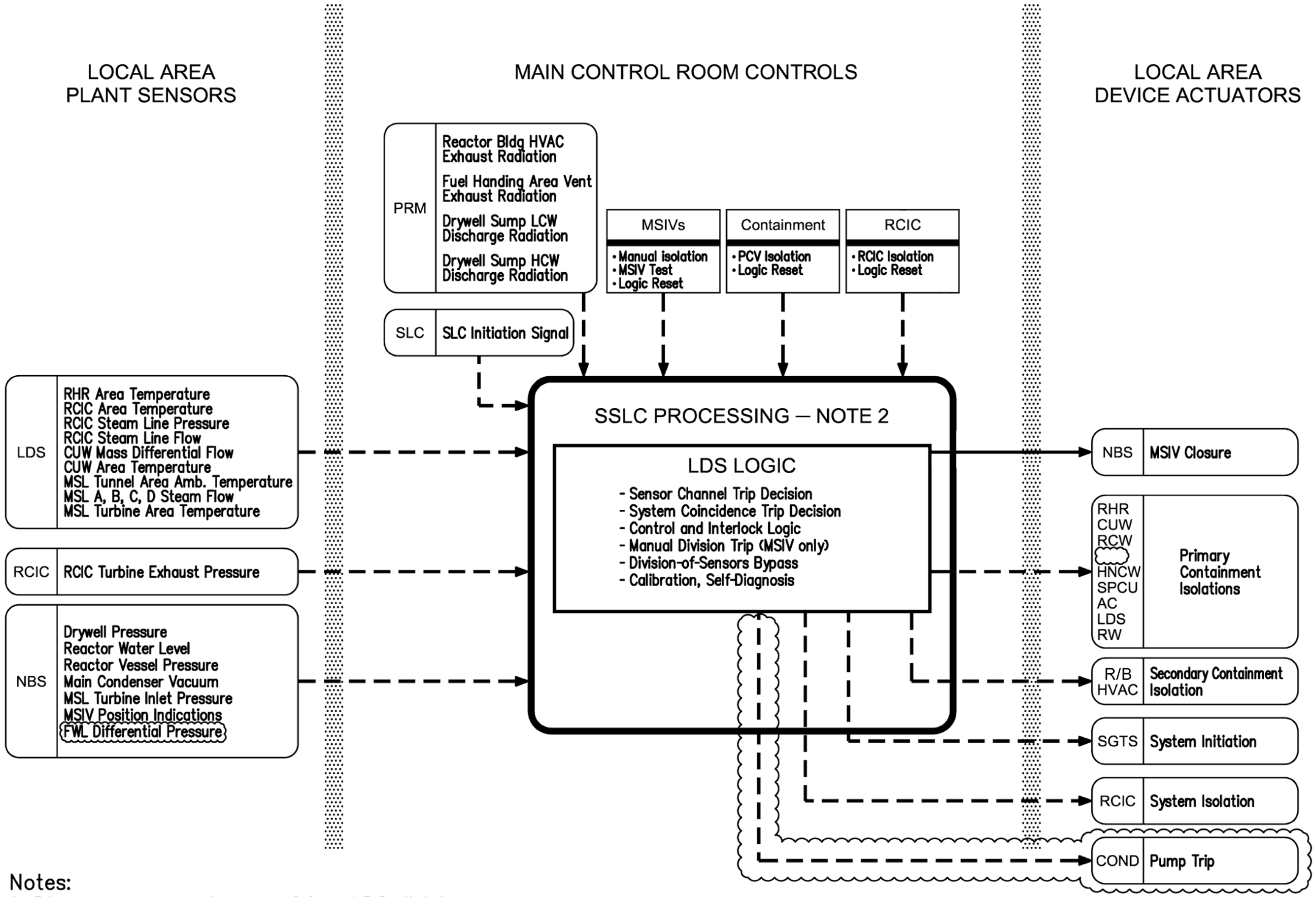
(1) Parameter displays for LDS plant sensors defined on Figure 2.4.3.

(2) LDS manual controls as described above.

(3) LDS divisional trip status.

Inspections, Tests, Analyses and Acceptance Criteria

Table 2.4.3 provides a definition of the inspections, tests, and/or analyses, together with associated acceptance criteria, which will be undertaken for the LDS.



