

Fort Calhoun Station Unit No. 1
 OPERATING INSTRUCTIONS
 OI-RC-4

Reactor Coolant System Normal Shutdown

I. Purpose

This instruction describes the procedure to be followed to shutdown the reactor coolant system from hot shutdown condition to a cold shutdown or refueling condition.

II. Prerequisites

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- A. Reactor and steam plant conditions are at the hot shutdown condition in accordance with OP-5. _____ / _____
- B. The CVCS is operable as necessary to provide boric acid at the concentration needed for a cold shutdown or refueling condition. _____ / _____
- C. The CVCS is in operation with purification and degasification at a maximum as per OI-CH-3, if reactor coolant system is to be opened. _____ / _____
- D. Pressurizer pressure low range pressure indicator PI-105 is operable. Pressurizer cold condition level indicator LI-106 shall be in operation. Pressurizer pressure and RCS temperature wide range recorders are operable. _____ / _____
- E. The operating RC pumps should be RC-3A and RC-3B to provide adequate pressurizer spray during the cooldown. _____ / _____

III. Precautions

- A. Flow through the core should be maintained at all times using a reactor coolant pump or the Shutdown Cooling System. A no flow condition is acceptable for some period of time provided the temperature difference between the cold legs of the idle loops and the average coolant temperature in the core as read by the core exit thermocouples shall not exceed 30°F and no change in the RCS boron concentration is being made.
- B. No more than three RC pumps may be operated below 500°F reactor coolant system temperature.
- C. Both steam generators shall be filled above the low steam generator water level trip setpoint and available to remove decay heat whenever the average temperature of the reactor coolant is above 300°F.

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III. Precautions (Continued)

- D. Observe cooldown limitations and pressure temperature limitations given in Figure 2-1B of the Technical Specifications and in Figure III.7.b of the T.D.B.
- E. The reactor vessel head studs must be loosened before reactor vessel temperature decreases below 82°F.
- F. During the cooldown of the RCS an effort should be made to maximize pressurizer cooldown by the use of pressurizer spray. Monitor the difference between RCS loop temperature and pressurizer steam phase temperature. Prior to exceeding 200°F difference between RCS loop temperature and pressurizer vapor temperature ensure pressurizer spray is in operation unless subsequent cycling of the pressurizer spray valves is not anticipated. If a "spray cycle" (defined in OI-RC-7) occurs when a 200°F difference exists, then a thermal cycle is deemed to have occurred and such a cycle must be recorded per OI-RC-7.
- G. Maintain pressurizer water temperature at least 30°F above the reactor coolant system temperature with RCS temperature greater than 200°F.
- H. Observe all reactor coolant pump precautions as stated in OI-RC-9.
- I. The temperature difference between the cold leg of an active loop and the temperature of the cold leg of an idle loop shall not exceed 30°F.
- J. Feedwater additions should be manually controlled to maintain water level between the low water level and high water level alarms (47.2% to 84.7%), to prevent uncovering the tubes and tripping the reactor or flooding the steam separators.

NOTE: Continuous feedwater addition is preferred to minimize thermal shock to the feed nozzles.

- K. Hydrogen concentration in the RC system must be reduced to less than 5 cc/kg if it is to be opened.
- L. The shutdown cooling system must not be placed in service until the reactor coolant system pressure is less than 265 psia and temperature is less than 300°F.
- M. The minimum RC pressure for RCP operation at different Reactor Coolant temperatures is specified in the Technical Data Book.

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III. Precautions (Continued)

- N. After a substantial change in RC boron concentration (greater than 50 ppm) the pressurizer spray valves should be operated at maximum spray, consistent with pressure requirements, until loop and pressurizer boron concentration is above cold shutdown boron requirements and the differential between pressurizer and loop is less than 30 ppm.
- O. Makeup to the RC system during cooldown must be at least the same boron concentration as that in the RC system NO DILUTION is permitted.
- P. Trippable CEA's should not be above their lower electrical limit when Reactor Coolant System pressure is less than normal operating pressure.
- Q. Operations during which the RCS is maintained in a water solid condition should be minimized. If the RCS is in a water solid condition an operator must be stationed at the CB-1/2/3 control panel continuously to monitor and control RCS pressure.
- R. Limit Reactor Coolant Cooldown rate to less than or equal to that specified in Figure 2-1B of the Technical Specifications.
- S. Do not restart a Reactor Coolant Pump during a Reactor Coolant cooldown operation with a solid water condition. The transfer of heat from the Steam Generator to the Reactor Coolant may cause a pressure surge of the RCS.

