BACKGROUND DOCUMENT FOR LOSS OF RECIRCULATION FLOW

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1.0 INTRODUCTION

This instruction provides the actions that would be taken if any of the recirc trains are inoperable when recirculation flow is being established or maintained. Loss of a recirc train would include failure of the pump, discharge valve, or common piping whereby minimal or no recirc flow can be established. This would be significant since the recirc system provides flow to the core via the charging pumps for long-term cooling when the RWST inventory has been discharged to the containment sump subsequent to a LOCA event. Additionally, the recirc system provides a suction source for the refueling water pumps if containment spray is required. Therefore, loss of either or both recirc trains could impact accident mitigation efforts due to the potential for inadequate core cooling or inability to respond to a high containment pressure condition.

Entrance into this instruction would be from any of the following instructions at the time that the recirc system is being placed in service:

S01-1.0-23, Transfer To Cold Leg Injection And Recirculation
S01-1.0-24, Transfer To Hot Leg Recirculation
S01-1.2-1, Response To Inadequate Core Cooling
S01-1.5-1, Response To High Containment Pressure

The main objective of this instruction is to minimize the time that the core is without cooling flow and thereby limit any potential core uncovery. This is accomplished by dividing the instruction into two sections: the first section for loss of one recirc train where the actions are not urgent but anticipate loss of the second recirc train, and the second section for loss of both recirc trains where restoration of core cooling should be expeditiously pursued.

The need for this instruction arose from the results of a probabilistic risk assessment (PRA) of a loss of coolant accident for Unit 1 (Reference 1). The results of this study found that the primary contributor to the likelihood of core meltdown was failure of both recirc pumps to continue operating for 30 days subsequent to a LOCA. The recirc pumps have a canned rotor configuration which uses the pumped fluid for motor and bearing cooling. Because of this, a reduced reliability was assessed subsequent to a LOCA since motor and bearing cooling will be provided by hot, unfiltered, borated sump water. Additionally, this instruction was required in order to conform to the Westinghouse ERG, Revision 1A.

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2.0 RECOVERY TECHNIQUE

2.1 Loss Of One Recirc Train

This part of the instruction deals with a loss of one recirc train whereby actions are taken to ensure its long-term availability while attempting to restore the inoperable train. To assure adequate core cooling, the operator verifies proper operation of the operable recirc train. Once verified, efforts are then taken to ensure its long-term reliability (electrical realignment) and anticipate its failure. Because of the potentially adverse consequences if core cooling flow is lost entirely, anticipatory actions are taken in this part of the instruction for the potential failure of the operable recirc train. This includes refilling the RWST, increasing containment cooling, and continuing efforts at restoring the inoperable train.

2.2 Loss Of Both Recirc Trains

Loss of both recirc trains presents a serious challenge to core cooling. Without any core cooling flow, this event could potentially escalate into an inadequate core cooling condition and result in core uncovery. Moreover, in this case the ability to rapidly align an alternate cooling source will probably not exist since RWST inventory, in all likelihood, will have been completely discharged into the containment sump via cold leg injection. As a result, this part of the instruction attempts to reestablish core cooling flow via cold leg injection once an alternate suction supply (from the spent fuel pool) has been aligned. The recirc system is placed in service when RWST level is between 7% and 12%. For charging pump NPSH considerations, RWST level must be greater than 7%. Therefore, in order to establish cold leg injection, an adequate suction supply must be identified since RWST level will, in all likelihood, be insufficient to support long-term cold leg injection. Consequently, direction is provided in the first part of this section to refill the RWST and, if level is insufficient for charging pump operation, align the charging pump suction to the spent fuel pool (SFP). There is a possibility that RWST level will be sufficient for charging pump operation since provisions are made in this instruction as well as in S01-1.0-23, Transfer To Cold Leg Injection And Recirculation, and S01-1.0-24, Transfer To Hot Leg Recirculation, to refill the RWST. However, this instruction specifies that RWST level exceed 20%; otherwise, charging pump suction is aligned to the SFP. Once an appropriate suction supply is aligned, cold leg injection is established using the same flowrate guidelines as delineated in the above mentioned EOIs. Although reference has been made in the foregoing to the charging pump, if neither charging pump will start, the refueling water pump is used as the alternate injection pump.