Notes:

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

Figure 2.4.3 Leak Detection and Isolation System Interface Diagram

Table 2.4.3 Leak Detection & Isolation System

Inspections, Tests, Analyses and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. The equipment comprising the LDS is defined in Section 2.4.3.	1. Inspection of the as-built system will be conducted.	1. The as-built LDS conforms with the description in Section 2.4.3.
2. LDS logic uses four independent sensor instrument channels of each process variable described in Section 2.4.3 for its automatic control and isolation functions.	2. Tests will be conducted using simulated input signals for each process variable to cause trip conditions in two, three, and four instrument channels of the same process variable.	2. Isolation signal is initiated when at least any two out of four channels have tripped.
3. Each MSIV can be subjected to a partial closure test from the main control room.	3. Tests will be conducted by actuating each MSIV test switch.	3. When the test switch is actuated, the MSIV partially closes and then reopens automatically.
4. LDS provides separate manual controls in the main control room for MSIV closure, for isolation of the primary and secondary containment, and for isolation of the RCIC System.	4. Tests will be performed on the as-built system as follows: a. Simultaneously actuate any two of the four MSIV isolation switches to close all MSIVs. b. Actuate each RCIC isolation switch (Divisions I and II) to isolate the RCIC System. c. Actuate each primary and secondary containment isolation switch (Divisions I, II and III) to isolate the containment.	4. Upon manual actuation, the following actions occur: a. Closure of all the MSIVs occurs only when any two out of four switches are actuated. b. Isolation of the RCIC System occurs when Division I switch closes the inboard or Division II switch closes the outboard isolation valves. c. Each divisional primary and secondary containment isolation switch closes only its respective containment isolation valves.
5. Manual reset controls are provided to perform reset functions as described in Section 2.4.3.	5. Tests will be performed using the LDS reset controls.	5. The logic circuitry resets for LDS operation.
6. LDS design is fail-safe in the event of loss of electrical power to one division of LDS logic.	6. Tests will be conducted by disconnecting electrical power to one division of LDS logic at a time.	6. Upon loss of electrical power to one division of LDS logic, the affected LDS divisional channel trips.

Table 2.4.3 Leak Detection & Isolation System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
7. Each of the four LDS divisional logic channels and associated sensors is powered from its respective divisional Class 1E power supply. In the LDS, independence is provided between Class 1E divisions, and between Class 1E divisions and non-Class 1E equipment.	7. a. Tests will be performed on the LDS by providing a test signal to only one Class 1E division at a time. b. Inspection of the as-installed Class 1E divisions in the LDS will be performed.	7. a. The test signal exists only in the Class 1E division under test in the LDS. b. In the LDS, physical separation or electrical isolation exists between Class 1E divisions. Physical separation or electrical isolation exists between these Class 1E divisions and non-Class 1E equipment.
8. Main control room displays and controls provided for the LDS are as defined in Section 2.4.3.	8. Inspections will be performed on the main control room displays and controls for the LDS.	8. Displays and controls exist or can be retrieved in the main control room as defined in Section 2.4.3.

2.4.4 Reactor Core Isolation Cooling System

Design Description

The Reactor Core Isolation Cooling (RCIC) System consists of a turbine, pump, piping, valves, controls and instrumentation. The RCIC turbine is driven by the steam from the reactor pressure vessel (RPV) which then drives the RCIC pump. The function of the RCIC System is to provide makeup water to the RPV.

The RCIC steam supply to the turbine branches off one of the main steamlines inside containment upstream of the inboard MSIV and exhausts to the suppression pool (S/P). The primary source of RCIC pump suction is the Condensate Storage Tank (CST). The suppression pool is the secondary source of RCIC pump suction. Figure 2.4.4a shows the basic system configuration and scope. Figure 2.4.4b shows RCIC System control interfaces.

The RCIC System shown on Figure 2.4.4a is classified as safety-related.

The RCIC System operates in the following modes:

(1) RPV water makeup.

(2) Full flow test.

(3) Minimum flow bypass.

RPV Water Makeup Mode

As shown on Figure 2.4.4b, the RCIC System channel measurements are provided to the Safety System Logic and Control (SSLC) System for signal processing, setpoint comparisons, and generating trip signals. The RCIC System is automatically initiated when either a high drywell pressure or low reactor water level condition exists. RCIC System is actuated at a reactor water level higher than the High Pressure Core Flooder (HPCF) system actuation level. The SSLC processors use a two-out-of-four voting logic for system initiation and shutdown. Manual RCIC System initiation can be performed from the main control room (MCR). The RCIC System can be started by local operation of RCIC System components outside the MCR.