CAUTION: A non-operating reactor coolant pump shall not be started unless at least one of the following conditions is met:

- a. A pressurizer steam space of 60% by volume or greater exists,

NOTE: An actual level of 60% in the pressurizer corresponds to 60% by volume in the pressurizer. Correct indicated level on LI-106 and/or LI-101X/Y to actual level by use of correction curves in the T.D.B.

- or b. The steam generator secondary side temperature is less than 50°F above that of the reactor coolant system cold leg.
- T. When Reactor Coolant System or Pressurizer temperature has been reduced below 225°F, then and only then can loads be transported over the RCS.

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III. Precautions (continued)

U. During a Reactor Coolant System cooldown with Natural Circulation, special care must be taken to avoid steam voiding in the RCS. Under natural circulation, pressurizer spray valves PVC-103-1 and PVC-103-2 will be ineffective. RCS pressure may be increased with the pressurizer heaters and reduced by charging through the auxiliary pressurizer spray valve, HCV-240. When charging through HCV-240, note charging and let-down flow rates and watch for an unexpected rise in pressurizer level. If an unexpected pressurizer level increase is observed, indicating a void in the RCS:

1. Discontinue spray and redirect charging to the loops.
2. Take manual control at letdown and charging.
3. Make sure that steam generator levels are sufficient to cover the tubes.
4. Continue charging to the loops while noting falling pressurizer level until decreasing level stops or reverses.
5. Reduce cooldown and depressurization rates. Under natural circulation head may cool at 10 to 20°F/hr.

Under natural circulation cooldown be aware of increased temperature gradients between the top of the vessel flange and the coolant nozzles. Also, low coolant flow rates and stagnant regions of coolant impair the ability to achieve equilibrium boron conditions throughout the RCS. Watch for possible dilution as stagnant regions eventually mix with recently borated flowing regions.

V. Cooldown below a T_{COLD} of $153^{\circ}F$ must be reduced to 20°F/hr or less.

W. The PORV lift setpoint (low) arms at 360°F decreasing.

$$290^{\circ}F < T_{loop} < 360^{\circ}F \quad 575 \text{ psia}$$

$$T_{loop} < 290^{\circ}F \quad 425 \text{ psia}$$

IV. Procedure

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A. Perform the following:

1. Prior to commencement of cooldown borate the RCS to cold shutdown boron concentration. _____ /

NOTE 1: Later in the cooldown boration to refueling boron concentration may be accomplished if desired.

NOTE 2: Makeup water can also be obtained by changing the suction of the charging pumps to the SIRWT.

CAUTION: In no case will DILUTION of the reactor coolant system take place.

2. Sample CVCS blended makeup at local sample valve CH-146 and verify that the boron concentration is equal to or greater than that required for the cold shutdown or refueling condition prior to initiating cooldown. If the boronmeter is inoperable, sample the RCS for boron every two hours during the cooldown to ensure no dilution of the RCS is occurring. (Formerly sample every hour.) _____ /

3. Operate the pressurizer spray valve at maximum spray consistent with pressure requirements. _____ /

B. Gaseous activity shall be analyzed and verified acceptable by the Supervisor-Chemistry and Radiation Protection or his designated alternate prior to opening the RC system. _____ /

Supervisor/CARP

C. If desired, two pump operation may be established at this time in accordance with OP-9. If possible, the operating RC pumps should be RC-3A and RC-3B to provide pressurizer spray. _____ /

CAUTION: When reactor coolant temperature decreases to 500^o F ensure that no more than 3 RC pumps are in operation.

D. Adjust pressurizer level setpoint during cooldown so as to maintain actual pressurizer level between 48 and 60%. _____ /

NOTE: Use level correction curves for LI-106 and/or Li-101X/Y in the T.D.B. to obtain actual level from indicated level.

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IV. Procedure (Continued)

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- E. Maintain pressure control during cooldown in accordance with OI-RC-7.