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2.2 Loss Of Both Recirc Trains (Continued)

With cold leg injection established, flow into the RCS and core will exit from the break and fill the containment sump. The long-term objective of this instruction is to place the plant in a condition where RHR can be started so that an inside containment, essentially closed loop system can be used. This would require sufficient inventory in the containment whereby the available NPSH to the RHR pumps is acceptable. A conservative estimate of 700,000 gallons of borated water in the containment should provide the NPSH necessary to allow RHR system operation. RCS injection will continue until core exit thermocouples exhibit a downward trend with RCS and RHR system temperatures. At that time, with the plant in Mode 5, a transition is made back to the procedure in effect.

3.0 BASIS FOR EOI STEPS

Availability of information which warrants continuous reference during performance of the instruction is provided on the reverse side of each page of the instruction. The basis for the event specific note CONTAINMENT SPRAY is to provide directions for aligning spray if needed based upon the suction supply to the refueling water pumps. If suction is being supplied by the spent fuel pool (SFP), the hose manifold located adjacent to the west AFW pump can be used to provide containment spray if desired. The reset value is provided to allow containment spray to be secured when it has been determined that it is no longer needed. The basis for the event specific note RWST/SFP ALIGNMENT CRITERIA is to provide criteria for aligning a source of suction to the charging pumps for cold leg injection. The first criteria ensures that the charging pump has adequate NPSH available if aligned to the RWST to prevent cavitation. Should RWST level decrease below 7%, any operating charging and refueling water pumps are tripped to prevent cavitation damage. The operator will then proceed to step 15 to align the SFP to the charging pump suction. The second criteria provides direction for returning the suction supply to the RWST if aligned to the SFP. The reason for the 90% RWST level requirement is to ensure that the RWST is filled sufficiently so that unnecessary and frequent swaps between the RWST and the SFP can be avoided to minimize personnel radiation exposure. It is not desirable to switch back and forth between the SFP and RWST due to the potentially high radiation doses. The reason for the 28′ SFP level requirement is that a loss of suction will occur at that level due to the installed anti-siphon. An alternate method for determining the SFP level is provided for ALARA reasons. 130,000 gallons of water represents the approximate amount of water that would be injected into the RCS from the SFP when the 28′ limit is reached. The basis for the event specific note LOSS OF RECIRCULATION is to provide guidance in the event that both recirc trains fail or one recirc train is restored so that prompt action can be taken. Also, an Executive Summary is provided as the last page to the instruction to facilitate a quick understanding of the instruction.

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Steps 1 Through 9 General Comment

The first nine steps of this procedure provide the necessary actions for loss of one recirculation train. The intent of these steps is to verify that the remaining recirc train is operating properly for core cooling considerations, while, at the same time, ensuring its long-term reliability as well as anticipating its potential failure. Additionally, corrective actions for the inoperable recirc train are identified. With one operable recirc train, the operator would implement the first nine steps of this instruction in conjunction with the controlling procedure in effect.

Step 1: Verify Recirc Train Status

The purpose of this step is to verify the operability of one recirc train to determine the appropriateness of this procedure and step. If no recirc trains are operable, the operator is directed to proceed to step 10 since the first nine steps of this procedure only address loss of one recirc rain. On the other hand, if both recirc trains are operable, the operator is directed to return to the procedure in effect. This step is designed so that it can be entered directly from another instruction (as identified in Section 1.0 of this background document), or from this instruction (from either the event specific step on the reverse side of each page or steps 10 or 12.

Step 2: Verify Operable Recirc Train Status

This step ensures that the one operable recirc train is operating properly since it is the sole source of cooling for the core. Without proper operation of at least one recirc train, significant and extraordinary contingency actions would need to be taken to restore core cooling. Therefore, if proper operation of the operable recirc train is not verified (which would be indicative of imminent failure or potentially inadequate core cooling), the operator is directed to proceed to step 10 to address loss of both recirc trains. Significant efforts will need to be undertaken as the operator attempts to reestablish core cooling from either recirc train or cold leg injection.

