MILLSTONE POWER STATION
ABNORMAL OPERATING PROCEDURE

Loss of Shutdown Cooling

AOP 2572

Rev. 009−03

Approval Date: 03/27/08

Effective Date: 06/18/08

Level of Use
Continuous

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1.0 PURPOSE

1.1 **Objective**

This procedure provides actions for recovering from a partial or total loss of shutdown cooling.

1.2 **Discussion**

During SDC operation, there may *not* be flow past the loop RTDs. Core inlet and outlet temperatures are accurately measured during those conditions using SDC to RCS temperature, T351Y, and RCS to SDC temperature, T351X, respectively. The average of these indicators provides a temperature that is equivalent to the average RCS temperature in the core.

Containment Closure is established when all of the following conditions exist:

- The equipment door is closed and held in place by a minimum of four bolts.
- A minimum of one door in each airlock is closed.
- Each penetration providing direct access from the containment atmosphere to the outside atmosphere is either:
    - Closed by a manual or automatic isolation valve, blind flange, or equivalent, or
    - Capable of being closed under administrative control

② The use of the CS pump for decay heat removal does not meet the definition of an Operable SDC train (LCO 3.9.8). Therefore no fuel movement is permitted when a CS pump is aligned to SDC per this procedure.

1.3 **Applicability**

② This procedure is applicable in MODEs 4, 5, 6 and Defueled.
Use of the CS pumps is limited to MODE 6 and Defueled.

2.0 ENTRY CONDITIONS

Loss of Shutdown Cooling may be entered when **ANY** of the following conditions exist:

- “A” or “B” LPSI pump tripped
- Low or oscillating SDC flow on FI-306
- Low or oscillating LPSI pump current
- Increasing RCS temperature
- Low or decreasing RCS level on any of the following:
  - ICC Reactor Vessel Level Monitoring System
  - L-112, RCS mid-loop wide range RCS level transmitter
  - L-122, No. 2 hot leg narrow range level instrument
  - LI-112, No. 1 hot leg RCS mid-loop level indicator (CCTV)
- “LPSI PUMP A SUCTION PRESSURE LO” annunciator lit (C-01, A-8)
- “LPSI PUMP B SUCTION PRESSURE LO” annunciator lit (C-01, B-8)
- “LPSI PUMP A MOTOR CURRENT HI/LO” annunciator lit (C-01, C-8)
- “LPSI PUMP B MOTOR CURRENT HI/LO” annunciator lit (C-01, D-8)

3.0 Initial Actions for Loss of SDC

INSTRUCTIONS | CONTINGENCY ACTIONS

CAUTION

1. On a loss of SDC, immediate action must be taken to establish "Containment Closure" *prior* to initiation of RCS boiling.
2. On a loss of AC power, Containment lighting may be degraded. Portable DC lighting may be used for Containment Closure activities.

② ___3.1 IF fuel movement is in progress, NOTIFY RE to stop fuel movement.

___3.2 OPEN placekeeper.

*___3.3 IF SDC is lost for greater than 15 minutes OR RCS temperature reaches 190°F, PERFORM the following:

a. NOTIFY Health Physics and COORDINATE an evacuation of Containment.

b. WHEN Containment evacuation is complete, ENSURE personnel airlock door closed.

___3.4 REVIEW Shutdown Safety Assessment Sheet for most recent calculated time to boil.

___3.5 NOTIFY designated personnel to establish Containment Closure prior to the most limiting of the following:

- RCS boiling
- 2 hours from loss of SDC [♣]

INSTRUCTIONS	CONTINGENCY ACTIONS
___3.6 REQUEST Health Physics perform the following: • IF the SG primary sides and loop areas are occupied, EVACUATE personnel. • MONITOR environmental conditions inside Containment. • IF conditions degrade, NOTIFY Control Room.	
___3.7 ENSURE that all available CAR coolers are in service, as indicated by: • CAR fan operating • RBCCW flow established	

CAUTION

With *no* SDC flow, T351X and T351Y do *not* provide an accurate indication of RCS temperature. Accurate indication is provided by UJTEM8-A, UJTEM8-B, UJTEM7-A, UJTEM7-B (PPC).

INSTRUCTIONS	CONTINGENCY ACTIONS
___3.8 IF available, MONITOR RCS level and temperature by use of PPC ICC level and temperature display, using unheated junction thermocouples in contact with RCS inventory for temperature indication.	
___3.9 Refer To MP-26-EPI-FAP06, "Classification and PARs," and DETERMINE applicability.	

INSTRUCTIONS | CONTINGENCY ACTIONS

CAUTION

On a loss of all AC power, RWST gravity feed makeup to the RCS may be desired. Due to RCS heatup and possible pressurization, use of this makeup path is time sensitive.

___3.10 IF AC power is *not* available, CONSIDER using Section 9.0 for the following:

- RWST gravity feed makeup to RCS
- Heat removal by an available steam generator

___3.11 DETERMINE cause of loss of SDC and PERFORM applicable action:

- IF lost due to loss of suction pressure, Go To Section 4.0, "SDC Lost Due to Loss of Suction Pressure or RCS Inventory"
- IF lost due to automatic tripping of running LPSI pump, Go To Section 5.0, "SDC Lost Due to Automatic Tripping of Running LPSI Pump"
- IF lost due to loss of bus 24C, Go To Section 6.0, "SDC Lost Due to Sustained Loss of Bus 24C (VR-11)"
- IF lost due to loss of bus 24D, Go To Section 7.0, "SDC Lost Due to Sustained Loss of Bus 24D (VR-21)"
- IF SDC flow is lost to SDC heat exchangers due to loss of power or instrument air to SDC HX flow control valve SI-657 or SI-306 Go To Section 8.0, "Loss of Power or Air to SI-657, SI-306 or Both"

4.0 SDC Lost Due to Loss of Suction Pressure or RCS Inventory [♣]

INSTRUCTIONS | CONTINGENCY ACTIONS

CAUTION

If the running LPSI pump was lost due to a loss of suction pressure, the standby LPSI pump must *not* be started until RCS level restoration provides adequate suction pressure to avoid damage to the standby pump and sustained loss of shutdown cooling.

NOTE

When RCS level is at the centerline of the hot leg and the RCS is vented, a minimum indicated suction pressure of 18 to 19 psig should be adequate to operate a LPSI pump. The following instruments can be used:

- P302X, "A" LPSI pump discharge pressure (C01/PPC)
- P302Y, "B" LPSI pump discharge pressure (C01/PPC)
- P3051, "A" LPSI pump suction pressure (PPC)
- P3053, "B" LPSI pump suction pressure (PPC)

___4.1 DETERMINE RCS level using **ALL** available indications from the following list:

- ICC Reactor Vessel Level Monitoring System (PPC)
- L-112, RCS Mid-Loop Wide Range RCS Level Transmitter
- L-122, No. 2 Hot Leg Narrow Range Level Instrument
- LI-112, No. 1 hot leg RCS Mid-Loop Level Indicator (CCTV)

INSTRUCTIONS	CONTINGENCY ACTIONS
___4.2 ENSURE SI-651, SDC system suction system isolation, and SI-652, SDC system suction containment isolation, open.	4.2.1 IF SDC was lost due to the closure of SI-651 or SI-652, Go To step 4.10.
___4.3 ENSURE suction path from BAST or RWST is available to charging pumps.	
___4.4 OPEN the following: • CH-518, Charging Isolation • CH-519, Charging Isolation	

CAUTION

The combination of charging and HPSI pumps capable of injecting into the RCS is limited as specified in T/S LCO 3.4.9.3 as follows:

- MODE 4, and MODE 5 with all RCS cold leg temperature > 190°F:
  - Maximum of two charging pumps and one HPSI pump may be capable of injecting into the RCS; and
  - Two OPERABLE PORVS with a lift setpoint ≤ 415 psia.
- MODE 5 with any RCS cold leg temperature ≤ 190°F, and MODE 6 either:
  - Maximum of one charging pump may be capable of injecting into the RCS; and
  - Two OPERABLE PORVS with a lift setpoint ≤ 415 psia.

  OR

  - Maximum of two charging pumps and one HPSI pump may be capable of injecting into the RCS; and
  - The RCS is depressurized and an RCS vent of > 2.2 sq. inches.

___4.5 START one charging pump.

INSTRUCTIONS	CONTINGENCY ACTIONS
___4.6 IF the requirements of T/S 3.4.9.3 allow operation of two charging pumps, and two charging pumps are desired in operation START *one* additional charging pump.	4.6.1 IF operation of an additional charging pump is required to restore RCS inventory, PERFORM the following: a. LOG entry into TSAS 3.4.9.3.D b. RESTORE charging pump availability. c. START one additional charging pump. (3)

CAUTION

Failure to closely monitor RCS level while filling may result in flooding from SG manways.

NOTE

Desired RCS level for plant conditions:

- With nozzle dams OR SG manways installed: +15 inches
- With nozzle dams AND SG manways removed: +2 inches
- With maintenance opening in RCS: the level of the opening (Attachment 1 contains reference levels)

INSTRUCTIONS	CONTINGENCY ACTIONS
___4.7 IF desired and requirements of T/S 3.4.9.3 allow operation of HPSI pump, PERFORM the following: a. OPEN available facility HPSI injection header stop: • SI-656, HPSI header "A" stop (Facility 1) • SI-654, HPSI header "B" stop (Facility 2) b. START available HPSI pump.	4.7.1 IF operation of a HPSI pump is required to restore RCS inventory, PERFORM the following: a. LOG entry into TSAS 3.4.9.3.D b. RESTORE HPSI pump availability. c. OPEN available facility HPSI injection header stop: • SI-656, HPSI header "A" stop (Facility 1) • SI-654, HPSI header "B" stop (Facility 2) d. START available HPSI pump. (3)

(continue)

INSTRUCTIONS

4.7 (continued)

c. THROTTLE open all applicable HPSI injection valves as necessary to raise and maintain RCS level and control RCS temperature:

- If Facility 1 is used, HPSI injection valves header "A":
  - SI-617, Loop 1A
  - SI-627, Loop 1B
  - SI-637, Loop 2A
  - SI-647, Loop 2B
- If Facility 2 is used, HPSI injection valves header "B":
  - SI-616, Loop 1A
  - SI-626, Loop 1B
  - SI-636, Loop 2A
  - SI-646, Loop 2B

CONTINGENCY ACTIONS

e. THROTTLE open all applicable HPSI injection valves as necessary to raise and maintain RCS level and control RCS temperature: ③

- If Facility 1 is used, HPSI injection valves header "A":
  - SI-617, Loop 1A
  - SI-627, Loop 1B
  - SI-637, Loop 2A
  - SI-647, Loop 2B
  - If Facility 2 is used, HPSI injection valves header "B":
  - SI-616, Loop 1A
  - SI-626, Loop 1B
  - SI-636, Loop 2A
  - SI-646, Loop 2B

INSTRUCTIONS CONTINGENCY ACTIONS

NOTE

The reactor vessel must be vented for the gravity feed method of filling.

___4.8 IF desired,
PERFORM the following
(gravity feed method for filling):

a. ENSURE SI-651, SDC system suction system isolation, and SI-652, SDC system suction containment isolation, open.

b. IF "A" LPSI is the unaffected pump,
PERFORM the following
("A" Safeguards Room):

1) ENSURE SI-441, "A" LPSI pump suction from SDC, open.

2) THROTTLE open SI-444, "A" LPSI pump suction from RWST.

3) WHEN level is re-established,
CLOSE SI-444, "A" LPSI pump suction from RWST.

c. IF "B" LPSI is the unaffected pump,
PERFORM the following
("B" Safeguards Room):

1) ENSURE SI-440, "B" LPSI pump suction from SDC, open.

2) THROTTLE open SI-432, "B" LPSI pump suction from RWST.

3) WHEN level is re-established,
CLOSE SI-432, "B" LPSI pump suction from RWST.

INSTRUCTIONS	CONTINGENCY ACTIONS

___4.9 Refer To OP 2310, "Shutdown Cooling System," and PERFORM applicable actions to evacuate SDC suction piping.

___4.10 DISPATCH operator to affected LPSI pump to check pump conditions.

___4.11 CLOSE all LPSI injection valves:

- SI-615, Loop 1A
- SI-625, Loop 1B
- SI-635, Loop 2A
- SI-645, Loop 2B

___4.12 Using applicable controller, PERFORM the following:

a. CLOSE SI-657, SDC HX flow control (HIC-3657).

b. ENSURE SI- 306, SDC total flow control, full open (FIC-306).

NOTE

Cooling of the core takes precedence over LPSI pump considerations. If the following conditions have been met, the affected LPSI pump may be started without venting:

- Adequate NPSH is obtained upon RCS level recovery
- SDC suction leg piping is evacuated

___4.13 IF **ANY** of the following conditions apply,
Go To step 4.17:

- Unaffected LPSI pump is available to restore SDC flow.
- Affected LPSI pump will be used to restore SDC flow AND pump venting time will potentially exceed expected time to core boiling.

INSTRUCTIONS | CONTINGENCY ACTIONS

___4.14 ESTABLISH direct communications between operators at LPSI pump and in Control Room.

NOTE

Vented water may be considered air-free when it contains no bubbles larger than the bubbles in carbonated water or soda.

STOP **W A R N I N G** STOP

Water from the LPSI pump vent is potentially hot and may cause serious burns.

___4.15 IF "A" LPSI pump is affected, PERFORM the following ("A" Safeguards Room):

a. CONNECT vent hose to SI-21A, "A" LPSI pump vent.

b. Slowly OPEN SI-21A, "A" LPSI pump vent.

c. WHEN air-free water is observed, CLOSE SI-21A, "A" LPSI pump vent.

___4.16 IF "B" LPSI pump is affected, PERFORM the following ("B" Safeguards Room):

a. CONNECT vent hose to SI-21B, "B" LPSI pump vent.

b. Slowly OPEN SI-21B, "B" LPSI pump vent.

c. WHEN air-free water is observed, CLOSE SI-21B, "B" LPSI pump vent.

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTE

When establishing RCS cooldown rate, optimum temperature response is achieved by maintaining SI-657 between 35 and 60% open.

CAUTION

1. When establishing SDC flow while in reduced inventory, due to concerns regarding boron dilution and vortexing at the SDC suction, SDC flow must be limited to between 1,400 to 1,600 gpm.
2. Caution should be used when reestablishing SDC heat exchanger flow due to the potential for water in the SDC heat exchangers to be much cooler than RCS temperature. Initiating flow slowly allows temperatures to equalize.

___4.17 ESTABLISH SDC flow as follows:

a. ENSURE **BOTH** of the following are open:

- SI-651, SDC system suction system isolation
- SI-652, SDC system suction containment isolation

b. ENSURE SI-657, SDC HX flow control, closed.

c. CRACK open **ONE** LPSI injection Valve:

- SI-615, Loop 1A
- SI-625, Loop 1B
- SI-635, Loop 2A
- SI-645, Loop 2B

(continue)

INSTRUCTIONS | CONTINGENCY ACTIONS

4.17 (continued)

d. ENSURE LPSI pump suction pressure is at least 18 psig, as indicated on LPSI pump discharge pressure instrument.

e. START **ONE** LPSI pump.

f. ENSURE the following:

- SDC flow is stable with *no* significant oscillations.
- LPSI pump motor amperage is stable.
- Associated LPSI pump annunciators are *not* lit.

g. IF in reduced inventory, slowly THROTTLE open LPSI injection valves, to raise SDC total flow to between 1,400 and 1,600 gpm:

- SI-615, Loop 1A
- SI-625, Loop 1B
- SI-635, Loop 2A
- SI-645, Loop 2B

h. IF *not* in reduced inventory, slowly THROTTLE open LPSI injection valves, to raise SDC total flow between 3,500 and 4,000 gpm:

- SI-615, Loop 1A
- SI-625, Loop 1B
- SI-635, Loop 2A
- SI-645, Loop 2B

(continue)

INSTRUCTIONS | CONTINGENCY ACTIONS

4.17 (continued)

i. WHEN establishing cooldown, Refer To SP 2602B, "Transient Temperature, Pressure Verification," and PERFORM the following:

- MONITOR RCS cooldown rate using T351Y.
- ENSURE system response is within cooldown limits.

j. Slowly ADJUST HIC-3657, SI-657 controller, to establish and maintain desired cooldown rate.

k. ADJUST HIC-3657, SI-657 controller, AND RBCCW outlet manual isolations (as required) to maintain desired cooldown rate:

- RB-14A, "A" RBCCW outlet manual isolation
- RB-14B, "B" RBCCW outlet manual isolation

l. ENSURE RBCCW flows do *not* exceed the following:

- Total applicable RBCCW header flow of 8,000 gpm
- A single SDC heat exchanger RBCCW flow of 4,800 gpm

INSTRUCTIONS	CONTINGENCY ACTIONS

___4.18 PERFORM the following to determine source of leakage:

- Refer To Attachment 2, “Potential Leakage Paths While on Shutdown Cooling,” and ATTEMPT to identify source of leakage.
- OBSERVE the following parameters for indications of RCS leakage:
  - Containment sump level
  - RWST level
  - PDT level and pressure
  - Quench tank level and pressure
  - Equipment drain sump tank level
  - SFP level
  - Primary sample flows (primary sample sink)
  - Clean Waste Panel Indications (C63)
  - Aerated Waste Panel Indications (C60)
- IF leaks are identified, ATTEMPT to isolate source of leakage.

INSTRUCTIONS | CONTINGENCY ACTIONS

* 4.19 WHEN desired RCS level is attained, AND leakage has been isolated, PERFORM the following:

a. STOP running HPSI pump and PLACE handswitch in "PULL-TO-LOCK."

b. STOP all charging pumps.

c. CLOSE applicable HPSI injection header stop:

- SI-656, HPSI Header A Stop
- SI-654 HPSI Header B Stop

d. CLOSE charging header isolations:

- CH-518, Charging Isolation
- CH-519, Charging Isolation

e. IF required, CLOSE applicable HPSI injection valves:

- If Facility 1 is used, HPSI Injection Valves Header A:
  - SI-617, Loop 1A
  - SI-627, Loop 1B
  - SI-637, Loop 2A
  - SI-647, Loop 2B
- IF Facility 2 is used, HPSI Injection Valves Header B:
  - SI-616, Loop 1A
  - SI-626, Loop 1B
  - SI-636, Loop 2A
  - SI-646, Loop 2B

③ f. VERIFY appropriate administrative controls are in place to comply with TS 3.4.9.3.

INSTRUCTIONS	CONTINGENCY ACTIONS
* ___4.20 MONITOR for the following: • Low or oscillating SDC flow • Low or oscillating LPSI pump motor current • Rising RCS temperature • Low or decreasing RCS level • LPSI pump annunciators lit	
* ___4.21 IF at any time, one or more of the conditions specified in step 4.20 indicate loss of suction pressure to the running LPSI pump, PERFORM the following: a. STOP running LPSI pump. b. Go To step 4.3 to commence RCS fill.	4.21.1 IF the loss of suction pressure damaged the LPSI pump(s) to the point where they cannot support SDC operations, PERFORM the following: ② a. PERFORM action in Section 4.0 to fill and vent the suction header. b. Go To Section 5.0 and PLACE a CS pump in service.
___4.22 IF RCS pressure is stable AND RCS temperature is less than 200°F and stable, STOP Containment Closure activities.	
___4.23 Go To Section 10.0.	

5.0 SDC Lost Due to Tripping of Running LPSI Pump

INSTRUCTIONS	CONTINGENCY ACTIONS

NOTE

1. This section assumes a running LPSI pump breaker trip without a concurrent loss of power to the associated bus.
2. Obtaining reference positions of SDC flow control valves may be helpful during SDC restoration.
3. If diverting additional flow through SDC heat exchangers is required, SI- 306 may be closed greater than its open limit stop (mid-position).

___5.1 Using applicable controller, PERFORM the following:

a. RECORD output of the following SDC flow controllers:

- HIC-3657_______________
- FIC-306________________

b. CLOSE SI-657, SDC HX Flow Control Valve (HIC-3657).

c. VERIFY SI-306, SDC Total Flow Control Valve, full open (FIC-306).

___5.2 CLOSE all LPSI Injection Valves:

- SI-615, Loop 1A
- SI-625, Loop 1B
- SI-635, Loop 2A
- SI-645, Loop 2B

INSTRUCTIONS | CONTINGENCY ACTIONS

___5.3 IF SDC was supplying only the RCS/Refuel Pool, CRACK open *one* LPSI Injection Valve:

- SI−615, "LPSI INJ VLVS" LOOP 1A
- SI−625, "LPSI INJ VLVS" LOOP 1B
- SI−635, "LPSI INJ VLVS" LOOP 2A
- SI−645, "LPSI INJ VLVS" LOOP 2B

___5.4 IF SDC was supplying both the Spent Fuel Pool and the RCS/Refuel Pool, PERFORM the following:

② a. RECORD position of RW−15, "SDC to SFPC Stop."

RW−15 percent open: _______

b. THROTTLE RW−15 to approximately 10% open.

c. CRACK open *one* LPSI Injection Valve:

- SI−615, "LPSI INJ VLVS" LOOP 1A
- SI−625, "LPSI INJ VLVS" LOOP 1B
- SI−635, "LPSI INJ VLVS" LOOP 2A
- SI−645, "LPSI INJ VLVS" LOOP 2B

INSTRUCTIONS	CONTINGENCY ACTIONS
___5.5 IF available, START standby LPSI pump.	5.5.1 IF the standby LPSI pump is *not* available, PERFORM the following:

a. IF time permits, EVALUATE cause of LPSI pump trip as follows:

1) DISPATCH operator to applicable 4160 VAC pump breaker to obtain protective relay status:

- “A” LPSI pump: A309
- “B” LPSI pump: A404

2) DISPATCH operator to applicable ESF room to observe pump condition.

b. IF SM permission is obtained, START LPSI pump that tripped.

INSTRUCTIONS | CONTINGENCY ACTIONS

CAUTION

② Prior to utilizing a CS pump for SDC, the RCS heat removal rate and associated SDC flow must be considered. Maximum SDC flow through any CS pump is limited to 1700 gpm. Additionally, the RWST suction header must be filled and vented in order to align the associated CS pump to the RCS. The applicable facility ECCS suction flowpath from the RWST is isolated.

___5.6 IF desired, USE the "A" CS Pump for SDC as follows:

a. COMPLETE "A" CS pump alignment verification (Attachment 6).

b. VERIFY one train of SFPC in service in accordance with OP 2305, "Spent Fuel Pool Cooling and Purification System."

c. ENSURE suction pressure is greater than or equal to 18 psig.

d. START the "A" CS pump.

___5.7 IF desired, USE the "B" CS Pump for SDC as follows:

a. COMPLETE "B" CS pump alignment verification (Attachment 7).

b. VERIFY one train of SFPC in service in accordance with OP 2305, "Spent Fuel Pool Cooling and Purification System."

c. ENSURE suction pressure is greater than or equal to 18 psig.

d. START the "B" CS pump.

INSTRUCTIONS	CONTINGENCY ACTIONS

② ___5.8 IF *no* LPSI or CS pumps are available, PERFORM the following:

a. Refer To Section 9.0, "RWST Gravity Feed Makeup to the RCS And SG Heat Removal," for alternate methods of heat removal.

② b. VERIFY one train of SFPC in service in accordance with OP 2305, "Spent Fuel Pool Cooling and Purification System."

c. WHEN *either* LPSI pump becomes available, PERFORM the following:

1) IF a SFPC train was placed in service in accordance with step 5.8.b., Refer To OP 2305, "Spent Fuel Pool Cooling and Purification System," and REMOVE SFPC from service.

2) VERIFY system alignment supports use of the LPSI pump.

3) ENSURE suction pressure greater than 18 psig.

4) START applicable LPSI pump.

d. WHEN *either* CS pump becomes available, PERFORM the following:

1) VERIFY system alignment supports use of the CS pump.

2) ENSURE suction pressure greater than 18 psig.

3) START applicable CS pump.

INSTRUCTIONS | CONTINGENCY ACTIONS

C A U T I O N

1. When establishing SDC flow while in reduced inventory, due to concerns regarding boron dilution and vortexing at the SDC suction, SDC flow must be limited to between 1,400 to 1,600 gpm.
2. SDC flow through any one LPSI pump must be limited to a maximum of 4,000 gpm.
3. SDC flow through any one SDC heat exchanger must be limited to a maximum of 4,800 gpm.
4. ② SDC flow through only one CS pump must be limited to a maximum of 1700 gpm.

② ___5.9 IF SDC was supplying flow to only the Refuel Pool, PERFORM the following:

a. IF the RCS is in reduced inventory, PERFORM the following:

1) IF a LPSI pump is in service, THROTTLE flow 1400 to 1600 gpm.

2) IF a CS pump is in service, PERFORM the following:

a) THROTTLE flow 1400 to 1600 gpm.

b) MONITOR for indications of cavitation.

INSTRUCTIONS	CONTINGENCY ACTIONS
5.9 (continued) b. IF the RCS is not in reduced inventory, PERFORM the following: 1) IF a LPSI pump is in service, THROTTLE flow 3500 to 4000 gpm. 2) IF a CS pump is in service, THROTTLE flow 1650 to 1700 gpm. ② ___5.10 IF SDC was supplying both the SFP and Refuel Pool, PERFORM the following: a. IF a LPSI pump in service, PERFORM the following: 1) THROTTLE the following valves to obtain previous flow splits: • SI−615, “LPSI INJ VLVS” LOOP 1A • SI−625, “LPSI INJ VLVS” LOOP 1B • SI−635, “LPSI INJ VLVS” LOOP 2A • SI−645, “LPSI INJ VLVS” LOOP 2B • 2−RW−15, “SDC to SFPC Stop” (continue)	

INSTRUCTIONS | CONTINGENCY ACTIONS

5.10 (continued)

② 2) CHECK pressure at 2−RW−66, "SFPC/RW Purification Return Sample Stop," less than 30 psig.

2) IF pressure at 2−RW−66 is greater than 30 psig, PERFORM the following:

a. THROTTLE 2−RW−15, "SDC to SFPC Stop" to obtain less than 30 psig at 2−RW−66.

b. CONTACT Engineering for additional guidance on decay heat removal.

Table 1.0				
Fuel Assemblies Off−Loaded	Flow splits with SFPC in service		Flow splits with SFPC *not* in service	
	Flow to RFP	Flow to SFP	Flow to RFP	Flow to SFP
0−80	1700	0	1250	450
81−170	1400	300	750	950
171−217	1100	600	400	1300

b. IF a CS pump is in service, PERFORM the following:

1) THROTTLE the following valves to obtain Table 1.0 flow splits:

- SI−615, "LPSI INJ VLVS" LOOP 1A
- SI−625, "LPSI INJ VLVS" LOOP 1B
- SI−635, "LPSI INJ VLVS" LOOP 2A
- SI−645, "LPSI INJ VLVS" LOOP 2B
- 2−RW−15, "SDC to SFPC Stop"

(continue)

INSTRUCTIONS	CONTINGENCY ACTIONS
5.10 (continued)	
② 2) CHECK pressure at 2−RW−66, "SFPC/RW Purification Return Sample Stop," less than 30 psig.	2) IF pressure at 2−RW−66 is greater than 30 psig, PERFORM the following: a. THROTTLE 2−RW−15, "SDC to SFPC Stop" to obtain less than 30 psig at 2−RW−66. b. CONTACT Engineering for additional guidance on decay heat removal.

CAUTION

Caution should be used when reestablishing SDC heat exchanger flow, due to the potential for water in the SDC heat exchangers to be much cooler than RCS temperature. Initiating flow slowly allows temperatures to equalize.

___5.11 WHEN establishing cooldown, Refer To SP 2602B, "Transient Temperature, Pressure Verification," and PERFORM the following:

- MONITOR RCS cooldown rate using T351Y.
- ENSURE system response is within cooldown limits.

___5.12 Slowly ADJUST HIC-3657, SI-657 Controller, to establish and maintain desired cooldown rate.

___5.13 IF additional flow through SDC heat exchangers is required, slowly CLOSE SI-306, SDC total flow control (FIC-306).

INSTRUCTIONS	CONTINGENCY ACTIONS
② ___5.14 CHECK pressure at 2−RW−66, "SFPC/RW Purification Return Sample Stop," less than 30 psig.	5.14.1 <u>IF</u> pressure at 2−RW−66 is greater than 30 psig, PERFORM the following: a. THROTTLE 2−RW−15, "SDC to SFPC Stop," to obtain less than 30 psig at 2−RW−66. b. CONTACT Engineering for additional guidance on decay heat removal.

NOTE

When establishing RCS cooldown rate optimum temperature response will be achieved by maintaining SI-657 between 35 and 60% open.

___5.15 ADJUST HIC-3657, SI-657 Controller, <u>AND</u> the RBCCW outlet manual isolations (as required) to maintain the desired cooldown rate:

- RB-14A, "A" RBCCW Outlet Manual Isolation
- RB-14B, "B" RBCCW Outlet Manual Isolation

___5.16 ENSURE RBCCW flows do *not* exceed the following:

- Total applicable RBCCW header flow of 8,000 gpm
- A single SDC heat exchanger RBCCW flow of 4,800 gpm

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTE

2−SI−306 has designed leakby that diverts flow around the SDC heat exchangers and could challenge heat removal with CS pumps supplying SDC.

②

___5.17 IF a CS pump is in service on SDC and sufficient cooling cannot be obtained with 2−SI−306 closed, CLOSE the applicable LPSI to SDC heat exchanger isolation valve:

- 2−SI−452, LPSI Pump Discharge to "A" SDC Heat Exchanger
- 2−SI−453, LPSI Pump Discharge to "B" SDC Heat Exchanger

___5.18 REPEAT steps 5.12 through 5.17 as needed to control RCS temperature.

② ___5.19 WHEN ready to shift SDC from a CS pump to a LPSI pump, PERFORM Attachment 8, "Realigning LPSI to Supply SDC and SFPC."

___5.20 WHEN RCS pressure is stable AND RCS temperature is less than 200°F and stable,
STOP Containment Closure activities.

___5.21 Go To Section 10.0.

6.0 SDC Lost Due to Sustained Loss of Bus 24C (VR-11)

INSTRUCTIONS | CONTINGENCY ACTIONS

C A U T I O N

If SDC is restored prior to restoration of VR-11, normal temperature monitoring with T351Y will be unavailable to perform SP 2602B, "Transient Temperature, Pressure Verification." Although SDC restoration is preferably performed with VR-11 powered instruments available, core cooling takes precedence over establishing normal or alternate temperature monitoring.

NOTE

This section assumes a loss of power to buses 24C, 22E and VR-11. Loss of power will have the following effects:

- A loss of power to the "A" LPSI pump
- The inability to close two LPSI injection
- Loss of power to the following SDC instrumentation:
  - T351X, RCS to SDC
  - T351Y, SDC to RCS
  - F6043, SDC HX A RBCCW Flow
  - T6051, SDC HX A RBCCW Temperature
  - F3023, SDC HX A SDC Flow
  - T303X, SDC HX A SDC Temperature
  - F312, LPSI Flow to Loop 1A
  - F322, LPSI Flow to Loop 1B
  - TR351, SDC Temperature Recorder

___6.1 Using HIC-3657 and FIC-306, PERFORM the following:

a. OBSERVE and MARK output of SI-657 controller and SI-306 controller.

(continue)

6.1.1 Refer To Section 8.0, "Loss of Power or Air to SI-657, SI-306 or Both," and CLOSE SI-657 or SI-306, as applicable.

INSTRUCTIONS | CONTINGENCY ACTIONS

6.1 (continued)

b. CLOSE SI-657, SDC HX flow control (HIC-3657).

c. CLOSE SI-306, SDC total flow control (FIC-306).

CAUTION

If ICC temperature monitoring is unavailable, remote RCS temperature monitoring may be lost. Once a LPSI pump is operating, RCS temperatures must be monitored using T351X and T351Y, or if VR-11 remains deenergized, by handheld infrared temperature gun measurements on piping adjacent to the temperature elements for T351X and T351Y.

___6.2 IF available,
MONITOR RCS level and temperature by use of Control Room PPC ICC level and temperature display using unheated junction thermocouples in contact with RCS inventory.

INSTRUCTIONS | CONTINGENCY ACTIONS

C A U T I O N

1. Due to LPSI pump minimum flow isolation valves (SI-449 and SI-450) being closed, SDC total flow control valve, SI-306, should be opened as soon as possible after starting the LPSI pump.
2. When establishing SDC flow while in reduced inventory, due to concerns regarding boron dilution and vortexing at the SDC suction, SDC flow must be limited to between 1,400 to 1,600 gpm.
3. SDC flow through any one LPSI pump must be limited to a maximum of 4,000 gpm.
4. SDC flow through any one SDC heat exchanger must be limited to a maximum of 4,800 gpm.

___6.3 IF bus 24D is energized AND "B" LPSI pump is available, PERFORM the following:

a. ENSURE "B" LPSI pump aligned for SDC.

b. START "B" LPSI pump.

c. Using FIC-306, Slowly OPEN SI-306, fully, *not* to exceed the following applicable SDC system flow limits:

- Reduced inventory SDC total flow between 1,400 and 1,600 gpm
- Normal (1 pump) operation SDC total flow between 3,500 and 4,000 gpm

d. Refer To AOP 2502C, "Loss of Vital 4.16 KV Bus 24C," and RESTORE bus 24C, while continuing in this procedure.

e. Go To step 6.5.

6.3.1 IF neither LPSI pump is available, PERFORM the following:

a. Refer To **ONE** of the following procedures as applicable, and RESTORE bus 24C or 24D (bus 24C preferred):

- AOP 2583, "Loss of All AC Power During Shutdown Conditions"
- AOP 2502C, "Loss of Vital 4.16 KV Bus 24C"

b. CONTINUE to monitor RCS temperature by any means available.

c. Refer To Section 9.0, "RWST Gravity Feed Makeup to the RCS And SG Heat Removal," for alternate methods of heat removal.

d. WHEN either LPSI pump becomes available, ENSURE adequate suction pressure., (18 to 19 psig) and START applicable LPSI pump.

INSTRUCTIONS	CONTINGENCY ACTIONS

___6.4 Slowly OPEN FIC-306, SI-306 Controller, fully, *not* to exceed the following applicable SDC system flow limits:

- Reduced inventory SDC total flow between 1,400 and 1,600 gpm
- Normal (1 pump) operation SDC total flow between 3,500 and 4,000 gpm

___6.5 IF, at any time, RCS temperature is greater than 200°F and rising OR indications of RCS boiling are observed,
Go To step 6.9 to commence cooling.

___6.6 IF bus 24C AND VR-11 are energized,
Go To step 6.9.

CAUTION

The SDC piping locations (AB -25'6" elev.) are in a high dose rate area. A handheld infrared temperature gun should be used to allow temperature readings to be taken at a distance from the piping, and the operator taking readings should wait in a low dose area between temperature readings.

___6.7 ESTABLISH alternate SDC temperature monitoring as follows:

a. OBTAIN a handheld infrared temperature gun from Control Room.

(continue)

INSTRUCTIONS	CONTINGENCY ACTIONS
6.7 (continued)	
b. Refer To Attachment 3, "Location of SDC Piping for Alternate Temperature Monitoring," and DISPATCH an operator with a handheld infrared temperature gun to applicable SDC piping location (AB -25′6″)	
c. ESTABLISH communications between operator at SDC piping and Control Room.	
d. MONITOR SDC piping temperature as directed by Control Room.	
e. WHEN normal SDC temperature monitoring is restored, RELEASE operator.	

INSTRUCTIONS | CONTINGENCY ACTIONS

___6.8 ALIGN alternate supply to VR-11 from B32 as follows:

a. IF bus 24A is deenergized AND bus 24B is energized, PERFORM the following to cross-tie bus 22C with bus 22D:

1) PLACE "SYN SEL SW 22C/22D" to "CL TIE TRIP C."

2) ATTEMPT to close B0313, "22C/22D TIE BKR."

3) PLACE SYN SEL SW22C/22D" to "OFF."

b. WHEN B32 is energized, PERFORM the following:

1) OPEN and LOCK breaker B5125, "REGULATING TRANS #1" (VR-11 Normal Supply).

2) UNLOCK and CLOSE breaker B3246, "ALT FDR FOR UAC-1" (VR-11 Alternate Supply).

① 3) On transfer switch RS1, OBSERVE the following:

- "NORMAL TO LOAD" lamp lit
- "EMERGENCY TO LOAD" lamp *not* lit

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTE

1. SP 2602B, "Transient Temperature, Pressure Verification" directs using T351Y to monitor heatup and cooldown rates. Although no provision exists to use any other temperature indication for this purpose, an attempt should be made to apply heatup and cooldown limits when using any alternate temperature indication. This procedure later directs engineering evaluation and analyses to determine the impact of this event and comply with the applicable Technical Specification.
2. When monitoring SDC to RCS piping temperature by handheld infrared temperature gun measurement, a delay in temperature response can be expected with any change in SDC heat removal rate due to pipe wall thickness.

___6.9 WHEN establishing cooldown, Refer To SP 2602B, "Transient Temperature, Pressure Verification," and PERFORM one of the following:

- IF VR-11 has been restored, MONITOR RCS cooldown using T351Y.
- IF time permits, MONITOR cooldown using handheld infrared temperature gun at location shown on Attachment 3.
- IF VR-11 is *not* restored AND RCS boiling is imminent, MONITOR RCS cooldown with any available instrumentation.

INSTRUCTIONS | CONTINGENCY ACTIONS

C A U T I O N

Caution should be used when reestablishing SDC heat exchanger flow due to the potential for water in the SDC heat exchangers to be much cooler than RCS temperature. Initiating flow slowly allows temperatures to equalize.

___6.10 Slowly ADJUST HIC-3657, SI-657 Controller, to establish and maintain desired cooldown rate.

___6.11 IF additional flow through SDC heat exchangers is required,
slowly CLOSE SI-306, SDC Total Flow Control Valve (FIC-306).

NOTE

1. When establishing RCS cooldown rate, optimum temperature response is achieved by maintaining SI-657 between 35 and 60% open.
2. Loss of power may have reduced RBCCW flow supporting SDC heat removal.

___6.12 ADJUST HIC-3657, SI-657 Controller, AND RBCCW outlet manual isolations, if required, to maintain the desired cooldown rate:

- RB-14A, "A" RBCCW outlet manual isolation
- RB-14B, "B" RBCCW outlet manual isolation

___6.13 ENSURE RBCCW flows do *not* exceed the following:

- Total applicable RBCCW header flow of 8,000 gpm
- A single SDC heat exchanger RBCCW flow of 4,800 gpm

___6.14 REPEAT steps 6.10 through 6.13 as needed to control RCS temperature.

INSTRUCTIONS	CONTINGENCY ACTIONS
___6.15 IF necessary to provide additional SDC heat removal, Refer To OP 2310, "Shutdown Cooling," as needed and CONSIDER alignment changes to SDC heat exchangers.	
___6.16 WHEN RCS pressure is stable AND RCS temperature is less than 200°F and stable, STOP Containment Closure activities.	
___6.17 Go To Section 10.0.	

7.0 SDC Lost Due to Sustained Loss of Bus 24D (VR-21)

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTE

This section assumes a loss of power to buses 24D, 22F and VR-21. Loss of power will have the following effects:

- A loss of power to the "B" LPSI pump
- The inability to remotely close two LPSI injection valves.
- Loss of power to the following SDC instrumentation:
  - F6042, SDC HX B RBCCW Flow
  - T6056, SDC HX B RBCCW Temperature
  - F3024, SDC HX B SDC Flow
  - T303Y, SDC HX B SDC Temperature
  - F332, LPSI Flow to Loop 2A
  - F342, LPSI Flow to Loop 2B

___7.1 Using HIC-3657 and FIC-306, PERFORM the following:

a. OBSERVE and MARK output of SI-657 controller, and SI-306 controller.

b. CLOSE SI-657, SDC HX flow control.

c. CLOSE SI-306, SDC total flow control (FIC-306).