The RCIC System automatically shuts down when a high reactor water level condition exists. Following RCIC shutdown on high reactor water level signal, the RCIC System automatically restarts to provide RPV water makeup, if the low reactor water level initiation signal recurs.

During this mode, the primary source pump suction is the CST. Automatic transfer of pump suction from the CST to the S/P occurs when a low CST water level or a high suppression pool water level signal exists. This transfer can be manually overridden from the MCR. The CST and S/P water level signals are processed through SSLC's two-out-of four voting logic to initiate suction transfer.

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 suction source) of 8.12 MPa. This flow rate is achieved within 29 seconds of receipt of the system initiation signal. The RCIC pump has sufficient net positive suction head (NPSH) available at the pump.

The RCIC System operates for a period of at least 2 hours under conditions of no AC power availability and no other simultaneous failures, accidents or other design basis conditions.

Full Flow Test Mode

The RCIC System has a full flow test mode to permit pump flow testing during plant operation. During the test, water is pumped from the suppression pool and returned to the suppression pool via the test return line. The vessel injection valve is kept closed.

If a system initiation signal occurs during the full flow test mode, the RCIC System automatically aligns to the RPV water makeup mode.

Minimum Flow Bypass Mode

The RCIC System has a minimum flow bypass mode that assures there is always flow in the RCIC pump when it is operating. This is accomplished automatically by monitoring pump discharge flow, and opening a minimum flow valve to the suppression pool when flow falls below minimum value. The minimum flow valve closes when the pump flow exceeds the minimum value. Minimum flow bypass operation is automatic based on a flow signal opening the minimum flow valve when the flow is low, with a concurrent high pump discharge pressure signal.

Other Provisions

The RCIC System shown on Figure 2.4.4a is classified as Seismic Category I. Figure 2.4.4a shows the ASME Code class for the RCIC System. The RCIC System is located inside primary containment and in the Reactor Building.

As shown on Figure 2.2.4a, the RCIC System components are powered from Class 1E Division I, except for the steam supply outboard containment isolation valve, which is powered from Class 1E Division II. All RCIC System components shown on Figure 2.2.4a except the inboard containment isolation valves are powered from DC sources. In the RCIC System, independence is provided between Class 1E divisions, and also between Class 1E divisions and non-Class 1E equipment.

Outside the primary containment, except for the piping from the CST, the RCIC System shown on Figure 2.4.4a is physically separated from the two divisions of the High Pressure Core Flooder (HPCF) System.

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 Figure 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.

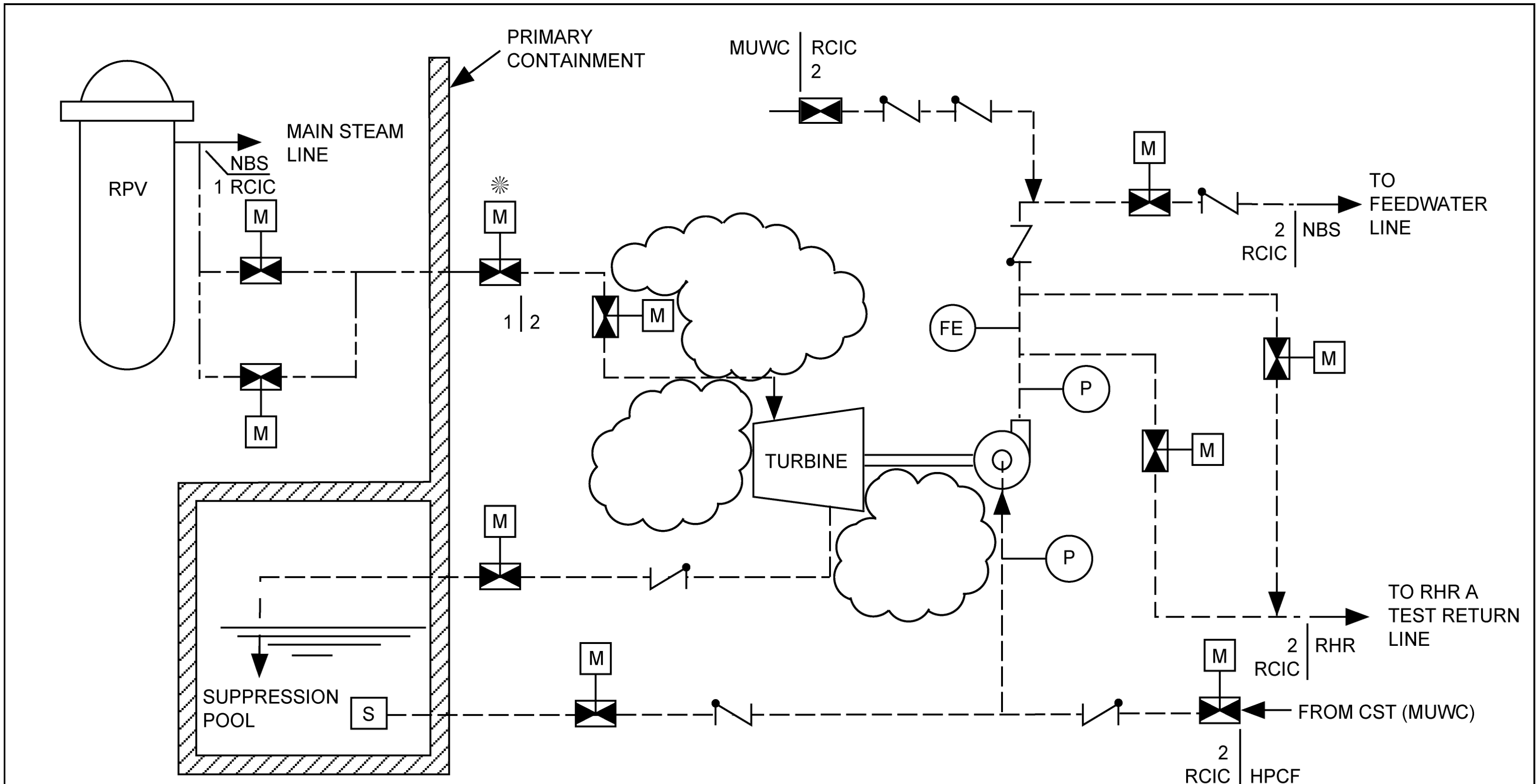
The check valves (CV's) shown on Figure 2.4.4a have active safety-related functions to open, close, or both open and close under system pressure, fluid flow, and temperature conditions.