In addition to verification of proper recirc train operation, the operator also ensures that only one charging and one refueling water pump is running. The reason for this is to preclude the potential loss due to cavitation of both high-head injection charging pumps and both containment spray pumps should the remaining recirc pump/train fail. At the same time, the containment spray line orifice isolation valves (CV 517 and 518) are closed, leaving only orifice RO 526 in service. This reduction of spray flow to
500 gpm accommodates the failure of the one recirc train since each recirc pump is capable of supplying only 50% of the total spray and reduced safety injection flow. With either CV 517 or 518 open, the single operating recirc pump will experience "run-out" with subsequent function impairment or damage.

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Step 3: Initiate HP Survey

This step directs a Health Physics survey of the major backyard areas where manual operator action may need to be taken to refill the RWST. The survey results would then be used to determine stay times, pathways, and RWST makeup sources.

Step 4: Refill RWST

This step directs the operator to refill the RWST while continuing with this procedure. Although this action is not presently considered urgent since the one operable recirc train is in operation, because of the potentially adverse consequences and impact on core cooling should the operable recirc train fail, it is therefore appropriate that these unusual and time-consuming actions be performed at this time. Refilling the RWST from the post-accident level of 7% to the minimum usable level of 20% could take anywhere from 2 hours to 12 hours depending upon the makeup source. The operator is also directed to record the total amount and boron concentration of the water added to the RWST. The reason for this is to enable determination of the total amount of water added to the containment to support long-term RHR system operation as well as ensure that the core remains subcritical.

Factors that would be considered in determining the appropriate source of makeup include:

1. Dose rates in the area where the alignments will occur.
2. Time required to perform the alignment and refill the RWST.
3. Urgency of reestablishing a suction source to the charging pumps.
4. Volume, boron concentration, and chemical contents of the water sources under consideration:
   - Unit 2/3 RWSTs (2) - 300,000 gallons each.
   - Unit 1 PMU Tank - 150,000 gallons.
   - Unit 1 BAST - 6,800 gallons.
   - Unit 1 Holdup Tanks (3) - 50,000 gallons each if full.

Step 5: Evaluate The Inoperable Recirc Train

This step attempts to ascertain the problems associated with the inoperable recirc train. The main purpose of this step is to determine the extent of the failure. As discussed in section 1.0 of this background document, the inoperability of the recirc train stems from a lack of sufficient recirc flow. This could be due to failure of the recirc pump, discharge valve, or recirc piping whereby flow is restricted or non-existent. The operator is directed to first ensure that the recirc pump in the inoperable train is running. If this cannot be performed, there are several reasons why the

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Step 5: (Continued)

pump may not be running, and the operator is directed to evaluate the lectrical status of the pump. Since there are no interlocks or automatic setpoints associated with the recirc pump, the non-running recirc pump most likely did not start or failed because it lost power or tripped due to an overcurrent or ground condition. Once the recirc pump in the inoperable train is verified running, or the RNO investigative actions have been performed (which may or may not have resulted in the pump running, the operator is directed to verify the proper operation of that recirc pump. This would include ensuring that the associated discharge valve is open, and pump flow and amps are stable. If proper operation cannot be verified, the affected recirc pump is stopped if not already stopped, and the condition is reported to the Technical Support Staff. The operator then proceeds to step 7 since the second recirc train remains inoperable.

Step 6: Verify Recirc Train Status

If the preceding step restored operability to the second recirc train, the operator is directed to return to the procedure in effect. Otherwise, the operator continues implementing this procedure at step 7.

Step 7: Check Electrical Alignment Of Operable Recirc Train

This step is provided to reduce the susceptibility of the operating charging and refueling water pumps to potential damage should the running recirc pump fail. With the charging and refueling water pumps powered from the same electrical train as the running recirc pump, loss of the respective 4 kV bus would deenergize all the pumps simultaneously. If, on the other hand, the pumps are on different electrical trains, loss of the running recirc pump could potentially result in damage to the charging and refueling water pumps due to the sudden loss of suction flow.

The respective electrical alignments are as follows:

1. Train 1 - Recirc pump G-45A (480 V bus 1)
   Charging pump G-8B (4 kV bus 1C)
   Refueling water pump G-27N (480 V bus 1)

2. Train 2 - Recirc pump G-45B (480 V bus 2)
   Charging pump G-8A (4 kV bus 2C)
   Refueling water pump G-27S (480 V bus 2)

To accomplish an orderly transfer, the listed sequence keeps the total system flow well below the 800 gpm design flow for one recirc pump by ensuring that:

1. A maximum of two pumps (in addition to the running recirc pump) are running at the same time, and

2. Two refueling water pumps are not running simultaneously.

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Step 7: (Continued)

This realignment is structured so that the operator indirectly determines the continued need for containment spray if in service. If the operator determines that containment spray is not needed, then the refueling water pump should not be started in the course of the realignment.