7.1.1 Refer To Section 8.0, "Loss of Power or Air to SI-657, SI-306 or Both," and CLOSE SI-657 or SI-306, as applicable.

___7.2 IF available, MONITOR RCS level and temperature by use of PPC ICC level and temperature display using unheated junction thermocouples in contact with RCS inventory.

INSTRUCTIONS | CONTINGENCY ACTIONS

C A U T I O N

1. Due to LPSI pump minimum flow isolation valves (SI-449 and SI-450) being closed, SDC total flow control valve, SI-306, should be opened as soon as possible after starting the LPSI pump.
2. When establishing SDC flow while in reduced inventory, due to concerns regarding boron dilution and vortexing at the SDC suction, SDC flow must be limited to between 1,400 to 1,600 gpm.
3. SDC flow through any one LPSI pump must be limited to a maximum of 4,000 gpm.
4. SDC flow through any one SDC heat exchanger must be limited to a maximum of 4,800 gpm.

___7.3 IF bus 24C is energized AND “A” LPSI pump is available, PERFORM the following:

a. ENSURE “A” LPSI pump aligned for SDC.

b. START “A” LPSI pump.

c. Slowly OPEN FIC-306, SI-306 controller, fully, *not* to exceed the following applicable SDC system flow limits:

- Reduced inventory SDC total flow between 1,400 and 1,600 gpm
- Normal (1 pump) operation SDC total flow between 3,500 and 4,000 gpm

d. Refer To AOP 2502D, ”Loss of Vital 4.16 KV Bus 24D,” and RESTORE bus 24D, while continuing in this procedure.

e. Go To step 7.5.

7.3.1 IF neither LPSI pump is available, PERFORM the following:

a. Refer To **ONE** of the following and RESTORE bus 24D:

- AOP 2583, “Loss of All AC Power During Shutdown Conditions”
- AOP 2502D, ”Loss of Vital 4.16 KV Bus 24D”

b. CONTINUE to monitor RCS temperature.

c. Refer To Section 9.0, “RWST Gravity Feed Makeup to the RCS and SG Heat Removal,” for alternate methods of heat removal.

d. WHEN either LPSI pump becomes available, START applicable LPSI pump and CONTINUE with this procedure.

INSTRUCTIONS		CONTINGENCY ACTIONS	
___7.4	Slowly OPEN FIC-306, SI-306 controller, fully, *not* to exceed the following applicable SDC system flow limits: • Reduced inventory SDC total flow between 1,400 and 1,600 gpm • Normal (1 pump) operation SDC total flow between 3,500 and 4,000 gpm		
___7.5	WHEN establishing cooldown, Refer To SP 2602B, "Transient Temperature, Pressure Verification," and PERFORM one of the following: • MONITOR RCS cooldown using T351Y. • ENSURE system response is within cooldown limits.		

CAUTION

Caution should be used when reestablishing SDC heat exchanger flow due to the potential for water in the SDC heat exchangers to be much cooler than RCS temperature. Initiating flow slowly allows temperatures to equalize.

___7.6	Slowly ADJUST HIC-3657, SI-657 controller, to establish and maintain desired cooldown rate.	7.6.1	Refer To Section 8.0, "Loss of Power or Air to SI-657, SI-306 or Both," and ADJUST SI-657 as applicable.
___7.7	IF additional flow through SDC heat exchangers is required, slowly CLOSE SI-306, SDC total flow control (FIC-306).	7.7.1	Refer To Section 8.0, "Loss of Power or Air to SI-657, SI-306 or Both," and ADJUST SI-306 as applicable.

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTE

When establishing RCS cooldown rate optimum temperature response is achieved by maintaining SI-657 between 35 and 60% open.

___7.8 ADJUST HIC-3657, SI-657 Controller, AND the RBCCW outlet manual isolations, as required, to maintain the desired cooldown rate:

- RB-14A, "A" RBCCW outlet manual isolation
- RB-14B, "B" RBCCW outlet manual isolation

___7.9 ENSURE RBCCW flows do *not* exceed the following:

- Total applicable RBCCW header flow of 8,000 gpm
- A single SDC heat exchanger RBCCW flow of 4,800 gpm

___7.10 REPEAT steps 7.6 through 7.9 as needed to control RCS temperature.

NOTE

Loss of power may have reduced RBCCW flow supporting SDC heat removal.

___7.11 IF necessary to provide additional SDC heat removal,
Refer To OP 2310,
"Shutdown Cooling," as needed and CONSIDER alignment changes to SDC heat exchangers.

___7.12 WHEN RCS pressure is stable AND RCS temperature is less than 200°F and stable,
STOP Containment Closure activities.

___7.13 Go To Section 10.0.

8.0 Loss of Power or Air to SI-657, SI-306 or Both

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTE

1. Loss of power or air to SDC flow control valves has the following affect:
   - SI-657 fails closed
   - SI-306 fails open to its limit stop (mid-position)
2. Loss of VA-10 fails both valves.
3. SI-306 can be throttled from its maximum open position (maximum flow limit stop position) when diverting additional flow through SDC heat exchangers is required.
4. Obtaining reference positions of SDC flow control valves may be helpful during SDC restoration. If a loss of VA-10 has occurred, the reference positions are only available as archive data in the PPC (PPC analog points 2SI657 and 2SI306).

___8.1 OBSERVE applicable controllers or PPC analog points to obtain a reference position for SDC flow control valves:

- Output of FIC-306 or archive PPC data for 2SI306
- Output of HIC-3657 or archive PPC data for 2SI657

② ___8.2 For the failed valve(s), ADJUST the controller output to match actual valve position.

- FIC−306
- HIC−3657

INSTRUCTIONS CONTINGENCY ACTIONS

NOTE

When establishing RCS cooldown rate, optimum temperature response is achieved by maintaining SI-657 between 35 and 60% open.

___8.3 IF ***only*** SI-306 had a loss of power or air, PERFORM the following:

a. WHEN establishing cooldown, Refer to SP 2602B, "Transient Temperature, Pressure Verification," and PERFORM the following:

- MONITOR RCS cooldown rate using T351Y.
- ENSURE system response is within cooldown limits.

b. ADJUST RCS temperature, as indicated on T351Y, as follows:

1) Slowly ADJUST HIC-3657, SI-657 controller, to establish and maintain desired cooldown rate.

2) ADJUST SI-657 position AND SDC HX RBCCW outlet manual isolations (as required) to maintain desired cooldown rate:

- RB-14A, "A" RBCCW outlet manual isolation
- RB-14B, "B" RBCCW outlet manual isolation

(continue)

INSTRUCTIONS | CONTINGENCY ACTIONS

8.3 (continued)

3) ENSURE RBCCW flows do *not* exceed the following:

- Total applicable RBCCW header flow of 8,000 gpm
- A single SDC heat exchanger RBCCW flow of 4,800 gpm

c. REPEAT step 8.3.b. as needed to control RCS temperature.

d. IF desired temperature control is *not* obtained,
PERFORM one or more of the following as required:

- Refer To OP 2310, "Shutdown Cooling," and START an additional LPSI pump on SDC.
- IF RBCCW is *not* available to a SDC heat exchanger, ISOLATE the applicable SDC heat exchanger as follows:
  - CLOSE SI-456, "A" SDC heat exchanger discharge to SDC.
  - CLOSE SI-457, "B" SDC heat exchanger discharge to SDC.
- Refer To step 8.9 and manually ADJUST SI-306 to achieve desired temperature control.

e. WHEN desired temperature control is obtained,
Go To step 8.10.

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTE

Loss of power or air may have caused RBCCW components to shift position, thereby diverting RBCCW flow from SDC heat exchangers; for instance, CAR cooler supply valves fail open due to loss of air or power.

___8.4 DETERMINE if loss of power or air affected other RBCCW loads.

___8.5 IF loss of power or air caused RBCCW flow to divert from SDC heat exchangers,
PERFORM the following, as needed:

a. OBSERVE previous RBCCW flow to SDC heat exchangers in PPC archive:

- F6043, SDC HX A RBCCW flow
- F6042, SDC HX B RBCCW flow

b. As needed,
manually ISOLATE RBCCW components to divert flow to SDC heat exchangers to obtain values at or near those in step 8.5.a. to include, but not limited to, closing the CAR cooler manual isolations.

NOTE

The 2 inch wrench needed for rotation of the SI-657 stem hex nut is staged on the stanchion between the “A HPSI and “A” LPSI pumps.

___8.6 OBTAIN a 2 inch wrench to rotate stem hex nut on SI-657.

___8.7 ESTABLISH direct communications between operator at SI-657 (“A” ESF Room) and Control Room.

INSTRUCTIONS | CONTINGENCY ACTIONS

CAUTION

Care should be used when establishing SDC heat exchanger flow due to the potential for water in the SDC heat exchanger to be much cooler than RCS temperature. Initiating flow slowly allows temperatures to equalize.

NOTE

1. SI-657 is a reverse-operating valve; *counterclockwise* rotation of the handwheel closes the valve and *clockwise* rotation of the handwheel opens the valve.
2. When establishing RCS cooldown rate, optimum temperature response is achieved by maintaining SI-657 between 35 and 60% open.

___8.8 IF SI-657 had a loss of power or air, PERFORM the following:

a. WHEN establishing cooldown, Refer to SP 2602B, "Transient Temperature, Pressure Verification," and PERFORM the following:

- MONITOR RCS cooldown rate using T351Y.
- ENSURE system response is within cooldown limits.

b. PERFORM the following to take manual control of SI-657 ("A" ESF Room):

1) UNLOCK the manual handwheel on valve.

2) CLOSE instrument air supply valve and VENT valve operator.

3) LOOSEN stem hex nut as required to allow stem movement.

4) ROTATE SI-657 handwheel as directed by the Control Room.

(continue)

INSTRUCTIONS | CONTINGENCY ACTIONS

8.8 (continued)

c. ADJUST RCS temperature, as indicated on T351Y, as follows:

1) Slowly ROTATE SI-657 handwheel to establish and maintain desired cooldown rate.

2) ADJUST SI-657 position AND the SDC HX RBCCW outlet manual isolations as required to maintain desired cooldown rate:

- RB-14A, "A" RBCCW outlet manual isolation
- RB-14B, "B" RBCCW outlet manual isolation

3) ENSURE RBCCW flows do *not* exceed the following:

- Total applicable RBCCW header flow of 8,000 gpm
- A single SDC heat exchanger RBCCW flow of 4,800 gpm

(continue)

INSTRUCTIONS	CONTINGENCY ACTIONS

8.8 (continued)

d. IF additional temperature control is needed,
PERFORM one or more of the following as required:

- Refer To OP 2310, "Shutdown Cooling," and START an additional LPSI pump on SDC.
- IF RBCCW is *not* available to a SDC heat exchanger, ISOLATE applicable SDC heat exchanger as follows:
  - CLOSE SI-456, "A" SDC heat exchanger discharge to SDC.
  - CLOSE SI-457, "B" SDC heat exchanger discharge to SDC.
- Refer To step 8.9 and manually ADJUST SI-306 to achieve desired temperature control.

e. WHEN adjustments to SI-657 position are complete,
TIGHTEN stem hex nut against handwheel body.

f. IF desired temperature control is *not* obtained,
Go To step 8.8.c.

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTE

SI-306 is a reverse-operating valve; *counterclockwise* rotation of the handwheel closes the valve and *clockwise* rotation of the handwheel opens the valve.

___8.9 As necessary, ESTABLISH local manual control of SI-306 as follows:

a. ESTABLISH communications between operators at the valve ("A" ESF Room) and Control Room.

b. CLOSE instrument air supply for SI-306, SDC total flow control.

c. OPEN petcock on instrument air supply pressure regulator and VENT SI-306, SDC total flow control, valve operator.

d. UNLOCK and REMOVE chain from manual handwheel.

e. ROTATE manual handwheel *counterclockwise* and ALIGN holes in outer shaft with hole in inner shaft.

f. INSERT the pin into shaft holes.

g. ENSURE SI-306, SDC total flow control, valve position indicator on the manual actuator is at throttled open position.

h. IF desired to manually operate valve, POSITION SI-306 handwheel as directed by the Control Room.

___8.10 WHEN recovery from manual operations is desired, PERFORM actions specified by the SM/US.

9.0 RWST Gravity Feed Makeup to the RCS and SG Heat Removal

INSTRUCTIONS | CONTINGENCY ACTIONS

CAUTION

1. On a loss of all AC power, RWST gravity feed makeup to the RCS may be desired. Due to RCS heatup and possible pressurization, use of this makeup path is time sensitive.
2. Failure to closely monitor RCS level while filling may result in flooding from SG manways.

___9.1 DETERMINE whether RCS makeup by gravity feed from RWST is desired.

___9.2 ENSURE adequate RWST inventory is available for RCS makeup.

___9.3 IF desired to use “A” LPSI pump suction path,
PERFORM the following
(“A” Safeguards Room):

a. ENSURE SI-441, “A” LPSI pump suction from SDC, open.

b. As necessary,
THROTTLE SI-444,
“A” LPSI pump suction from RWST, to makeup for RCS inventory loss or boil-off.

___9.4 IF desired to use “B” LPSI pump suction path,
PERFORM the following
(“B” Safeguards Room):

a. ENSURE SI-440, “B” LPSI pump suction from SDC, open.

b. As necessary,
THROTTLE SI-432, “B” LPSI pump suction from RWST, to makeup RCS inventory.

INSTRUCTIONS | CONTINGENCY ACTIONS

NOTE

When U-tubes are empty, steam generators may still be used as a heat removal path by reflux boiling if primary manways are installed. However, verification of heat removal is more difficult.

___9.5 REVIEW the following plant conditions and
DETERMINE whether a steam generator is available as heat removal path:

- SG corrected level
- Plant outage work status and effect on SG and Main Steam System components
- SG primary manways status
- SG secondary manways status
- Nozzle dam installation
- Status of AFW System to feed SGs

INSTRUCTIONS | CONTINGENCY ACTIONS

C A U T I O N

If SG secondary manways are *not* installed, the atmospheric dump valves must *not* be opened because a direct path from containment atmosphere to outside atmosphere will be created.

___9.6 IF a steam generator is available for heat removal,
PERFORM the following:

a. Refer To OP 2322, "Auxiliary Feedwater System," and PERFORM necessary actions to establish a feed source to the available SG.

b. MAINTAIN SG corrected level greater than 10%.

c. OPEN applicable atmospheric dump valve fully:

- MS-190A, #1 SG atmospheric dump
- MS-190B, #2 SG atmospheric dump

d. Refer To SP 2602B, "Transient Temperature, Pressure Verification," and MONITOR applicable parameters for effective SG heat removal and RCS temperature stability.

10.0 Follow-up Actions for Loss of SDC [♣]

INSTRUCTIONS	CONTINGENCY ACTIONS

___10.1 As required, Refer To SP 2602B, "Transient Temperature, Pressure Verification," and PERFORM applicable actions.

___10.2 IF SDC can *not* be restored, PERFORM the following to determine time to core uncovery:

a. REVIEW Shutdown Safety Assessment Sheet for most recent calculated time to boil.

b. IF RCS is in a refueling condition with refuel pool full, Refer To Attachment 4, "Time to Boil Refuel Pool to Top of Fuel vs. Shutdown Time," and DETERMINE time to boil the refuel pool to top of fuel.

c. Refer To Attachment 5, "Time to Core Uncovery Calculations," and CALCULATE time to core uncovery.

___10.3 ENSURE RCS temperature is lowering within cooldown limits.

___10.4 REQUEST Engineering Department perform the following:

- EVALUATE impact of any RCS heatup or cooldown resulting from loss of shutdown cooling.
- IF required, PERFORM thermal stress evaluation.

② ___10.5 EVALUTE resumption of fuel movement

Attachment 1
RCS Component Elevation in Relation to Hot Leg Centerline
(Sheet 1 of 1)

SG Cold Leg Wet Nozzle Dam (Bottom) .... +6.5″

SG Hot Leg Wet Nozzle Dam (Bottom) .... +9.5″

SG Manway (Bottom) .... +11″

Bottom of RCP Seal Package .... +20″

Top of RCP Seal Package .... +52″

Reactor Vessel Flange .... +79.5″

Attachment 2
Potential Leakage Paths While On Shutdown Cooling
(Sheet 1 of 5)

1. POTENTIAL LEAKAGE PATHS TO PDT

- Cold leg drains to PDT (loop 1):
  - Through RC-234 and RC-035A
  - Through RC-235 and RC-035B
- Cold leg drains to PDT (loop 2):
  - Through RC-233 and RC-035C
  - Through RC-232 and RC-035D
- Hot leg drains to PDT (loop 1), through RC-215 and RC-040
- Reactor vessel head O-ring to PDT (loop 2), leakage past inner O-ring through RC-211 (local) and RC-406
- Pressurizer spray line drains to PDT:
  - Through RC-036B and RC-037B (pressurizer)
  - Through RC-036A and RC-037A (pressurizer)
- SDC suction relief to PDT, through SI-469 (local)
- Charging and letdown drains to PDT (Exists when system is isolated):
  - Through letdown drains to PDT, CH-654 and CH-655 (local)
  - Through auxiliary spray line drain to PDT, CH-752 and CH-753 (local)
  - Through charging line drain to PDT, CH-685 and CH-686 (local)
  - Through charging line drain to PDT, CH-681 and CH-682 (local)

Attachment 2
Potential Leakage Paths While On Shutdown Cooling
(Sheet 2 of 5)

- Check valve leakage drains to PDT
  (through recirculation header drain, SI-661):
  - Check valve leakage drain, SI-618
  - Check valve leakage drain, SI-628
  - Check valve leakage drain, SI-638
  - Check valve leakage drain, SI-648

2. POTENTIAL LEAKAGE PATHS TO QUENCH TANK:

- Pressurizer Safety Valves to quench tank
  - Through RC-200 (local)
  - Through RC-201 (local)
- PORVs to quench tank:
  - Through RC-403 and RC-402 (local)
  - Through RC-405 and RC-404 (local)
- Check valve leakage drains to quench tank
  (through SI-466, recirculation header relief):
  - Check valve leakage drain, SI-618
  - Check valve leakage drain, SI-628
  - Check valve leakage drain, SI-638
  - Check valve leakage drain, SI-648

Attachment 2
Potential Leakage Paths While On Shutdown Cooling
(Sheet 3 of 5)

3. POTENTIAL LEAKAGE PATHS TO SAMPLE SYSTEM

- No. 1 hot leg to sample system through RC-213 (local), RC-244 (local), and RC-001 (primary sample panel)
- Pressurizer surge line to sample system through RC-210 (local), RC-43 (local), and RC-002 (primary sample panel)
- Pressurizer steam space to sample system through RC-238 (local), RC-006 (local), and RC-003 (primary sample panel)
- SDC suction to sample system through SI-443 (local), S-19 and S-20 (primary sample sink)
- Safety injection header discharge to sample system
    - Through SI-725 (local), SI-806 (local), SI-807 (local), S-19 and S-20 (primary sample sink)
    - Through SI-724 (local), SI-804 (local), SI-807 (local), S-19 and S-20 (primary sample sink)

4. POTENTIAL LEAKAGE PATHS TO EDST

- SDC suction relief to EDST, through SI-468 (local)
- SDC heat exchanger drain to EDST
    - Through CS-008A (local)
    - Through CS-008B (local)
- SDC heat exchanger discharge relief to Equipment Drain Sump Tank
    - Through SI-431 (local)
    - Through SI-430 (local)
- SDC System discharge header relief to EDST, through SI-439 (local)
- Letdown heat exchanger relief valve discharge drain to EDST, through CH-916 (local)

Attachment 2
Potential Leakage Paths While On Shutdown Cooling
(Sheet 4 of 5)

5. POTENTIAL LEAKAGE PATHS TO NITROGEN SYSTEM

    - Pressurizer spray line to nitrogen header through RC-015 and RC-030 (local)

6. POTENTIAL LEAKAGE PATHS TO SFP COOLING SYSTEM
    (The following valves may be open to supplement SFPC)

    - SFPC supply to SDC, through SI-442 (local)
    - SDC return to SFPC, through SI-458 (local)

7. POTENTIAL LEAKAGE PATHS TO LETDOWN SYSTEM
    (The following valves are normally open for Excess Letdown)

    - Letdown System supply to SDC, through CH-024 (local)
    - SDC return to Letdown System, through CH-040 (local)

8. POTENTIAL LEAKAGE PATHS TO PASS SYSTEM

    - Safety injection pump discharge to PASS System, through SI-084 (local)

9. POTENTIAL LEAKAGE PATHS TO RWST

    - Safety injection pump suction from RWST
        - Through SI-444 (local)
        - Through SI-432 (local)
    - LPSI pump minimum flow recirculation to RWST
        - Through SI-449 (local), SI-660, and SI-659
        - Through SI-450 (local), SI-660, and SI-659
    - SDC recirculation to RWST, through SI-460 (local)

Attachment 2
Potential Leakage Paths While On Shutdown Cooling
(Sheet 5 of 5)

10. POTENTIAL LEAKAGE PATH TO RBCCW SYSTEM

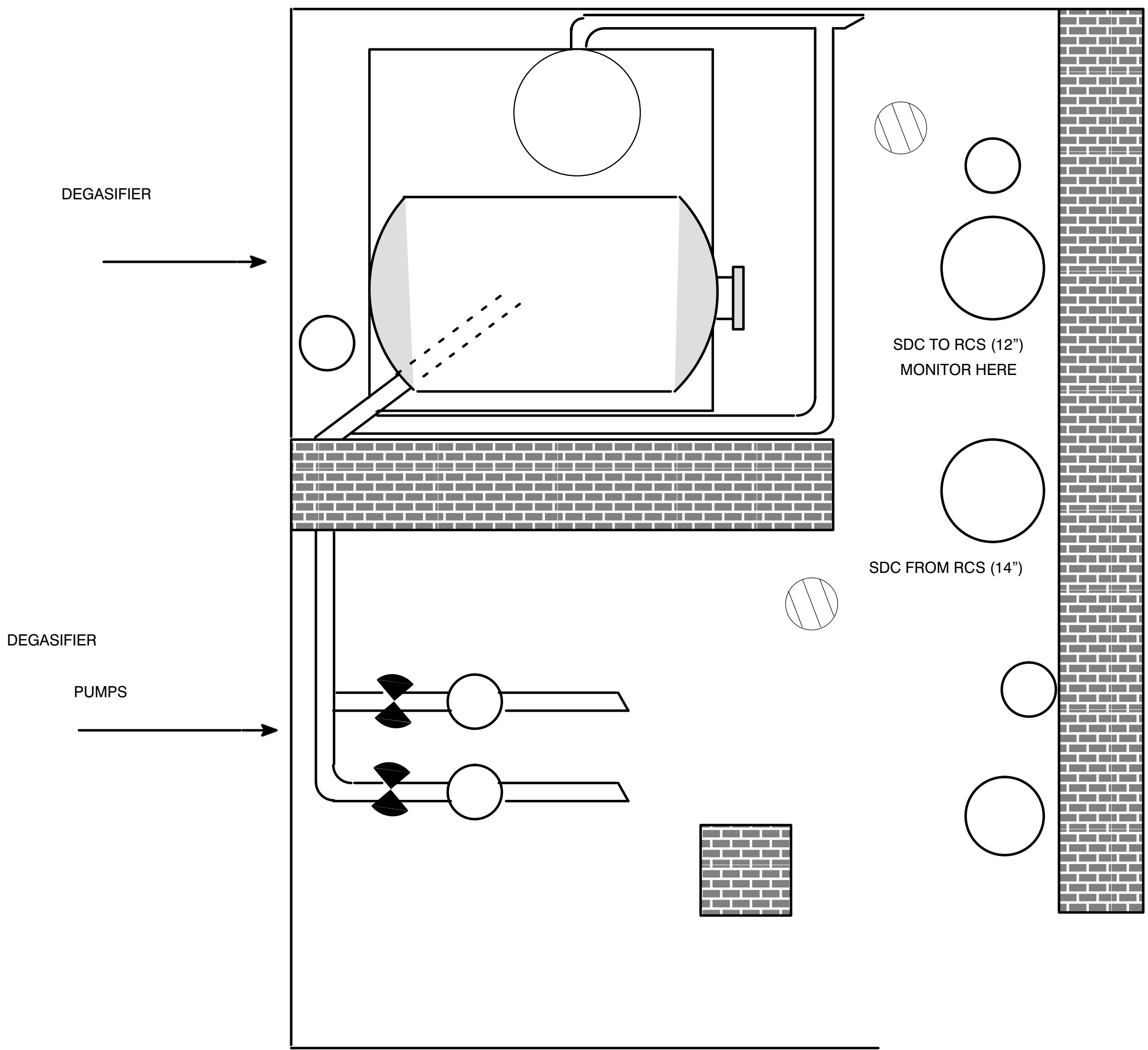
- SDC heat exchanger(s) via a tube leak

11. ADDITIONAL PURIFICATION/EXCESS LETDOWN TO SAMPLE SYSTEM

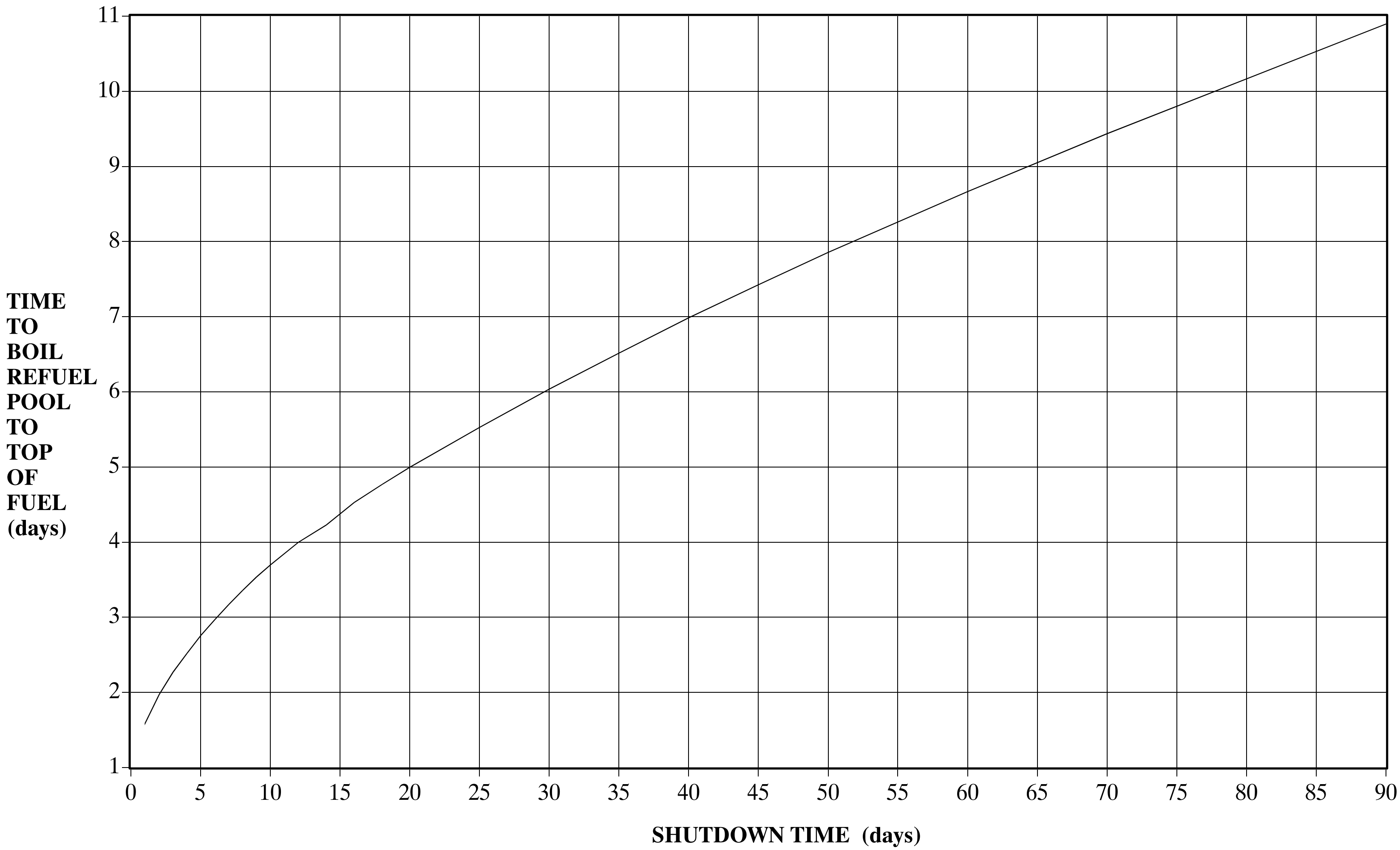
- Through CH-353 (local), S-210, S-209, S-55, S-54 and S-56 (primary sample sink)

Attachment 3
Location of SDC Piping for Alternate Temperature Monitoring
(Sheet 1 of 1)

-25′6″ Auxiliary Building Degasifier Area



Attachment 4
Time to Boil Refuel Pool to Top of Fuel vs. Shutdown Time
(Sheet 1 of 1)



Attachment 5
Time to Core Uncovery Calculations
(Sheet 1 of 1)

PLANT CONDITION	TIME TO CORE UNCOVERY CALCULATION
Reduced Inventory RCS Filled	**Time to Core Uncovery** = **RCS Time to Boil (Equipment Status Board)** (Conservative time for worst case conditions)
Refueling with Refuel Pool Full	**Time to Core Uncovery** = **RCS Time to Boil (Equipment Status Board)** + **Time to Boil Refuel Pool to Top of Fuel (Attachment 4)**

Attachment 6
Aligning "A" CS Pump to SDC
(Sheet 1 of 1)

Establish the following conditions:

1. All HPSI pump handswitches in Pull−to−Lock.
2. RBCCW System is operating and supplying CS pump seal coolers
3. Facility 1 RWST Header is filled and vented
4. 2−CS−1A, "A" CS Pump Suction, OPEN
5. 2−CS−7A, "A" CS Pump Minimum Flow Recirc, CLOSED ②
6. 2−CS−16.1A, "A" Containment Sump Outlet Header Isolation, CLOSED
7. 2−CS−13.1A, "A" RWST Outlet Header Isolation, CLOSED
8. 2−CS−3A, "A" Containment Spray Pump Discharge, OPEN
9. 2−SI−441, "A" LPSI Pump Suction from SDC, OPEN
10. 2−SI−453, LPSI Pump Discharge to "B" SDC Heat Exchanger, CLOSED
11. 2−SI−452, LPSI Pump Discharge to "A" SDC Heat Exchanger, OPEN
12. 2−SI−432, "B" LPSI Pump Suction from RWST, CLOSED
13. 2−SI−444 "A" LPSI pump suction from RWST, OPEN

Attachment 7
Aligning “B” CS Pump to SDC
(Sheet 1 of 1)

Establish the following conditions:

1. All HPSI pump handswitches in Pull to Lock.
2. Charging Pumps are aligned to a BAST tank or handswitches in PTL.
3. RBCCW System is operating and supplying CS pump seal coolers
4. Facility 2 RWST header is filled and vented
5. ② 2−CS−1B, “B” CS Pump Suction, OPEN
6. 2−CS−7B, “B” CS pump minimum flow recirc, CLOSED
7. 2−CS−16.1B, “B” Containment Sump Outlet Header Isolation, CLOSED
8. 2−CS−13.1B, “B” RWST Outlet Header Isolation, CLOSED
9. 2−CS−3B, “B” Containment Spray Pump Discharge, OPEN
10. 2−SI−440, “B” LPSI pump suction from SDC, OPEN
11. 2−SI−452, LPSI Pump Discharge to “A” SDC Heat Exchanger, CLOSED
12. 2−SI−453, LPSI Pump Discharge to “B” SDC Heat Exchanger, OPEN
13. 2−SI−444, “A” LPSI pump suction from RWST, CLOSED
14. 2−SI−432, B LPSI pump suction from RWST, OPEN

Attachment 8
Realigning LPSI to Supply SDC and/or SFPC
(Sheet 1 of 3)

1. Slowly OPEN the applicable LPSI pump discharge valve:
   - 2−SI−447, “A” LPSI PUMP DISCHARGE STOP
   - 2−SI−435, “B” LPSI PUMP DISCHARGE STOP
2. MONITOR CS pump discharge pressure and amps.
3. IF at any time, oscillations are observed on the running CS pump discharge pressure or amps, PERFORM the following:
   a. STOP the running CS Pump (C−01).
   b. VENT “A” CS pump using 2−CS−023A, “A” Containment Spray Pump casing vent.
   c. VENT “B” CS pump using 2−CS−023B, “B” Containment Spray Pump casing vent.
   d. START affected CS pump.
   e. DETERMINE cause of oscillations.
4. STOP Running CS pump.
5. IF “B” SDC heat exchanger will be used, OPEN 2−SI−453, LPSI Discharge to “B” SDC Heat Exchanger.
6. IF “A” SDC heat exchanger will be used, OPEN 2−SI−452, LPSI Discharge to “A” SDC Heat Exchanger.
7. IF all SDC flow is returning to only the RCS/Refuel Pool, PERFORM the following:
   a. CLOSE all LPSI injection valves (C−01):
      - SI−615, “LPSI INJ VLVS” LOOP 1A
      - SI−625, “LPSI INJ VLVS” LOOP 1B
      - SI−635, “LPSI INJ VLVS” LOOP 2A
      - SI−645, “LPSI INJ VLVS” LOOP 2B

②

Attachment 8
Realigning LPSI to Supply SDC and/or SFPC
(Sheet 2 of 3)

b. THROTTLE open *one* of the following LPSI injection valves until dual indication is observed (C−01):

- SI−615, "LPSI INJ VLVS" LOOP 1A
- SI−625, "LPSI INJ VLVS" LOOP 1B
- SI−635, "LPSI INJ VLVS" LOOP 2A
- SI−645, "LPSI INJ VLVS" LOOP 2B

8. IF SDC flow is returning to both the Spent Fuel Pool and RCS/Refuel Pool, PERFORM the following:

   a. RECORD position of RW−15, "SDC to SFPC Stop."

      - ② RW−15 percent open: __________

   b. THROTTLE RW−15 to approximately 10% open.

   c. CRACK open ONE LPSI Injection Valve:

      - SI−615, "LPSI INJ VLVS" LOOP 1A
      - SI−625, "LPSI INJ VLVS" LOOP 1B
      - SI−635, "LPSI INJ VLVS" LOOP 2A
      - SI−645, "LPSI INJ VLVS" LOOP 2B

9. START applicable LPSI Pump (C−01).

10. IF SDC was supplying flow to only the RCS/Refuel Pool, PERFORM the following:

    a. IF in reduced inventory, THROTTLE open LPSI injection valves to raise SDC total flow to between 1400 and 1600 gpm.

    b. IF not in reduced inventory, THROTTLE open LPSI injection valves to raise SDC total flow to between 3500 and 4000 gpm.

Attachment 8
Realigning LPSI to Supply SDC and/or SFPC
(Sheet 3 of 3)

11. IF SDC was supplying both the SFP and RCS/Refuel Pool, THROTTLE the following valves to obtain previous flow splits:
    - SI−615, "LPSI INJ VLVS" LOOP 1A
    - SI−625, "LPSI INJ VLVS" LOOP 1B
    - SI−635, "LPSI INJ VLVS" LOOP 2A
    - SI−645, "LPSI INJ VLVS" LOOP 2B
    - 2−RW−15, "SDC to SFPC Stop"
12. ② CLOSE the applicable CS pump discharge valve:
    - 2−CS−3A, "'A' CS PUMP DISCHARGE"
    - 2−CS−3B, "'B' CS PUMP DISCHARGE"
13. ESTABLISH the following conditions:
    - 2−SI−432, "B" LPSI Pump Suction from RWST, CLOSED
    - 2−SI−444, "A" LPSI Pump Suction from RWST, CLOSED
    - CS−13.1A, "A" RWST Outlet Header Isolation Valve, OPEN
    - CS−13.1B, "B" RWST Outlet Header Isolation Valve, OPEN
    - 2−CS−7A, "A" CS Pump Minimum Flow Recirc, OPEN
    - 2−CS−7B, "B" CS Pump Minimum FLow Recirc, OPEN
14. ALIGN HPSI Pump handswitches as directed by SM/US.
15. IF desired, ALIGN charging pump suction to RWST.
16. Go To OP 2310, "Shutdown Cooling," and OPERATE SDC cooling system as directed by US/SM.
17. Go To OP 2305, "Spent Fuel Pool Cooling and Purification System," and OPERATE SFPC as directed by the US/SM.