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

The RCIC System piping and components from the pump suction MOVs up to the pump inlet have a design pressure of 2.82 MPaG for intersystem loss-of-coolant accident (ISLOCA) conditions.

Inspections, Tests, Analyses and Acceptance Criteria

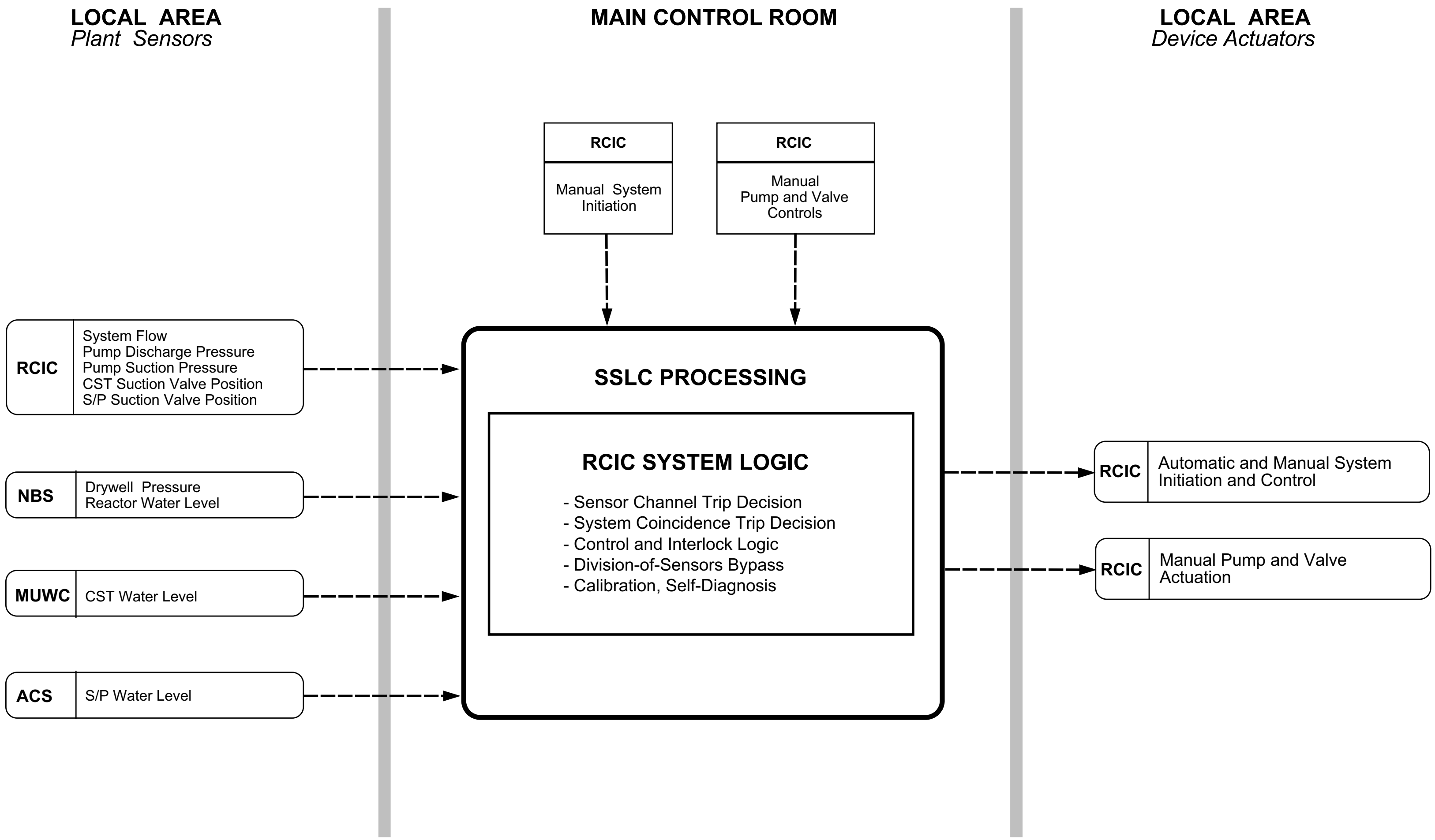
Table 2.4.4 provides a definition of the inspections, test and/or analyses, together with associated acceptance criteria, which will be undertaken for the RCIC System.