Step 8: Increase Containment Cooling

This step provides several methods of supplementing the existing containment cooling. Additional cooling will reduce the heat load on the impaired recirc system and may also allow containment spray to be secured. This would then reduce the total flow required from the recirc system. Although the containment air circulation and SEB fans were not considered as part of the LOCA analysis, any increase in containment cooling will further mitigate the containment pressure and temperature excursion. Based on the analysis contained in Attachment H of Reference 5, the calculated peak containment temperature is 289°F at 45 seconds after the LOCA event. For the worse case analyzed event where there is no CCW flow to the recirc heat exchanger for the first two hours post-LOCA, followed by partial CCW flow restoration (435 gpm as compared to 1000 gpm design flow), the plant is maintained well within the design limits with a secondary peak containment temperature of 273°F at 1.6 days. This analysis assumes that the recirc system is placed in service at 1250 seconds into the LOCA. Therefore, while an increase in containment cooling is not necessary at this time (since the analysis does not take any credit for this), it is important that containment pressure and temperature be limited by every means available. Since a loss of all recirc will impact the containment spray system, increasing containment cooling at this time will serve as a precautionary step in the event of a loss of the second recirc train. This is essentially a precautionary step for the unlikely event of a loss of the second recirc train.

In the event of a SISLOP, the SEB fans, TPCW pumps, and containment air circulation fans will deenergize. Therefore, direction is provided to restart them if required. Additionally, a list of those containment fans that should not be submerged throughout this event is provided.

Attachment 4 provides direction for restarting a TPCW pump to reestablish cooling flow to the containment coolers. With one exception, this is the same lineup normally used for starting a TPCW pump. To minimize radiation exposure, an alternate valve (TCW 338) located in the cable tray above the auxiliary cooler is throttled in lieu of the normal manual isolation valve (TCW 339) which is located adjacent to the SEB in the "valve alley" area.

Increasing CCW flow to the RHR heat exchangers should provide some cooling of the ambient environment - particularly if the heat exchangers are submerged.

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Step 9: Subsequent Action

This step concludes the implementing actions for loss of one recirc train. Since actions have been taken to ensure the reliability of the operable recirc train and attempt to restore the inoperable recirc train, the operator is directed to return to the procedure in effect for further casualty directions. However, because of the potential failure of the remaining recirc train, the operator should continue to restore the inoperable train.

Steps 10 Through 30 General Comment

The remaining steps of this procedure provide the necessary actions for loss of both recirculation trains. The intent of these steps is to align a suction supply to the injection pump, reestablish cold leg injection, attempt to restore at least one recirc train, and if unsuccessful, flood the containment to a level sufficient for placing the RHR system in service. Because of the loss of both recirc trains, efforts are initially directed at injecting a cooling source into the core. Once a suction source has been aligned to the injection pump, cold leg injection is established with the same flowrate limitations as found in S01-1.0-23, Transfer To Cold Leg Injection And Recirculation. The only exception would be if the injection pump suction is aligned to the spent fuel pool during the first five hours into the event wherein a limitation of 220 gpm (as opposed to 300 gpm) is imposed. Eventually, at nineteen hours after the LOCA, hot leg injection is established. RHR will be placed in service when greater than 700,000 gallons of borated water has been added to the containment.

Note Preceding Step 10

This note informs the operator that should a RED or ORANGE path condition develop, this procedure should be continued in conjunction with the applicable RED or ORANGE path instruction. Because of the urgency of establishing core cooling, a transition to another instruction, albeit RED or ORANGE, would not be appropriate at this time. However, the criticalness of these instructions is acknowledged by directing that they be carried out in parallel with this procedure. It is possible that the RED or ORANGE path condition could be a result of the loss of recirc flow. Therefore, continuing in this procedure would be appropriate.

Step 10: Verify Loss Of Both Recirc Trains

This step merely serves as a check of the appropriateness of being in this part of the procedure due to the actions that will subsequently be taken. If one or both recirc trains are found operable, the operator is directed to go to step 1 to receive the proper direction.