Attachment 9
Placekeeper
(Sheet 1 of 7)

STEP	INSTRUCTIONS	PAGE	START	DONE
3.0	**Initial Actions for Loss of SDC**	5		
② 3.1	If fuel moving fuel notify RE to stop	5	❑	❑
3.3	Containment evacuation and airlock closure.	5	❑	❑
3.4	Determining time to boil.	5	❑	❑
3.5	Establishing Containment Closure.	5	❑	❑
3.6	HP notification.	6	❑	❑
3.7	Ensuring all available CAR coolers are in service.	6	❑	❑
3.8	Monitoring RCS level and temperature.	6	❑	❑
3.9	MP-26-EPI-FAP06, “Classification and PARs,” review.	6	❑	❑
3.10	AC power *not* available, consider section 9.0	7	❑	❑
3.11	Branching to appropriate section.	7	❑	❑
4.0	**SDC Lost Due to Loss of Suction Pressure**	8		
4.1	Determining RCS level.	8	❑	❑
4.2	Ensuring SI-651 and SI-652 are open.	9	❑	❑
4.3	Ensuring suction path to charging pumps.	9	❑	❑
4.4	Opening CH-518 and CH-519.	9	❑	❑
4.5	Starting one charging pump.	9	❑	❑
4.6	Starting additional charging pump.	10	❑	❑

Attachment 9
Placekeeper
(Sheet 2 of 7)

STEP	INSTRUCTIONS	PAGE	START	DONE
4.7	Starting HPSI pump.	10	❑	❑
4.8	Performing gravity feed if desired.	12	❑	❑
4.9	Evacuating SDC suction piping.	13	❑	❑
4.10	Dispatching operator to affected LPSI pump.	13	❑	❑
4.11	Closing all LPSI Injection Valves.	13	❑	❑
4.12	Aligning flow control valves.	13	❑	❑
4.13	Branching to start of unaffected LPSI pump.	13	❑	❑
4.14	Establishing communications.	14	❑	❑
4.15	Venting “A” LPSI pump.	14	❑	❑
4.16	Venting “B” LPSI pump.	14	❑	❑
4.17	Establishing SDC flow.	15	❑	❑
4.18	Locating and isolating leak.	18	❑	❑
4.19	Stopping RCS fill.	19	❑	❑
4.20	Monitoring listed parameters.	20	❑	❑
② *4.21	Actions for loss of suction pressure.	20	❑	❑
4.22	Stopping Containment Closure activities.	20	❑	❑
4.23	Branching to Section 10.0.	20	❑	❑

Attachment 9
Placekeeper
(Sheet 3 of 7)

STEP	INSTRUCTIONS	PAGE	START	DONE
5.0	**SDC Lost Due to Automatic Tripping of Running LPSI Pump**	21		
5.1	Aligning flow control valves.	21	❑	❑
5.2	Closing all LPSI Injection Valves.	21	❑	❑
5.3	Opening one LPSI Injection Valve.	22	❑	❑
5.4	Actions if SDC supplying both SFP and RCS/Refuel Pool	22	❑	❑
5.5	Starting standby LPSI pump.	23	❑	❑
5.6	Using the "A" CS Pump for SDC , if desired	24	❑	❑
5.7	Using the "B" CS Pump for SDC , if desired	24	❑	❑
② 5.8	Actions if no LPSI or CS pumps available.	25	❑	❑
5.9	Actions if SDC supplying only RCS/Refuel Pool.	26	❑	❑
5.10	Actions if SDC supplying both SFP and RCS/Refuel Pool	27	❑	❑
5.11	Establishing cooldown.	29	❑	❑
5.12	Adjusting controller	29	❑	❑
5.13	Establishing additional flow through SDC HXs.	29	❑	❑
5.14	Checking pressure at 2−RW−66 less than 30 psig		❑	❑
5.15	Maintaining cooldown rate.	30	❑	❑
5.16	Limiting RBCCW flows.	30	❑	❑

Attachment 9
Placekeeper
(Sheet 4 of 7)

	STEP	INSTRUCTIONS	PAGE	START	DONE
②	5.17	Closing LPSI to SDC heat exchanger isolation valve	31	❑	❑
	5.18	Controlling RCS temperature.	31	❑	❑
②	5.19	Shifting SDC from “A” CS pump to “A” LPSI pump	31	❑	❑
	5.20	Stopping Containment Closure activities.	31	❑	❑
	5.21	Branching to Section 10.0.	31	❑	❑
	6.0	**SDC Lost Due to Sustained Loss of Bus 24C (VR-11)**	32		
	6.1	Aligning flow control valves.	32	❑	❑
	6.2	Monitoring RCS level and temperature.	33	❑	❑
	6.3	Starting “B” LPSI pump.	34	❑	❑
	6.4	Opening SI−306.	35	❑	❑
	6.5	Actions for RCS temperature greater than 200°F or RCS boiling.	35	❑	❑
	6.6	Branching if bus 24C and VR−11 are energized.	35	❑	❑
	6.7	Establishing alternate SDC temperature monitoring.	35	❑	❑
	6.8	Aligning alternate supply to VR−11 from B32.	37	❑	❑
	6.9	Monitoring cooldown.	38	❑	❑
	6.10	Establishing cooldown.	39	❑	❑
	6.11	Establishing additional flow through SDC HXs.	39	❑	❑

Attachment 9
Placekeeper
(Sheet 5 of 7)

STEP	INSTRUCTIONS	PAGE	START	DONE
6.12	Maintaining cooldown.	39	❑	❑
6.13	Limiting RBCCW flow.	39	❑	❑
6.14	Controlling RCS temperature.	39	❑	❑
6.15	Providing additional SDC heat removal.	40	❑	❑
6.16	Stopping Containment Closure activities.	40	❑	❑
6.17	Branching to Section 10.0.	40	❑	❑
7.0	**SDC Lost Due to Sustained Loss of Bus 24D (VR-21)**	41		
7.1	Aligning flow control valves.	41	❑	❑
7.2	Monitoring RCS level and temperature.	41	❑	❑
7.3	Starting the “A” LPSI pump.	42	❑	❑
7.4	Opening SI−306.	43	❑	❑
7.5	Monitoring cooldown.	43	❑	❑
7.6	Establishing cooldown.	43	❑	❑
7.7	Establishing additional flow through SDC HXs.	43	❑	❑
7.8	Maintaining cooldown.	44	❑	❑
7.9	Limiting RBCCW flow.	44	❑	❑
7.10	Controlling RCS temperature.	44	❑	❑

Attachment 9
Placekeeper
(Sheet 6 of 7)

STEP	INSTRUCTIONS	PAGE	START	DONE
7.11	Providing additional SDC heat removal.	44	❑	❑
7.12	Stopping Containment Closure activities.	44	❑	❑
7.13	Branching to Section 10.0.	44	❑	❑
8.0	**Loss of Power or Air to SI-657, SI-306 or Both**	45		
8.1	Obtaining a reference position for SDC flow control valves.	45	❑	❑
8.2	Adjusting controller output for failed valves	45	❑	❑
8.3	Actions if only SI-306 is affected.	46	❑	❑
8.4	Determining if loss of power or air affected other RBCCW loads.	48	❑	❑
8.5	Diverting flow to SDC heat exchangers.	48	❑	❑
8.6	Obtaining wrench for SI-657.	48	❑	❑
8.7	Establishing communications.	48	❑	❑
8.8	Actions if SI-657 had a loss of power or air.	49	❑	❑
8.9	Establishing local manual control of SI-306.	52	❑	❑
8.10	Recovery from manual operations.	52	❑	❑
9.0	**RWST Gravity Feed Makeup to the RCS and SG Heat Removal**	53		
9.1	Determining whether gravity feed is desired.	53	❑	❑
9.2	Ensuring adequate RWST inventory.	53	❑	❑

Attachment 9
Placekeeper
(Sheet 7 of 7)

STEP	INSTRUCTIONS	PAGE	START	DONE
9.3	Using “A” LPSI pump suction path.	53	❑	❑
9.4	Using “B” LPSI pump suction path.	53	❑	❑
9.5	Determining whether a steam generator is available.	54	❑	❑
9.6	Establishing SG heat removal.	55	❑	❑
10.0	**Follow−up Actions for Loss of SDC**	56		
10.1	Performing SP 2602B.	56	❑	❑
10.2	Determination of time to core uncovery.	56	❑	❑
10.3	Maintaining cooldown rate limits.	56	❑	❑
② 10.4	Requesting Engineering evaluation.	56	❑	❑

DOMINION NUCLEAR CONNECTICUT

MILLSTONE 2

Lesson Title: **Shutdown Cooling System**

Revision: **4/2**

ID Number: **SDC-00-C**

See *Page 10* of 82 for information on how P-103 and P-103-1 effect the SDC Suction Valves, SI-651 and SI-652

Submitted by:	Pete Strickland	10/31/07
	Developer	Date
Reviewed by:	Sandy Doboe	11/05/07
	Technical Reviewer	Date
Reviewed by:	N/A	N/A
	Cognizant Plant Supervisor *(Optional)*	Date
Approved by:	Mike Cote	11/05/07
	Training Supervisor	Date

RECORD OF CHANGES

AI/COMMITMENT NO.	DESCRIPTION OF CHANGE	AFFECTED PAGES	REV/ CH
940174	This material has been upgraded to address program improvements based on student feedback identified in commitment 940174 and associated documents.		
97-3221	SDC System procedure revisions		
98-5144	LPSI pump operation on minimum flow inconsistent with engineering recommendations		
NA	Incorporate RO learning objectives		
1999-1985	Incorp. DCR-98055 (SI-651 App R mods), DCR 98052 (HPSI PTL HSs); increase clarity; and correct typos	Substance: 10, 29, 52. Typos: var.	
1999-00003155	Revised Figures 2, 21, and 22 to reflect the differences in height between the top of the cold leg and the top of the fuel.	Figures 2, 21, and 22	
1999-5300	Incorporate Certification class feedback	10, 15, 20, 43	3/0
1998-011424	Changed PEO objective to be consistent with RO Objective	5, 6, 8, 20, 33, 72	3/1
2001-3259	Added new Tech Spec bases information defining components needed to constitute an Operable SDC train in Modes 4, versus 5 and 6.	43, 44	3/2
2002-306	Added TS basis info re: restrictions on using alternate suction flow path from SFP.	42	3/3
2002-632	Added TS change regarding Mode 5 Operability revisions for 1 & 2 SDC trains.	44	3/4
2004-128 DAP 09/30/2004	Included info from TR4-33, Review of Loss of SDC Events Jan, 2004	58 & 59	3/5
2007 – 031	Updated material prior to teaching NLIT	All	4
2004-589	Added OE for RHR gas Binding event-CR-04-06166	61	4/1
2007-0739	Updated 2-SI-306 information to reflect design change DM2-00-0166-07.	18	4/2

TABLE OF CONTENTS

C. PURPOSE	
2. System Purpose	
The Shutdown Cooling System (SDC) cools the reactor when Reactor Coolant System (RCS) temperature is too low to effectively transfer decay heat via the steam generators. It also functions to maintain a suitable temperature for refueling and maintenance activities. Portions of the Low Pressure Safety Injection (LPSI) and Containment Spray (CS) systems are used as the Shutdown Cooling (SDC) System.	PEO-1
D. SYSTEM DESCRIPTION	
2. System Overview	
During non-accident conditions, when allowed by Technical Specifications (<1750 psia), portions of the ESF systems are aligned to function as SDC components. When the Reactor Coolant System (RCS) is less than 300° F and less than 265 psia, sections of the Low Pressure Safety Injection System and the Containment Spray System are aligned as the Shutdown Cooling (SDC) System. The Shutdown Cooling System uses the LPSI pumps to circulate reactor coolant through the shutdown cooling heat exchangers.	
The Low Pressure Safety Injection System can also be used to transfer water, in either direction, between the Refueling Water Storage Tank (RWST) and the refueling cavity. Interconnections with the Chemical Volume Control System (CVCS) and with the Spent Fuel Pool Cooling and Purification systems are also provided.	
3. System Flow Paths	
The Shutdown Cooling System takes suction through a common header that originates at the Loop 2 RCS hot leg and then splits to provide a flow path to both of the Low Pressure Safety Injection (LPSI) pumps. The LPSI pumps discharge to a common header that contains a total flow control valve (2-SI-306) and two SDC heat exchangers. The discharge flow from the SDC heat exchangers and the flow from the total flow control valve combine. The combined SDC system flow enters the four RCS cold legs through the safety injection nozzles.	PEO-2A, RO-1A Figure 1 Figure 2
The Shutdown Cooling System contains borated water which is a weak acid, so all system piping is constructed of stainless steel. The common 12 inch diameter suction line connects to the bottom of Loop 2 RCS hot leg. The suction line is equipped with two motor operated suction isolation valves (2-SI-652 & 2-SI-651). The common suction line is routed inside Containment to the piping penetration area. The pipe run rises to about 10 inches above the centerline of the Loop 2 hot. This elevation difference creates a high point loop downstream of the motor operated isolation valves but inside Containment. This loop seal can	Figure 3 Figure 4

collect entrained air that could threaten the prime on a LPSI pump operating in the SDC mode. Air entrainment can occur during conditions when level is lowered in the RCS, so a High Point Vent And Vacuum Priming Subsystem has been installed to take a suction at this high point loop seal.	
After passing through the containment wall, the Shutdown Cooling Suction pipe continues for about 10 feet to a manual isolation valve (2-SI-709). After the manual isolation valve, the pipe expands to 14 inches in diameter and runs down to the ESF rooms on the -45 foot level of the Auxiliary Building where it then divides to supply both LPSI pumps. The LPSI pumps are located on the -45 foot elevation of the Auxiliary Building.	Figure 5
The discharge piping for each Shutdown Cooling (LPSI) Pump is 10 inch stainless steel pipe that increases to 12 inch diameter pipe at the point where the LPSI pump discharge lines combine to form the common header containing the SDC Total Flow Control Valve (2-SI-306). The ‘A’ & ‘B’ LPSI pumps are also connected to the SDC heat exchangers. The LPSI pumps are connected to the SDC heat exchangers via 10 inch piping unique to the SDC system. The heat exchangers, which are aligned to the Containment Spray pumps during power operation, are aligned for RCS heat removal while shutdown. Reactor coolant flow is manually aligned to the tube side of either or both heat exchangers. On initial startup both heat exchangers are placed in service and depending on decay heat load, the second heat exchanger may be removed from service. The outlets of the SDC heat exchangers are connected to the common LPSI header downstream of the SDC Total Flow Control Valve (2-SI-306) via 12 inch piping which is also unique to the SDC system. The SDC Total Flow Control Valve is operated in the remote manual mode during Shutdown Cooling operation. The valve is maintained fully open once cooling is initiated.	Figure 5 PEO-2B, RO-1B
SDC flow (and therefore heat transfer) through the SDC heat exchangers is manually controlled utilizing an air operated SDC HX Flow Control Valve (2-SI-657) which is located in the common heat exchanger outlet piping and is positioned from C0-1. The discharge flow from the SDC heat exchangers and the discharge flow from the total flow control valve (2-SI-306) combine, and the total SDC system flow enters the four RCS cold legs through the Safety Injection nozzles. The nozzles penetrate the top of the cold legs and have thermal sleeves that minimize thermal stress imposed on the RCS piping due to the introduction of cold water. The benefits of thermal sleeves are most significant during safety injection when the differential temperature between the metal and the fluid is the greatest.	

The total Shutdown Cooling System flow to the four reactor coolant system cold leg injection points is regulated by throttling the motor operated LPSI loop injection valves during SDC operations. The SIAS open signal to the LPSI injection valves is defeated during Reduced Inventory operations to prevent excessive system flow.	
The Shutdown Cooling System is designed to withstand a static pressure of 300 psig plus an additional 200 PSID of head added by an operating LPSI pump. The pump suction and the pump discharge piping are protected by relief valves. Additional over pressure protection is provided by an interlock which prevents the SDC Suction Isolation valves (2-SI-652 & 2-SI-651) from being opened when wide range Pressurizer pressure exceeds 265 psia. The 300 psig static suction pressure that the Shutdown Cooling System is designed to withstand is the sum of 265 psia Pressurizer pressure plus an additional 35 psia of static pressure due to elevation head.	
4. System Interfaces	
d. Emergency Core Cooling Systems (ECCS)	
The Shutdown Cooling System has only a limited amount of piping and valves used exclusively for SDC system operation. The Shutdown Cooling System makes extensive use of the components and piping of other systems to perform its cooling function. The SDC HXs are shared between the Containment Spray system and the Shutdown Cooling system. LPSI pumps provide the flow of coolant through the SDC heat exchangers. The LPSI and CS systems are ECC systems. The Containment Spray pumps are racked down during SDC operation.	PEO-3A Figure 6
e. Reactor Coolant System (RCS)	
During Shutdown Cooling operations the LPSI pumps take a suction from the RCS through a nozzle on the bottom of the RCS Loop 2 hot leg pipe.	PEO-3B Figure 4
Return SDC flow is through the safety injection nozzle on each of the four reactor coolant system cold leg pipes. This provides four separate flow paths from the SDC system to the reactor core.	Figure 1
f. Reactor Building Closed Cooling Water System (RBCCW)	
The Shutdown Cooling system heat exchangers are cooled by RBCCW which flows through the shell side of the heat exchangers. RBCCW also cools the LPSI pump seals.	PEO-3C

g. Chemical and Volume Control System (CVCS)	
Connections to and from the Chemical and Volume Control System are provided to permit excess letdown and additional purification.	PEO-3D
When RCS pressure is less than 265 psia, insufficient differential pressure exists to achieve the maximum letdown flow rate of 128 gpm using the normal CVCS flow path. Under this condition, the interconnection between SDC and the letdown heat exchanger (via SI-040) is used to provide additional, or "excess," letdown capability. While on SDC, purification of the RCS coolant and refueling pool water may be accomplished utilizing the ion exchangers in the CVCS system. This process is referred to as "Additional Purification."	Figure 7 Figure 8
The cross-connect between the Shutdown Cooling System and the Chemical & Volume Control System (CVCS) allows RCS coolant from the outlet of the SDC heat exchanger to enter the inlet of the letdown heat exchanger (via 2-SI-040). The coolant is then returned to the Shutdown Cooling System at the LPSI pump suction via 2-CH-024.	
h. Spent Fuel Pool Cooling System (SFPC)	
The Shutdown Cooling System can be used to supplement or replace the Spent Fuel Pool Cooling (SFPC) System during periods of high heat load in the Spent Fuel Pool. There is a connection on the LPSI pump suction cross-connect line from the Spent Fuel Pool Cooling system (2-SI-442). The SFPC water is cooled in the SDC heat exchanger and returned to the SFPC system through a return line (2-SI-458) on the outlet of the SDC heat exchangers.	PEO-3E Figure 9 PEO-2C, RO-1C
i. Safety Injection Tanks (SITs)	
The existing Engineered Safety Features (ESF) piping can be used to fill or drain the Safety Injection Tanks using the LPSI pumps.	Figure 10
All SIT isolation valves are maintained closed during normal Shutdown Cooling operation.	
j. Refueling Water Storage Tank (RWST)	
The existing Engineered Safety Features (ESF) piping can be used to transfer water, in either direction, between the RWST and the refueling cavity.	Figure 1

k. Radwaste and ESF Room Ventilation	
The ESF rooms are normally cooled by the Radwaste Ventilation system. To ensure that ambient conditions will allow continuous operation of the LPSI pump motors, room cooling is provided by ESF Room Ventilation during SDC operation. The A and B pump rooms each contain an ESF fan and cooler that provide a closed cycle recirculation of the air within the room. The coolers reject heat to the Reactor Building Closed Cooling Water (RBCCW) System.	
l. In-house Electrical	
The LPSI pumps and LPSI system motor operated valves are powered from emergency buses 24C and 24D. The emergency buses can be powered from the emergency diesel generators on a loss of normal power to the buses and either emergency bus can be powered from Unit 3 through 34A or B.	
m. Equipment Drain Sump Tank	
The Equipment Drain Sump Tank collects the potentially contaminated leak off from the LPSI pump seal packages, drain lines from valves and equipment leak off, LPSI pump drains, and system relief valve discharges for future disposal.	
n. Instrument Air	
Instrument air is used as the motive force for two SDC valves, the SDC Total Flow Control Valve (2-SI-306) and the SDC heat exchanger Flow Control Valve (2-SI-657). Instrument air, along with backup air bottles, also supplies operating air to the Safety Injection Mini Flow Valves (2-SI-659, 660).	
E. MAJOR COMPONENTS	
2. SDC (LPSI) Suction Isolation Valves (2-SI-652, 651)	
d. Purpose	
The SDC Suction Isolation Valves provide for separation of the RCS Loop 2 Hot Leg and the LPSI pump suction during normal power operation.	PEO-4A
e. Design and Operating Characteristics	
The Low Pressure Safety Injection System (Shutdown Cooling suction line) is isolated from the Reactor Coolant System by two, 12-inch, motor operated gate valves (2-SI-652 and 2-SI-651) in series with each other. Both valves are located inside Containment. The valves will fail as is on a loss of power.	PEO-4A Figure 1

Outside containment, there is a 12 inch manual isolation gate valve (2-SI-709) in the LPSI pump suction line. This SDC Suction Header Isolation valve provides for Containment isolation during power operations.	
f. Control and Instruments	
The Suction Line Isolation Valve motor operators are powered from MCC B61 (SI-652) and MCC B51 (SI-651). The 480V power supply to 2-SI-652 is normally isolated in order to prevent inadvertent opening and subsequent system over pressurization during power operation. This isolation switch is located in the Control Room behind panel C80. Operation of this switch will actuate annunciator D-39 on C-01 whenever power is made available to 2-SI-652. To address single-failure concerns for post-accident boron precipitation, 2-SI-651 is equipped with an alternate power supply from 480 volt MCC B61. An administratively controlled kirk-key shifts control to local panel and bypasses the RCS pressure interlock (280 psia).	PEO-4B
The control switches for SI-651 and SI-652 are located in the Control Room on panel C-01. They are two position OPEN/CLOSE keylock switches. Each of the valves has RED (open) and GREEN (closed) indication lights.	RO-2A
Procedurally, the LPSI system, SDC heat exchangers, and interconnecting piping can not be exposed to an RCS pressure greater than 265 psia or temperature greater than 300° F. To protect the piping against excessive pressure SI-651 and SI-652 are interlocked with the low range Pressurizer pressure channels (P-103 and P-103-1). The range of these instruments is 0 to 1600 psia. Pressure is displayed on C-03 and on C-21 and can also be monitored on the Plant Process Computer. The SDC Suction Isolation Valves are interlocked closed if RCS pressure is greater than 280 psia. If SI-651 or SI-652 were already open (i.e. SDC in service) and pressure rose above 280 psia an alarm is received on C01 alerting the operators.	
Each Suction Isolation Valve motor operator has a manual handwheel and clutch mechanism allowing local operation of the valve.	

3. Shutdown Cooling (LPSI) Pumps	
d. Purpose	
When used for Shutdown Cooling operation, the purpose of the LPSI Pumps is to provide shutdown cooling flow through the reactor core and shutdown cooling heat exchangers.	PEO-4C
e. Design and Operating Characteristics	
The LPSI pumps are single stage centrifugal pumps capable of delivering 4500 gpm each at run-out conditions. The pumps are designed to withstand the sum of their suction pressure (300 psig maximum) and the maximum expected discharge head which totals approximately 500 psig. Under no circumstance should the pump discharge pressure (e.g., system pressure) be allowed to exceed 500 psig.	PEO-4C Figure 1
Each pump is equipped with a mechanical shaft seal to minimize leakage of potentially contaminated fluid from the system to the ESF rooms. Seal leakage is contained and directed to the Equipment Drain Sump Tank. The seal package temperature is maintained within limits by water from the pump discharge that has been cooled by RBCCW in its respective seal cooler. The RBCCW flow to the seal coolers is facility specific. The seal package is designed to operate, without the aid of seal cooling, at temperatures as high as 350° F, but cooling is provided to extend the expected operating lifetime for the seal package.	
The LPSI pumps must pump a minimum of 100 gpm each to carry away heat produced by mechanical friction within the pump itself. This minimum flow prevents pump overheating and resultant damage to the pump and pump seal package. To provide this minimum flow, each pump has an orificed minimum flow recirculation line. The recirc line routes a portion of the pump discharge flow back to the Refueling Water Storage Tank (RWST) through a line common to the LPSI, HPSI, and CS Pumps.	
Plant data shows actual minimum flow is approximately 115 gpm. Pump discharge pressure while operating on minimum flow is approximately 220 psig. During inservice testing with a flowrate of approximately 3,100 gpm discharge is approximately 175 psig.	
f. Control and Instruments	
The driving force for the pumps is provided by 400 HP electric motors powered from 4.16 KV emergency buses 24C and 24D for LPSI pumps A and B respectively. The motors are air cooled.	PEO-5
A motor breaker trip will occur as the result of an over-current condition (in excess of 100 amps), or a ground fault. A trip will also	

occur if the motor is running for a non-SIAS condition and a Loss of Normal Power (LNP) occurs. This "Load-shed" trip, generated from the "Main Generator Final Coastdown Circuit," locks out the LPSI pump breaker in preparation for energizing the 24C and 24D buses from the Emergency Diesel Generator (EDG). The LPSI pump breaker must then be reset before the pump can be restarted by the operator. The "Load-shed" trip, generated from the Main Generator Final Coastdown Circuit is blocked during SDC operation.	
The LPSI system pumps will also trip on receipt of a Sump Recirculation Actuation Signal (SRAS). The Engineered Safeguards Actuation System (ESAS) system generates an SRAS when the RWST level lowers to the appropriate level. The occurrence of inadvertent LNP and SRAS signals while on Shutdown Cooling have caused a simultaneous loss of both LPSI pumps and a corresponding loss of core cooling. Because of this, these signals are defeated when Shutdown Cooling is in operation.	Attachment 4
Each LPSI pump has a START/STOP pistol switch with GREEN/YELLOW/RED indicating lights on C-01. The GREEN/YELLOW/RED lights are off, tripped, and run indications.	
Each LPSI pump also has two sets of BLUE/WHITE indicating lights on panel C01X. One set of lights is for SIAS, the other for SRAS. The BLUE light indicates that the pump is in its 'accident required' position and the WHITE light indicates that the pump is unable to perform its accident required function. The white light will light when a loss of control power to the motor's control circuit occurs.	RO-2B
The discharge pressure for each LPSI pump is displayed on C-01 and can be monitored on the Plant Process Computer. The control board meter for the "A" pump (PI-302X) and for the "B" pump (PI-302Y) have a range of 0 to 500 psig.	Figure 11
4. LPSI Mini Recirc Valves (2-SI-659, 660)	
d. Purpose	
The SDC Mini Recirc Valves provide a flow path to protect the LPSI pumps (and other ECCS pumps) from dead headed operation. They provide a flowpath through the pump to remove the heat produced from mechanical friction of pump operation.	PEO-4D

e. Design and Operating Characteristics	
The two valves (2-SI-659, 660) are 4 inch air operated globe valves that fail open on a loss of air. The valves use instrument air as the motive force and each have two accumulators installed in the air supply lines. The accumulators provide sufficient capacity to operate the valves for two cycles following a loss of instrument air supply. An isolated air bottle and regulator for each valve are available as a backup supply in the event of an accident to the instrument air system.	PEO-4D Figure 1
The valves are in series in the recirculation line providing single failure protection when the valves are required to be shut. The valves are normally maintained open.	
During the "warm up" phase of SDC preparation the valves are closed to allow system temperature and pressure to rise.	
During accident conditions the valves are closed during sump recirc to prevent an unmonitored release through the RWST vent to atmosphere.	
When warmup is complete, just prior to initiating Shutdown Cooling, the LPSI pump manual recirc isolation valves (2-SI 449/450) are closed, and 2-SI-659 and 2-SI-660 are re-opened to provide minimum flow protection for the HPSI pumps.	
f. Control and Instruments	
The recirc valves are normally disabled in the OPEN position by a key switch (OPER/INOP) on C-01 to provide for pump recirculation flow during normal plant operation and surveillance. Each valve has a key switch and a handswitch (CLOSE/N/OPEN) for individual operation. With the key switches in the OPER position the valves will automatically close on a Sump Recirculation Actuation Signal (SRAS) or can be manually closed by the operator. In the INOP position the valves cannot be closed either manually or automatically.	RO-2C
The recirc valves CLOSE/N/OPEN handswitch is on C-01 in the main control room and has GREEN/RED indicating lights.	
There are also BLUE/WHITE indicating lights on C-01X in the main control room. The BLUE light indicates that the valve is in its 'accident required' position for SRAS and the WHITE light indicates that the valve is unable to perform its accident required function.	

5. Shutdown Cooling HXs (X-23A, B)	
d. Purpose	
The Shutdown Cooling Heat Exchangers (SDC HXs) transfer heat from the RCS to the RBCCW system during plant cooldown and cold shutdown conditions (i.e., SDC, SFPC operations).	PEO-4E
e. Design and Operating Characteristics	
The SDC HXs (X-23A/B) are U-tube, shell and tube type heat exchangers. There is single pass RBCCW flow on the shell side of the HX. The shell side of the HX is constructed of carbon steel with the wetted surfaces clad with stainless steel. The maximum design pressure and temperature on the shell side are 150 psig and 250° F. The two pass borated water flow is through the U-tubes that are made of Austenitic stainless steel. The maximum design pressure and temperature on the tube side are 500 psig and 400° F.	PEO-4E Figure 1
During power operation, the heat exchangers are aligned to the Containment Spray system. During SDC operations the outlet of the heat exchangers are cross connected to the LPSI System for SDC cooling and related operations.	
The two Shutdown Cooling heat exchangers are located in the "A" and "B" Engineered Safety Features (ESF) rooms on the -45 foot elevation in the Auxiliary Building. Shutdown Cooling System flow through the tube side of the heat exchanger must be maintained at less than 4800 gpm in order to prevent damage to the tubes. Reactor Building Component Cooling Water (RBCCW) from the respective facility is provided to the shell side of the heat exchanger at a rate of up to 4800 gpm. Flow on the shell side is controlled by throttling the RBCCW outlet manual isolation valves (2-RB-14A/B).	
The two heat exchangers are sized to cool the RCS from approximately 300° F to 130° F (and maintain this temperature) 27.5 hours after shutdown.	
f. Control and Instruments	
There are local temperature indicators associated with the shell and tube flows through the heat exchangers. There is a SDC HX OUT TEMP indicator for each heat exchanger on C-01. It has a range of 0° F to 400° F. Additionally, indication of the fluid temperature at the inlet to the Shutdown Cooling heat exchangers is displayed locally on TI-3025 and TI-3026. Heat exchanger temperatures are also available on the Plant Process Computer.	Figure 11

6. SDC Heat Exchanger Flow Control Valve (2-SI-657)	
d. Purpose	
The SDC Heat Exchanger (HX) Flow Control Valve controls the rate of flow through the SDC HX thereby controlling the heat removal rate from the reactor core.	PEO-4F
e. Design and Operating Characteristics	
The SDC Heat Exchanger Flow Control Valve (2-SI-657) is a 10 inch air operated ball valve that fails closed on a loss of instrument air or control power. The operating solenoid for SI-657 receives power from 125 VDC DV10 and the HIC receives power from 120 VAC VA10.	PEO-4F
During SDC operation, flow through the SDC heat exchangers (and therefore heat transfer) is manually controlled by positioning flow control valve (2-SI-657) from HIC-3657 on C0-1. The optimum output range of HIC-3657 is between 35% and 60%. This range was chosen to provide adequate valve motion when responding to SDC temperature perturbations, while yielding a controllable flow change for a small change in controller output. However, controlling outside of this band is acceptable based on what is considered necessary to adequately stabilize SDC and RCS temperatures. Maintaining "SDC FLOW CNTL, FIC-306" in manual and full open also reduces the sensitivity of SDC to RCS, T351Y, to 2-SI-657 position changes.	
When SDC is not in service, the HX flow control valve is disabled in the closed position to ensure system and facility separation during normal plant operation. This is accomplished by:	PEO-6
• Key locked closed on C-01.	
• Manual handwheel disengaged (stem backed out of actuator, locking hex nut tightened) and handwheel locked.	
A manual handwheel was installed on the HX flow control valve because the valve fails closed in the event that a loss of either Instrument Air (IA) or control power resulting in a loss of shutdown cooling. Credit is taken for the handwheel in order to comply with 10CFR50 Appendix R for cold reactor shutdown following a fire.	
The HX flow control valve is equipped with a lantern ring between two sets of stem packing. Leakage collected in the lantern ring is piped to the Auxiliary Building Drains system.	

f. Control and Instruments	
The SDC HX Flow Control valve has a two position keylock (LOCKED CLOSED/MANUAL) switch on C-01 with GREEN/RED indicating lights. The key can only be inserted and removed when the switch is in the LOCKED CLOSED position. The valve can be aligned for remote positioning to support Shutdown Cooling System operation by taking the keylock switch to MANUAL position. In the MANUAL position the solenoid valve (HY657) is energized admitting air to the valve positioner. The valve can then be positioned from the Control Room utilizing HIC-3657 located on C-01. In this alignment the controller allows the Control Room Operator to manually adjust the Shutdown Cooling System flow rate through the Shutdown Cooling heat exchanger(s), and thereby regulate the temperature of fluid being returned to the Reactor Coolant System (RCS).	RO-2D PEO-6
HIC-3657 has a potentiometer and a 0 to 100% scale on its faceplate. When required to operate the SDC HX Flow Control Valve, the key is inserted in the keylock switch and placed in MANUAL. The potentiometer is adjusted to open/close SI-657. When full open the meter will indicate 100% and 0% when full close.	RO-3A
The outlet flow from the Shutdown Cooling heat exchangers is monitored by FE-3023 and FE-3024 for heat exchanger "A" and "B", respectively. The control board meters have a range of 0 to 5000 gpm. Flow is also indicated on the plant process computer.	Figure 11
The Shutdown Cooling heat exchanger flow control valve (2-SI-657) is normally positioned from the Control Room utilizing HIC-3657 on C-01. The valve can also be operated locally using a manual handwheel. The manual operator is normally locked in the full open position whenever the valve is being operated in the air operator mode. In order to use the handwheel a hex nut on top of the actuator needs to be loosened allowing the handwheel to move downward on top of the actuator diaphragm.	
The manual actuator for 2-SI-657 is reverse acting, i.e., clockwise rotation of the local manual handwheel opens the valve by pushing down on the actuator and the valve stem. The downward motion opens the valve. Care must be taken when operating the valve manually to avoid over-torquing and damaging valve components.	
There are two temperature indications available to monitor the SDC performance. These are displayed on a strip chart recorder on C-01 and monitored by the Plant Process Computer. Each has a range of 0 to 400° F. The temperature of the Shutdown Cooling suction line from the Reactor Coolant System (RCS) is monitored by TE-351X and displayed on recorder TR-351 along with the temperature from the LPSI pump discharge common header, downstream of the SDC	Figure 11

Total Flow Control Valve, 2-SI-306 (TE-351Y). The discharge fluid being monitored is the combination of the flow from the heat exchanger(s) and the flow through the total flow control valve.	
7. SDC Total Flow Control Valve (2-SI-306)	
d. Purpose	
The SDC Total Flow Control Valve is normally full open during SDC operations. A mechanical valve stop limits the flowrate in the LPSI system during SIAS operation preventing LPSI pump runout.	PEO-4G
During SDC operations SI-306 and SI-657 are adjusted as necessary to control the rate of temperature change.	
e. Design and Operating Characteristics	
The SDC Total Flow Control Valve (2-SI-306) is a 12 inch air operated ball valve that fails open on a loss of instrument air or control power. The operating solenoid for SI-306 receives power from 125 VDC DV10 and the FIC receives power from 120 VAC VA10.	PEO-4G Figure 1
The discharge of both LPSI pumps passes through the total flow control valve during SDC operation (and SIAS injection). The valve has a mechanical stop that limits how far the valve will open (approximately 50 % open). The purpose of this stop is to limit the flowrate and aid in preventing runout of the LPSI pumps.	
The SDC Total Flow Control Valve is equipped with a pneumatic actuator and a manual actuator that are connected to opposite sides of the valve plug shaft. The air actuator is a spring-to-open diaphragm type actuator.	
The SDC Total Flow Control Valve is aligned to support Shutdown Cooling System operation by taking the keylock switch to the SDC position and operating the FIC in remote manual. Positioning in this alignment is based on maintaining a set Shutdown Cooling system flow based on LPSI pump operation (1 or 2 pumps). Valve position is set using the potentiometer on the front of the controller (FIC-306) located on C-01. A flow sensor, located downstream of the union of the total flow control valve outlet and the SDC HX flow control valve return, measures total system flow. The flow signal from the transmitter is used as an input to the Plant Process Computer (PPC).	PEO-6
When SDC is not in service, the solenoid valve located in the pneumatic signal line to the diaphragm of the actuator for HV-306 is electrically disabled to prevent air pressure from reaching the diaphragm. With no air applied, spring force is sufficient to hold thevalve in the full open position. The manual operator on the opposite side of the shaft can be manually engaged and disengaged from the valve plug shaft by means of a coupling pin. When engaged, this operator has sufficient mechanical advantage to over-ride	PEO-6

operation of the pneumatic actuator in all cases. This handwheel is normally locked to prevent inadvertent operation.	
During power operation, when SDC is not in service, extraordinary care is taken to make certain that the SDC total flow control valve (2-SI-306) cannot be closed when the Emergency Core Cooling Systems (ECCS) are required to be operable. Since it is located in the common LPSI pump discharge header, closure of this valve would prevent LPSI injection flow. Therefore, whenever the LPSI system is required as part of an Operable train of Emergency Core Cooling Systems (ECCS) this valve is aligned such that it becomes a "passive" component (i.e., similar to a piece of piping) by ensuring the valve is:	PEO-6
• Key locked open at C-01. This de-energizes the control circuit and vents the pneumatic operator.	
• Control solenoids for the pneumatic actuator are de-energized electrically by removal of the fuse block associated with the control circuit.	
• The Instrument Air supply to the pneumatic actuator is isolated and the actuator is vented in order to fail the valve open.	
• The local manual operator is engaged, pinned and opened.	
• The local manual operator is chained and locked open.	
The SDC Total Flow Control Valve is equipped with a lantern ring between two sets of stem packing. Leakage collected in the lantern ring is piped to the Auxiliary Building Drains system. During 2R18 a new valve body will be installed due to chronic valve stem leakage in the past. The new packing box will be provided with an enhanced packing arrangement, which will consist of moving the lantern ring to the bottom of packing box and then installing a 5 ring set consisting of Duramettalic D 110, 3 graphite rings and then a Duramettalic packing D 110. This will require removing the packing leak off lines in this DCN package. DM2-00-0166-07.	
f. Control and Instruments	
The SDC Total Flow Control valve has a two position keylock (SDC/SI) switch on C-01 with GREEN/RED (close/open) indicating lights.	
In the SI position the solenoid valve (HY306) is de-energized causing the valve to fail open. The key can only be inserted and removed when the switch is in the SI position.	

The valve is aligned to support Shutdown Cooling System operation by inserting the key and taking the keylock switch to the SDC position and operating the FIC in remote MANUAL. Valve position is manually adjusted using the potentiometer on the front of the controller (FIC-306) located on C-01. A 0 to 100% meter is located on the face of the controller. When the valve is full open the output is 0% and 100% when full closed.	RO-2E RO-3B
A loss of either Instrument Air or control power to the valve results in the valve failing to the full open position. The majority of flow control circuit failures will also cause the valve to fail to the open position. The LPSI injection Valves are maintained in a throttled position during Shutdown Cooling System operation which ensures that the LPSI pumps will not reach run-out conditions in the event that the flow control valve were to fail to its full open position.	
The manual actuator for 2-SI-306 is reverse acting, i.e., clockwise rotation of the local manual handwheel will open the valve. Care must be taken when operating the valve manually to avoid over-torquing and damaging valve components.	
Total flow through the Low Pressure Safety Injection System is monitored by FE-306 and is displayed on a control board meter (FIC-306) which has a range of 0 to 7000 gpm. Total flow indication is also available from the Plant Process Computer.	Figure 11
8. LPSI Injection Throttle Valves	
d. Purpose	
The four LPSI injection valves control the rate of SDC flow into the RCS cold legs.	PEO-4H
e. Design and Operating Characteristics	
The injection valves (2-SI-615, 625, 635, 645) are 6 inch motor operated globe valves. These valves are powered from 480 VAC buses MCC-22-1E and MCC-22-1F (B5118, B5119, B6116, and B6111 respectively). The four injection valves automatically open on receipt of a Safety Injection Actuation Signal (SIAS) from the Engineered Safeguards Actuation System (ESAS). When SDC is in service during reduced inventory operations, the SIAS open signal to the LPSI injection valves is blocked and the valves are positioned by the control room operator.	PEO-4H
The division of Shutdown Cooling flow to the four RCS cold legs is controlled by the motor operated LPSI injection valves. The valves are maintained in a throttled position during Shutdown Cooling System operation to limit total SDC system flow.	

f. Control and Instruments	
Each injection valve has a three position, CLOSE/NORM/OPEN, switch on C-01 with GREEN/RED (close/open) indicating lights.	
There are BLUE/WHITE indicating lights on C-01X in the main control room. The BLUE light indicates that the valve is in its 'accident required' position. The WHITE light indicates that the valve is unable to respond to an accident signal.	RO-2F
Each motor operator has a manual handwheel and clutch mechanism allowing local operation of the valve.	
Each LPSI injection line to the Reactor Coolant System (RCS) contains a flow sensor. These indications (FI-312, 322, 332, 342) are displayed in the Control Room on C-01 utilizing a digital read-out. They are also used as an input to the Plant Process Computer.	Figure 11
A two-inch warming line, containing a manual isolation valve (2-SI-400), extends from the Loop 2A LPSI injection header to the SDC suction line. This warm up line taps off the Loop 2A LPSI injection header prior to the motor operated injection valve (2-SI- 635) and provides a closed loop flow path for SDC warm-up prior to operation of the Shutdown Cooling System. During warm-up of the Shutdown Cooling System, the "LPSI to RCS Loop 2A" flow indicator (FI-332) can be used to monitor warm-up flow. Nominal warm-up flow is approximately 280 gpm. Minimum acceptable flow indication on this meter during system warm-up is 100 gpm (pump minimum flow requirement). Because the meter has a range of 0 to 2000 gpm, the flow rate can be read more accurately at these low flow conditions on the Plant Process Computer.	PEO-4I PEO-2D, RO-1D Figure 12 Figure 11
9. LPSI/SDC Relief Valves (2-SI-469, 468, 439)	
d. Purpose	
Relief valves provide over pressure protection to the SDC system components and piping.	
e. Design and Operating Characteristics	
All the relief valves for the LPSI system are the fully enclosed, pressure tight type relief valve with provisions for gagging the valves.	
Two relief valves are provided on the Shutdown Cooling suction line portion of the Low Pressure Safety Injection system to provide over pressure protection. One of the reliefs (2-SI-469), located between the two motor-operated suction isolations inside the Containment Building relieves to the Primary Drain Tank (PDT).	