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 II 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



Notes:
1. See Section 3.4, Figure 3.4b for SSLC Processing.
2. The inboard steam supply isolation valve has diverse actuation and status indication. See Section 3.4.

Figure 2.4.4b Reactor Core Isolation Cooling System Control Interface Diagram

Table 2.4.4 Reactor Core Isolation Cooling System

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
1. The basic configuration of the RCIC System is as shown on Figures 2.4.4a and 2.4.4b.	1. Inspections of the as-built system will be conducted.	1. The as-built RCIC System conforms with the basic configuration shown on Figures 2.4.4a and 2.4.4b.
2. The ASME Code components of the RCIC System retain their pressure boundary integrity under internal pressures that will be experienced during service.	2. A hydrostatic test will be conducted on those Code components of the RCIC System required to be hydrostatically tested by the ASME Code.	2. The results of the hydrostatic test of the ASME Code components of the RCIC System conform with the requirements in the ASME Code Section III.
3.	3.	3.
a. The RCIC System is automatically initiated in the RPV water makeup mode when either a high drywell pressure or a low reactor water level condition exists.	a. Tests will be conducted using simulated input signals for each process variable to cause trip conditions in two, three, and four instrument channels of the same process variable.	a. The RCIC System receives an initiation signal.
b. Manual RCIC System initiation can be performed.	b. Tests will be conducted by manually initiating RCIC System.	b. The RCIC System receives an initiation signal.

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
c. Following receipt of an initiation signal, the RCIC System automatically initiates and operates in the RPV water makeup mode.	c. Tests will be conducted on the RCIC System using simulated initiation signal.	c. Upon receipt of a simulated initiation signal, the following occurs: (1) Not Used (2) Test return valves receive close signal. (3) CST suction valve receives open signal. (4) Injection valve receives open signal. (5) Steam admission valve receives open signal.
d. The RCIC System automatically shuts down when a high reactor water level condition exists.	d. Tests will be conducted using simulated high reactor water level signals to cause trip conditions in two, three, and four instrument channels of water level variable.	d. RCIC System receives shutdown signal.
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) Not Used (2) RCIC initiation logic resets. (3) Injection valve receives close signal. (4) Steam admission valve receives close signal.

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

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 reactor 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) Not Used (2) Test return valves receive close signal. (3) CST suction valve receives open signal. (4) Injection valve receives open signal. (5) Steam admission valve receives open signal.
g. The RCIC System automatically initiates suction transfer from the CST to the suppression pool when either a low CST water level or a high suppression pool water level exists.	g. Tests will be conducted using simulated input signals for each process variable to cause trip conditions in two, three, and four instrument channels of the same process variable.	g. The RCIC System receives suction transfer initiation signal.
h. Following receipt of suction transfer initiation signal, the RCIC System automatically switches pump suction. This transfer can be manually overridden from the MCR.	h. Tests will be conducted using simulated suction transfer initiation signals.	h. Upon receipt of simulated suction transfer initiation signals, the following occurs: (1) Suppression pool suction valve opens. (2) CST suction valve closes. The suction transfer can be manually overridden from the MCR.