CAUTION: Pressure must not exceed the limits of pressure-temperature curve in Tech. Specs. Figure 2-1B.

- F. Start cooldown by taking manual control of the steam dump and bypass system in accordance with OI-MS-3 and OI-MS-4.

NOTE 1: Follow RC loop and pressurizer temperature during cooldown. (This can be accomplished by trending loop and pressurizer vapor temperature on computer trend recorder.)

NOTE 2: As RC temperature decreases the steam dump valves will have to be opened more to maintain the cooldown rate with the lower steam pressure. If necessary, the steam dump to atmosphere may be used but consideration of water inventory must be observed.

NOTE 3: Re-adjust charging pump accumulator pressure as per OI-CH-1 as pressurizer pressure decreases.

- G. When steam generator pressure decrease to 550 psia (Low Pressure SG-1 and Low Pressure SG-2 Channel PRETRIP alarms actuate on CB-4) manually block SGLS A and B on CB-4 and manually bypass Steam Generator Low Pressure Trips on the RPS cabinets.

CAUTION: The main steam isolation valve HCV-1041A and 1042A will close when steam generator pressure drops to 500 psia if these bypasses and blocks are not affected. If steam generator pressure increases above 500 psia the SGLS Block and the RPS low steam generator pressure bypass will be defeated automatically. To reblock SGLS in this case, decrease pressure below 550 psia; place the SGLS Block switches on CB-4 in the NORMAL and then to the BLOCK position, and place the RPS low steam generator pressure bypass switches on the RPS cabinets to the OFF and then to the BYPASS position.

NOTE: When these bypasses and blocks are in effect, the following alarms/lights shall be energized:

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IV. Procedure (continued)

G. NOTE: (continued)

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- a. SGLS Block A alarm on CB-4
- b. SGLS Block B alarm on CB-4
- c. RPS steam generator low pressure bypass lights on each RPS cabinet.
- d. LOW SG PRESSURE BYPASS alarm on CB-4

- H. When reactor coolant system pressure decreases below 1650 psia, manually block PPLS A and B on CB-1/2/3. _____ /

CAUTION: PPLS will initiate if reactor coolant pressure decreases below 1500 psia, with PPLS unblocked. If pressure increases above 1650 psia, PPLS block will be defeated automatically. To re-block PPLS in this case, decrease pressure below 1650 psia and place PPLS block switch on CB-1/2/3 in the NORMAL and then in the BLOCK position.

NOTE: When PPLS is blocked, the following alarms should be energized.

- a. PPLS A Block alarms on AI-30A and CB-1/2/3
- b. PPLS B Block alarms on AI-30B and CB-1/2/3
- c. PPLS A1 Block alarm on AI-30B
- d. PPLS B1 Block alarm on AI-30A

- I. After verifying that PPLS is blocked, perform ST-PORV-1 (F.1). _____ /

CAUTION: The setpoint for low pressure PORV actuation is variable. RCS pressure must be reduced below lift setpoint prior to dropping T_{COLD} below initiation setpoint.

NOTE: This test must be performed prior to reducing RCS cold leg temperature below 375°F during a scheduled cooldown (reference Tech. Spec. Table 3-3 Item 18). This must be accomplished prior to cooling down below 360°F to avoid opening the PORV's.

- J. After verifying that PPLS is blocked, caution tag and place all HPSI pump control switches in the pull out position. In addition, lock shut and Caution tag the HPSI header isolation valves HCV-306 and HCV-307 provided that a flow path for boric acid injection is available from the CVCS. _____ /

IV. Procedure (continued)

J. (continued)

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NOTE: Caution tagging the HPSI pump control switches in PULL-OUT after PPLS is BLOCKED insures that Technical Specification 2.3.(3) will be satisfied.

- K. At 400°F reactor coolant system temperature, hydrazine may be added if deemed necessary by the C/RP Group. _____ /

CAUTION 1: A limiting cooldown rate of 20°F/hr is in force when T_c is below 153°F.

CAUTION 2: The PORV must be set to lift at their low setpoint prior to 290°F decreasing.