The other suction relief valve (2-SI-468) is located on suction line between the outboard containment isolation valve and the pump suctions. This relief discharges to the Equipment Drain Sump Tank.	
Both valves have a lift setting of 300 psig. These relief valves are referred to as thermal reliefs because they are sized to protect against normal thermal expansion that might occur when these portions of piping are isolated and heat up. 2-SI-468 is also sized to provide overpressure protection with all three charging pumps running on a solid RCS. The reliefs do not have sufficient capacity to protect the system against a pressure excursion resulting from exposure to normal RCS pressure (i.e. SDC suction valves opening at NOT/NOP).	
The LPSI discharge header is protected with a single relief valve (2-SI-439), with a lift setting of 500 psig, located on the system discharge piping. This relief valve is connected to the RCS Loop 2B injection line upstream of the LPSI injection valve. It relieves to the Equipment Drain Sump Tank (EDST). The relief valve has backpressure compensation with its setpoint based on the LPSI pump design pressure of 500 psig.	
f. Control and Instruments	
NONE	
10. SDC High Point Evacuation Subsystem	
d. Purpose	
The High Point Vent and Vacuum Priming System has been installed to take a suction at the high point loop seal and remove any collected air and non-condensable gases that could threaten prime on LPSI pump operating in SDC.	PEO-4J
e. Design and Operating Characteristics	
A permanent evacuation system is installed because the common suction line is routed about 10 inches above the centerline of the hot leg over the course of its run from the loop to the piping penetration inside Containment. This elevation difference creates a high point loop downstream of the motor operated isolation valves but inside Containment. This loop seal can collect entrained air that could threaten the prime on a LPSI pump operating in the SDC mode. Air entrainment can occur during conditions when level is lowered in the hot leg.	PEO-4J Figure 4
The 12-inch suction line for the Shutdown Cooling System rises to the 6' 8" elevation before dropping down to the 0'6" level containment penetration. Approximately 27 feet of 12-inch pipe runs horizontally at the 6' 8" elevation (about 10 inches above the	Figure 13

centerline of the hot leg) creating a significant volume in which air can collect. The evacuation sub-system connects to a 3/4" vent on the top of this horizontal piping run by means of a flexible stainless steel hose.	
The Vacuum Priming System consists of a vacuum pump (P-174), a carry over tank, and a vacuum flask. The vacuum pump draws a vacuum on the carryover tank which is connected to the vacuum flask. The vacuum in the vacuum flask draws air and other gases from the SDC system high point vent. Any liquid pulled from the SDC system is collected in the vacuum flask and if that becomes full, the liquid overflows to the carry over tank.	
This connection is made prior to draining the RCS for the purpose of establishing RCS level within the hot leg. A check valve, installed close to the manual vent valve (2-SI-43A), prevents air back-flow into the system and eliminates the need for the operator to manually control the vent valve position during each evacuation. Any water collected in the evacuation system is drained to a SIT sample sink in Containment.	
f. Control and Instruments	
All components and controls are located within a cabinet located in the west electrical penetration area on the 14’6” level of Containment. This location was chosen to limit the radiation exposure during use.	
The cabinet is energized by taking a switch, inside the cabinet to ON. The vacuum pump, P-174, has a START/STOP switch used to control operation. The system is powered from Lighting Panel L94, supplied by B61. The unit is operated locally whenever reactor level is lowered below 21 inches above the centerline of the hot leg and the possibility for vortexing exists.	
11. Reactor Coolant System Level Indication	
d. Purpose	
Reactor Coolant System level indication is required to support Shutdown Cooling System operation under reduced RCS level conditions by ensuring adequate monitoring and control of RCS inventory.	
e. Design and Operating Characteristics	
Under reduced RCS level conditions, reactor vessel level increases can result in coolant overflowing through openings, scalding workers or damaging equipment. Reactor vessel water level decreases of a few inches threaten core cooling by disabling SDC through air entrainment. Because of the reduced coolant inventory at these levels, a loss of SDC can result in rapid heatup rates, boil-off of reactor coolant, and potential core damage. Under reduced RCS	

level conditions, additional attention is required to ensure adequate monitoring and control of RCS inventory.	
Two standpipe assemblies are connected to the Loop 1 RCS hot leg low point drain header. One standpipe contains a thermal dispersion continuous level sensor (LT-112) which uses a heated/unheated RTD for readout via the Plant Process Computer. The other (LI-112) contains a magnetic float that repositions "flags" for local direct visual indication. On Loop 2 of the RCS an ultrasonic level sensor non-obtrusively measures level in the hot leg piping. These detectors are zero referenced to the RCS hot leg centerline.	Figure 14 Figure 15
The standpipe level indicators are normally isolated from the Reactor Coolant System in Modes 1 through 4 by manual valves (2-RC-214 and 2-RC-433). These level detectors are connected to this point via flange adapters and quick disconnects. The high side of these detectors connects, via a transition tubing assembly, to the Reactor Vessel head vent, to the Pressurizer vent, and to the inlet of the Enclosure Building Filtration System fan at 2-EB-86.	Figure 4
f. Control and Instruments	
The Loop #1 standpipes provide a continuous readout of RCS level from -21" to +99", while the Loop #2 ultrasonic level sensor has a range of -17" to +21". These are both in reference to the hot leg centerline. During RCS level changes the ultrasonic level detector updates immediately if an RCS level change occurs. The response of Loop #1 RTD level sensor will lag the ultrasonic sensor by approximately 2 minutes. Direct visual indication of RCS level is provided by the magnetic flags within the Loop #1 standpipe, either locally or by remote television monitoring in the Control Room. This remote visual indication is designed to be used as a "cross-check" of the two electronic hot leg sensors.	Figure 15
Both hot leg electronic level instruments send their outputs to the Plant Process Computer for processing and display. The ultrasonic level indication is calibrated for a water density that corresponds to a fluid temperature of 110° F. Therefore, the output of the ultrasonic level detector on Loop #2 must be corrected for any change in the water temperature. This is automatically accomplished by the Plant Process Computer.	Figure 16 Figure 17
The Heated Junction thermocouple (HJTC) Reactor Vessel Level Monitoring System (RVLMS) provides reliable indication of reactor vessel level during Reactor Coolant System drain down evolutions. HJTCs #4, #5, and #6 correspond to the top, center, and bottom of the hot leg. This indication system is only available when the Reactor Vessel head is in place and the HJTCs are electrically connected. Indication is provided on the Plant Process Computer (PPC) and the Inadequate Core Cooling Monitoring panels in the computer room.	Figure 18 Figure 19

F. OPERATION	
2. Normal Operation (Shutdown Cooling in Service)	
Normal Shutdown Cooling (SDC) operation involves using the LPSI system as a portion of the SDC system. As such, it is routinely operated when in Modes 4, 5, and 6.	
In Modes 4 and 5 Technical Specifications require two operable cooling loops. If RCPs and steam generators are inoperable, then both SDC trains are required to be operable.	T/S 3.4.1.3a
In Mode 6 Technical Specifications require two SDC loops to be Operable if Vessel water level is not at or above the vessel flange.	TS 3.9.8.2
In Mode 6 Technical Specifications require a Shutdown Cooling loop must be in operation unless core alterations in the vicinity of the RCS hot leg requires flow to be stopped. In this case flow can be secured for up to one hour per 8 hour period.	T/S 3.9.8.1
Both LPSI trains contain cross-connections with the Containment Spray System for Shutdown Cooling operation.	
The LPSI system has interconnections with the Chemical & Volume Control System to provide purification and inventory control.	
The LPSI system has interconnections with the Spent Fuel Pool Cooling (SFPC) system to provide supplemental cooling during periods of high heat load on the SFPC system.	
The LPSI system is used for some infrequent non-routine operations such as transferring water between the Refueling Water Storage Tank (RWST) and Refueling Cavity and for Recirculation of the RWST. The LPSI pumps, as a portion of the Shutdown Cooling system, can also be used to fill the SITs.	
An engineering evaluation of LPSI pump operations has determined that operation of the LPSI pumps at low flows for extended periods of time (greater than 30 minutes) has the potential to cause severe pump damage. When the LPSI pumps are operated at flows significantly less than design flow, internal recirculation flows develop which cause cavitation, pressure pulsations, unbalanced forces, and vibration. These effects can lead to erosion, unstable head-flow characteristics, and failures of pump internals, seals, and thrust bearings. Extended operation at low flow can progressively damage a pump with no evidence from performance testing until eventual failure.	Engineer's Memo TS2-97-530
The minimum flow recirculation is sized only to prevent short term overheating of the pump and is not designed for long term operation. For short term testing, flow provided by the recirculation line is acceptable for periods of 15 to 30 minutes.	

Extended operation at low flow will not result in noticeable short term degradation, but will result in accelerated wear of pump components. The decision to operate the pumps for longer or lower flow rates than recommended must be made carefully. An immediate plant safety issue takes precedence over meeting the recommended flow rates. However, meeting the recommended flow rates clearly takes precedence over operations of convenience. In all cases, for pump operation below design flow, the pump flow rate should be as high as reasonably achievable up to the design flow rate.	
d. Precautions	
The following precautions, their bases, and parameters used for monitoring the conditions (if available) are associated with the SDC System:	OP 2310
RCS heatup and cooldown rates shall be maintained as specified in SP 2602B, "Transient Temperature, Pressure Verification."	RO-4
Basis -- Technical Specifications require that temperatures will be determined at least once every hour. Using SP 2602B allows the operator to meet the surveillance requirement and enables closer trending by determining the temperatures at shorter time intervals.	
When returning "SDC SYS HX FLOW CNTL, SI-657," to the air operated mode, to prevent a restriction to closing, the handwheel must be locked in full up position.	PEO-7
Basis -- A manual handwheel was installed on the HX flow control valve because the valve fails closed in the event of a loss of either Instrument Air or control power resulting in a loss of shutdown cooling. The manual actuator for 2-SI-657 is reverse acting, i.e., clockwise rotation of the local manual handwheel opens the valve by pushing down on the actuator and the valve stem. During normal SDC operation, when the valve is in the air operated mode, the manual operator is disengaged and locked in the full out position which allows unimpeded control of flow through the SDC heat exchangers by positioning flow control valve (2-SI-657) from Main Control Board C0-1.	

During operation of SDC, the following limits shall not be exceeded: • *RCS pressure greater than 265 psia, indicated on pressurizer pressure low range instruments, P-103 and P103-1* • *RCS T_{HOT} greater than 300° F* • *LPSI pump discharge pressure greater than 500 psig* • *LPSI pump motor amps less than 52 amps* • *LPSI pump flow less than 4,000 gpm* • *SDC flow through each SDC heat exchanger greater than 4,800 gpm [Ref. 6.10]* • *RBCCW flow through each SDC heat exchanger greater than 4,800 gpm [Ref. 6.10]* • *RBCCW header flow greater than 8,000 gpm*	RO-4
Basis -- The Shutdown Cooling System is designed to withstand a static pressure of 300 psig plus an additional 200 psid of head added by an operating LPSI pump. Relief valves on the suction piping are set for 300 psig, and the pump discharge piping is protected by relief valves set to lift at 500 psig. Additional over pressure protection is provided by an interlock which prevents the RCS outlet valves (2-SI-652 & 2-SI-651) from being opened when Pressurizer pressure exceeds 280 psig. The 300 psig static suction pressure that the Shutdown Cooling System is designed to withstand is the sum of 265 psia Pressurizer pressure plus an additional 35 psi of static pressure due to elevation head.	PEO-8
The limit of 4,800 gpm SDC flow through a single SDC heat exchanger is to prevent tube side HX damage. The SDC flow can be read from the CS FLOW indicators (FI-3023, 3024) on C-01 or from the PPC.	
The limit of 4,800 gpm RBCCW flow through a single SDC heat exchanger is to prevent shell side HX damage. The RBCCW flow can be read from the SDC HX A(B) RBCCW OUT FLOW indicators (FI-6042, 6043) on C-06 or from the PPC.	
Limiting RBCCW header flow to 8000 gpm prevents run out of the RBCCW pump.	
The SDC system is potentially radioactive. Radiological procedures must be strictly adhered to during any venting, draining, or other operations which could result in radiation exposure or contamination of personnel.	PEO-7 RO-4
Basis -- The RWST is used as the supply for filling the LPSI system piping. The water flowing through the SDC system is RCS water. This is contaminated water and when vented or drained must be	

contained to prevent an uncontrolled radioactive release. As this water is being vented it is possible for airborne contamination levels to increase requiring air monitoring and proper breathing apparatus.	
The SDC System may be secured for up to 1 hour per 8 hour period, during core alterations in the vicinity of the reactor vessel hot legs.	RO-4
Basis -- This is a footnote to the Tech Spec requirement for SDC operability to allow for fuel movement without the induced movement of refueling mast/fuel assemblies due to SDC flow.	
One SDC train shall have an OPERABLE diesel generator. The other train of SDC may be supplied from its normal power supply (e.g. diesel generator is not required to be OPERABLE).	RO-4
Basis -- This meets the electrical power supplies required by Tech Specs and still allows for flexibility of maintenance during outages.	
With fuel in the reactor vessel, RCS temperatures shall be maintained greater than or equal to 68° F [Ref. 6.5].	RO-4
Basis -- This is the minimum temperature that the reactor vessel will experience deformation prior to a fracture of the vessel.	
To minimize the consequences of boron dilution accidents, SDC flow shall be maintained greater than or equal to 1000 gpm based on the sum of LPSI injection flow indicators. [Ref. 6.6].	RO-4
Basis -- This precaution applies only when SDC is initiated without concurrent RCP operation. Maintaining flow greater than or equal to 1000 gpm ensures sufficient coolant circulation through the reactor core to minimize the effects of a boron dilution incident and to prevent boron stratification. This flow can be read on SDC FLOW indicator (FI-306) on C-01 or from the PPC.	
The following valves are reverse operating valves; counterclockwise rotation of the handwheel closes it and clockwise rotation of the handwheel opens the valve: • *SDC System total flow valve, 2-SI-306* • *SDC System heat exchanger flow control valve, 2-SI-657* • *SDC to SFPC stop, 2-RW-15*	PEO-7
Basis -- Because these valves are reverse operated, counterclockwise rotation of the handwheel closes the valves and clockwise rotation of the handwheel opens the valves. This is the opposite of standard engineering practices for manual valve operation. Care must be taken when operating these valves manually to avoid over-torquing and damaging valve components.	
When SDC is not in service, the solenoid valve located in the pneumatic signal line to the diaphragm of the actuator for SI-306 is	

electrically disabled to prevent air pressure from reaching the diaphragm. With no air applied, spring force is sufficient to hold the valve in the full open position. The manual operator on the opposite side of the shaft can be manually engaged and dis-engaged from the valve plug shaft by means of a coupling pin. When engaged, this operator has sufficient mechanical advantage to over-ride operation of the pneumatic actuator in all cases. This handwheel is normally locked to prevent inadvertent operation.	
A mechanical stop has been placed on "SDC SYS TOTAL FLOW, SI-306" to limit flow and prevent run out of LPSI pumps during SI operation. It is still necessary to throttle LPSI injection valves. Total SDC flow must not exceed 4000 gpm during single pump operation or 7000 gpm during 2 pump operation [Ref. 6.4 and 6.6].	RO-4
Basis -- Total Flow control Valve, 2-SI-306, has a mechanical stop that limits how far the valve will open (approximately 50 % open). The discharge of both LPSI pumps pass through the flow control valve during SIAS injection. The purpose of the mechanical stop is to limit the LPSI flowrate, preventing runout of the LPSI pumps during SIAS injection. During Shutdown Cooling operation, the LPSI injection valves are maintained in a throttled position which ensures that a single LPSI pump will not reach run-out conditions.	
IF in MODE 4 or higher with the following open, a dedicated operator shall be stationed: • *SIT injection header recirculation stop, 2-SI-463*	PEO-7 RO-4
Basis -- The SIT injection header recirculation stop, 2-SI-463, and *SDC System suction isolation valve, 2-SI-709,* are containment isolation valves that are required to be closed and locked in Operational Modes 1 through 4 for Containment integrity. However, the valves may be opened on an intermittent basis under administrative control (dedicated operator), as specified in Technical Specifications LCO, 3.6.3.1, Table 3.6-2.	
Operation of LPSI pumps at less than 1,650 gpm should be minimized. Prolonged operation of LPSI pumps at reduced flow, less than 1,650 gpm, can cause premature wear of pump components. Operation of LPSI pumps at less than 100 gpm (minimum flow requirement) is prohibited.	RO-4
Basis -- An engineering evaluation of LPSI pump operations has determined that operation of the LPSI pumps at low flows for extended periods of time (greater than 30 minutes) has the potential to cause severe pump damage. When the LPSI pumps are operated at flows significantly less than design flow, internal recirculation flows develop which cause cavitation, pressure pulsations, unbalanced forces, and vibration. These effects can lead to erosion, unstable head-flow characteristics, and failures of pump internals, seals, and	

thrust bearings. Extended operation at low flow can progressively damage a pump with no evidence from performance testing until eventual failure. This flow can be read on SDC FLOW indicator (FI-306) on C-01 or from the PPC.	
System adjustments covered in this procedure can significantly reduce core heat removal for short periods of time. Total loss of core heat removal may, depending on power history, cause a RCS heatup of up to 5° F in one minute. To minimize impact, careful coordination of activities is required to reduce the time required for adjustments.	PEO-7 RO-4
Basis -- Due to the integrated relationship between the RCS, SDC, RBCCW systems, and their interconnected systems a change in any parameter or configuration has the potential to ultimately affect core heat removal capabilities. All actions must be carefully planned, slowly performed, and system changes anticipated prior to and during plant activities.	
e. Startup	
The SDC system can be aligned and operated either with or without concurrent RCPs operating during the cooldown. In order to place SDC in service the following major evolutions associated with the SDC system are performed:	PEO-9
• Preliminary SDC preparations	
• Boron equalization	
• SDC system warmup	
• SDC Initiation	
1. Preliminary SDC preparations	
Preparations for Shutdown Cooling System initiation are commenced as soon as Mode 3 is entered and primary plant pressure has been decreased to less than 1750 psia. The preliminary SDC preparations are the same, independent of whether or not RCPs will be left running. The following major actions are performed in preparation of starting up SDC:	
1) The "Load-shed" trip, generated from the "Main Generator Final Coastdown Circuit is blocked to prevent LPSI pumps from tripping during turbine testing or 345 KV breaker operation.	
2) RBCCW is manually aligned to the SDC heat exchangers, and ESF Room Ventilation is placed in service on room(s) in which LPSI pumps will be operated.	
After the preliminary preparations are completed the decision is made on whether the SDC system cooldown will be conducted with or	

without concurrent RCP operations. If the decision is made to perform SDC operations with concurrent RCP operation than the SDC evolutions performed include the applicable actions for SDC system alignment, warmup, and initiation. If the decision is made to perform SDC operations without concurrent RCP operation than the SDC evolutions performed include the applicable actions for SDC system alignment, boron equalization, warmup, and initiation.	
Prior to aligning SDC to the RCS, the required HPSI pump is placed in the PTL position to prevent an inadvertent start from overpressurizing the SDC piping.	
2. Preparation For SDC Operation With Concurrent RCP Operation	
Because the SDC system will be providing cooling flow with RCP flow through the RCS the preparations and warmup of the SDC system are not as time consuming or restrictive as they are without RCP operation. With RCP operation there is better mixing and less thermal transients to the RCS and especially the reactor vessel belt line.	
The following major actions are performed in preparation of SDC operation with concurrent RCP operation:	
1) The SDC Total Flow Control Valve is placed in manual remote control.	Figure 12
2) The system is recirculated to partially warmup the SDC system by opening the SDC warm-up valve (SI-400) and establishing a closed loop flow.	
3) Warmup is stopped after a concurrent temperature and pressure rise is observed. A concurrent pressure and temperature increase indicates a “tight” system. A full warmup of the SDC system is not required when initiating Shutdown Cooling with concurrent RCP operation.	
4) RBCCW flow is established through the shell side of the Shutdown Cooling Heat Exchanger(s).	
During the warmup, one LPSI pump is in operation and can heat-up the system at about 11° F/hr. Operation of two LPSI pumps in this line-up is prohibited in order to prevent operation of pumps with insufficient cooling flow through them. This could occur if the discharge check valve on one of the two operating LPSI pumps were to be forced closed as the result of unbalanced LPSI pump performance. If this were to occur, the pump could overheat resulting in severe damage.	
After the SDC preliminary preparations have been completed, at the appropriate time in the cooldown evolution the SDC system is placed	

in service concurrent with RCP operation.	
3. Shutdown Cooling Initiation With Concurrent RCP Operation	
The SDC system is placed in operation when RCS Tcolds are between 240 to 260 °F with RCS pressure less than 265 psia. Also, the SDC boron concentration must be 1.1 times the required RCS Cold Shutdown Concentration. This requirement will prevent the SDC system from diluting the RCS below the Cold Shutdown Concentration. The following major actions are performed to initiate SDC with concurrent RCP operation:	
1) Prior to placing SDC in operation, all SIT isolation valves are checked closed, and the SIT isolation valve circuit breakers are red tagged OFF.	Figure 1
2) Provide a suction from the RCS via 2-SI-651 and 2-SI-652, and then cracking open one of 4 LPSI throttle valves (2-SI-615, 625, 635, or 645) as indicated by dual indication on C-01.	
3) Monitor pressurizer level for indications of leakage from the SDC as indicated by a lowering pressurizer level when the SDC system is opened to the RCS.	
4) One LPSI pump is started.	
5) When SDC to RCS temperature (T351Y) is within 20° F of hot leg temperature, the desired LPSI flow is established by throttling open all four of the LPSI injection valves.	
6) RBCCW flow is then adjusted to the required value.	
7) SDC cooling flow through the Shutdown Cooling Heat Exchangers is initiated (using HIC- 3657) to obtain a 40° F delta T between SDC suction temperature (T351X) and SDC return flow (T351Y).	
Once SDC cooldown has been established the operators must ensure that RCS system response is within Technical Specification Cooldown limits. SDC flow through the SDC HXs is controlled to control the cooldown rate. If required by decay heat, a second LPSI pump is started and the LPSI injection valves are throttled to maintain flow limits.	
4. Preparation For SDC Operation Without Concurrent RCP Operation	
If the decision has been made to place SDC inservice without concurrent RCP flow then additional requirements with SDC boron equalization and warmup are performed. The SDC system must be recirculated to ensure that the boron concentration within the Shutdown Cooling System piping is equal to, or greater than the	Figure 20

existing RCS boron concentration. This ensures that an inadvertent dilution of the RCS and corresponding loss of shutdown margin does not occur when system flow is initiated. This is performed prior to decreasing RCS pressure below the shutoff head of the LPSI pumps (approximately 220 psig), ensuring that the SDC system does not inject water into the RCS while recircing to the RWST.	
The following major actions are performed for preparing the SDC system for operations without concurrent RCP operation:	
1) Ensure the Safety Injection Actuation Signals are blocked then align and vent the SDC system for boron equalization.	
2) The SDC system is aligned for recirculation back to the RWST.	
3) The Safety Injection Tank (SIT) isolation valves (2-SI-614, 624, 634, & 644) are closed to prevent discharging the Safety Injection Tanks, via the recirculation header, to the RWST.	
4) The recirculation lineup is completed and a LPSI pump is started.	
5) After 10 minutes operation the first LPSI pump is shutdown and the idle LPSI pump is started to ensure the boron concentration is equalized in all the SDC system piping.	
6) When SDC boron concentration has been equalized the LPSI pump is shutdown and the recirculation path secured.	
The boron equalization flow path recirculates the entire SDC system. Water is taken from the RWST and pumped through each LPSI pump and SDC heat exchanger. The discharge from the common discharge header goes through all four LPSI Injection Valves. The four Check Valve Leakage Drain Stop Header valves are opened which aligns the LPSI injection lines to the SIT injection header recirculation line. The water flows through this line back to the RWST.	PEO-2E, RO-1E
During this evolution, because the SITs are isolated, Boron Equalization must be completed in the minimum time possible. In no case may this time exceed 3 hours. Minimizing the period of time these tanks are isolated is done due to concern for a LOCA occurring between 1750 and 600 psia.	
After Boron Equalization has been established the SDC is then warmed up prior to being placed in service.	

5. System Warmup Without Concurrent RCP Operation	
Warm-up of the Shutdown Cooling Systems is commenced after Chemistry has confirmed that the boron concentration in the Shutdown Cooling System is equal to or greater than the existing RCS boron concentration. The following major actions are required to warmup the SDC system prior to placing it in service without concurrent RCP operation:	
1) The Total Flow Control Valve and the SDC HX Flow Control Valve are both opened.	
2) The SDC warm-up valve (SI-400)is opened and the closed loop flowpath is establish.	
3) One LPSI pump is started to commence SDC system warmup.	
4) Continue running one LPSI pump until the SDC to RCS Temperature (T351Y) is greater than 150° F.	
When the SDC to RCS Temperature (T351Y) is greater than 150° F and a LPSI pump is operating, the SDC system can be aligned to commence cooling the RCS without concurrent RCP operation. The 150 F value bounds the	
The concern when initiating SDC flow without concurrent RCP operation is the rate of change in the temperature of the water to which the reactor vessel belt line is exposed. When SDC is first initiated the temperature of the water near the belt line changes from a value in the range of 230 to 260 °F to 150 °F. This cooldown rate exceeds that allowed by Tech Specs. This exceedence requires the performance of an Engineering evaluation. Since this evaluation must be made each time SDC is initiated without concurrent RCP operation Engineering has generated a generic evaluation to cover this event in advance. The 150 °F limit ensures that the bounding assumption made regarding initiation temperature is valid. Therefore the generic evaluation can be used to fulfill the Engineering evaluation for each occurrence.	
6. Shutdown Cooling Initiation Without Concurrent RCP Operation	
The Shutdown Cooling System is placed in operation after boron equalization and system warmup have been completed and the RCS is less than 260° F (preferably approximately 230° F) and less than 265 psia.	
The following major actions are performed to initiate SDC without concurrent RCP operation:	
1) SDC system alignment for initiation is verified.	
2) All SIT isolation valves are closed, and the SIT isolation valve	

circuit breakers are red tagged OFF prior to placing SDC in operation.	
3) The operating RCPs are stopped and RCS pressure is reduced to less than 265 psia using auxiliary spray.	
4) The SDC system suction isolation valves (SI-651, 652) are opened.	
5) The SDC total flow control valve is opened and the SDC HX flow control valve is closed.	
6) RBCCW flow is established through the SDC HXs.	
7) All four LPSI injection valves are throttled open (400 - 600 gpm each) to establish initial flow to RCS.	
8) When SDC to RCS temperature (T351Y) is greater than RCS Tcold temperatures the SDC warmup valve (SI-400) is closed.	
9) The SDC injection valves are throttled open (800 - 1000 gpm each) to establish total system flow of 3500 - 4000 gpm to RCS.	
10) RCS cooldown is established by adjusting SDC HX and RBCCW flow rates.	
11) The LPSI minimum flow manual isolation valves (SI-449/450) are closed and the minimum flow valves (SI-659/660) are re-opened to maintain a minimum flow path for the HPSI pumps.	
The plant can then be cooled down at a rate to be established by the Control Room Operator but not to exceed 50° F/hr (Less than or equal to 50° F/hr below 220° F).	
Any time any of the following parameters are changed, clear strategies need to be developed and discussed:	
• SDC Total Flow Control valve position.	
• SDC HX Flow Control Valve position.	
• SDC HX manual outlet valve's position.	
• RBCCW flows and temperature changes.	
Changing the position of SI-306, SDC Total Flow Control Valve, affects the system pressure upstream of the valve. Specifically, if SI-306 is throttle in the closed direction then the upstream pressure rises and the down stream pressure lowers. This additional differential pressure is felt across the parallel path that includes the SDC heat exchangers and SI-657, SDC HX Flow Control Valve. This pressure rise is sensed at the inlet to the SDC heat exchangers and SI-657. Since the position of SI-657 is controlled from C01, without operator action the flow through the heat exchangers and SI-657 will rise when	

SI-306 is throttled closed. This will cause SDC return temperature to lower. If SI-306 is throttled open the flow through the SDC heat exchangers will lower causing SDC return temperature to rise.	
7. Shifting SDC Heat Exchanger Operations	
When shifting from two SDC HX operation to one SDC HX operation the following conditions should be considered:	
• It is preferable to do this while maintaining a steady RCS temperature. This evolution could cause a change in RCS temperatures due to removing the HX. If RCS temperatures are already changing, this activity could increase the temperature changes.	RO-5A
• It is preferable to use only one LPSI pump while performing this evolution. When going from two HXs to one HX the possibility exists to exceed the maximum SDC flow rate through the one HX before completing the evolution.	RO-5B
• This evolution can not be performed during concurrent RCP operation. With an RCP in operation, one SDC HX can not remove the pump heat and maintain core temperatures.	RO-5C
• If RCS temperature is low and decay heat load is high performing this evolution may cause RCS temperatures to rise. The operator should be aware that with high decay heat loads, one HX may be operating close to its thermal capacities.	RO-5D
Shifting from two HXs to one HX consists of the following major actions:	
1) RBCCW flow to the HX left inservice is increased to maintain RCS temperatures.	
2) The LPSI inlet valve, outlet valve, and RBCCW outlet valve for the HX being removed from service are closed.	
3) SDC temperatures and flows are monitored and adjusted as necessary.	
Placing a second SDC HX in service should be a slow controlled evolution. SDC temperatures can change drastically by even minute changes in SDC parameters .	
Shifting from one HX to two HXs consists of the following major actions:	
1) Boron concentration in idle components is verified greater than or equal to required RCS boron concentration.	
2) The LPSI pump inlet to the idle HX is opened and the SDC side of the HX is vented.	

3) PPC trend of SDC data is established to monitor system changes.	
4) RBCCW flow is established through the idle HX.	
5) SDC flow through the idle HX is established by opening the SDC HX outlet isolation valve.	
6) SDC and RBCCW flows are modulated to maintain desired SDC and RCS temperatures	
Whenever SDC HXs are shifted, it is important to ensure that the maximum SDC flow (4800 gpm) and RBCCW flow (4800 gpm) through a single HX not be exceeded. Also, to prevent exceeding the applicable heatup and cooldown rates the SDC temperature to the RCS should be as stable as possible prior to starting the evolution.	
f. Power Operation	
The SDC System is not operated when the plant is at power. However, Technical Specifications require that the LPSI system components that are normally part of the ECCS must be operable whenever the plant is in Modes 1, 2 or 3* (* RCS pressure greater than 1750 psia).	
An Administrative requirement also exists to have these components operable whenever the primary plant pressure is greater than 400 psia. This maximizes the availability of LPSI to inject should a Loss of Coolant Accident occur while at reduced RCS pressures.	
g. Shutdown (Securing SDC)	
At the completion of the plant shutdown preparations are made to commence a plant heatup and startup. At the appropriate time the SDC system is shutdown and realigned for heatup/startup.	
The following major evolutions are performed to shutdown the SDC system and align its components for plant operation:	PEO-10
• SDC flow is terminated.	
• Safety injection headers are recirculated following SDC termination.	
1. Shutdown Cooling Termination	
The Shutdown Cooling System is removed from operation when Shutdown Cooling inlet temperature is between 200 °F and 240 °F. The 200 °F limit protects the piping between SI-651 and SI-709 from rupturing in a post LOCA environment. This section of pipe is not protected by a relief. By ensuring the temperature of the water in pipe when isolated is greater than 200 °F the thermal expansion of that water volume will not rupture the pipe. To prevent thermal binding of SDC suction valves 2-SI-651 and 2-SI-652 the water temperature	

in the pipe must be less than 240 °F when isolating SDC. This ensures the valves will not bind after they cool to ambient temperatures.	
The following major actions are performed to terminate SDC flow:	
1) The SDC HX flow control valve is closed.	
2) The running LPSI pump is shutdown.	
3) The LPSI injection valves and the SDC suction isolation valves are closed.	
4) Two RCPs are started and the SGs are used for heat removable.	
5) The SDC system is aligned to flush the system with RWST water to ensure boron concentration is at the RWST value.	
6) Each LPSI pump is run for 15 minutes on recirc back to the RWST.	
7) The LPSI and Containment Spray systems are aligned for normal at power operation.	
After the LPSI pumps are recirculated/flushed back to the RWST the Safety Injection Headers are recirculated/flushed to ensure their boron concentration is at RWST concentration. Normal at power operation requires that the ECCS system inject borated water at greater than 1720 ppm on a Safety Injection actuation.	RO-6
2. Recirculating SI Headers Following Termination of SDC	
The Safety Injection (SI) headers are recirced when RCS pressure is greater than 295 psia and the LPSI and CS systems have been aligned for normal power operation. Prior to initiating recirculation the SIT outlet valves are closed to prevent draining SITs to the RWST via the recirculation line.	
The following major actions are performed to recirculate the SI headers following termination of SDC flow:	
1) The recirculation header is aligned for flow back to the RWST.	
2) One LPSI pump is started to pressurize the system.	
3) The SDC heat exchangers and their piping are flushed through SI-460 at 1500 gpm for 15 minutes.	
4) The #1 and #2 SIT outlet isolation valves are closed. Then SI-615 and SI-625 are opened. Next SI-618 and SI-628 are throttled open to obtain approximately 15 gpm flow back to the RWST for at least 15 minutes. This action can be done while flowing water through SI-460.	