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

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 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 suppression pool with water level at the minimum value. (3) 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.

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
k. The RCIC System operates for a period of at least 2 hours under conditions of no AC power availability and no other simultaneous failures, accidents, or other design basis conditions.	k. Inspections and analyses of the as-built RCIC and supporting systems will be performed to determine RCIC capability.	k. The RCIC System can operate for a period of at least 2 hours under conditions of no AC power availability and no other simultaneous failures, accidents, or other design basis conditions.
l. The RCIC can be started by local operation of the RCIC System components outside the MCR.	l. Tests will be conducted locally on RCIC System components required for system operation.	l. RCIC System components required for system operation can be actuated locally.
4. If a system initiation signal occurs during the full flow test mode, the RCIC System automatically aligns to the RPV water makeup mode.	4. Test will be conducted using simulated initiation signals.	4. The RCIC System automatically aligns to RPV water makeup mode from test mode upon receipt of an initiation signal.
5. The RCIC System has a minimum flow bypass mode that assures there is always flow in the RCIC pump when it is operating.	5. Tests will be conducted on the pump minimum flow valve interlock logic using simulated pressure and flow signals.	5. The pump minimum flow valve receives a signal to open when signals indicative of the following conditions exist concurrently: a. Pump discharge pressure is high when the pump starts. b. Pump flow is low. The pump minimum flow valve receives a signal to close when a signal indicative of the following condition exists: a. Pump flow exceeds minimum value.

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
6. As shown on Figure 2.4.4a, the RCIC System components are powered from Class 1E division I, except for the steam supply outboard containment isolation valve which is powered from Class 1E division II. All RCIC System components shown on Figure 2.4.4a except the inboard containment isolation valves are powered from DC sources. In the RCIC System, independence is provided between Class 1E Divisions and between Class 1E Divisions and non-Class 1E equipment.	6. a. Tests will be performed in the RCIC System by providing a test signal in only one Class 1E division at a time. b. Inspections of the as-built Class 1E divisions in the RCIC System will be performed.	6. a. The test signal exists only in the Class 1E division under test in the RCIC System. b. In the RCIC System physical separation or electrical isolation exists between Class 1E divisions in the RCIC System. Physical separation or electrical isolation exists between Class 1E divisions and non-Class 1E equipment.
7. Outside the primary containment, except for the piping from the CST, the RCIC System shown on Figure 2.4.4a, is physically separated from the two divisions of the HPCF System.	7. Inspections of the as-installed RCIC System will be performed.	7. Outside the primary containment, except for the piping from the CST, the RCIC System shown on Figure 2.4.4a, is physically separated from the two divisions of the HPCF System by structural and/or fire barriers.
8. Main control room displays and controls provided for RCIC System are as defined in Section 2.4.4.	8. Inspections will be performed on the main control room displays and controls for the RCIC System.	8. Displays and controls exist or can be retrieved in the main control room as defined in Section 2.4.4.

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
9.	9.	9.
a. MOVs designated in Section 2.4.4 as having active safety-related function open, close or both open and close under differential pressure, fluid flow, and temperature conditions.	a. Tests of installed valves for opening, closing, or both opening and closing will be conducted under pre-operational differential pressure, fluid flow, and temperature conditions.	a. Upon receipt of the actuating signal, each MOVs opens, closes, or both opens and closes, depending upon the valve's safety functions. The following valves open, or close, in the following time limits: Valve — Time Steam Supply Containment Isolation Valves — ≤ 30 s Close Injection Valve — ≤ 15 s Open
b. CVs designated in Section 2.4.4 as having an active safety-related function open, close, or both open and close, under system pressure, fluid flow, and temperature conditions.	b. Tests of installed valves for opening, closing, or both opening and closing, will be conducted under system preoperational pressure, fluid flow, and temperature conditions.	b. Based on the direction of the differential pressure across the valve, each CV opens, closes, or both opens and closes, depending upon the valve's safety functions.
10. The RCIC turbine is tripped if low suction pressure condition is present.	10. Test will be conducted using a simulated low suction pressure signal.	10. The turbine trip and throttle valve receives a trip signal.