- L. When reactor coolant pressure decreases below 400 psia, isolate the safety injection tanks in accordance with OI-SI-1. _____ /

- M. When the reactor coolant system pressure is less than 265 psia, the reactor coolant system temperature is less than 300°F, place the shutdown cooling system in operation in accordance with OI-SC-1. _____ /

1. If the RCS is to be opened, connect Reactor Vessel Head Vent RC-100 to pressurizer sample line at "T" provided when RCS temperature is less than 210°F and vent the Reactor Vessel Head as per procedure OI-CH-3, E. or degas the pressurizer using OI-CH-3, D. _____ /

- N. Maintain reactor coolant system pressure from 215 to 265 psia and at least one RC pump in operation until the following is completed/verified.

1. Boron concentration meets or exceeds that required for the cold shutdown condition or refueling boron concentration whichever is applicable. _____ /

2. The steam generator secondary temperature has been reduced to as low as possible by performing the following:

- a. Verify RCS temperature has been reduced to the desired value. _____ /

IV. Procedure (continued)

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- N. 2. b. Drain both steam generators to 0% indicated level.

NOTE: Prior to lowering a Steam Generator water level below the Low Steam Generator level Reactor trip setpoint disable all four RFS low level trip units and log same in the jumper log (this will maintain CEDM clutches energized). Disregard this operation if clutches are de-energized.

- c. Refill both steam generators to 100% indicated plus 10,000 gallons (add chemicals as specified by C/RP Group) from the Emergency Feedwater Storage Tank.

3. The pressurizer steam bubble has been collapsed per Step 0 of this procedure (if the RCS is to be opened).

_____/_____
_____/_____
_____/_____

IV. Procedure (Continued)

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- 0. Collapse the pressurizer steam bubble by performing the following:

NOTE: Specific permission from the Supervisor-Operations/ Manager-Fort Calhoun Station or his designated alternate has been obtained to place the RCS in a water solid condition.

CAUTION 1: Maintain RCS pressure between 215 psia and 265 psia while collapsing pressurizer steam bubble.

CAUTION 2: An operator must be assigned full time to control RCS pressure whenever the RCS is in a water solid condition.

- 1. Open letdown valves fully. _____ /
- 2. Insure PIC-210 is controlling RCS pressure. _____ /
- 3. Utilizing either both pressurizer spray valves (PCV-103-1 and PCV-103-2) or auxiliary pressurizer spray valve HCV-240 collapse the pressurizer steam bubble. _____ /

NOTE: If HCV-240 is used, the pressurizer spray valves (PCV-103-1 and PCV-103-2) should be shut.

- 4. Pressurizer heater operation may be required to maintain RCS pressure above that required for reactor coolant pump operation as colder loop water enters a pressurizer. _____ /
- 5. Shut the charging inlet valves to Loops 1A and 2A when HCV-240 is open if required. _____ /
- 6. Degas the pressurizer as required to reduce the dissolved hydrogen and Xe-133 activity to a level specified by the C/RP Group. _____ /
- 7. Caution tag and place all pressurizer heaters to the OFF position. _____ /
- 8. Continue pressurizer cooldown by closing both pressurizer spray valves (if not already closed) and opening the pressurizer auxiliary spray valve HCV-240 (if not already open) and close the loop charging stop valve(s) (if not already closed) to ensure flow to the pressurizer. _____ /

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IV PROCEDURE (Continued)

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- P. After bubble is collapsed and when pressurizer steam phase temperature is within 200°F of pressurizer water temperature operation of power operated relief valves may be used to further cooldown the pressurizer
- Q. Pressurizer cooldown may also be conducted by establishing let down flow through the shutdown cooling system by opening SI-342, SI-185, and HCV-2983 and operating two charging pumps to increase flow through the auxiliary spray line.
- R. Stop all operating reactor coolant pumps in accordance with OI-RC-9. Caution tag and place all RCP control switches in the pullout position. _____ /
- S. Ensure loop and pressurizer temperatures are less than 200°F prior to dropping pressure to that of VCT. Caution tag and place all charging pump control switches to the pullout position.

CAUTION 1: An operator must be stationed at CE-1/2/3 continuously whenever the RCS is in a water solid condition.

CAUTION 2: Do not open the Reactor Coolant System directly to containment atmosphere until nitrogen backfill of the system has been done during drain operation.

- T. If it is desired to drain the RCS for refueling or maintenance, proceed in accordance with OI-RC-5. _____ /

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