5) The LPSI pumps are swapped to flush the pump. SI-460 is throttled again to 1500 gpm for 15 minutes.	
6) The #3 and #4 SIT outlet isolation valves are closed. Then SI-635 and SI-645 are opened. Next SI-638 and SI-648 are throttled open to obtain approximately 15 gpm flow back to the RWST for at least 15 minutes. This action can be done while flowing water through SI-460.	
7) Upon completion of the flush the pump is stopped and the valves properly aligned.	
When flushing operations have been completed, the RWST is sampled to ensure that it has not been diluted to below the required boron concentration (greater than 1720 PPM) for power operation.	
3. Restoration of SIAS Open Capability to LPSI Injection Valves when exiting Reduced Inventory Operations	
When Reduced Inventory Operations was entered the SIAS signal was prevented from positioning the LPSI Injection Valves on an inadvertent SI actuation signal. This protected the SDC from the excessive flowrates that would have occurred if the LPSI valves were to get an SIAS actuation signal during reduced inventory operation.	
When reduced Inventory Operations is exited the SIAS open capability is restored to the LPSI injection valves. The Maintenance department removes the jumpers and reinstalls the lifted leads for each of the LPSI injection valves. When the SIAS open capability has been restored, the operators will conduct the SIAS Operability test for all four LPSI Injection Valves.	
3. Abnormal Operation	
d. Loss of Shutdown Cooling	
The loss of Shutdown Cooling requires that timely action be taken by the operator to restore cooling to the core. Prompt restoration of cooling flow will help to avoid core boiling. Loss of shutdown cooling has been most commonly initiated by the accidental closure of a SDC suction valve, low reactor vessel level resulting in a loss of LPSI pump suction, or an inadvertent trip of the running LPSI pump. The inadvertent closure of a suction valve would require a manual trip of the running pump(s) and termination of any evolutions in progress (such as "Excess Letdown", filling a SIT, etc.). Guidance is provided in AOP 2572 (and OP 2310 and 2306) on the actions required to be taken by the operator for any of these events.	
e. Additional Purification	
While on SDC, purification of the RCS coolant and refuel pool water may be accomplished utilizing the ion exchangers in the CVCS	Figure 7

system. This process is referred to as "Additional Purification."	
The cross-connect between the Shutdown Cooling System and the Chemical & Volume Control System (CVCS) allows reactor coolant from the outlet of the SDC heat exchanger to enter the inlet of the letdown heat exchanger (via 2-SI-040). This provides additional assurance that the fluid temperature at the inlet of the ion exchangers will be maintained at less then 135° F for protection of the resin. Additionally, if the fluid temperature was to exceed 140° F, then the ion exchangers will be automatically bypassed.	
In the Additional Purification mode, flow through the CVCS system filters and ion exchangers is limited to less then 128 gpm by controlling the position of the back pressure regulators (2-CH-201 P/Q). The coolant is then returned to the Shutdown Cooling System at the LPSI pump suction via 2-CH-024.	
f. Excess Letdown	
When RCS pressure is less than 265 psia, insufficient differential pressure exists to drive much letdown flow through the CVCS flow path. The interconnection between the SDC heat exchangers and the letdown heat exchanger (via SI-040) is used to provide additional, or "excess," letdown capability.	Figure 7
The driving head for the "Excess Letdown" flow path is provided by the LPSI pump that is in operation for Shutdown Cooling. The flow path in this line-up is similar to that used for "Additional Purification" with the exception that flow is not returned to the LPSI pump suction. The flow is either directed to the VCT or CLRW. Aligning the flow to VCT allows the Charging pumps to inject the water back to the RCS. This path allows reactor coolant to be drained to the CLRW System at approximately the same rate that could be achieved if the RCS were at normal operating pressure.	
g. Supplementing Spent Fuel Pool Cooling	
Periodically during the operating lifetime of the plant, it may be necessary to perform a complete core off-load from the reactor vessel to the Spent Fuel Pool. This would impose a heat load in excess of the design capacity on the cooling capabilities of the Spent Fuel Pool Cooling System. If this were to occur, then the Shutdown Cooling System would be used to supplement the Spent Fuel Pool Cooling System.	Figure 9
Flow between these two systems is aligned via a supply spool piece located on the discharge of SDC heat exchanger (between 2-SI-458 & 2-RW-11) and a return spool piece to the LPSI pump suction (between 2-SI-442 & 2-RW-15). In this alignment both the reactor vessel and Spent Fuel Pool Cooling System may be in parallel with	

the Shutdown Cooling System.	
While operating in this alignment, care must be taken to maintain the following: 1. SFP temperature at less than 140 °F 2. SFPC System pressure less than 30 psig 3. LPSI pump amps less than or equal to 52 4. LPSI pump flow (SDC and SFPC supplemental) less than 4000 gpm	
The SFP suction lines extend approximately six inches below the surface of the spent fuel pool. Due to the large flow rates of the SDC system it is possible to create a vortex action at the inlet to the suction lines. The formation of a vortex can result in voiding and air binding of the LPSI pumps. Proper SFP level (between 36' 8" and 37') will prevent air entrainment of the LPSI pumps. Oscillations in the LPSI pump discharge pressure and LPSI pump amps are indications of air binding in the pump.	RO-7
h. Filling Safety Injection Tanks	
Filling of the Safety Injection Tanks can be accomplished while the Shutdown Cooling System is in operation without securing any portion of the Shutdown Cooling System. This is normally performed following a refueling outage and when the SITs have been drained for maintenance.	Figure 10
If all the SITs have been drained, the tanks are filled sequentially to various levels. The SITs are filled by opening its Fill and Drain Valve and then opening its Vent Valve. Levels in the SIT ,the refueling cavity, and/or RWST are closely monitored during each tank filling evolution.	
Once the SITs have been filled, they are sequentially pressurized with nitrogen and the water is sluiced between them to equalize level and pressure.	
i. Transferring Water Between the RWST and the Refueling Cavity	
The Shutdown Cooling System can be used for some infrequently performed, non-routine operations such as transferring water between the RWST and Refueling Cavity. A variation of this line-up can also be used to recirculate and/or heat the RWST.	
The LPSI pumps provide the preferred method for filling the refueling cavity from the RWST. However, care must be taken since the high flow rates that occur when using this method may cause decreased clarity within the Refueling Pool and increased airborne activity within Containment. These problems are a result of "CRUD" breaking	

loose in the vessel under the high flow conditions imposed. Filling of the Refueling Cavity is terminated when the level in the Refueling Pool reaches 36' 6" or the RWST level drops to 6%.	
The transfer of water from the refueling cavity to the RWST can also be accomplished using SDC. The use of the Shutdown Cooling System in this capacity allows for the rapid transfer of water, but it does not allow for purification of the water during the process. Therefore unless high flow rates are desired the Spent Fuel Purification system should be used for this task.	
j. Alternate flowpath taking suction from the SFP	
Either SDC pump can be aligned to take suction from the SFP through 2-RW-11 and 2-SI-442 instead of the normal suction flowpath. When using this flowpath, flow restrictions in the procedure must be adhered to in order to avoid vortexing at the suction. The evaluation for this evolution assumes that this option would not be used until after the fuel shuffle which would provide at least 14 days from shutdown for decay heat to decrease. Additionally, core alterations shall be suspended while this alignment is in use. This flow path should normally be used for short periods, only, approximately 12 hours or less. If this flowpath is to be used for >24 hours or the core has not been shutdown for >14 days, further evaluation must be done prior to using this option.	3.9.8
4. Maintenance and Testing	
d. Monthly Testing	
On a monthly basis the LPSI system components must be proved operable to satisfy the requirements of tech specs.	
The following monthly tests are performed:	
• Checking the electrical alignment of the LPSI pumps.	
• Checking the LPSI valve alignment to ensure an operable flowpath.	
• Checking the operability of the LPSI injection valves.	
e. Quarterly Testing (Inservice Testing)	
On a quarterly basis the LPSI pumps are run and operational data is taken to determine operational readiness and detect degradation of the LPSI pumps, per tech spec requirements.	
The quarterly test involves:	
1. Isolating the LPSI flowpath to the RCS	

2. Start the LPSI pump on recirculation	
3. Measure and record recirculation flow, pump D/P, and pump vibration data	
When the LPSI pumps are aligned for SDC the discharge check valves are tested quarterly for closure and tightness.	
This quarterly test involves:	
1. Ensure LPSI pump operating on SDC.	
2. Check flow greater than 3800 gpm.	
3. Shift LPSI pumps and check for reverse rotation of stopped pump.	
4. Shift LPSI pumps again and check for reverse rotation of the opposite pump.	
f. Cycle Testing	
At least once per cycle (18 months) the LPSI system is tested to verify that it is capable of performing its design functions, per tech spec requirements.	
The following cycle tests are performed:	
• LPSI injection valves are cycled in manual.	
• LPSI pump high flow inservice test.	
5. Administrative Requirements	
d. Technical Specifications	
The following Technical Specifications are associated with the LPSI subsystems of the ECCS:	RO-8
3.3.2 ESAS Instrumentation	
3.4.1.3 and 3.4.1.4 Coolant Loops and Coolant Circulation	
3.5.2 ECCS Subsystems T-avg 300° F	
3.9.8 Shutdown Cooling and Coolant Circulation	
TRM 3.1.2.7	
The Technical Specifications associated with the LPSI system components ensure that sufficient LPSI flow will be available in the event of a LOCA assuming the loss of one facility LPSI system through any single failure consideration. Either LPSI train operating in conjunction with the other ECCS systems is capable of supplying sufficient core cooling to limit the peak cladding temperatures within acceptable limits for all postulated break sizes ranging from the double ended break of the largest RCS cold leg pipe on downward.	RO-9 RO-10

The RWST has minimum limits on the tank volume and boron concentration. The limits ensure that sufficient water is available within containment to permit recirculation cooling flow to the core and that the reactor will remain subcritical with all rods inserted except for the most reactive rod stuck out.	
In mode 4 the Tech Specs specify that two loops of trains consisting of any combination of RCS loops or SDC trains shall be Operable with at least one in operation. Mode 5 requires one SDC train Operable and in operation and a second train Operable or the RCS loops filled and at least one SG with >10% level.	
In Mode 5 one Operable SDC train requires a facility consistent SDC pump and heat exchanger with cooling water provided from an RBCCW pump and a SW pump both powered from the same facility as the SDC pump and piping capable of delivering the cooling water. Administratively this allows using a Z1 pump and Z2 piping or vice-versa for providing SW or RB cooling flow. In Mode 5 when two Operable SDC trains are required, facility consistency is required for everything except a single SW header may provide the cooling water flow path to 2 RBCCW heat exchangers, 2 SW pumps, (Z1 & Z2), are required.	#2002-632
In Mode 6, there is a refueling Technical Specification that specifies when one or two loops of SDC are required to be operable. At all reactor water levels, at least one loop of SDC must be operating to ensure:	
• That sufficient cooling capacity is available to remove decay heat and maintain the water in the vessel below 140° F.	
• Sufficient coolant circulation is maintained through the reactor core to minimize the effects of a boron dilution incident and prevent boron stratification.	
• Boron dilution analysis assumptions are met.	
The requirement to have two shutdown cooling loops operable when the refueling pool is unavailable as a heat sink ensures that a single failure of the operating SDC loop will not result in a complete loss of decay heat removal capability.	
Tech Spec bases define what is required to constitute an Operable SDC train. In Mode 4, an Operable SDC train requires an SDC pump, SDC Hx, RBCCW header, RBCCW pump, SW header, and SW pump all from the same facility, as well as the manual valves needed to properly align the systems. Mode 5 and 6 are different in that a single SDC train can be Operable supplied from either SW header. This is possible due to the redundancy inherent in the SW headers and valving with respect to the RBCCW HXs.	

G. MALFUNCTIONS AND FAILURES	
2. Core Boiling with RCS Vent Path or Nozzle Dams Installed	
If the reactor vessel head is installed and, concurrently, a large vent path exists at the Reactor Coolant Pump (RCP) (such as during an RCP seal replacement), a significant potential problem exists. This is due to the location at which the Shutdown Cooling System returns to the Reactor Coolant System. Under these conditions, during a Loss of Shutdown Cooling, steam formation in the core region may cause level to be suppressed within the reactor vessel. Level in the vessel would decrease as water is forced out of the RCP. This would continue until steam could be vented through the open suction of the RCP. In order for a steam vent path to be established, level must decrease to 57 inches below the hot leg centerline. Only then can steam begin to flow through the SG tubes, down through the open RCP suction leg, and out of the disassembled RCP. It must be noted that the active fuel is only 10 inches below the top of the open RCP suction leg.	Figure 2 Figure 21
The core can be further jeopardized while the RV head is installed, if the hot leg nozzle dams are also installed. Any failure of the Shutdown Cooling System that permits core boiling could result in depression of the water level in the core to below the bottom of the Core Support Barrel. Under this condition, if prompt action is not taken to prevent the onset of boiling, there is no operation that may be performed that would prevent core melt from occurring.	Figure 22
Because of the potential problems that these situations present, a vent path from the RCS hot legs is required to be provided anytime the plant is placed in a "reduced inventory" condition while Shutdown Cooling is in operation. To ensure an adequate vent path is present for the steam that might be generated during a Loss of Shutdown Cooling, the Pressurizer manway is normally removed prior to entering a "reduced inventory" condition. This ensures that these situations cannot develop and present a challenge to core cooling.	
3. Failures leading to a Loss of Shutdown Cooling	
Loss of shutdown cooling has been most commonly initiated by the accidental closure of a SDC suction valve, low reactor vessel level resulting in a loss of LPSI pump suction, or an inadvertent trip of the running LPSI pump.	
An electrical trip of the LPSI pump motor supply breaker may be caused by either an overcurrent condition on the LPSI pump motor or a ground fault on the load side of the supply breaker. The overcurrent trip on this breaker is set at approximately 100 amps.	

The LPSI pump will also trip if a Sump Recirculation Actuation Signal (SRAS) is received from the Engineered Safeguards Actuation System (ESAS). This signal is normally blocked during Shutdown Cooling System operation. Blocking of this signal is accomplished by bypassing all four SRAS channels on the Emergency Safeguards Actuation System (ESAS) cabinets.	
A pump motor trip will also occur if the motor is running and a Loss of Normal Power (LNP) occurs. This "Load-shed" trip, generated from the "Fast transfer circuit" associated with the transfer from the Normal Station Services transformer to the Reserve Station Services Transformer, locks out the LPSI pump breaker in preparation for energizing the 24C and 24D 4160 VAC electrical buses from the Emergency Diesel Generators (EDG). This trip is disabled prior to initiating Shutdown Cooling System operation by opening fingers in the 94TG-1 and 94TG-2 test circuits (OP 2310). The test circuits are located on the rear of C08. This operation minimizes spurious LPSI pump trips that might occur while the plant is shutdown. These spurious "Load-shed" trips could occur as the result of either Main Turbine control system testing or breaker operations in the switchyard. If a "Load-shed" trip does occur, the operator must reset the pump breaker, by placing the handswitch to "STOP" after power has been restored, prior to restarting the pump.	
When Shutdown Cooling is required to be in operation, a loss of power to either bus 24C or 24D would require operator action to restore core cooling. After the associated electrical bus has been re-energized by the Emergency Diesel Generator (EDG), the effected LPSI pump will not automatically restart. This is due to the fact that a Safety Injection Actuation Signal (SIAS) Block is present and the Engineered Safeguards Actuation System (ESAS) has not generated an auto start signal (i.e. SIAS). Therefore the operator must manually restart the associated LPSI pump in accordance with the guidance contained in the Abnormal Operating Procedure (AOP 2572).	RO-11A
A complete loss of power to the ‘A’ Train components would involve a loss of the following buses: 24C, 22E, and VR-11. If the buses are not re-energize the following SDC components are affected:	RO-11B
• A LPSI Pump	
• LPSI Injection Valves SI-615 and 625	
• Loss of power to following instrumentation	
• T351X, T351Y, and TR351 - SDC temperatures and recorder	
• F6043 and T6051 - SDC HX A RBCCW flow and temperature	
• F3023 and T303X - SDC HX A SDC flow and temperature	

• F312 and F322 - LPSI flow to Loop 1A and 1B	
A complete loss of power to the ‘B’ Train components would involve a loss of the following buses: 24D, 22F, and VR-21. If the buses are not re-energize the following SDC components are affected:	
• B LPSI Pump	
• LPSI Injection Valves SI-635 and 645	
• Loss of power to following instrumentation	
• F6042 and T6056 - SDC HX B RBCCW flow and temperature	
• F3024 and T303Y - SDC HX B SDC flow and temperature	
• F332 and F342 - LPSI flow to Loop 2A and 2B	
A loss of RBCCW cooling flow to the SDC HXs could be caused by a loss of power to the RBCCW components or a loss of RBCCW system integrity. Any malfunction associated with the RBCCW system will have a corresponding effect on the associated SDC system trains ability to cool the core. A loss of RBCCW flow through the SDC HX would require shifting to the opposite SDC system train or re-establishing the affected RBCCW system.	RO-11C
A loss of Instrument Air will cause a loss of control of the two SDC flow control valves, SI-657 and SI-306. The SDC HX Flow Control Valve, SI-657, will fail close resulting in a loss of cooling flow from the SDC HXs. The SDC Total Flow Control Valve, SI-306, will fail open maintaining SDC flow through the system and RCS. Both valves have the capability of local manual control. Prolonged operation without instrument air will require taking local control of the valves and adjusting flow using manual handwheel control.	RO-11D
A prolonged loss of SDC can occur when the RCS is in a reduced inventory condition (i.e. drained below the top of the hot leg). Events involving a loss of SDC capability with reduced reactor vessel water level have occurred rather frequently. More than 10 events involving the loss of SDC capability for greater than one hour occurred between mid 1985 and mid 1988. Three of these events resulted in boiling in the reactor core.	
With reduced vessel water level, there is an increased probability that a vortex may form within the RCS in the vicinity of the SDC suction line. Vortexing is most likely to occur if high SDC flow rates and low level at the hot leg suction co-exist. The formation of a vortex can result in voiding and air binding of the SDC suction line. The arrangement of the suction line piping is such that a loop seal is formed between the RCS and LPSI pumps. Thus, this piping configuration can prevent the suction line from reflooding once it has	Figure 3

been voided. In the event that the suction line has been voided, priming of the LPSI pump suction line can be accomplished by either:	
1. Raising RCS hot leg level with a charging pump (which has been aligned to take a suction on the RWST) in order to flood the LPSI pump suction.	
2. Flooding the pump suction directly from the RWST.	
If the line remains air bound, it can be evacuated using the vacuum priming sub-system. This sub-system is connected to the Shutdown Cooling System suction line high point vent inside the Containment Building.	
It is also possible, when in a reduced RCS inventory condition, to pressurize the RCS cold leg with air. This occurs when air bubbles are entrained within the coolant at the SDC suction as the result of minor vortexing. These air bubbles are carried through the Shutdown Cooling System and come out of solution in the piping on the RCP discharge legs. These bubbles can cause a small pressure buildup in this region of the RCS. A pressure build-up in this piping, in turn, causes level at the steam generator to rise and level in the RCS cold leg, within the RCP discharge piping, to drop. This outcome is the result of the physical arrangement of the piping that results in the creation of a manometer within the Reactor Coolant System. Because of this, level measurements taken at the Steam Generator may not be a valid indication of actual level in the vicinity of the SDC suction line. This effect on the level indication has misled operators into inadvertently draining the RCS, with an ensuing loss of suction pressure at the SDC pumps.	Figure 2
The most frequent type of decay heat removal incident is a loss of flow due to an inadvertent, automatic SDC suction valve closure. Automatic suction valve closure events have resulted in loss of Shutdown Cooling System flow more frequently than any other failure mode.	
A loss or malfunction of the SDC system will adversely affect the systems it was designed to support. If SDC is not available to cool the RCS then an alternate means of RCS cooling will need to be established. If the plant is in Operational Mode 5, then a RCS Loop and its SG and RCP can be used for core cooling. If the plant is in Operational Mode 6 and one SDC loop is not available than conditions must be established to ensure there is sufficient capability of flooding the reactor vessel/refueling cavity with borated water.	RO-12A
If the ability to cool the core is lost because of a causality to the SDC system then actions are taken to protect personnel and the public from core boiling. Any refueling activities and maintenance activities in containment will be stopped and actions will be taken to establish Containment Closure prior to the most limiting of the following:	RO-12B

• RCS boiling	
• 2 hours from loss of SDC	
If there is available level in the RWST, it can be used to gravity feed makeup to the RCS when SDC can not be made available i.e., a loss of all AC. This method uses the SDC system alignment into the RCS and requires the LPSI pump suctions from the RWST to be throttled open. The use of this gravity flow makeup path is time sensitive due to RCS heatup and possible pressurization.	RO-12C
If the SDC system is being used to supplement the SFPC system, then alternate methods to keep the spent fuel pool cooled will need to be implemented. These methods include re-establish SFP cooling or initiate feed and bleed cooling from either the RWST, or Primary Makeup Water system, or Auxiliary Feedwater system.	RO-12D
H. OPERATING EXPERIENCES	
2. Introduction	
These events take place during cold shutdown conditions while the Shutdown Cooling System is in operation to remove decay heat. Shutdown cooling events which occur in Mode 5 or 6 are often initiated or complicated by changing plant conditions and by concurrent maintenance operations. Reduced decay heat levels present during these events usually permit more time to respond than is generally available during power operation. However, fewer protective features are operative in these lower modes. This results in a much greater reliance on operator action for prevention or termination of these events.	
According to a report by the Office of Analysis and Evaluation of Operational Data (AEOD/C503), 130 events related to decay heat removal malfunctions were reported between 1976 and 1981 These events occurred during approximately 500 reactor years of operation. This equates to 0.25 events per reactor year or, to put it differently, 1 event approximately every 4 years. Although none of the 130 events analyzed by the AEOD report resulted in core uncovery, the Office concluded that these events should be considered "Significant Precursors" to more serious incidents.	
Until 1983, virtually all risk assessment studies (including the Final Safety Analysis Report) looked at decay heat removal system failures from the standpoint of an accident initiated from power operation. In other words, the analyses were directed towards the inability to achieve shutdown cooling entry conditions rather than what would happen if the shutdown cooling system malfunctions after initiation.	
In 1983 the Nuclear Safety Analysis Center (NSAC) reviewed approximately 100 decay heat removal incidents looking for root	

causes and published a report (NSAC-52) stating their findings and recommendations. In 1985, NSAC performed a probabilistic risk assessment of the Zion Station's decay heat removal systems and procedures to investigate the likelihood of fuel damage as a result of decay heat removal incidents (NSAC-84).

Of particular interest is that the AEOD study and both NSAC studies concluded that "major hardware improvements would have had little effect in preventing or mitigating the outcome (of the event)" (NSAC-52). On the other hand, all three studies cited human factors: operating and maintenance procedures, administrative controls, and personnel error as the significant factors in most of the decay heat removal incidents studied. It should also be noted that loss of shut down cooling events have continued to occur. SOER 85-4 and SOER 88-3 document 74 additional events that occurred between the time of the NSAC--52 study and May of 1988, a seven year period. These SOERs support and amplify the findings of the NSAC studies.

After evaluating 96 shutdown cooling events that occurred between 1976 and 1981, NSAC-52 concluded that there are three main safety concerns involved with these types of incidents. These concerns are 1) loss of coolant inventory, 2) loss of decay heat removal capability, and 3) inadvertent pressurization (cold over pressure). Many incidents involve one or more of these safety concerns.

3. Loss of Coolant Inventory

The probability for a loss of coolant inventory event may actually be increased during shutdown periods because large normally isolated systems, such as the Shutdown Cooling System, are connected to the Reactor Coolant System. NSAC-52's analysis of one cold shutdown LOCA, which was accompanied by a degradation of safety injection capability, demonstrated a potential for the core being uncovered. If it had occurred at the higher temperatures and higher decay heat levels seen immediately after entry into shutdown cooling, the operators would have had approximately 25 minutes to take corrective actions before the core would have begun to uncover.

Ten of the events analyzed in NSAC-52 demonstrated various scenarios for losing RCS inventory via the Shutdown Cooling System. Every loss of inventory occurring during SDC operation resulted from a fluid loss path within the boundaries of the Shutdown Cooling system (none have resulted from breach in the RCS itself). Furthermore, nine of the ten events resulted from maintenance actions or valve alignments (automatic or manual) in which no physical breach of Shutdown Cooling System pressure boundary occurred. The only failure of a pressure boundary that occurred (a gross packing leak on a SDC valve) was compounded by fluid contraction within the RCS. The following occurrences at plants have resulted in a loss of coolant inventory which in turn caused a loss of

shutdown cooling:	
• Inadvertent containment spray, with flow supplied by the SDC system, as the result of unintentional manual actions (including St. Lucie, a CE plant, on November 3, l978).	
• Inadvertent loss of inventory via the SDC suction relief valve (resulting in a loss of SDC due to leak isolation).	
• Inadvertent loss of inventory due to miss-positioned cross-connect or drain valves.	
• SDC valve packing gland removal during plant pressurization, dislodging the valve packing and gland.	
• Gross packing leakage resulting in a rapid cool down using SDC in order to effect repairs. The rapid cool down caused fluid contraction in the RCS, contributing to the event.	
• Another loss of coolant inventory event was an accidental loss of inventory to the Containment Building sump as the result of an inadvertent SRAS.	
SOER 85-4 points out that isolation of Shutdown Cooling would have stopped the inventory loss in each of the 10 events outlined in the NSAC 52 report.	
4. Loss of Decay Heat Removal Capability	
The loss of decay heat removal capability can be the result of a loss of flow within the Shutdown Cooling System or the loss of a heat sink for the Shutdown Cooling System. Events occurring shortly after SDC entry leave the operator little time to respond before bulk boiling conditions are reached. Heat-ups of over 100° F in less than 20 minutes have occurred in plants that had been partially drained for maintenance.	
Two major types of loss of flow events can occur which can induce a loss of decay heat removal capability for an extended period of time.	
• Loss of flow due to an inadvertent, automatic SDC suction valve closure. This is the most frequent type of decay heat removal incident. Twenty-seven separate automatic suction valve closure events resulted in loss of Shutdown Cooling System flow over the five year period of the NSAC study. SOER 85-4 documents an additional 21 events caused by inadvertent, automatic SDC suction valve closure in the three years immediately following the NSAC study.	
• Loss of Shutdown Cooling System flow caused by reactor vessel level indication errors during intentional RCS inventory reductions. Evolutions requiring RCS drain-down to mid loop often place the water level very close to the point at which	

vortexing at the SDC pump suction will develop. This in turn can lead to air binding or cavitation of the SDC pumps. Higher flow rates and higher fluid temperatures increase the possibility of air entrainment and/or pump cavitation. Twelve of the 96 events analyzed by NSAC-52 were the result of erroneous level indication. In the three years immediately following the NSAC study, SOER 85-4 documents an additional 20 events during intentional RCS inventory reduction.	
Other loss of decay heat removal events include:	
• Loss of flow or degraded cooling due to other valve closures. Although this occurs with moderate frequency, system redundancy helps to mitigate the consequences of this event.	
• Degraded cooling as the result of a loss of heat sink. The heat sink for the Shutdown Cooling System performs safety related tasks while in "Hot" modes, and therefore is a system with which most operators are fairly familiar. It is also quite reliable. Most events involving a loss of heat sink occur when maintenance on the system has reduced its redundant capabilities.	
• Loss of flow due to the loss of the running SDC pump. This event occurs quite frequently (14 times during the NSAC-52 study), but is fairly minor owing to the ability to run the alternate SDC pump. Note that in this case "Loss" refers to an electrical or mechanical failure, not cavitation or air binding, which tends to affect both pumps. In the three years immediately following the NSAC study, SOER 85-4 documents an additional 13 events caused by loss of the running LPSI pump.	
• Inadvertent loss of flow due to automatic SRAS. Although highly unlikely (due to administrative controls), it is possible for this event to occur at MP 2. The LPSI pumps would trip, but the stop signal could be overridden. The containment sump suction valves would open, but three check valves should prevent loss of inventory from the RCS to the containment sump via the SDC suction.	
• Inability to establish SDC flow as a result of the failure of the SDC suction valves in the closed position. Although this event occurs with moderate frequency, it usually occurs during initial attempts to enter SDC (five of six events analyzed by NSAC-52). This typically delays plant cool-down and raises some concern about the ability to obtain cold shutdown conditions. However, the plant is still capable of being cooled by the steam generators at this point, so the probability of core damage is low.	
RCS void formation during SDC operation interfere with the ability to operate the Shutdown Cooling System. However, during cold shutdown conditions, it is difficult to form a steam void. Four plants have experienced voids while on shutdown cooling. Three of these	

were caused by rapid cool-down and depressurization. The other event was a Reactor Vessel head bubble that developed when RCS temperature was below 200° F. An improper valve lineup, while draining the RCS, resulted in sufficient vacuum being drawn within the RCS for water at approximately 150° F to flash to steam.

5. Cold Over Pressure Events

Cold over pressurization (COP) is the third safety concern associated with decay heat removal incidents. In cold over pressure events, the primary concern is not core damage but exceeding the reactor vessel brittle fracture prevention limit. Unless the cold over pressure causes a catastrophic failure of the reactor vessel, core damage is far from likely. Cold over pressurization is not the same as pressurized thermal shock because for COP, no thermal gradient, and hence no thermal stress, is present in the reactor vessel wall. Only the pressure stress and fracture toughness of the reactor vessel are of concern.

The condition most likely to lead to cold over pressurization is operation with the primary plant water solid. As in loss of inventory and loss of heat removal events, the most significant factor contributing to the events has been the performance of maintenance and/or testing activities. Analyzing or predicting the occurrence of a cold over pressure event is more difficult than other decay heat removal safety concerns, because usually a combination of events must occur to cause the over-pressure condition; however, these combinations can and have occurred. One PWR event, which occurred during cold shutdown with a solid Pressurizer, resulted in pressurization to 1100 psig. The potential existed to pressurize all the way to primary safety setpoints without automatic protective action.

Cold over pressurization may be more likely due to reliance on power operated relief valves (PORVs) which have had their setpoints lowered, thus introducing the possibility of calibration error or detector malfunction.

Operation of HPSI pumps during cold shutdown conditions can result in over-pressurization. Other plants have experienced problems as a result of inadvertent SIAS actuation during low temperature, low pressure conditions. Administrative controls limit the number of HPSI pumps during shutdown cooling and solid plant operations in an attempt to avoid this concern.

Additionally, the HPSI pumps are equipped with a Pull-to-Lock feature on the handswitches which will be used to protect SDC from an overpressure condition by preventing an inadvertent start when the RCS is >190F and an available HPSI is required.

6. Conditions Affecting the Severity of a Shutdown Cooling Incident	
Given that the main purpose for cold shutdown operations is to perform maintenance/testing on equipment that cannot be taken out of service while in "hot" conditions, it must be assumed that equipment conditions and availability will be degraded from normal conditions. Thus, the limiting factor as to which equipment is removed from service and when, is the operational mode of the plant.	
NSAC-84 uses a set of six procedure related sequence of event "trees" to describe the various activities normally associated with cold shutdown outages:	
• Plant Shutdown	
Takes the plant from hot shutdown, using the steam generators and AFW, to cold shutdown with decay heat removal by SDC. The RCS is placed in one of two conditions.	
1. Bubble (N^2 or steam) in the Pressurizer	
2. Solid plant conditions	
• Draining for refueling or maintenance	
Takes the plant from a solid condition to a drained condition with system level being maintained at the RCS mid loop elevation.	
• Filling for refueling	
The reactor vessel head is removed and system level raised to refueling level in the refueling cavity.	
• Draining the refueling cavity after refueling	
The refueling cavity is drained and the Reactor Vessel head is replaced.	
• Refilling the RCS after refueling or maintenance	
Takes the plant from a drained condition to a solid condition.	
• Cold Start-up	
Takes the plant from a cold, solid condition to a hot shutdown condition with SDC secured.	
It is possible to have an event that could affect any or all of the three safety concerns during any of these event trees. However, some events are more likely to occur at certain times. Also, some events are more likely to lead to core damage if certain plant conditions exist.	
Listed below are the six sequence of event trees and the safety concern(s) most likely to be affected by events that could occur.	

• Plant Shutdown	
All three safety concerns can be significantly impacted by any SDC event during this evolution. NSAC-52 recommends during plant cool-down when shutdown cooling is first initiated high RCS temperatures, pressures and decay heat levels demonstrate the potential for more severe losses of inventory or loss of decay heat removal capability. It is therefore prudent to exclude all but emergency evolutions for this short time period of hot shutdown (shutdown cooling) operation.	
• Draining for Refueling or Maintenance	
During this evolution, shutdown cooling has been placed in service and is operating. Most plants limit maintenance on SDC during this period of time, so the likelihood of a LOCA through valve miss-operation or mistaken loosening/disassembly of fittings is small. (Random pipe break LOCAs could occur at any time). The draining process has left room for fluid expansion, so cold over pressure conditions are unlikely. Loss of heat removal is the prime concern since decay heat levels tend to still be significant. RCS volume is diminished, so there is less room for heat absorption and, most importantly, loss of suction head or air entrainment to the SDC pumps becomes much more likely.	
NSAC-52 recommends:	
1. Tight administrative controls over evolutions that remove coolant inventory.	
2. Frequent visual checks of local standpipe level and comparison to other level indications.	
3. Continuous trend analysis of Reactor Vessel water level changes.	
4. In addition, the study recommends that both SDC trains should be continuously available in Mode 4 and during the first few days of Mode 5 operation. Technical Specifications additionally require that at least one heat removal loop/train be continuously in service.	
• Filling for refueling	
This appears to be the safest mode of operation for shutdown cooling. Cold over pressure is impossible due to removal of the Reactor Vessel head. Loss of heat removal is less of a concern due to the large volume of water available for boil-off. Loss of inventory is less of a concern because:	

1. Low system pressures minimize leakage flow rates.	
2. Large quantities of water in the refueling cavity provide the operators with more time to respond.	
• Draining the cavity after refilling	
Risk is low during this evolution as well. However, two potential concerns do exist, both of which are associated with loss of inventory. They are:	
1. Loss of inventory is harder to recognize due to the large amount of water being transferred. Operators should ensure all inventory is accounted for.	
2. Over draining could result in inadequate shielding and possibly inadvertent core uncovery. Possible exposure hazards to personnel in containment.	
• Refilling the RCS after refueling or maintenance	
Loss of inventory concerns are minimal due to the fact that systems are already lined up to provide makeup to the RCS. Loss of heat removal is less of a concern due to the lower decay heat levels. Cold over-pressure events present the greatest hazard. Inattentiveness, or inaccurate level indication can lead to unanticipated over-pressurization.	
• Cold Start-up	
Loss of inventory and cold over-pressure are the primary concerns due to the increased energy content of the RCS fluid.	
• In addition, valve manipulations during the removal of shutdown cooling present the possibility of inadvertently releasing RCS water. Again concern over loss of heat removal is less because:	
1. Lower decay heat levels exist.	
2. The steam generators are usually available as a heat sink.	
7. Conclusion	
The NSAC studies and SOER 88-3 conclude that cold shutdown periods present significant challenges to the safe operation of a nuclear power plant. Fewer protective features combined with changing plant status due to maintenance and testing evolutions cause a much greater reliance on operator action for prevention or termination of events occurring during cold shutdown. Analyses have identified the loss of SDC as a significant contributor to the potential for core damage. In several events after the period of the NSAC study, the temperature of an open RCS has approached the boiling point during the loss of SDC capability (SOER 85-4). The probability of uncovering the core by the loss of inventory due to boiling is greatly	

	increased upon the loss of SDC.	
	Given the inevitability of cold shutdown operation, the operator should be aware of the type of shutdown cooling events most likely to occur during a given plant condition. Operators should also be aware of how to respond to possible shutdown cooling events. NSAC-52 concludes that increased awareness by Control Room Operators of maintenance and testing in progress, increased awareness of plant status by maintenance personnel, and improved communications systems and usage formality, can all contribute to improved shutdown reactor safety.	
	The probability of a shutdown cooling event occurring is high (0.25 events per reactor year) and while certain changes to administrative controls help lower the probability, it cannot be eliminated. This review has noted a number of instances where inadvertent mode changes and bulk boiling in the core have occurred. Core uncovery is possible in as little as 30 minutes in some circumstances.	
	In all the reports reviewed, there was a striking similarity in their conclusion. Some minor hardware changes might improve plant safety during cold shutdown operations but major improvements would have had little effect in preventing or mitigating the SDC events studies. Procedures and correct operator response are the key to safe shutdown cooling operation.	
8.	**SER 12-86 High Cooldown Rate Due To Inaccurate Closed Position Indication On Motor-Operated Valves**	
	During a plant cooldown, the cooldown rate exceeded the technical specification limits when the Shutdown Cooling System (SDCS) was aligned to the Reactor Coolant System (RCS). The high cooldown rate occurred because the SDCS heat exchangers were not completely isolated from the system. The heat exchanger isolation valves indicated closed in the control room but were actually partially open. The inaccurate closed position indication on these valves resulted from changes made to their motor operator limit switch settings. The limit switch setting changes were made to modify the motor operators' torque bypass set points, but also affected the closed position indication that comes from the same limit switch assembly.	
	This event is significant because it demonstrates how changing motor-operator limit switch settings to resolve one problem, i.e., inappropriate torque switch bypass settings, can lead to another problem, i.e., motor-operated valves indicating closed when they are actually partially open.	
9.	**SER 19-91 Loss Of Decay Heat Removal Capability Due To Inappropriate Maintenance And Testing**	

During a refueling outage, reactor vessel water level was inadvertently drained to the bottom of the Reactor Coolant System hot legs during post-maintenance testing of a decay heat removal pump suction isolation valve. Decay heat removal was lost and radiation levels above the reactor vessel increased from less than 80 mrem/hour to 8,000 mrem/hour.	
At another station during a refueling outage, maintenance on a check valve caused an interruption of decay heat removal capability by admitting air into the system and air binding the shutdown cooling pump.	
These events are significant because incorrect performance and scheduling of maintenance and testing resulted in a loss of decay heat removal capability.	
10. Review of Loss of Shutdown Coolant Events 01/2004	INPO Topical Report TR4-33
1) Key Concepts	
a) After years of improvement, rates have increased. A fivefold increase in 2003 as compared to 2002	
b) Major contributor was lack of self-checking.	
• Of the 34 events, 25 occurred on BWRs	
• Three-fourths of the events were due to human performance, including all five events in 2005.	
♦ 10 due to Inadequate Self Checking	
♦ 8 due to Inadequate Procedures	
c) Categories of events causes.	
• 12 of 34 while placing SDC in service.	
♦ 9 of the 12 were PWRs	
♦ this 9 to 12 ratio is the same as the ratio of BWRs to PWRs in the country, 34 to 69 respectively.	
• 8 due to Testing.	
• 6 due to Maintenance.	
• 4 while restoring or swapping systems	

• 3 due to Tagging.	
• 4 due to Other causes.	
• 10 due to lack of Self Checking	
• 8 due to Inadequate Procedures	
d) Causal analysis	
• There was not enough information to determine why the rise in Loss of SDC is occurring, or why BWRs are having more problems.	
• 4 events resulted in > 10°F rise in Temp.	
♦ UE/D1 EU1 –Uncontrolled RCS Temp increase > 10°F.	
11. Review of CR-04-06166 Reportability evaluation for gas binding of RHR Pumps on Millstone Unit #3. Review with trainees the basic causal factors for the Unit #3 event.	CR-04-06166

I. TABLES

2. Component Design Data Table	
Component	**Design Data**
1. LOW PRESSURE SAFETY INJECTION PUMPS	
Quantity	2
Type	Single stage, Vertical, Centrifugal
Manufacturer	Ingersoll-Rand
Basic Material	ASTM A351 GR CR8M
Pumped Fluid	Borated Water
Temperature of pumped fluids	40 to 300° F
Motor Voltage	4160 VAC
Power Supply	
A:	24C (A-309)
B:	24D (A-404)
Horsepower	400 BHP
Acceleration time; at rated voltage	4 sec.
Design maximum suction pressure	300 psig
Design Pressure	500 psig
Design Temperature	350° F
Design Flow (excluding min. flow)	3000 gpm
Minimum flow	100 gpm
Maximum flow	4500 gpm
1. Head at maximum flow	121 PSID
Design head	154 PSID
Shutoff head	185 PSID
NPSH required at 3000 gpm	13 ft.
NPSH available minimum	25 ft.
Seals	Mechanical
Seal Cooling	RBCCW
2. RWST	
Manufacturer	Richmond Engineering Company

2. Component Design Data Table	
Component	**Design Data**
Design Pressure	Atmospheric
Design Temperature	120° F
Net Capacity	475,000 gallons
3. Shutdown Cooling Heat Exchangers	
Manufacturer	Engineering & Fabricators, Inc.
Quantity	2
Type	Shell & Tube
Codes	ASME Section III, Class C, 1968 Edition through Summer 1969 Addendum
Tube Side:	
Fluid	Reactor Coolant (1% Boric Acid)
Design Flow, gpm	3400 gpm
Design Pressure	500 psig
Design Temperature	400° F
Pressure drop (at 1.5 x 10^6 lb/hr)	10 PSID
Materials	Austenitic Stainless Steel
Shell Side:	
Fluid	Reactor Building Closed Cooling Water
Design Flow	5400 gpm
Design Pressure	150 psig
Design Temperature	250° F
Pressure drop (at 2.41 x 10^6 lb/hr)	10 PSID
Material	Carbon Steel
Heat Load	27.2 million Btu/hr
Service Transfer Rate	256 Btu/hr - °F - ft.^{2}

2. Component Design Data Table	
Component	**Design Data**
4. Miscellaneous Components	
Valves:	
2-1/2 in. and larger	Butt-welded, ANSI 1500 lb. rating, stainless steel
2 in. and smaller	Socket-welded, ANSI 600 lb. rating, stainless steel
Standard	Draft ASME Code for pumps and valves for Nuclear Power Class 2, 1968
Seismic	Class 1
Piping:	
Material	ASTM A-312, Type 304
2-1/2 in. and larger	Sch 10S
2 in. and smaller	Sch 40S
Fittings:	
2-1/2 in. and larger	Butt-welded except at flange
2 in. and smaller	Socket-welded

3. Power Supply Summary Table

Component	**Main Power**	**Alternate Power**	**Control Power**
LPSI A (P-42A)	24C		DV10
LPSI B (P-42B)	24D		DV20
SDC Suction Isolation 2-SI-652	MCC B61		
SDC Suction Isolation 2-SI-651	MCC B51		

4. Alarm Summary Table

Alarm Title	Module	Source Instrument	Setpoint
LPSI Pump A Overload/Trip	C-01 A-2	51X relay 3 relay	overcurrent ground fault
LPSI Pump B Overload/Trip	C-01 B-2	51X relay 3 relay	overcurrent ground fault
Engineered Safeguards Room A Temp Hi	C-01 A-7	TS-8052	110° F
Engineered Safeguards Room B Temp Hi	C-01 B-7	TS-8053	110° F
LPSI Pump A Suction Pressure Lo	C-01 A-8	PT 3051	13.5 psig
LPSI Pump B Suction Pressure Lo	C-01 B-8	PT 3053	13.5 psig
LPSI Pump A Motor Current Hi/Lo	C-01 C-8	I 3700A	Hi: 50 amps Lo: 20 amps
LPSI Pump B Motor Current Hi/Lo	C-01 D-8	I 3700A	Hi: 50 amps Lo: 20 amps
SI-651 Open	C-01 C-9	P-103-1 ZS-651	$\geq$ 280 psia and 2-SI-651 open
SI-652 Open	C-01 D-9	P-103 ZS-652	$\geq$ 280 psia and 2-SI-652 open
SI-652 Opening Coil Energized	C-01 C-39	42-0 relay	
SI-652 Manual Disc Closed	C-01 D-39	89-SI-652	
Loop 1A Low Press SI flow	Computer	F-312	Lo: 0.0 gpm Hi: 1800 gpm
Loop 1B Low Press SI flow	Computer	F-322	Lo: 0.0 gpm Hi: 1800 gpm

4. Alarm Summary Table

Alarm Title	Module	Source Instrument	Setpoint
Loop 2A Low Press SI flow	Computer	F-332	Lo: 0.0 gpm Hi: 1800 gpm
Loop 2B Low Press SI flow	Computer	F-342	Lo: 0.0 gpm Hi: 1800 gpm
LPSI Pump A Disch Press	Computer	P302-X	Lo: 0.0 psig Hi: 450 psig
LPSI Pump B Disch Press	Computer	P302-Y	Lo: 0.0 psig Hi: 450 psig

5. Instrument Summary Table

Noun Name	Tag	Readout Location	Range	Uses	Normal Reading
Low Pressure Safety Injection Flow to Loop 1A Cold Leg	FI-312	C-01			1500 gpm
Low Pressure Safety Injection Flow to Loop 1B Cold Leg	FI-322	C-01			1500 gpm
Low Pressure Safety Injection Flow to Loop 2A Cold Leg	FI-332	C-01			1500 gpm
Low Pressure Safety Injection Flow to Loop 2B Cold Leg	FI-342	C-01			1500 gpm
Total Shutdown Cooling System Flow	FIC-306	C-01			7000 gpm
"A" LPSI Pump Discharge Pressure	PI-302X	C-01			200 psig
"B" LPSI Pump Discharge Pressure	PI-302Y	C-01			200 psig
"A" LPSI Pump Suction Pressure	PI-3051	Local			40 to 265 psig
"B" LPSI Pump Suction Pressure	PI-3053	Local			40 to 265 psig
Shutdown Cooling System Return Temperature to RCS	TR-351Y	C-01			65° F to 300° F
Shutdown Cooling System Suction Temperature	TR-351X	C-01			65° F to 300° F
"A" SDC Heat Exchanger Inlet Temperature	TI-3025	Local			65° F to 300° F
"B" SDC Heat Exchanger Inlet Temperature	TI-3026	Local			65° F to 300° F
"A" SDC Heat Exchanger Outlet Temperature	TI-303X	C-01			80° F to 120° F
"B" SDC Heat Exchanger Outlet Temperature	TI-303Y	C-01			80° F to 120° F
Position indication for 2-SI-306 (SDC System Flow Control Valve)	TI-3025	C-01			Open
Position indication for 2-SI-440 (LPSI Pump Suction Cross-connection)	ZS-440	C-01			Open

5. Instrument Summary Table

Noun Name	Tag	Readout Location	Range	Uses	Normal Reading
Position indication for 2-SI-441 (LPSI Pump Suction Cross-connection)	ZS-441	C-01			Open
Position indication for 2-SI-651 (SDC Suction Line Isolation Valve)	ZS-651	C-01			Open
Position indication for 2-SI-652 (SDC Suction Line Isolation Valve)	ZS-652	C-01			Open
Position indication for 2-SI-657 (SDC Heat Exchanger Flow Control Valve)	ZS-657	C-01			Throttled
Position indication for 2-SI-659 (ECCS Pump Minimum Flow Recirculation Isolation)	ZS-659	C-01			Open
Position indication for 2-SI-660 (ECCS Pump Minimum Flow Isolation)	ZS-660	C-01			Open
Position indication for 2-SI-615 (LPSI Flow to Loop 1A Cold Leg throttle valve)	ZI-615	C-01			Throttled
Position indication for 2-SI-625 (LPSI Flow to Loop 1B Cold Leg throttle valve)	ZI-625	C-01			Throttled
Position indication for 2-SI-635 (LPSI Flow to Loop 2A Cold Leg throttle valve)	ZI-635	C-01			Throttled
Position indication for 2-SI-645 (LPSI Flow to Loop 2B Cold Leg throttle valve)	ZI-645	C-01			Throttled

J. REFERENCES

Procedures

1. OP 2207 Plant Cooldown
2. OP 2304F CVCS Operation While in Cold Shut Down
3. OP 2306 Safety Injection Tanks
4. OP 2307 LPSI System
5. OP 2310 Shutdown Cooling
6. AOP 2572 Loss of SDC
7. ARP 2590A Alarm Response for Control Room Panel C-01
8. SP 2604C/D LPSI Pump and Valve Tests, Facility 1/2
9. SP 2604L/M LPSI System Alignment Check and Valve Operability Test, Facility 1/2

Drawings

1. P&ID 25203-26015 SH. 1 of 3 LP Safety Injection Pumps
2. P&ID 25203-26015 SH. 2 of 3 HP Safety Injection Pumps
3. P&ID 25203-26056 Process flow for RBCCW
4. P&ID 25203-28115 Pump Recirc. Header Stop, SH. 22 Valve (Logic)
5. P&ID 25203-28115 Logic for 2-SI-657, SH. 23
6. P&ID 25203-28115 Logic for SI flow control, SH. 43 valves
7. P&ID 25203-28115 Logic for 2-SI-651/652, SH. 47
8. P&ID 25203-32008 Breaker for 2-SI-651 & 2-SI-652 SH. 11 & 33

Manuals

1. Technical Specifications 3.3.2.1 ESF Actuation System Instrumentation.
2. Technical Specifications 3.5.2 ECCS Subsystems T avg. = 300° F
3. Design Basis Document Package - Safety Injection System Volume 1
4. MNPS-2 FSAR Chapter 6 Engineered Safety Features Systems
5. MNPS-2 FSAR 7.3 Engineered Safety Features Actuation System
6. CFR 50 Appendix A criterion 34
7. FSAR Chapter 6, Engineered Safety Features Systems
8. FSAR Chapter 9, Section 3, Shutdown Cooling System

Operating Experience

1. NSAC-52, Residual Heat Removal Experience Review and Safety Analysis
2. NSAC--84, Probabilistic Risk Assessment of Decay Heat Removal Systems

3. SOER 85-4, Loss or Degradation of RHR Capability in PWRs.
4. SOER 88-3, Rev. 1, Losses of RHR with Reduced Reactor Vessel Water Level at PWRs.
5. SER 12-86 High Cooldown Rate Due To Inaccurate Closed Position Indication On Motor-Operated Valves
6. SER 19-91 Loss Of Decay Heat Removal Capability Due To Inappropriate Maintenance And Testing

K. FIGURES

L. ATTACHMENTS

Attachment 1 Objectives

Terminal Objective

Apply the knowledge from classroom training to the normal and abnormal operation of the Shutdown Cooling System in accordance with the plant procedures.