Step 11: Perform Protective Actions

Since both recirc trains were previously verified inoperable, to preclude damaging the charging and refueling water pumps due to a loss of suction, all pumps are stopped to ensure long-term protection and availability when suction can be reestablished.

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Step 12: Attempt To Place One Recirc Train In Service

In this step, the operator attempts to place one of the recirc trains in service. Although both trains were previously verified to be inoperable, the need for some form of core cooling is imperative and a reattempt is warranted due to the relative ease (start pump, open valve) of this action. Because of the actions that will subsequently be taken, an attempt is made to restore one train since this is the best solution to a loss of all recirc. If this attempt is unsuccessful, the operator proceeds to the next step while continuing efforts to start at least one train.

Step 13: Initiate HP Survey

The reason for this step is discussed in step 3. Although not explicitly stated here, consideration should be given to dispatching an operator with the HP technician to minimize the total time required to refill the RWST. However, the simplicity and minimal effort of this step as opposed to the complexity and much more involved effort and coordination of the next step justifies two separate steps.

Step 14: Refill RWST

The reason for this step is discussed in step 4. In this case, however, the urgency of this situation requires that this action be expeditiously pursued.

Step 15: Align Injection Pump Suction

With the loss of both recirc trains, it is imperative to establish some form of core cooling. Efforts are therefore directed at establishing injection from either the charging pump or the refueling water pump. Because of the loss of suction from the recirc pumps, the operator must realign the suction if RWST level is inadequate. If RWST level is greater than 20%, the operator ensures that the outlet valve is open and CV 517 and 518 are closed (for reasons discussed in step 2). On the other hand, if RWST level is less than 20%, suction is aligned to the spent fuel pool using Attachment 5.

The 20% value was chosen since it allows sufficient time to review, coordinate, and align the suction supply before the 7% lower limit is reached (at which time the injection pump will have to be secured to preclude cavitation damage).

Step 16: Start Injection Pump

This step directs the operator to start a RCS injection pump in order to establish injection flow in the subsequent steps. The primary injection pump would be the charging pump which would allow normal cold leg injection to be established. In the event neither of the charging pumps will start, a refueling water pump would then be used as an alternate injection pump. Prior to starting the charging pump, the operator closes the RCP seal flow controllers and the normal charging valves to preclude a potential for charging pump runout.

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Step 16: (Continued)

Should neither of the charging pumps start, the contingency step establishes a lineup that would allow alternate cold leg injection (refueling water pump through MOV 880 and the RCP seal flow controllers, and then to the cold leg loops). Prior to starting a refueling water pump, direction is provided to close CRS 341, the alternate hot leg recirc manual crosstie valve between the spray line and the letdown line. The reason for this is that this instruction could be entered directly from SO1-1.0-24, Transfer To Hot Leg Recirculation, where the alternate hot leg injection lineup may be in effect. Consequently, closure of this valve would provide protection for the refueling water pump. Additionally, this lineup opens the RCP filter bypass valves (Note: these valves may already be open from the previous instruction). Although this has no effect on the injection flowpath at this time with FCV 1112 closed, hot leg injection could be subsequently established via this path (refueling water pump through MOV 880, FCV 1112, and CV 305, and then ultimately to loop B hot leg via the pressurizer surge line). As a result, either the charging pump or the refueling water pump could be used for cold or hot leg injection.

The containment spray valves are also closed prior to starting a refueling water pump simply for runout considerations. If the need for containment spray exists at this time, based on the event specific step, the operator will initiate containment spray as required.

Caution Preceding Step 17

Charging pump damage can occur as a result of prolonged cavitation if the pump NPSH requirement is not satisfied. Marginal NPSH exists for operating a single charging pump at 363 gpm with two refueling water pumps in operation and RWST level between 7 and 9% per Reference 3. Utilizing 300 gpm allows for approximately 5% total error (15 gpm) in adjusting the flow to ensure that the above NPSH requirement is met.

For similar reasons, a flowrate limitation of 220 gpm is imposed if the charging pump suction is aligned to the SFP.

Step 17: Establish Cold Leg Injection

This is the first step of a loop whereby the injection flowrate is adjusted based upon the expected decay heat input and the need to prevent boron precipitation in the core. The operator will loop between steps 17 through 24 until adequate containment inventory exists to support RHR system operation.