Enabling Learning Objectives

PEO Enabling Learning Objectives

1. State the purpose of the Shutdown Cooling System as given in SDC-00-C. (MB-00878)
2. Given a simplified diagram of the Shutdown Cooling System, identify major components and trace the flowpaths for the following operating configurations: (MB-00879)
   A) Normal single-loop operation with one heat exchanger
   B) Normal two-loop operation
   C) Supplementing or providing Spent Fuel Pool cooling
   D) System warmup
   E) Boron equalization
3. Describe how the Shutdown Cooling System affects or is affected by the following as given in SDC-00-C: (MB-00880)
   A) ECCS
   B) RCS
   C) RBCCW
   D) CVCS
   E) SFPC
4. State the purpose and describe the operating characteristics of the following major Shutdown Cooling System components as given in SDC-00-C: (MB-00881)
   A) Hot Leg Isolation Valves, 2-SI-651/652/709
   B) 2-SI-652 control power disconnect
   C) LPSI Pumps
   D) SDC Min Flow Recircs 2-SI-659/660
   E) SDC HXs
   F) SDC HX Flow Control Valve, 2-SI-657
   G) SDC Total Flow Control Valve, 2-SI-306
   H) LPSI Injection Valves
   I) SDC Warming Line Isolation, 2-SI-400
   J) SDC High Point Evacuation Subsystem
5. State the power supply to the Shutdown Cooling (LPSI) Pumps. (MB-00888)

PEO Enabling Learning Objectives

6. Describe the general sequence of events associated with enabling and disabling 2-SI-306/657 as given in OP 2310. (MB-00889)
7. Given a precaution or list of precautions from OP 2310, give the basis for Shutdown Cooling System precautions applicable to the PEO, and describe the methods available to monitor associated parameters. (MB-00884)
8. State the Temperature/Pressure Limits for Shutdown Cooling Initiation and valve interlocks as given in OP 2310. (MB-00887)
9. Describe the general sequence of events associated with startup of the Shutdown Cooling System as given in OP 2207. (MB-00885)
10. Describe the general sequence of events associated with shutdown of the Shutdown Cooling System as given in OP 2310. (MB-00886)
11. Locate each of the following major Shutdown Cooling System components and local controls: (MB-00882)
    - A) SDC HX Flow Control Valve 2-SI-657
    - B) SDC Total Flow Control Valve 2-SI-306
    - C) SDC Loop 2 Outlet 2-SI-651/652 *
    - D) SDC Warmup Line Isolation 2-SI-400
    - E) SDC to SFPC 2-SI-458
    - F) SDC to CVCS purification 2-SI-040
    - G) SFPC to SDC 2-SI-442
    - H) SDC HX A/B SI Inlet 2-SI-452/453
    - I) SDC HX A/B SI Outlet 2-SI-456/457
    - J) SDC HX A/B CS Outlet 2-CS-4A/4B
    - K) LPSI Pumps (2)
    - L) SDC Suction Header High Point Vent 2-SI-043A *
    - M) Min Flow Isolations 2-SI-659/660
    - N) SDC Manual Isolation 2-SI-709
    - O) SDC HX A/B RBCCW Outlet 2-RB-13.1 A/B
    - P) SDC HX A/B RBCCW Outlet Isolation 2-RB-14 A/B
    - Q) SDC Discharge to RWST 2-SI-460
    - R) LPSI Pump Min Flow Valves 2-SI-449/450

* Inaccessible at power operations, acceptable to discuss or locate on floor plan, drawing, etc.

Terminal Objective

Apply the knowledge from classroom training to the normal and abnormal operation of the Shutdown Cooling System in accordance with the plant procedures.

RO Enabling Learning Objectives

1. Given a simplified diagram of the Shutdown Cooling System, identify major components and trace the flowpaths for the following operating configurations: (MB-03178)
    A) Normal single-loop operation with one heat exchanger
    B) Normal two-loop operation
    C) Supplementing or providing Spent Fuel Pool cooling
    D) System warmup
    E) Boron equalization
2. As given in SDC-00-C, describe the functions of the following Shutdown Cooling System Control Room hand or keylock switches at Panel C-01, including how controlled components are affected by each mode or position of the switch: (MB-03187)
    A) Shutdown Cooling System Suction Isolation keylocks, 2-SI-651, 652
    B) Low Pressure Safety Injection Pump A and B control switches
    C) Minimum Flow Recirculation Valves control switches and bypass keylocks, 2-SI-659, 660
    D) Shutdown Cooling System Heat Exchanger Flow Control keylock, 2-SI-657
    E) Shutdown Cooling System Total Flow keylock, 2-SI-306
    F) LPSI Injection Throttle Valve control switches
3. As given in SDC-00-C, describe the functions of the following Shutdown Cooling System Control Room controls at Panel C-01, including how controlled components are affected by each mode or position of the control: (MB-03188)
    A) Shutdown Cooling Heat Exchanger Flow Controller HIC-3657
    B) Shutdown Cooling Flow Controller FIC-306
4. Given a copy of OP 2310, give the basis for each Shutdown Cooling System precaution and describe the methods available to monitor associated parameters. (MB-03191)
5. Explain the reasons for the following considerations when removing a Shutdown Cooling Heat Exchanger from service: (MB-03192)
    A) A steady Reactor Coolant System temperature should be maintained
    B) Only one LPSI Pump should be used
    C) The evolution cannot be performed during concurrent Reactor Coolant Pump operation
    D) If Reactor Coolant System temperature is low and decay heat load is high, this operation may cause Reactor Coolant System temperature to rise
6. As given in SDC-00-C, state the purpose for recirculating Safety Injection Headers following termination of shutdown cooling. (MB-03181)
7. As given in SDC-00-C, describe the operational implications of vortexing at the Spent Fuel

RO Enabling Learning Objectives

Pool suction pipe when supplementing with Shutdown Cooling. (MB-03191)

8. Given any operating condition for the Shutdown Cooling System, state whether the condition requires entry into the Technical Specifications. (MB-03184)
9. Given plant operating conditions or mode, and given a Shutdown Cooling System Technical Specifications LCO, identify the bases for the LCO and evaluate any implications for plant operation. (MB-03190)
10. Given a list of plant conditions and a copy of the Technical Specifications, determine if any Shutdown Cooling System LCOs are violated and identify the appropriate action statement(s). (MB-03189)
11. As given in SDC-00-C, describe the effects on the Shutdown Cooling System of a loss or malfunction of the following: (MB-03179)
    A) 4.16 kVAC Electrical Distribution System
    B) Vital 120 VAC Electrical Distribution System
    C) Reactor Building Closed Cooling Water System
    D) Instrument Air System
12. Describe the effects of a loss or malfunction of the Shutdown Cooling System on the following: (MB-03180)
    A) Reactor Coolant System
    B) Refueling operations
    C) Refueling Water Storage Tank
    D) Spent Fuel Pool cooling

Attachment 2 - Controls

Instrument Number	Location	Function
FIC-306	C-01	Inoperative during normal plant operation (i.e. Mode 1, 2, & 3). When operative, it can control total Shutdown Cooling System flow by automatically positioning 2-SI-306 to maintain the "set" system flow. Normal mode will be in manual and open.
HIC-657	C-01	Inoperative during normal plant operation (i.e. Mode 1, 2, & 3). When operative, it controls the Shutdown Cooling System discharge temperature by manually positioning 2-SI-657, to control flow through the Shutdown Cooling Heat Exchangers.
HS-3017	C-01	Provides remote manual control of "A" LPSI pump.
HS-3018	C-01	Provides remote manual control of "B" LPSI pump.
HS-3306	C-01	Key operated switch to override operation of 2-SI-306. Maintained in the "SI" position during normal plant operation (i.e. Mode 1, 2, & 3). "SI" position fails valve to the open position.
HS-3615	C-01	Provides remote manual control for throttling of LPSI Flow to Loop 1A Cold Leg throttle valve.
HS-3625	C-01	Provides remote manual control for throttling of LPSI Flow to Loop 1B Cold Leg throttle valve.
HS-3635	C-01	Provides remote manual control for throttling of LPSI Flow to Loop 2A Cold Leg throttle valve.
HS-3645	C-01	Provides remote manual control for throttling of LPSI Flow to Loop 2B Cold Leg throttle valve.
HS-3657	C-01	Key operated switch to override operation of 2-SI-657. Maintained in the "LOCKED CLOSED" position during normal plant operation (i.e. Mode 1, 2, & 3). The "LOCKED CLOSED" position fails the valve to the closed position.
HS-3651	C-01	A key operated switch that provides remote manual control of the shutdown cooling suction line isolation valve, 2-SI-651.

Instrument Number	Location	Function
HS-3652	C-01	A key operated switch that provides remote manual control of the shutdown cooling suction line isolation valve, 2-SI-652.
HS-3659	C-01	Provides remote manual control of 2-SI-659 (minimum flow recirc. valves).
HS-3660	C-01	Provides remote manual control of 2-SI-660 (minimum flow recirc. valves).
HS-3659A	C-01	Blocks a Sump Recirculation Actuation Signal (SRAS) and HS-3659 closure signals to 2-SI-659 (minimum flow recirc. valves) when in the "INOP" position. Maintained in the "INOP" position during all modes of operation except during SDC operations and SRAS.
HS-3660A	C-01	Blocks a Sump Recirculation Actuation Signal (SRAS) and HS-3660 closure signals to 2-SI-660 (minimum flow recirc. valves) when in the "INOP" position. Maintained in the "INOP" position during all modes of operation except during SDC operations and SRAS.

Attachment 3 - Interlocks & Automatic Features

Instrument #	Feature
LT-3001 LT-3002 LT-3003 LT-3004	Two out of four Refueling Water Storage Tank (RWST) level indications less than setpoint will initiate a Sump Recirculation Actuation Signal (SRAS) from the Engineered Safeguards Actuation System (ESAS). Provided ESAS were not bypassed and a signal were to occur, the following Shutdown Cooling System components would be affected: • LPSI Pump "A" and "B" would trip; • SI/CS Minimum flow recirc valves (2-SI-659 & 2-SI-660) would close (provided that HS-3659A and HS-3660A are in the "OPER" position); • Containment Sump Outlet Valves (CS-16.1 A/B) open. • Shutdown Cooling (SDC) Heat Exchanger RBCCW outlet valves would open (RB-13.1 A/B).
PT-102A PT-102B PT-102C PT-102D	Two out of four Pressurizer Pressure indications less than setpoint will initiate SIAS from the Engineered Safeguards Actuation System (ESAS). SIAS is blocked during SDC operation, but if it was not blocked, the following components within the LPSI system or affecting LPSI system performance would be effected: • LPSI Pump "A" and "B" start. • LPSI injection valves (2-SI-615, 2-SI-625, 2-SI-635, & 2-SI-645) open. • ESF Room Fans (F-15A & F-15B) start.
PT-103	Prevents the shutdown cooling suction line isolation valve 2-SI-652 from being opened if a high Reactor Coolant System (RCS) pressure condition exists (setpoint: 280 psia increasing).
PT-103-1	Prevents the shutdown cooling suction line isolation valve 2-SI-651 from being opened if a high Reactor Coolant System (RCS) pressure condition exists (setpoint: 280 psia increasing).

Instrument #	Feature
PT-8113 PT-8114 PT-8115 PT-8116	Two out of four Containment Pressure indications greater than setpoint will initiate SIAS from the Engineered Safeguards Actuation System (ESAS). This cannot be blocked during SDC operation. Components actuated within the LPSI system or affecting LPSI system performance are: • LPSI Pump "A" and "B" start. • LPSI injection valves (2-SI-615, 2-SI-625, 2-SI-635, & 2-SI-645) open. • ESF Room Fans (F-15A & F-15B) start.
FIC-306	Inoperative during normal plant operation (i.e. Mode 1, 2, & 3). FIC--306 is used to set valve position (2-SI-306) in the remote manual mode during Shutdown Cooling (SDC)operation. Once SDC is initiated, 2-SI-306 is maintained fully open by establishing a full open demand signal using the FIC--306 manual potentiometer.

Attachment 4 - ESAS Setpoint Requirements

SIGNAL	TECH SPEC TRIP SETPOINT
Safety Injection Actuation Signal (SIAS) * setpoints same for CIAS and EBFS	
Pressurizer Pressure	≥1714 PSIA lowering
Containment Pressure	≤ 4.42 psig rising
Main Steam Line Isolation (MSI)	
Containment Pressure	≤ 4.42 psig rising
Steam Generator Pressure	≥ 572 PSIA lowering
Sump Recirculation Actuation Signal (SRAS)	
RWST level	46 ± 3” above tank bottom (~9.5%)
Containment Spray Actuation Signal (CSAS)	
Containment pressure	≤ 9.48 psig rising
4.16 KV Emergency Bus Undervoltage - Level 1 Loss of Normal Power (LNP)	
Voltage on bus 24C or 24D	≥ 2912 volts for 2.0 ± 0.1 seconds (approx. 70% of rated bus voltage)
4.16 KV Emergency Bus Undervoltage - Level 2 (RSS)	
Voltage on bus 24C or 24D	≥ 3700 volts for 8 ± 2 seconds (approx. 88% of rated bus voltage)

INSTRUCTIONAL MATERIALS COVER SHEET

Handout

- SDC-00-C, Shutdown Cooling Student Handout

Training Aids

- Visual aids

Instructional Equipment

- Attendance Sheet
- Lesson Plan
- Pointers, Markers etc.

Instructional Objectives and References

See Module Report MB 00113 SDC-04-C NLIT Systems, Shutdown Cooling System

See Module Report MB 00501 SDC-01-C LOIT Shutdown Cooling System

CONTENT	ACTIVITIES/NOTES
I. INTRODUCTION	
	Introduce self and lesson. Explain to trainees the overall structure and format of the lesson to include: - schedule - break/lunch policy - parking - phone calls/messages - attendance requirements - examinations and criteria for satisfactory completion - safety requirements - building evacuations and smoking policy Encourage trainees to ask questions and contribute pertinent information. Make students aware of the OSHA tagging system used in the Simulator and Technical Training buildings. Students must not attempt to manipulate items that are tagged and/or locked under this system.
A) Lesson Overview/Purpose	
i) Method of Instruction	Lecture/discussion
ii) Questions/Note taking	
iii) Instruction period, approximately 50 minutes	
B) Lesson Objectives/Outline	
i) Objectives	

CONTENT	ACTIVITIES/NOTES
ii) Topic Outline	Review Lesson Outline
C) Student Reference Materials	
i) Lesson Text	
ii) Visual Aids	
iii) Lesson Objectives	
D) Assignments/Exams	Describe quizzes and examinations
i) Study notes and procedures	
ii) Use objectives to prepare for exam	
II. LESSON BODY	
Refer to attached	
III. SUMMARY	
A. Review Lesson Objectives	
B. Questions and Answers	
C. Assignments	
D. Conduct a System Walkdown	PEO-10

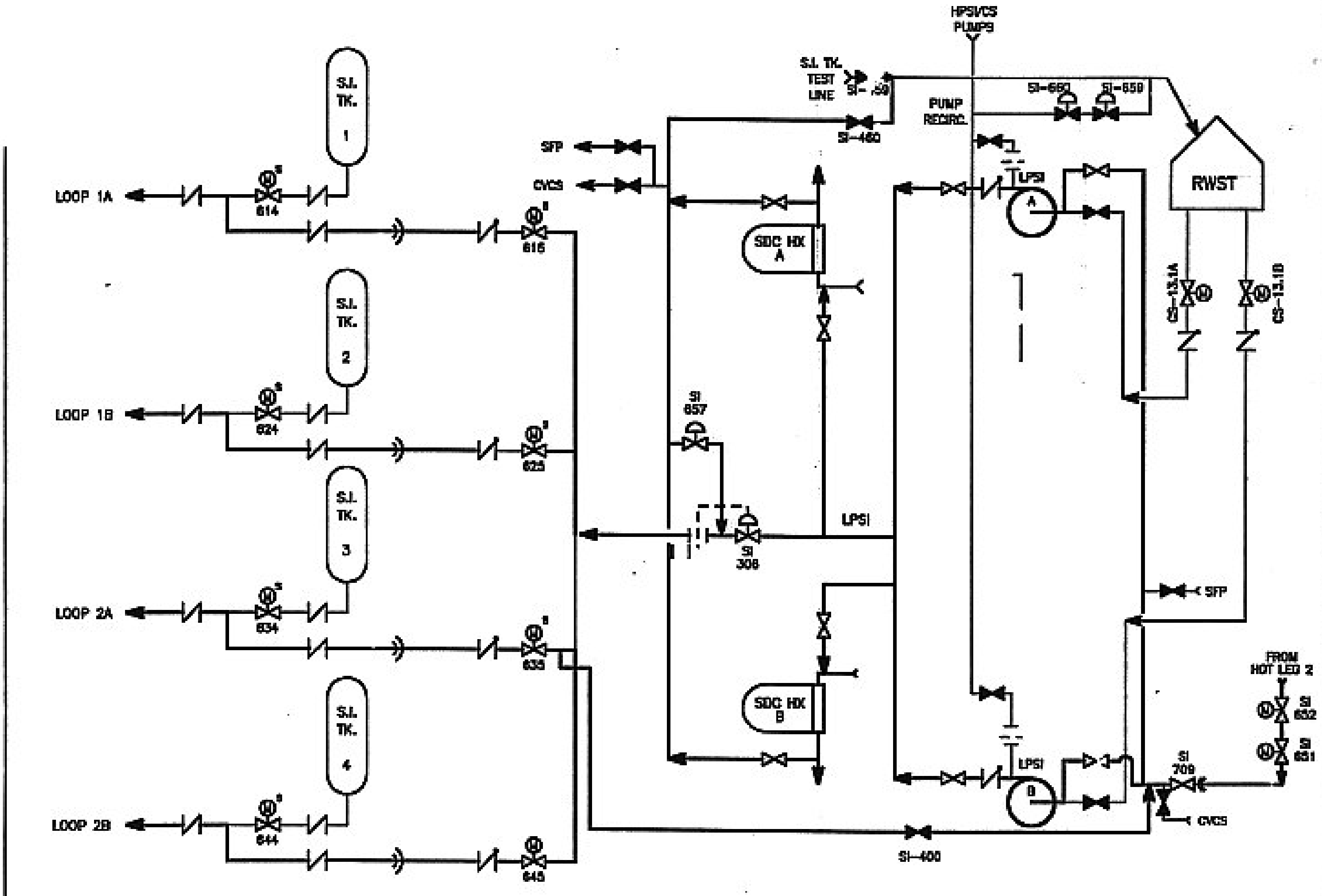


FIGURE 1

SHUTDOWN COOLING SYSTEM

M2 | 09/10/98 | REVISION 2 | 88000775

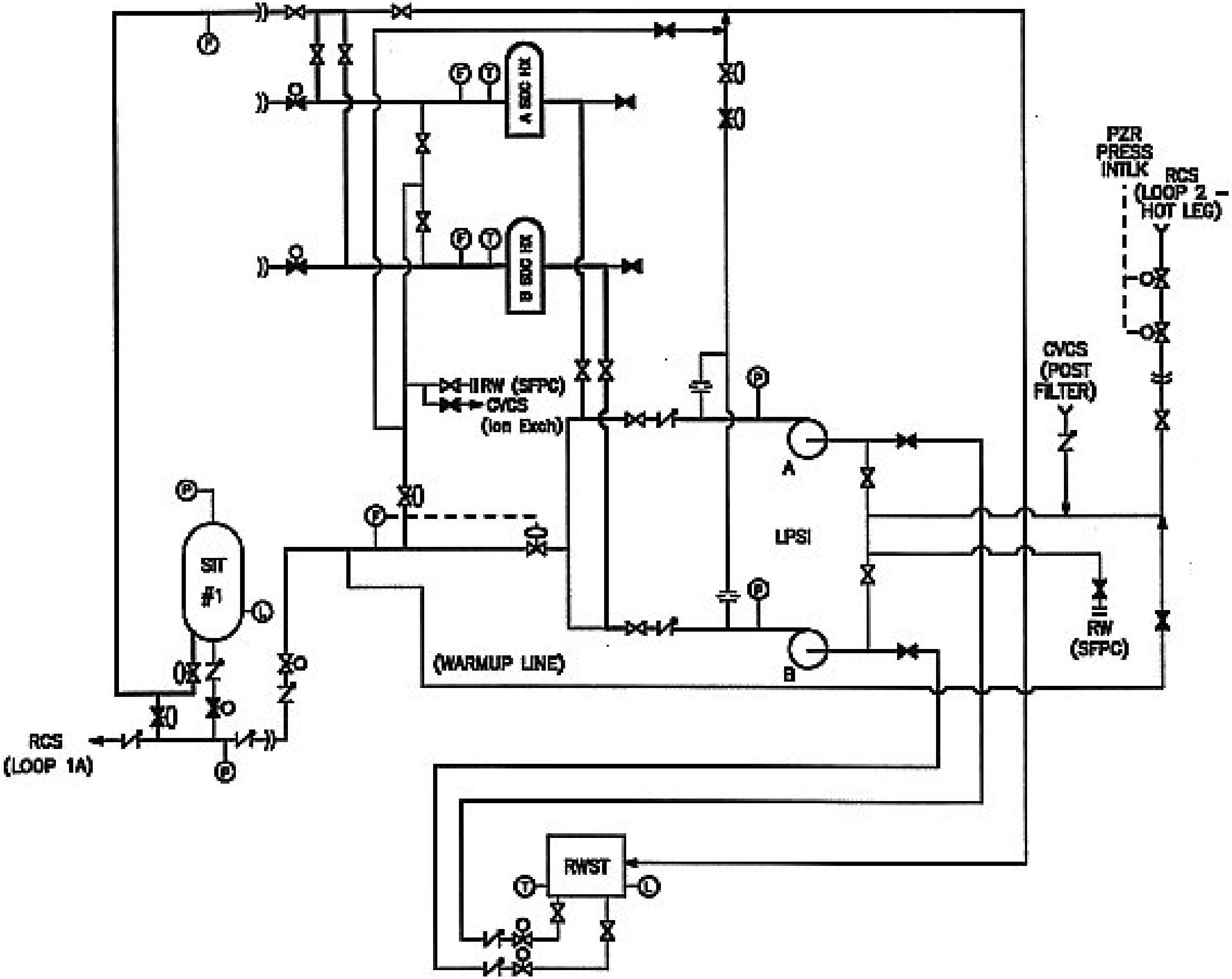


FIGURE 10

FILLING SAFETY INJECTION TANKS WITH SDC

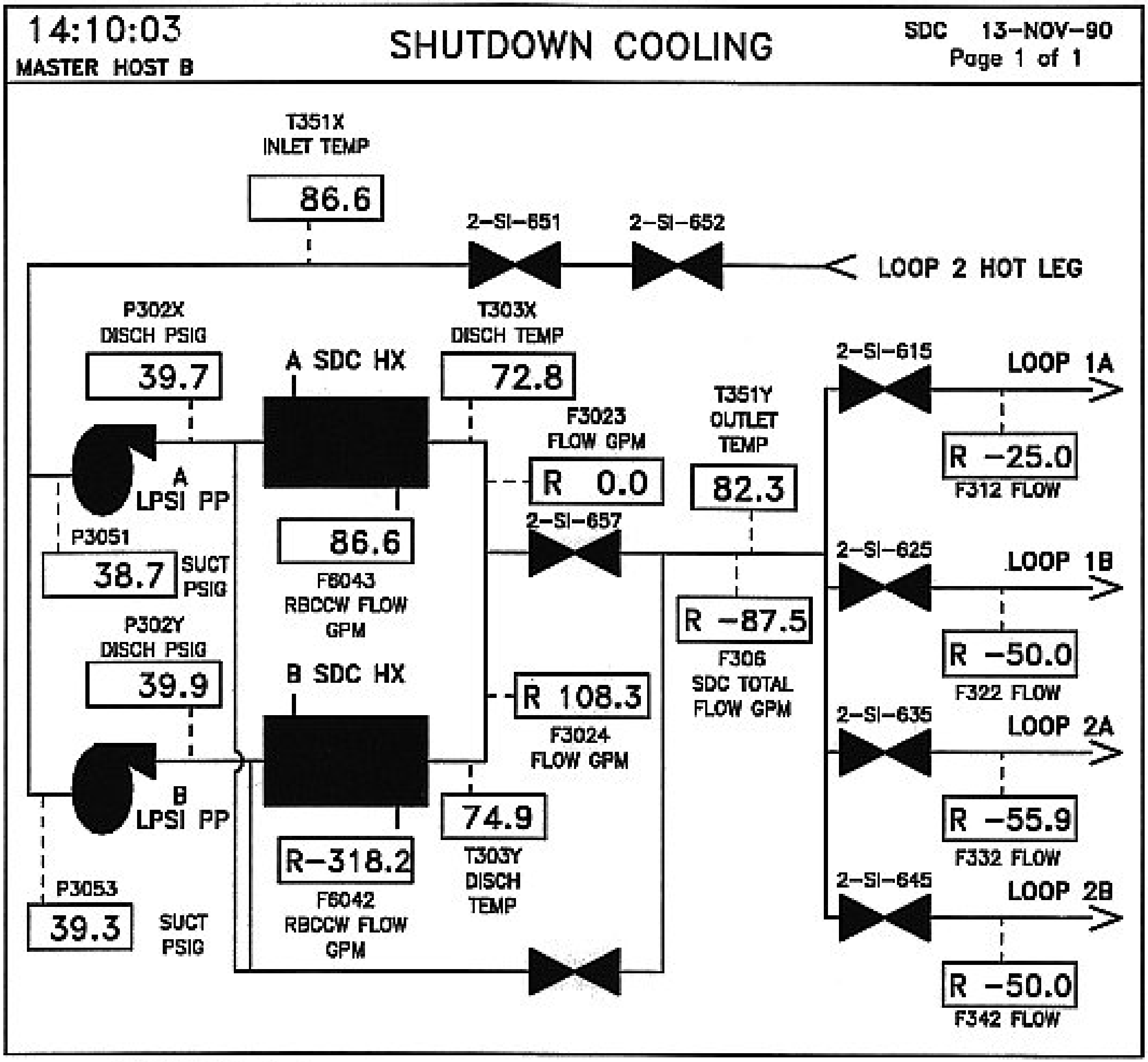


FIGURE 11
PPC SHUTDOWN COOLING DISPLAY

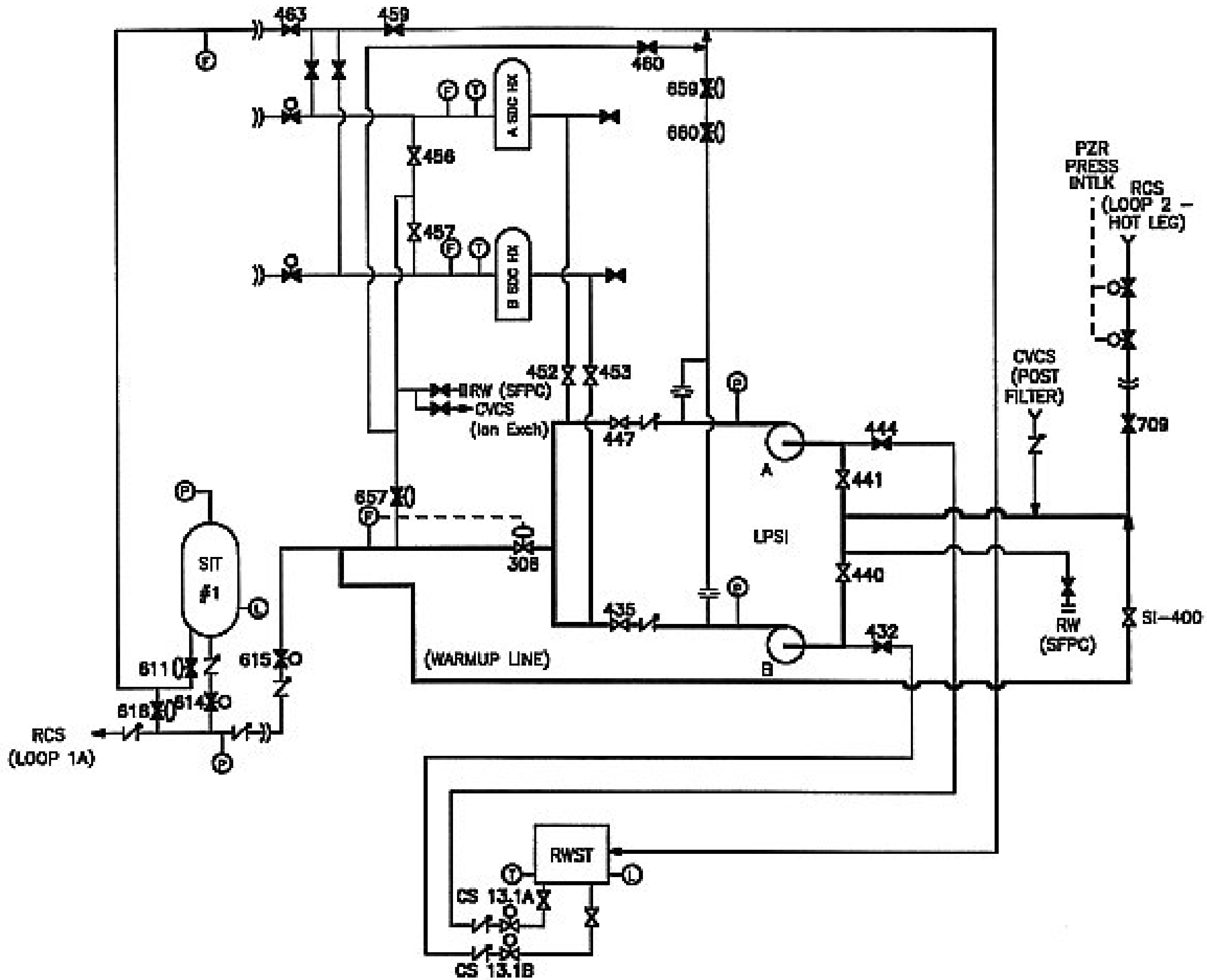


FIGURE 12
SDC WARMUP

M2	09/10/98	REVISION 2	88000782

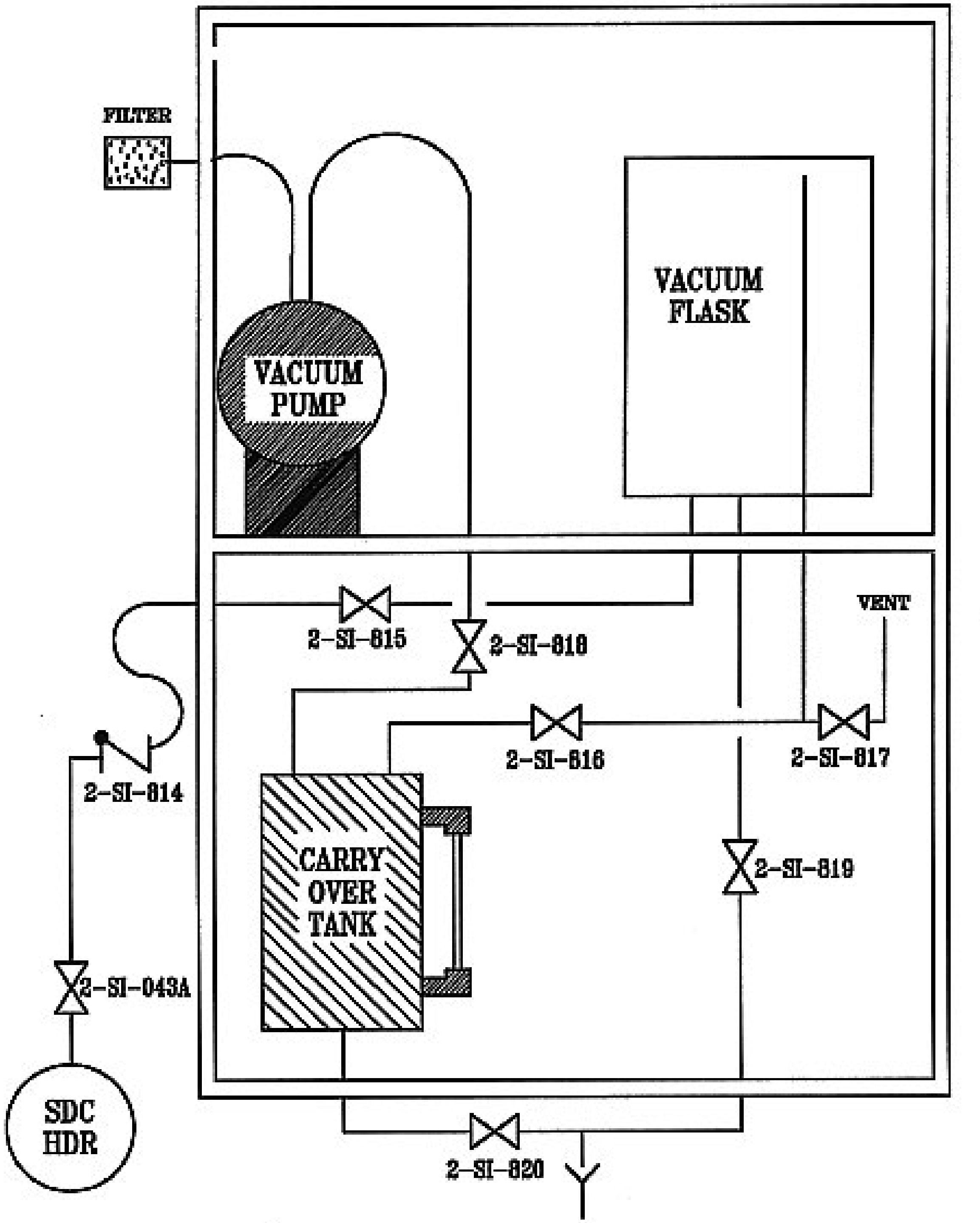


Figure 13

Shutdown Cooling Vacuum Cabinet Assembly

FIGURE 14

RCS HOT LEG LEVEL MONITORING INSTRUMENTATION

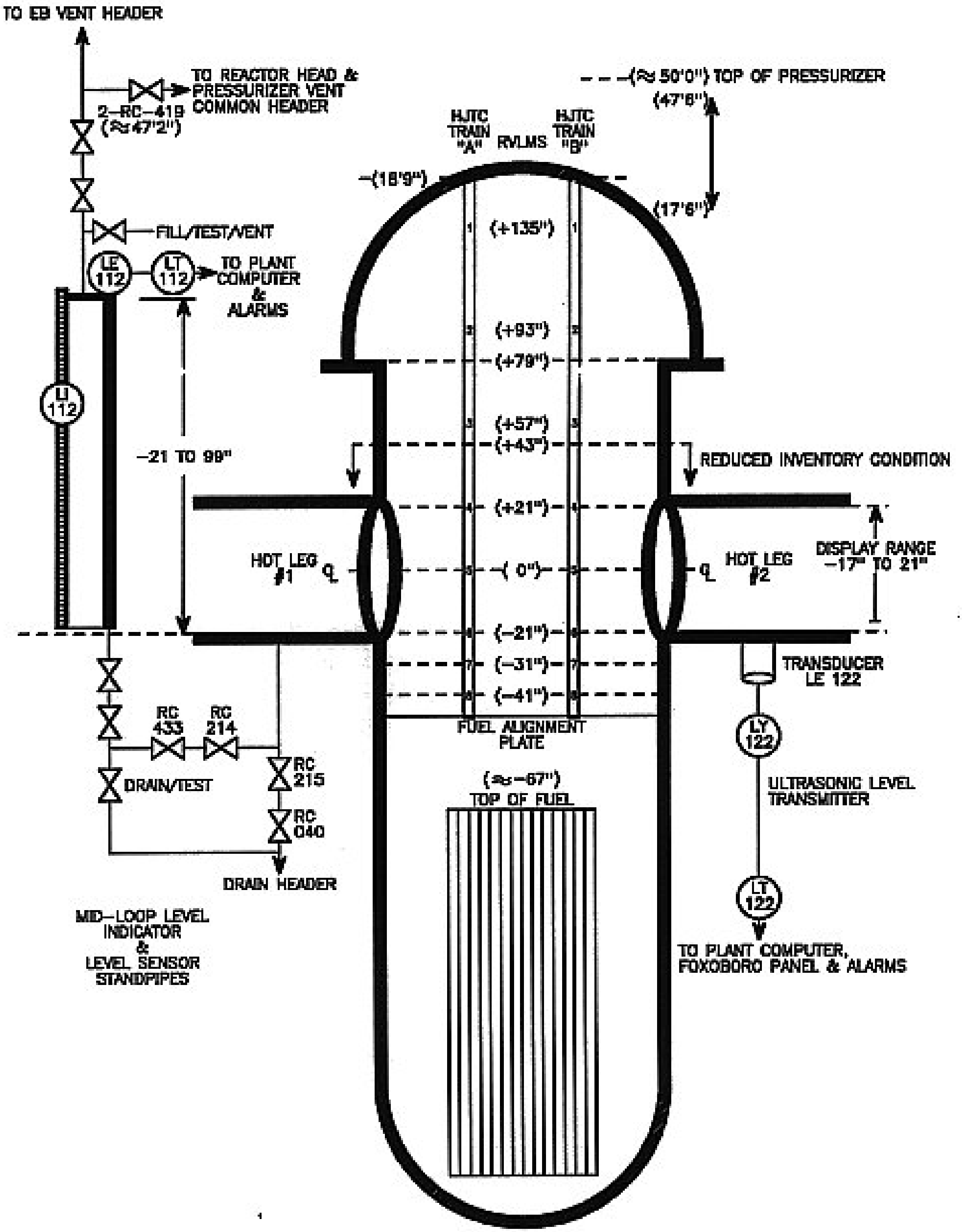


Figure 15

Magnetic Flag Level Indicator

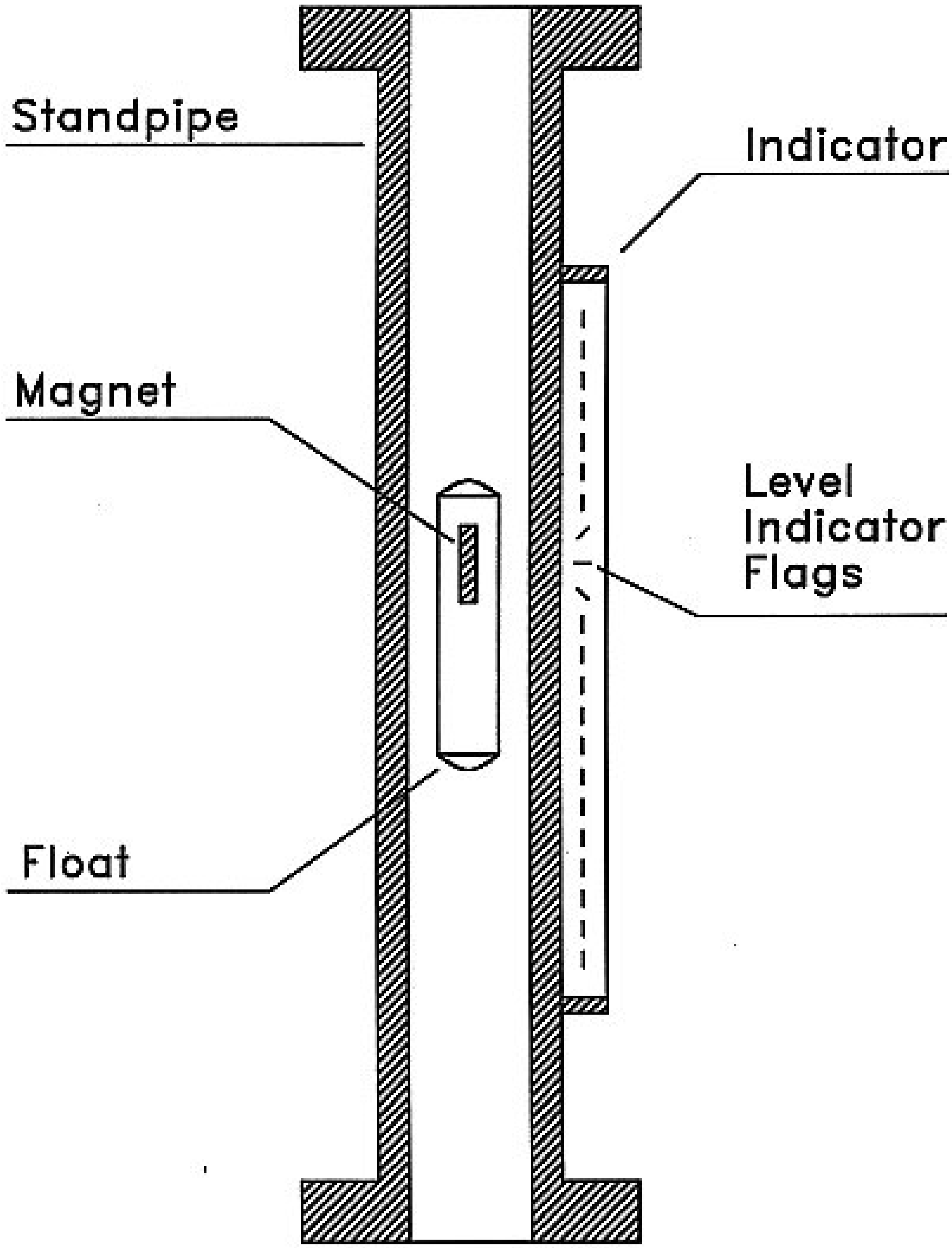


Figure 16
PPC Shutdown RCS Level Display

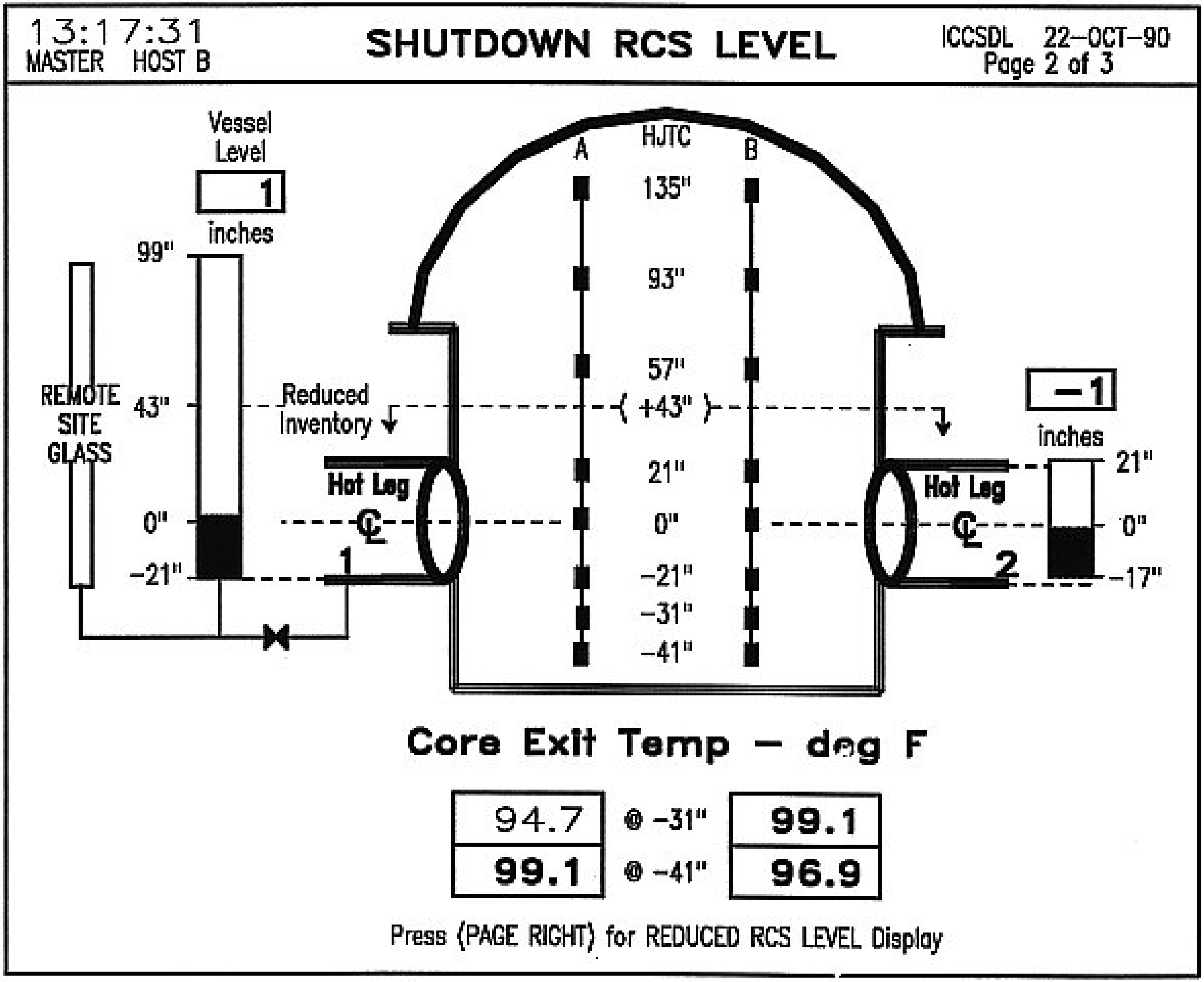


Figure 17
PPC Reduced RCS Level Display

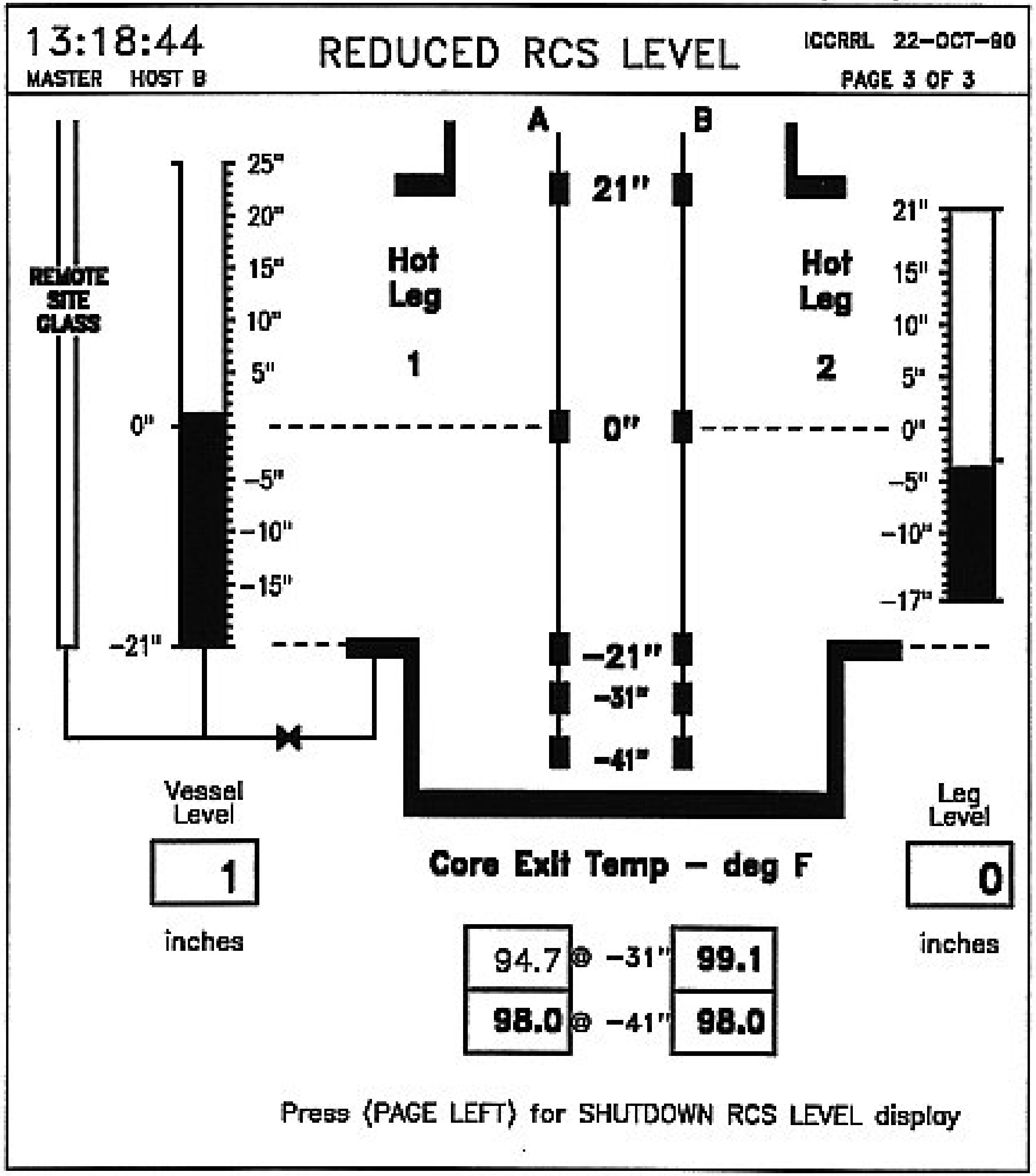
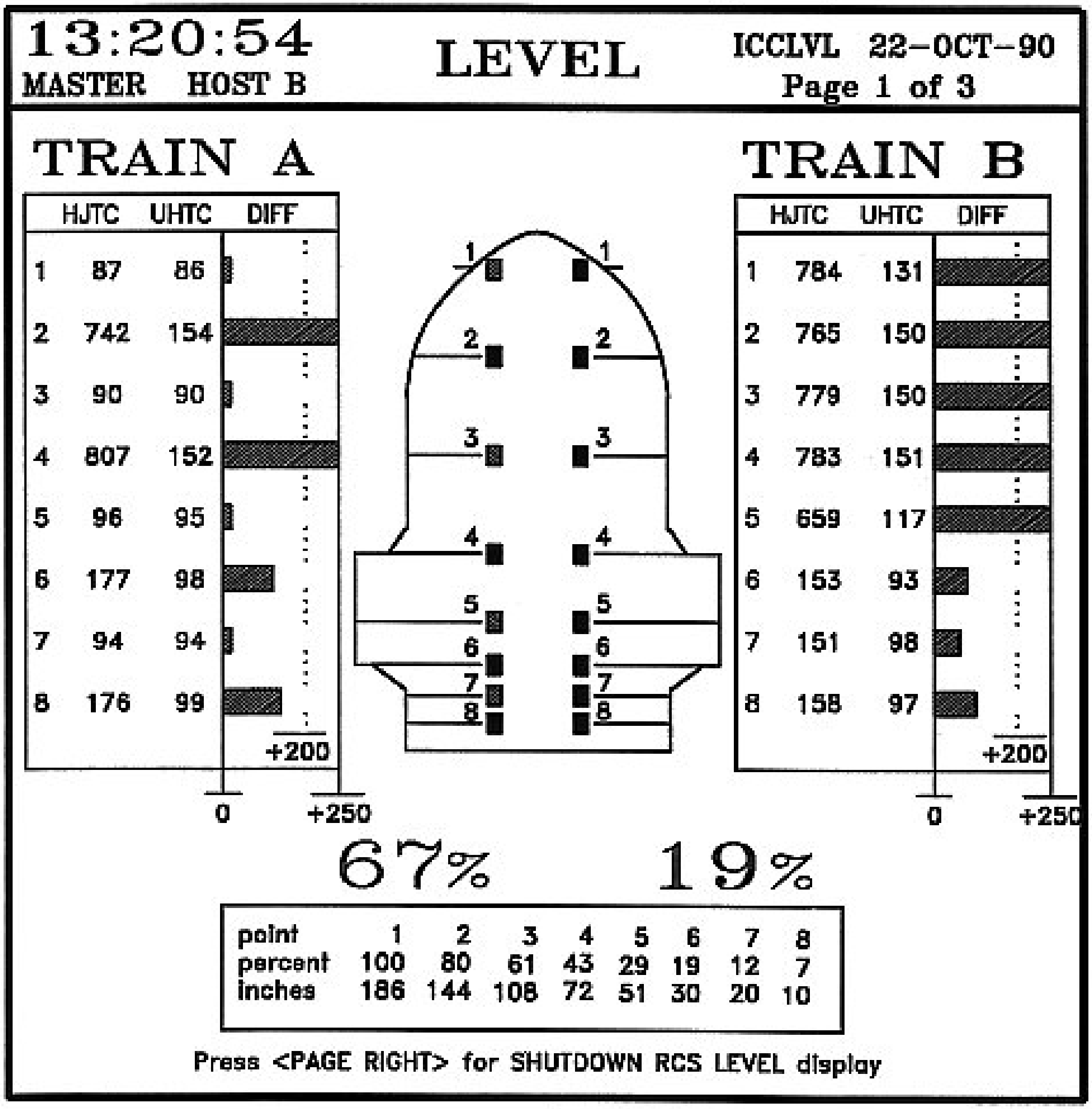


Figure 18

PPC Level Display



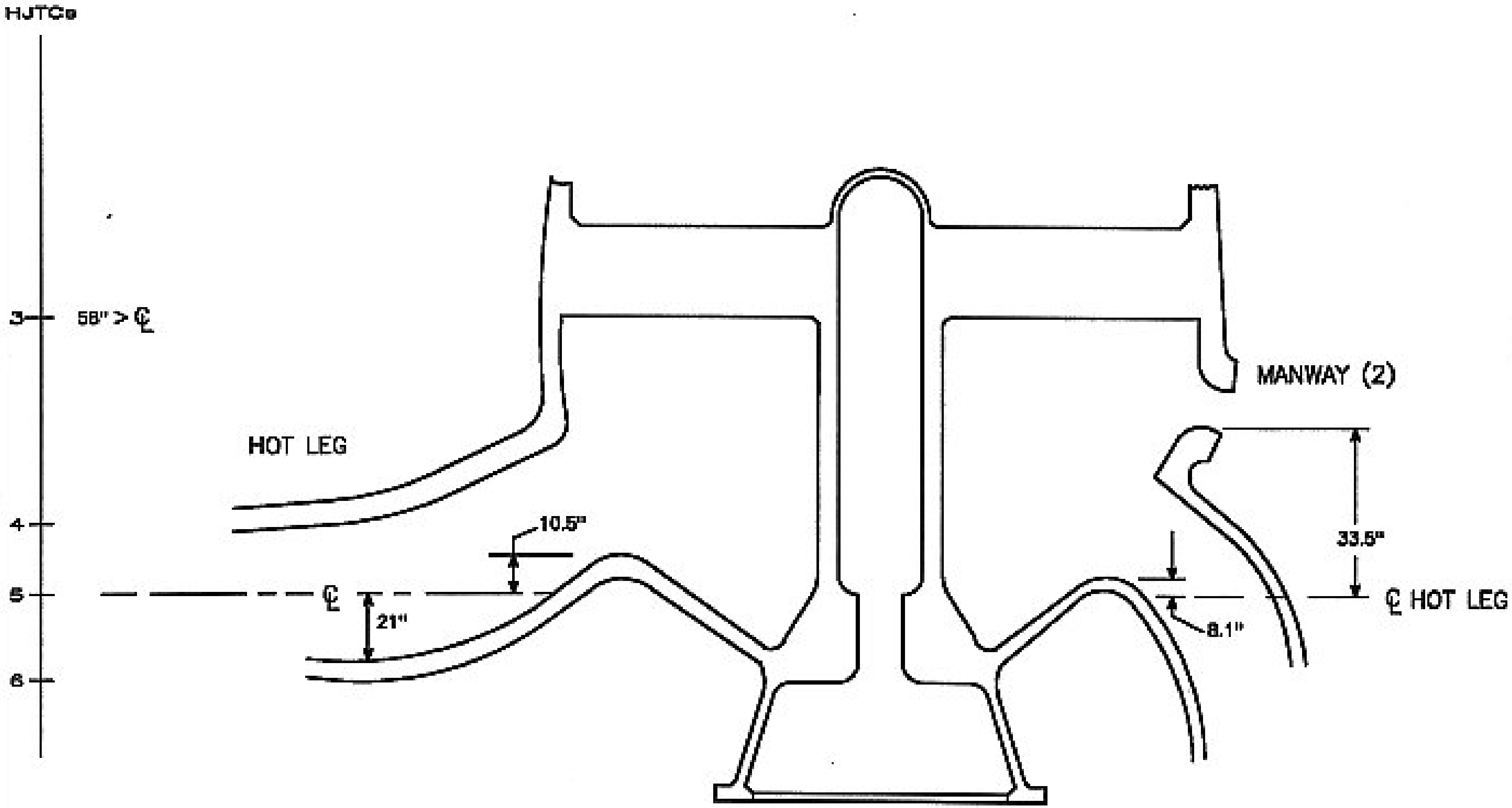


FIGURE 19

SDC SG LEVELS

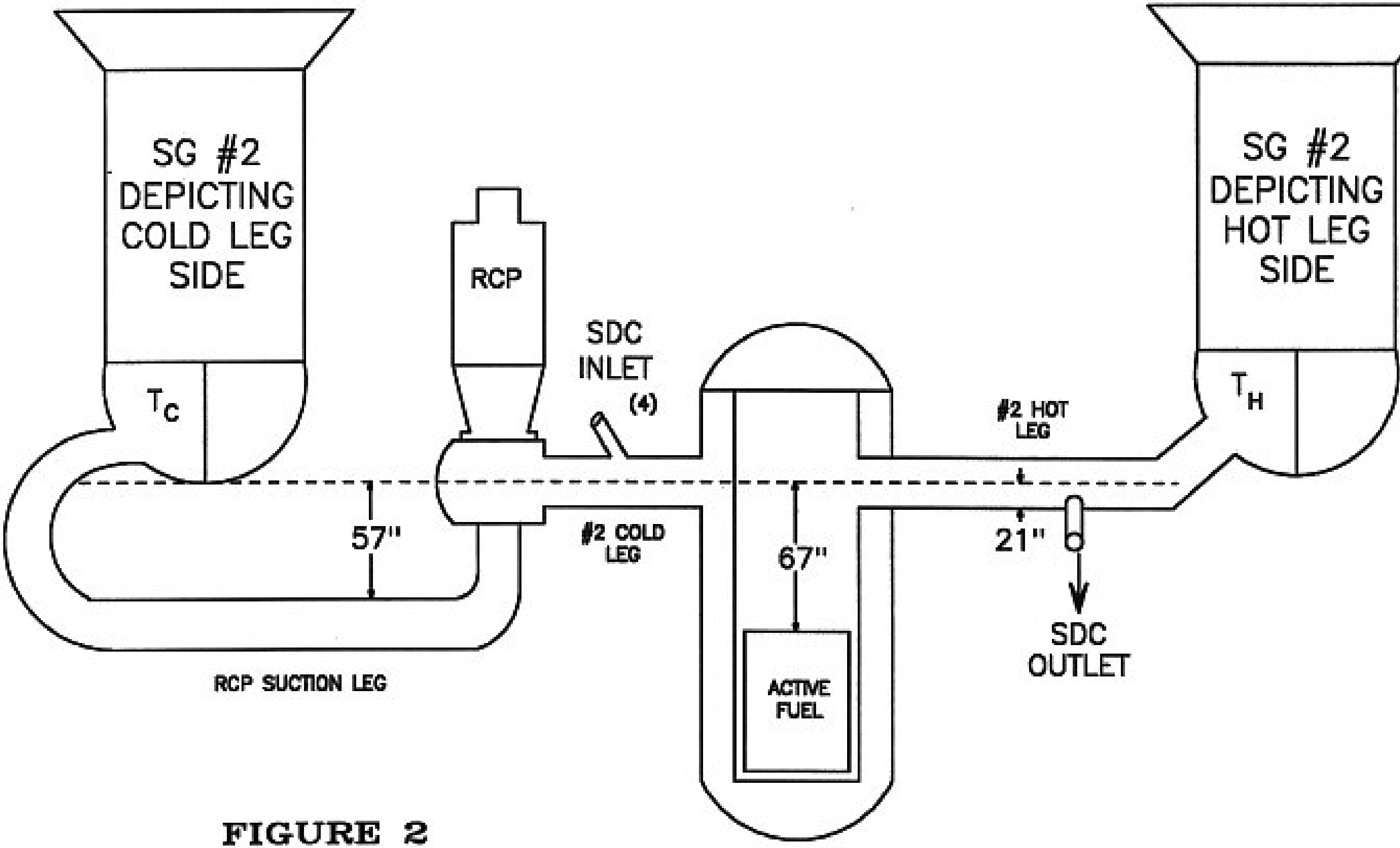


FIGURE 2

SDC/RCS INTERFACE

M2 | 09/08/98 | REVISION 2 | 88000777

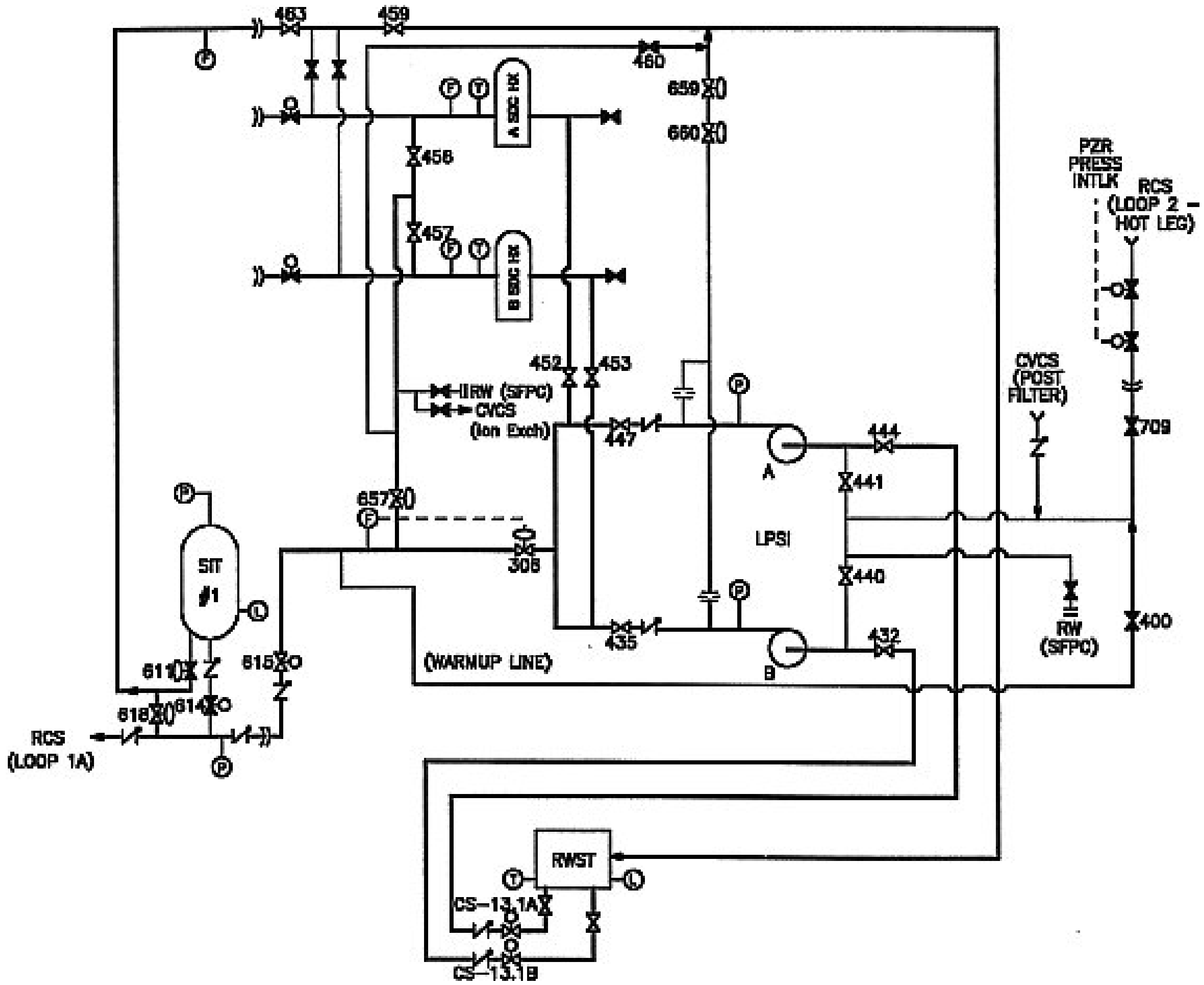


FIGURE 20

BORON EQUALIZATION

M2	09/11/98	REVISION 3	88000781

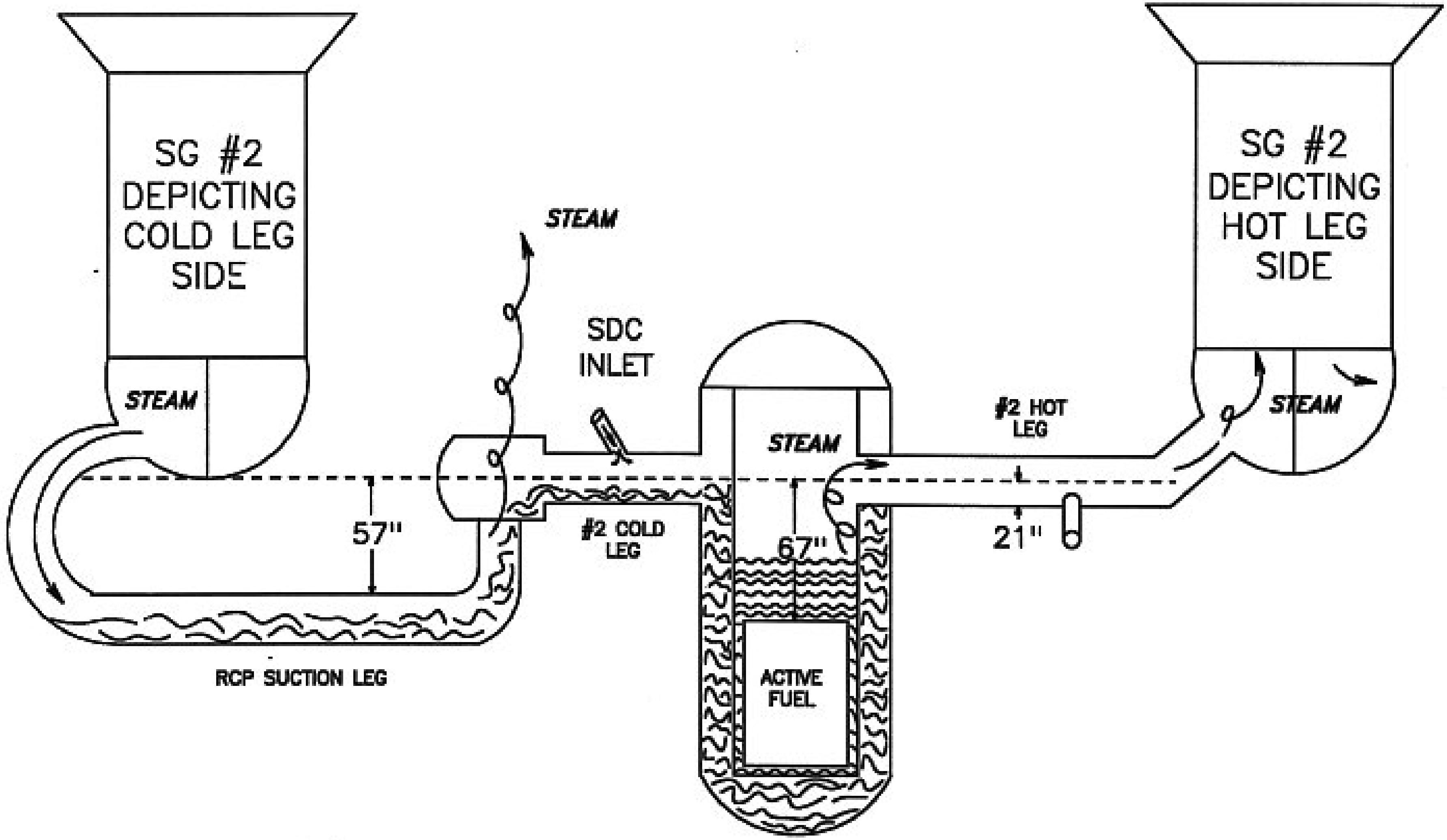


FIGURE 21

POTENTIAL CORE DRYOUT DURING RCP REPAIR (REACTOR HEAD ON)

M2	09/11/98	REVISION 2	88000778

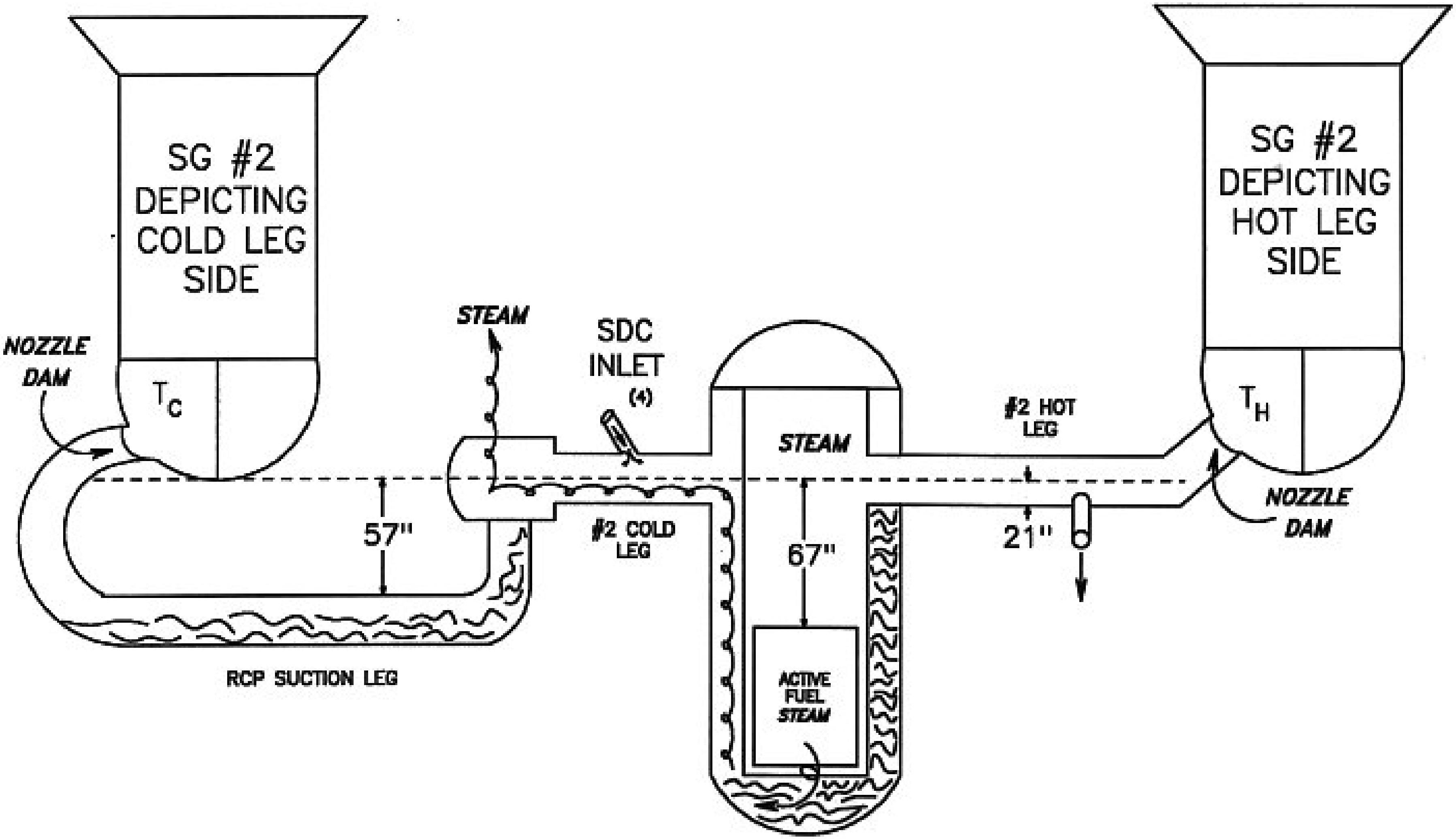
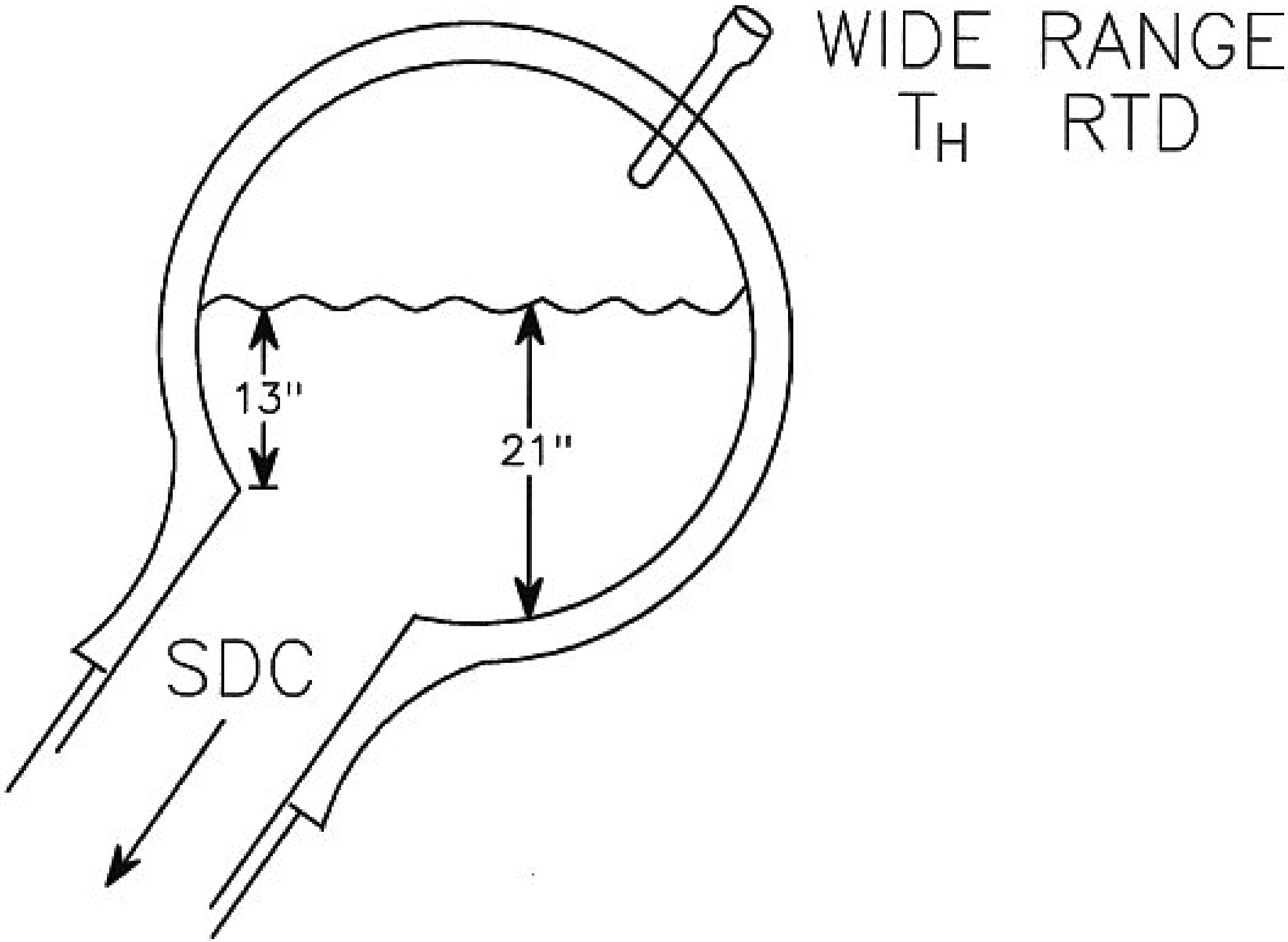