This step establishes direction for the adjustment of cold leg injection to the available injection lines by throttling the RCP seal water flow controllers. A total charging flow of 300 gpm if aligned to the RWST or 220 gpm if aligned to the SFP is specified. Contingency instructions are provided for the situation in which instrument air is unavailable to the controllers. Because this procedure can be entered at almost any time subsequent to the LOCA event (from ten minutes to 30 days), the required injection flowrate will vary dependent upon the total elapsed time from the

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Step 17: (Continued)

LOCA. Therefore, upon entering this step, the operator will check if five hours have elapsed since initiation of the LOCA in order to determine the requisite flowrate to preclude loss of inventory in the reactor vessel. If less than five hours have elapsed since the LOCA, the operator throttles the RCP seal flow controllers to the specified value and then proceeds to step 20 - thereby bypassing those steps that require that more than five hours have elapsed from the LOCA initiation. Contingency instructions are provided for the situation in which instrument air is unavailable to the controllers.

Step 18: Reduce Cold Leg Injection Flow

If greater than five hours have elapsed since the LOCA event, the operator would have been directed to this step from step 17. A check is made to determine that less than nineteen hours have elapsed from the LOCA in order to determine the requisite amount of cold leg injection or the need to establish hot leg injection. This step directs the operator to reduce the cold leg injection flowrate from 300 gpm (or 220 gpm) to 210 gpm if the total elapsed time from the LOCA is between 5 and 19 hours. The basis for this is provided in S01-1.0-23.1, Background Document For Transfer To Cold Leg Injection And Recirculation, and essentially prevents a loss of inventory in the reactor vessel. It should be noted that the injection flowrate is the same regardless if the charging pump is aligned to the RWST or the SFP since this flowrate is less than the 220 gpm limit for the SFP.

Step 19: Establish Hot Leg Injection Nineteen Hours After LOCA

This step provides the actions to transfer a portion of the injection flow from the cold leg to the hot leg to preclude boron precipitation in the core. A detailed discussion of the 19 hour basis and the required flowrates is provided in S01-1.0-24.1, Background Document For Transfer To Hot Leg Recirculation. It should be noted that the alternate hot leg injection flowpath (which establishes reverse flow through the RHR heat exchangers and bypasses the pumps) is not specified as a contingency action since the long-term objective is to place the RHR system in service.

Step 20: Increase Containment Cooling

The reason for this step is provided in step 8 of this background document. In this case, however, both recirc trains are inoperable, and cold leg injection is flooding the containment. Since the containment air handling fans (A-1, 2, 3 and 4) draw air from the 15' elevation, there is the potential that the suction lines could be submerged if RCS injection continues significantly beyond the time that the containment level required for RHR operation is reached. However, this would occur very late into the recovery process and the need to limit containment temperature and pressure takes precedence over maintaining fan operability. Therefore, the operator is directed to start these fans early in the recovery process so that maximum containment cooling can be achieved initially in the casualty.

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Caution Preceding Step 21

The design maximum containment water level is grade 3'11" and is based on submergence qualifications of the electrical conduit and junction boxes below that level per Reference 4. Above this elevation, the electrical conduit is only qualified for a post-accident steam environment. Therefore, prior to the containment water level exceeding grade plus 4 feet, the RHR system valves should be opened to preclude the possibility that they might not open when needed. This caution is provided since the containment is purposely being flooded so that the RHR system can be used to keep the core cool.

Note Preceding Step 21

This note is provided to inform the operator that the normal 350°F temperature criterion for placing RHR in service is not required due to the significance of this casualty and the need to establish long-term core cooling.

Step 21: Ensure Status Of RHR Valves

MOVs 822 A and B are located inside containment at the grade minus 8.5 foot level, below the calculated post-LOCA flooding level of 3 feet 11 inches. These valves are postulated to fail based on their lack of environmental qualification documentation (Reference 18 of SO1-1.0-20.1, Background Document For Loss Of Reactor Coolant). Second order effects from these component failures have been identified in which valve submergence leads to the propagation of a short circuit fault which disables the power source (MCC 1 and 2). Opening the power supply breakers at the MCCs is a reasonable and effective measure. Deenergizing MOVs 822 A and B in the open position will also ensure that backflow through these valves for alternate hot leg recirculation will be possible if required.