FIGURE 22
CORE DRYOUT DURING RCP REPAIR
(HEAD ON & NOZZLE DAMS INSTALLED)

M2	09/11/98	REVISION 2	88000779

FIGURE 3

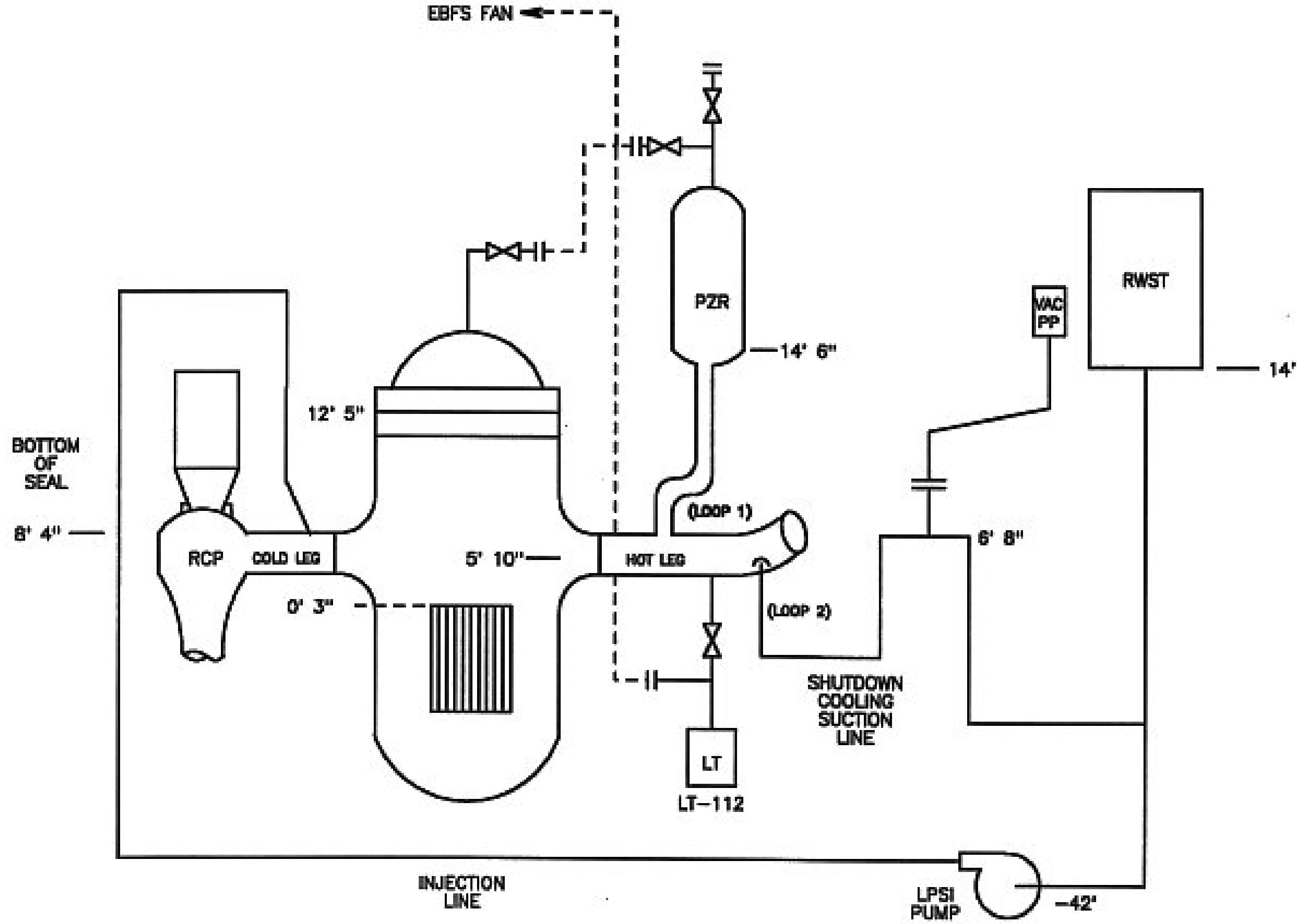
LOOP 2 HOT LEG



M2 | 09/08/98 | REVISION 3 | 88000776

FIGURE 4

SHUTDOWN COOLING SYSTEM ELEVATIONS



M2 09/10/98 REVISION 3 88000915

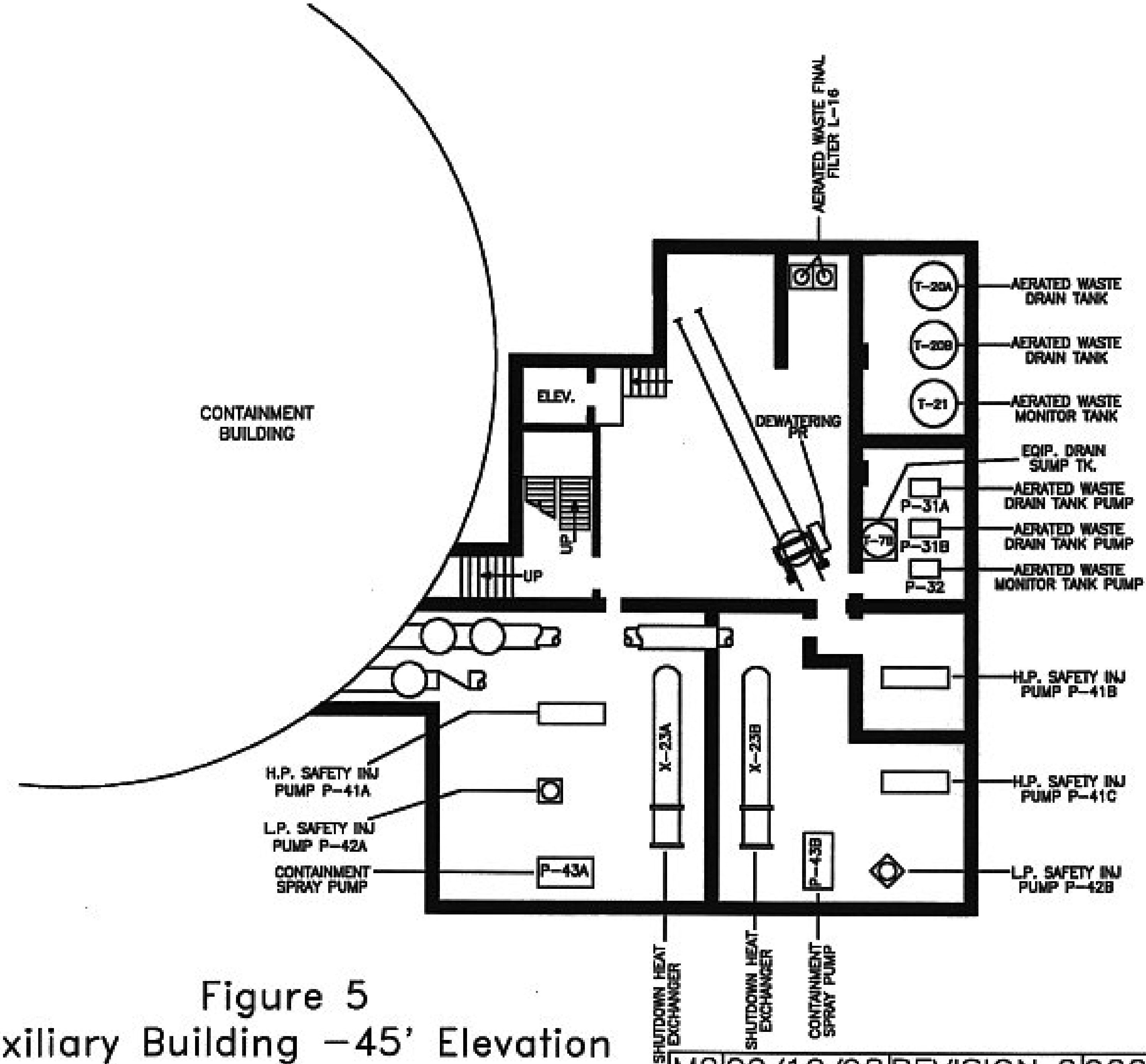


Figure 5
Auxiliary Building -45' Elevation

M2 | 09/10/98 | REVISION 2 | 90000178

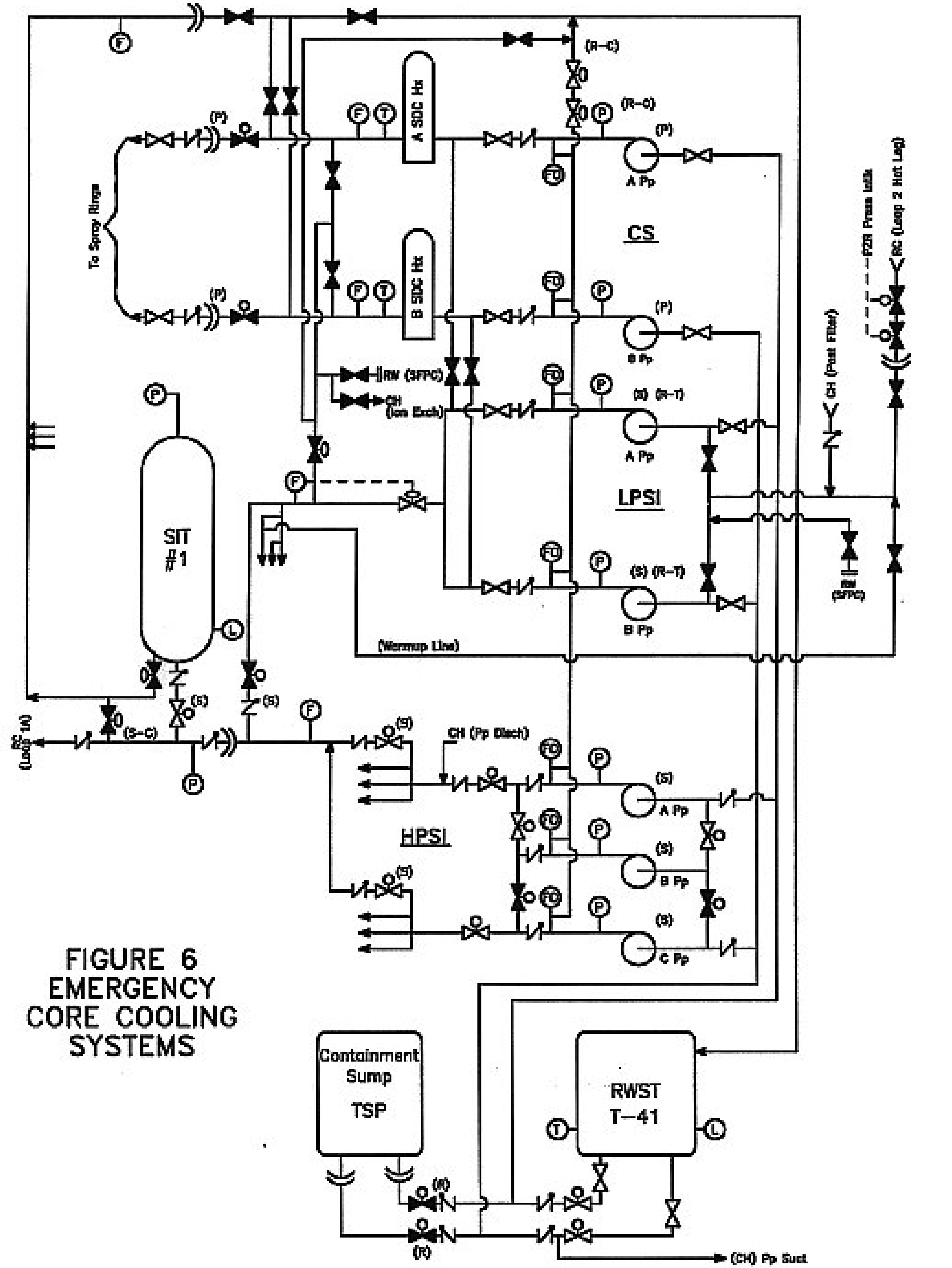


FIGURE 6
EMERGENCY
CORE COOLING
SYSTEMS

M2 | 05-11-98 | REVISION 0 | 9800025C

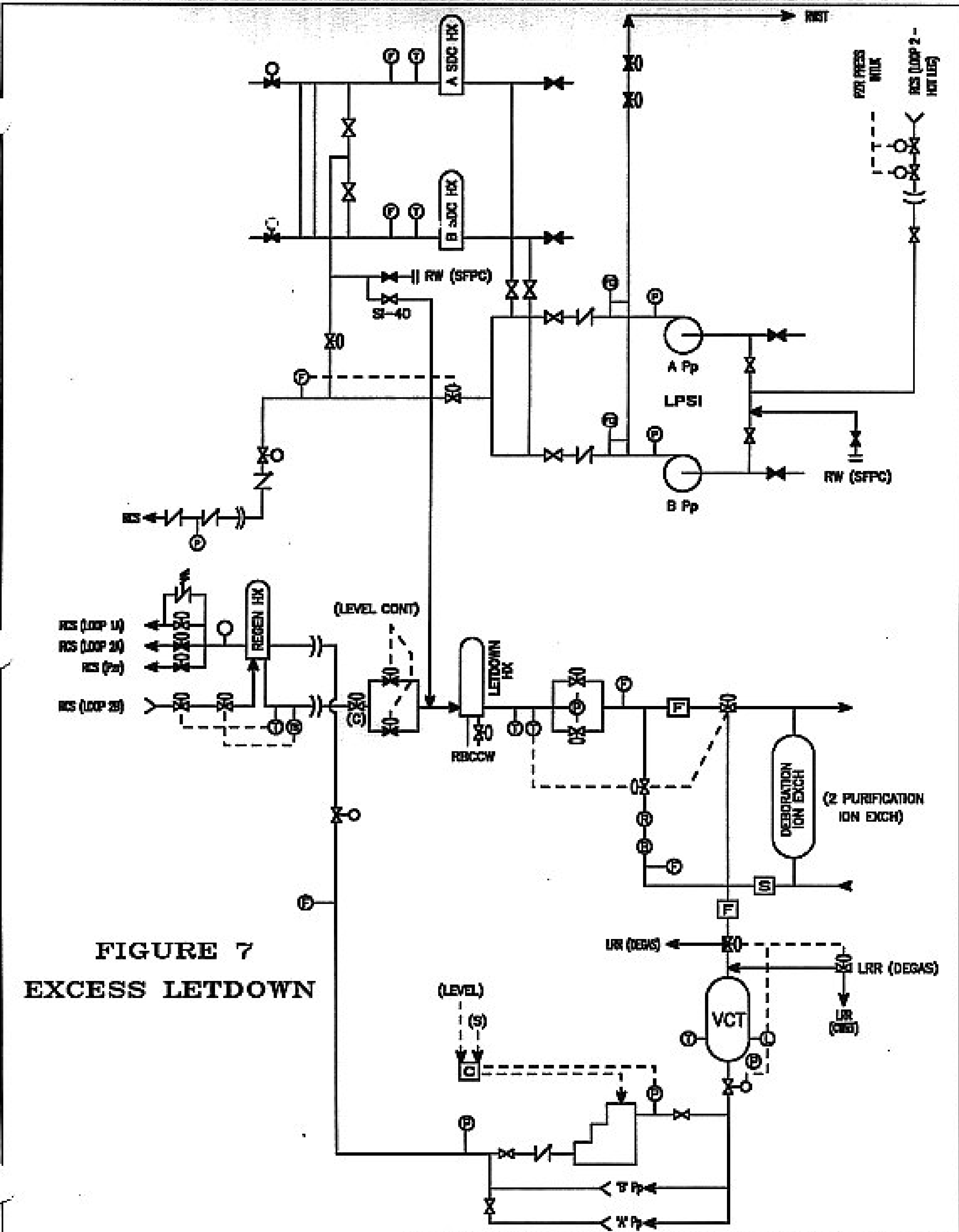


FIGURE 7
EXCESS LETDOWN

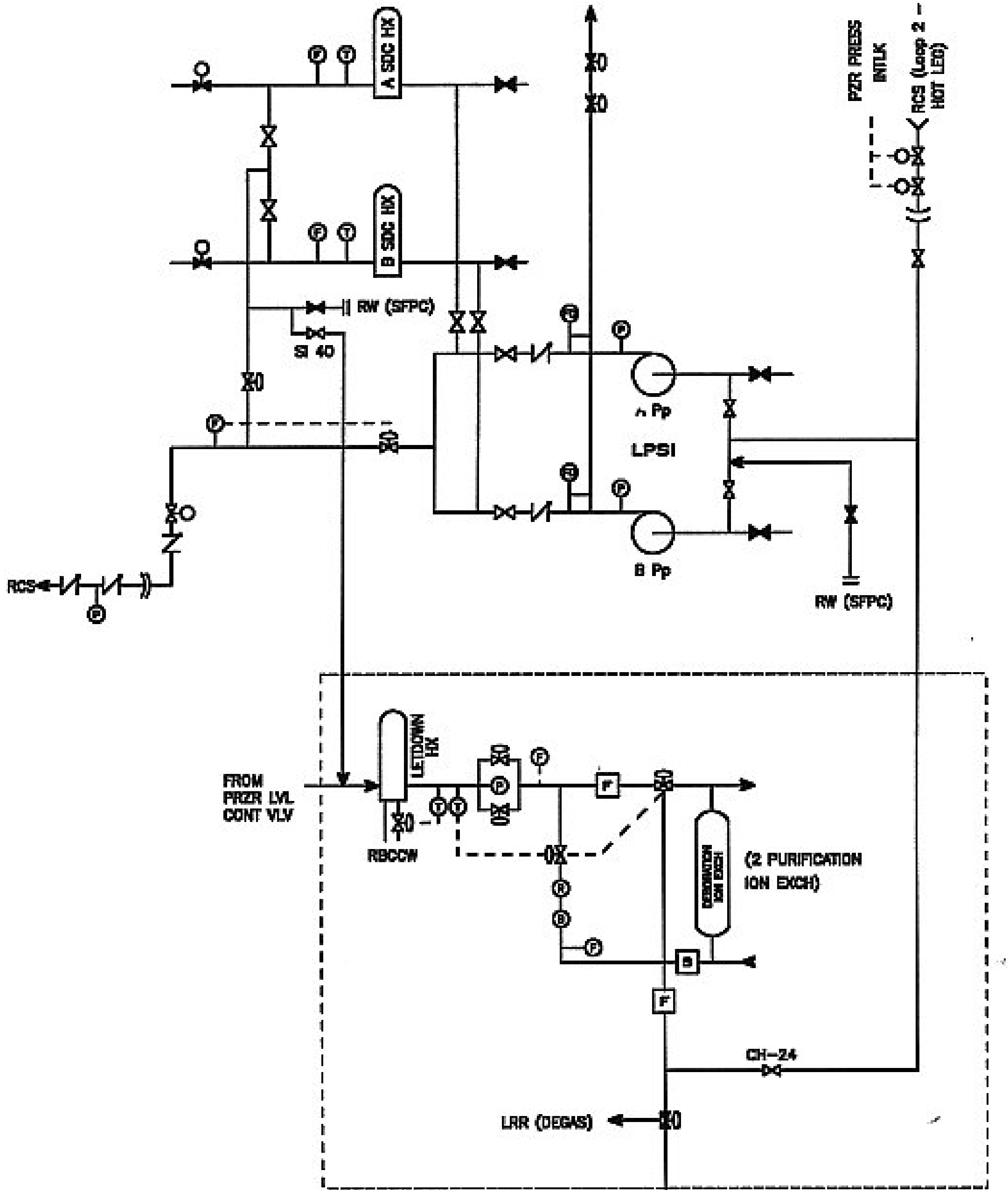


FIGURE 8

ADDITIONAL PURIFICATION

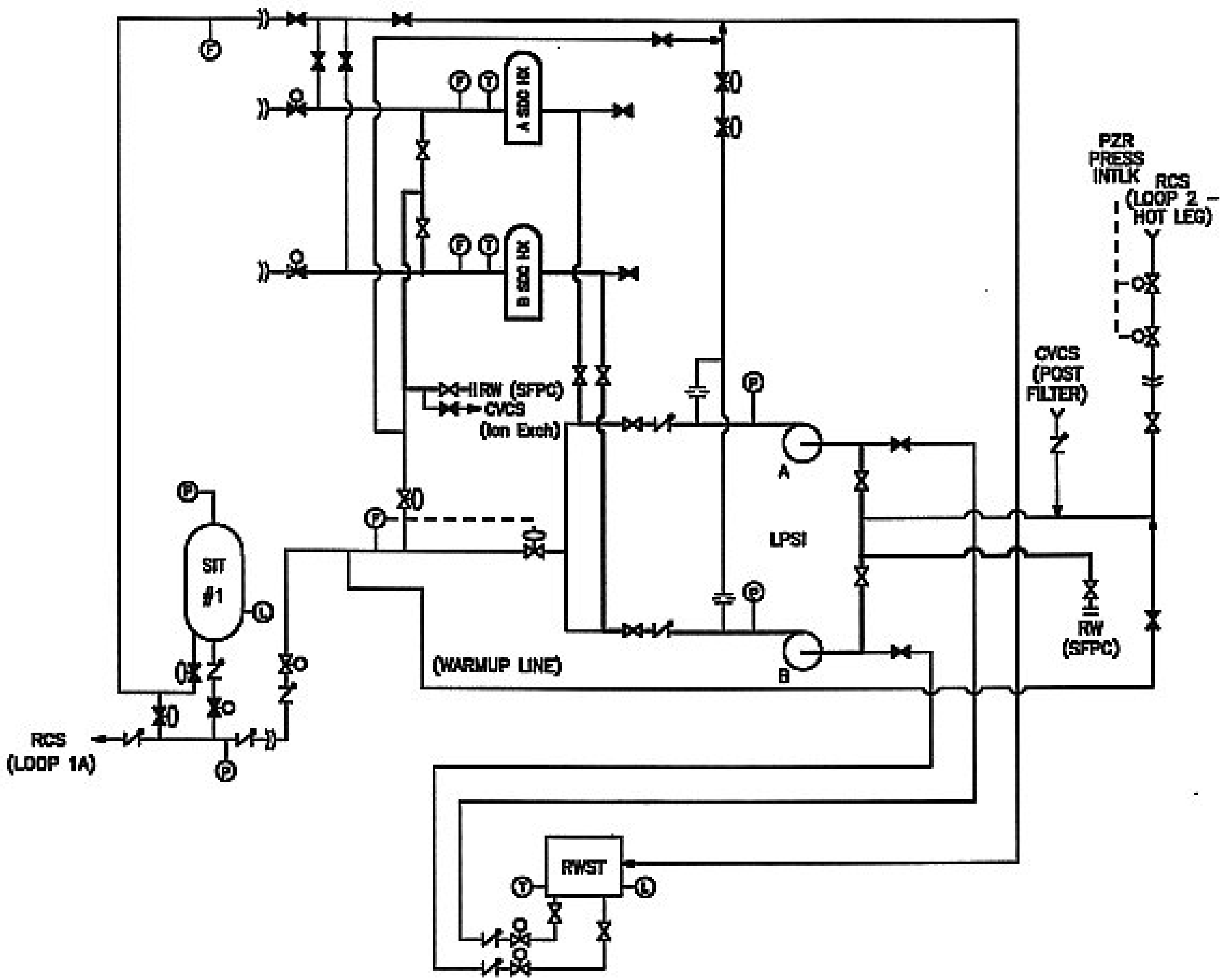


FIGURE 9

SDC CROSSCONNECT TO SPENT FUEL POOL

Setpoint:

- ❑ Pressurizer pressure greater than 280 psia with 2−SI−651 open
- ❑ P103−1 deenergizes

C−9

**SI−651
OPEN**

AUTOMATIC FUNCTIONS

1. None

CORRECTIVE ACTIONS

1. OBSERVE “SDC SYS SUCT SYS ISOL, SI−651,” position (C−01).
2. IF “SDC SYS SUCT SYS ISOL, SI−651” is *not* desired to be open, CLOSE “SDC SYS SUCT SYS ISOL, SI−651” (C−01).
3. ENSURE “SDC SYS SUCT SYS ISOL, SI−651,” closes and alarm clears (C−01).
4. IF annunciator does *not* clear AND “SDC SYS SUCT SYS ISOL, SI−651,” is open, REDUCE RCS pressure to less than 280 psia.
5. IF annunciator does *not* clear AND “SDC SYS SUCT SYS ISOL, SI−651,” is closed, SUBMIT Priority 2 Trouble Report to I&C Department.

SUPPORTING INFORMATION

1. Initiating Devices
   - ❑ 2−SI−651 limit switch and pressurizer pressure, P103−1 bistable, PA−103−1C
   - ❑ 63X/P103−1
2. Computer Points
   - ❑ SI651 (digital)
3. Procedures
   - ❑ OP 2310, “Shutdown Cooling System”
4. Control Room Drawings
   - ❑ 25203−26015, Sheet 3
   - ❑ 25203−32008, Sheet 33
5. Annunciator Card Location: TB2−J18

12/11/03
Approval Date

12/16/03
Effective Date

Setpoint:

- ❑ Pressurizer pressure greater than 280 psia with 2–SI–652 open
- ❑ P103 deenergizes

D–9

SI–652
OPEN

AUTOMATIC FUNCTIONS

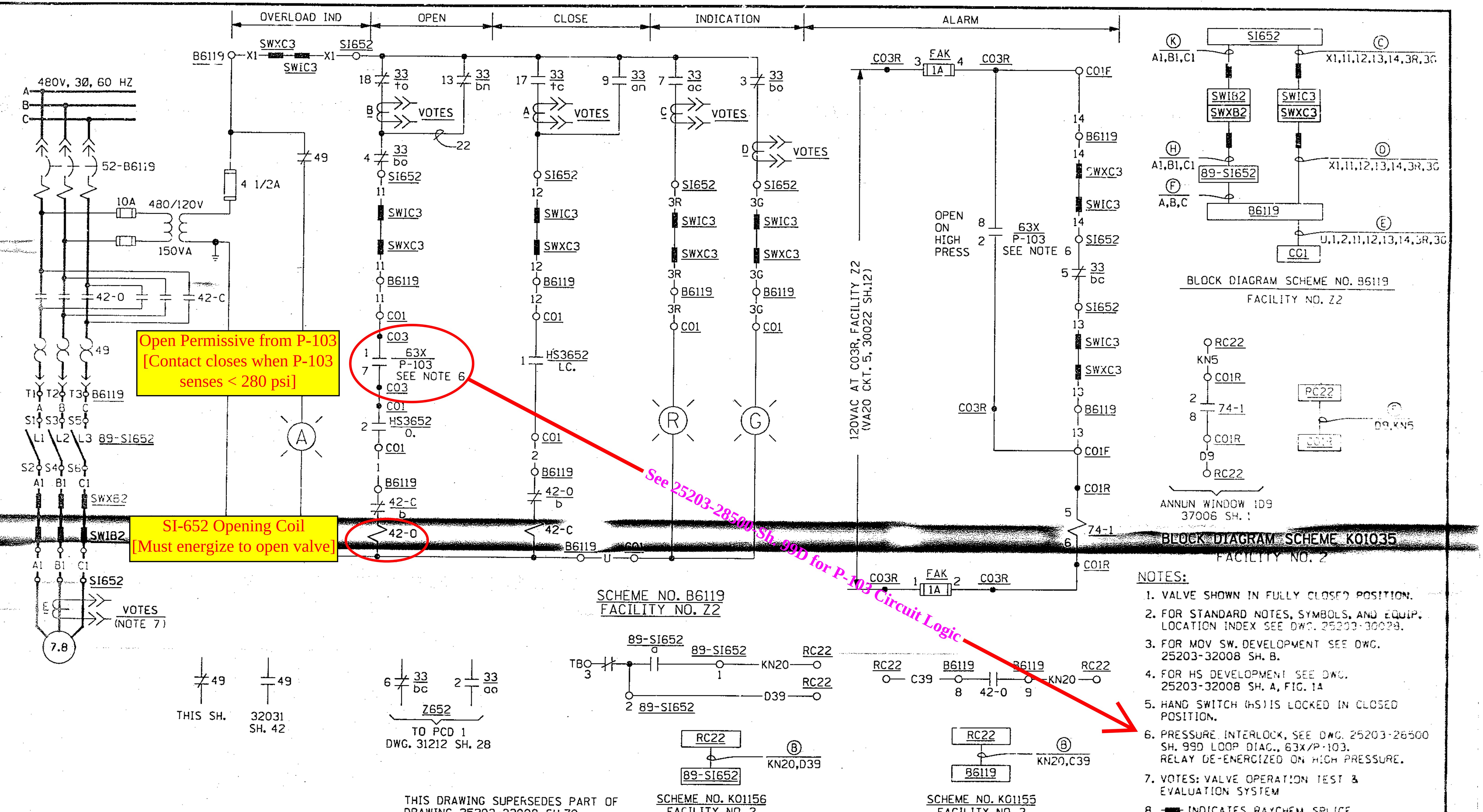
1. None

CORRECTIVE ACTIONS

1. OBSERVE "SDC SYS SUCT CTMT ISOL, SI–652," position (C–01).
2. IF "SDC SYS SUCT CTMT ISOL, SI–652" is *not* desired to be open, CLOSE "SDC SYS SUCT CTMT ISOL, SI–652" (C–01).
3. ENSURE "SDC SYS SUCT CTMT ISOL, SI–652," closes and alarm clears (C–01).
4. IF annunciator does *not* clear AND "SDC SYS SUCT CTMT ISOL, SI–652," is open, REDUCE RCS pressure to less than 280 psia.
5. IF annunciator does *not* clear AND "SDC SYS SUCT CTMT ISOL, SI–652," is closed, SUBMIT Priority 2 Trouble Report to I&C Department.

SUPPORTING INFORMATION

1. Initiating Devices
   - ❑ 2–SI–652 limit switch and pressurizer pressure P103, bistable, PA–103–C
   - ❑ 63X/P103
2. Computer Points
   - ❑ SI652 (digital)
3. Procedures
   - ❑ OP 2310, "Shutdown Cooling System"
4. Control Room Drawings
   - ❑ 25203–26015, Sheet 3
   - ❑ 25203–32008, Sheet 33
5. Annunciator Card Location: TB2–J18



NOTES:

1. VALVE SHOWN IN FULLY CLOSED POSITION.
2. FOR STANDARD NOTES, SYMBOLS, AND EQUIP. LOCATION INDEX SEE DWG. 25203-30028.
3. FOR MOV SW. DEVELOPMENT SEE DWG. 25203-32008 SH. B.
4. FOR HS DEVELOPMENT SEE DWG. 25203-32008 SH. A, FIG. 1A
5. HAND SWITCH (HS) IS LOCKED IN CLOSED POSITION.
6. PRESSURE INTERLOCK, SEE DWG. 25203-28500 SH. 99D LOOP DIAG., 63X/P-103. RELAY DE-ENERGIZED ON HIGH PRESSURE.
7. VOTES: VALVE OPERATION TEST & EVALUATION SYSTEM
8. ▬ INDICATES RAYCHEM SPLICE.

THIS DRAWING SUPERSEDES PART OF DRAWING 25203-32008 SH.70

REFERENCES

25203-30011 SH. 39	MCC B61 LOAD SUMMARY
25203-31025 SH. 15	CONN. DIAG. MCC B6119
25203-39007 SH. 1008	MCC B61 OUTLINE & SUMMARY
25203-31162 SH. 47	CONN. DIAG. SI652
25203-31162 SH. 0A	CONN. DIAG. VOTES

MF	P.A.•	NO.	DATE	REVISIONS	BY	CHK	APP	APP
		16		INCORP. DCN DM2-00-1181-98	WBZ			
		15	10/22/98	INCORP. DCN DM2-00-1042-98	WBZ	MM	MBR	MBR
		14	8/28/98	INCORP. DCN DM2-00-0268-98 & DM2-01-1094-97	WBZ	MM	MBR	MBR

REDRAWN FROM SAME DWG. NO., REV. 11

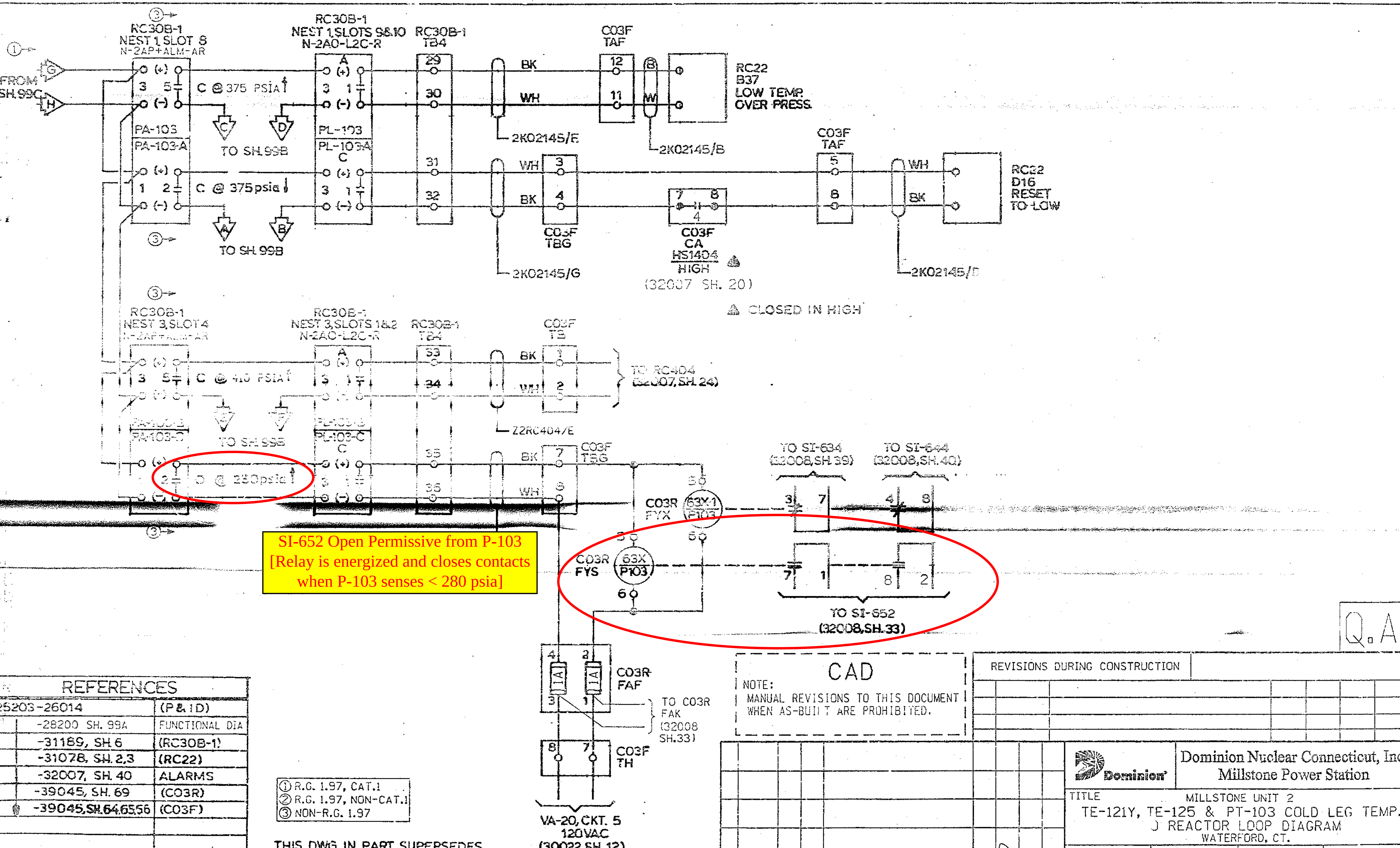
Q.A.

CAD MANUAL REVISIONS TO THIS DOCUMENT WHEN AS-BUILT ARE PROHIBITED

TITLE MILLSTONE UNIT NO. 2
SHUTDOWN COOLING ISOLATION MOV SI652
WATERFORD, CT.

Northeast Utilities System
NORTHEAST NUCLEAR ENERGY CO.

BY DMM | CHKD. | APP | APP
DATE 7/13/93 | DATE | DATE | DATE
SCALE | DWG. NO. 25203-32008 SH. 33
P.A.•



REFERENCES

25203-26014	(P & ID)
-28200 SH. 99A	FUNCTIONAL DIA
-31189, SH. 6	(RC30B-1)
-31078, SH. 2,3	(RC22)
-32007, SH. 40	ALARMS
-39045, SH. 69	(C03R)
-39045, SH.64,65,56	(C03F)

① R.G. 1.97, CAT.1
② R.G. 1.97, NON-CAT.1
③ NON-R.G. 1.97

THIS DWG. IN PART SUPERSEDES 25203-28500, SH. 60 AND IS REDRAWN IN PART FROM 25203-28500, SH.99A, REV. 2.

REDRAWN FROM SAME NNECO DWG. NO. REV. 2

CAD

NOTE:
MANUAL REVISIONS TO THIS DOCUMENT WHEN AS-BUILT ARE PROHIBITED.

REVISIONS DURING CONSTRUCTION

NO.	DATE	REVISIONS	BY	CHK	APP	APP
7	1/6/07	INCORP. DC. 0M2-02-0237-05	MEL			

Dominion

Dominion Nuclear Connecticut, Inc.
Millstone Power Station

TITLE MILLSTONE UNIT 2
TE-121Y, TE-125 & PT-103 COLD LEG TEMP. J REACTOR LOOP DIAGRAM
WATERFORD, CT.

BY JMM	CHKD.	APP.	APP.
DATE 10/19/95	DATE	DATE	DATE
SCALE N/A	DWG. NO. 25203-28500 SH. 99D		

W:\MFCAD\MFDESIGN\USERS\mlcl599\DGN\MP\25203\PROJECT\20030\P28500990.H12 15-DEC-2006