Additionally, this step directs the operator to check RCS pressure to determine if the RHR system valves can be opened. To ensure RHR piping integrity, an interlock exists whereby MOV 813 and 834 will not open if RCS pressure is greater than 400 psig. Therefore, if RCS pressure is less than 400 psig, the operator is directed to open the valves in preparation for placing the RHR system in service when sufficient water level in containment exists. It is possible that containment water level may not be sufficient at this time for RHR operation. However, these valves are opened as soon as the RCS pressure criterion is met in light of the caution preceding this step. Additionally, the valve breakers are opened to ensure the valves remain open throughout the casualty recovery. Although MOV 833 and 834 are located at approximately grade plus 18 feet, their breakers are also opened due to the potential for overfilling and since these breakers are near those of MOV 813 and 814. A contingency step is provided if RCS pressure is greater than 400 psig when the operator initially enters this step. With one PORV open, RCS pressure should decrease below the 400 psig requirement as the operator loops through the subsequent steps.

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Step 22: Monitor RWST Level

This step serves as a reminder to ensure that makeup to the RWST is in progress. Additionally, if the charging pump suction is aligned to the SFP, this step reminds the operator of the 28 foot minimum water level requirement to anticipate the potential realignment to the RWST. At that level, suction will be lost from the SFP due to the installed anti-siphon.

Step 23: Commence RCS And SG Cooldown

If steam pressure exists in the secondary, the operator is directed in this step to dump steam in order to assist the injection flow cooling of the RCS and will also help cool the containment. The minimum cooldown rate specified for natural circulation is used since RCPs should not be running and this value is conservative. Also, direction is provided to maintain adequate steam generator inventory.

Step 24: Check If RHR Can Be Placed In Service

This step checks the conditions necessary for placing the RHR system in service. Throughout the time that cold/hot leg injection is occurring into the RCS, the containment is being filled with water as the injection water spills out the break and into the containment. The most important criterion for starting RHR is sufficient water inventory in containment whereby the RHR pumps will have an adequate NPSH. Since the wide range containment water level indicators only indicate a maximum of grade plus 12 feet, the operator checks that level exceeds grade plus 9.5 feet for verification that the containment is in fact flooding. This check will also assist the operator in monitoring the filling trend and will provide an indirect and independent check of the manual calculation of the total containment water inventory. To ensure that the RHR pumps will have adequate NPSH when started, the containment water level must be above any break that can occur in the RCS loops. Therefore, since this minimum level is above the indicating range for the wide range level indicators, a determination of the containment water level is made based upon the total amount of water that was injected into the core. A conservative value of 700,000 gallons was calculated to correspond to approximately grade plus 13 feet. This value is considered conservative since it only accounts for the structural concrete and the reactor vessel, and does not consider the volume displaced by other major components such as pumps, heat exchangers, and RCS piping. From Piping Section Drawing 568570-8 and Reactor Coolant System Piping Drawing 568585-4, a containment elevation of plus 13 feet was selected as the level necessary to assure that the design basis break (RCS loop) will be covered prior, and subsequent to RHR system operation. Using the data presented in Reference 2, this represents approximately 677,000 gallons of water that will need to be spilled into the Unit 1 containment. A final value of 700,000 gallons was selected to account for any errors in calculation and provide a reasonably conservative margin. The operator must calculate the approximate total amount of water that was injected into the RCS/containment from all sources. This would include the water injected from the RWST, SFP, and any external containment spray. It should be recognized that depending on the injection flowrate, it could take roughly 40 hours to fill the containment [700,000 gallons ÷ 300 gpm (flowrate could be higher due to spray, and could be lower due to throttling)].

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Step 24: (Continued)

If the required water inventory is not available at the time that the operator reaches this step, a loop is set up whereby the operator is directed back to step 17. The operator will then continue cold/hot leg injection into the RCS as he progresses through steps 17 through 23. Once the operator determines that sufficient containment inventory exists (i.e., greater than 700,000 gallons), the operator will exit this loop and proceed to place the RHR system in service.

Step 25: Establish RHR In Service

This is the standard step used to place the RHR system in service, and the basis for this step can be found in S01-1.0.22, Post-LOCA Cooldown And Depressurization. A slight difference is that only one RHR pump is started in this step to minimize the potential for cavitation due to the uncertainty of the actual containment water level relative to the break. Starting one pump at this time will also allow the operator to evaluate its performance and avoid potentially damaging both pumps. Also, since letdown will not be placed in service subsequent to RHR operation, the letdown isolation valves (CV 525 and 526) are closed in lieu of the pressure control valve (PCV 1105). Finally, in all likelihood, the RHR system valves will have been opened in step 21 since opening the PORV will eventually decrease RCS pressure below 400 psig. However, should this action be bypassed as the operator loops through steps 17 through 23, direction is provided to ensure that these valves and associated breakers are open prior to starting the RHR pump.

Step 26: Verify RHR Pump Operation

Because of the uncertainty of actual containment water level relative to the break (and therefore, available NPSH to the RHR pumps), a verification of proper RHR pump operation is made to ensure that it is not cavitating. Therefore, the operator is directed to verify that the flow and amps are stable prior to proceeding to the next step where the second RHR pump may be started. If flow and amps are not stable, direction is provided to throttle the system discharge valve to limit flow and amps and attempt to stabilize the pump. If this is unsuccessful, the operator is then directed to stop the affected pump and consult the Technical Support Staff for direction. It is possible that the RCS has voided and this should be considered. Additionally, the containment inventory should also be rechecked to ensure adequate volume exists. Meanwhile, RCS injection continues.

BACKGROUND DOCUMENT FOR LOSS OF RECIRCULATION FLOW

Step 27: Start Second RHR Pump

With the first RHR pump operating properly, the operator is directed to start the second RHR pump if needed for the cooldown. Appropriate actions are taken to ensure that the second RHR pump is needed and to protect it if started. The 800 gpm requirement ensures that the weaker pump is not overpowered by the stronger pump. This could result in damage due to insufficient miniflow per Reference 15 of S01-1.0-22, Post-LOCA Cooldown And Depressurization.

Step 28: Check If RCS Injection Flow Can Be Stopped

A check of core exit thermocouples compared to RCS loop and RHR temperatures is made to ascertain the effectiveness of the RHR system. If core exit thermocouples are trending down with RCS loop and RHR temperatures, then there is reasonable assurance that an effective cooling loop exists from the containment through the break and to the core via the RHR pumps. Therefore, RCS injection is secured. If, on the other hand, core exit thermocouples are not trending down with RCS loop and RHR temperatures, RCS injection is maintained, and the operator will remain at this step while consulting with the Technical Support Staff.

Step 29: Check If One RHR Pump Can Be Stopped

To extend the in-service life of the running core cooling pumps, one RHR pump is stopped when the RCS has been cooled to cold shutdown conditions. Upon securing one of the RHR pumps, if RCS temperatures start to increase, the pump is restarted to reestablish the appropriate cooling flow.

Step 30: Subsequent Action

At this point, adequate core cooling is being maintained by one or both RHR pumps, and the plant is in cold shutdown. Direction is provided to continue with this alignment as directed by the Technical Support Staff while returning to the procedure in effect.

BACKGROUND DOCUMENT FOR LOSS OF RECIRCULATION FLOW

4.0 REFERENCES

1) SCE Memo W. W. Strom to J. L. Rainsberry, dated September 14, 1987, Subject: Proposed License Change DPR-13-151, San Onofre Unit 1.

2) Memorandum For File, F. R. Byer, dated January 2, 1981, Subject: Containment Water Level Calculations, San Onofre Unit 1.

3) (a) Bechtel Calculation MC-734-012, "NPSHA for Charging Pumps G-8A, G-8B," dated July 7, 1986.

   (b) Supplement A to Bechtel Calculation MC-734-012, "NPSHA for Charging Pumps G-8A, G-8," dated May 9, 1988.

   (c) Supplement B to Bechtel Calculation MC-734-012, "NPSHA for Charging Pumps G-8A, G-8B," dated May 11, 1988.

4) San Onofre Unit 1 Retrofit General Design Criteria Manual, M-37387 Section 1.3.2.A.4.

5) Letter from K. P. Baskin (SCE) to J. B. Martin (NRC), dated March 17, 1989, "Technical Issues Impacting San Onofre Unit 1 Restart."