WCAP-16204
Revision 1

March 2004

Evaluation of Potential ERG and EPG Changes to Address NRC Bulletin 2003-01 Recommendations (PA-SEE-0085)

Volume 3 – Proposed Changes to CEN-152 (Combustion Engineering Emergency Procedure Guidelines)

WCAP-16204
Revision 1

Evaluation of Potential ERG and EPG Changes to Address NRC Bulletin 2003-01 Recommendations (PA-SEE-0085)

Volume 3 – Proposed Changes to CEN-152 (Combustion Engineering Emergency Procedure Guidelines)

Westinghouse Electric Company LLC
P.O. Box 355
Pittsburgh, PA 15230-0355

© 2004 Westinghouse Electric Company LLC
All Rights Reserved

WESTINGHOUSE COPYRIGHT NOTICE AND LIABILITY STATEMENT

"This report bears a Westinghouse copyright notice. You as a member of the Westinghouse Owners Group are permitted to make the number of copies of the information contained in this report which are necessary for your internal use in connection with your implementation of the report results for your plant(s) in your normal conduct of business. Should implementation of this report involve a third party, you are permitted to make the number of copies of the information contained in this report which are necessary for the third party's use in supporting your implementation at your plant(s) in your normal conduct of business, recognizing that the appropriate agreements must be in place to protect the proprietary information for the proprietary version of the report. All copies made by you must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary."

"This report was prepared by Westinghouse as an account of work sponsored by the Westinghouse Owners Group (WOG). Neither the WOG, any member of the WOG, Westinghouse, nor any person acting on behalf of any of them:

- Makes any warranty or representation whatsoever, expressed or implied, (I) with respect to the use of any information, apparatus, method, process, or similar item disclosed in this report, including merchantability, and fitness for a particular purpose, (II) that such use does not infringe on or interfere with privately owned rights, including the party's intellectual property, or (III) that this report is suitable to any particular user's circumstance; or

- Assumes responsibility for any damages or other liability whatsoever (including any consequential damages, even if the WOG or any WOG representative has been advised of the possibility of such damages) resulting from any selection or use of this report or any information, apparatus, method, process, or similar item disclosed in this report."

MASTER TABLE OF CONTENTS

VOLUME 1 – ENGINEERING EVALUATIONS AND ANALYSES REPORT

LIST OF FIGURES xi

EXECUTIVE SUMMARY xiii

1 INTRODUCTION AND BACKGROUND 1-1

2 EVALUATION ASSUMPTIONS 2-1
- 2.1 COMBUSTION ENGINEERING REFERENCE PLANT 2-1
  - 2.1.1 Safety Injection System (SIS) 2-1
  - 2.1.2 Containment Atmosphere Control System (CACS) 2-5
  - 2.1.3 Containment Isolation System (CIS) (07) 2-8
- 2.2 WESTINGHOUSE REFERENCE PLANT 2-12
  - 2.2.1 Safety Injection (SI) System 2-12
  - 2.2.2 Containment Spray System 2-18
  - 2.2.3 Containment Atmosphere Control System 2-18
  - 2.2.4 Containment Isolation System 2-22
- 2.3 OPERATOR ACTION TIMES 2-25
  - 2.3.1 Operator Actions With Time Assumptions 2-25
  - 2.3.2 Standards Employed 2-26
  - 2.3.3 Times Assumed 2-26

3 TASK B1/B13 – IDENTIFY UFSAR SECTIONS AFFECTED BY RECOMMENDED CHANGES 3-1
- 3.1 TASK OBJECTIVE 3-1
- 3.2 IMPACT OF THROTTLING FLOW IN RECIRCULATION MODES ON DESIGN BASIS 3-1
- 3.3 UFSAR SECTIONS TO BE CONSIDERED FOR REVIEW OR REVISION 3-2
- 3.4 CONCLUSION 3-4

4 TASK B2 – IDENTIFICATION OF MANUAL OPERATOR ACTIONS ASSOCIATED WITH THE TERMINATION OF ECCS/CSS 4-1
- 4.1 INTRODUCTION/TASK OBJECTIVE 4-1
- 4.2 SUMMARY OF CHANGES TO MANUAL OPERATOR ACTIONS 4-1
- 4.3 CONCLUSIONS 4-14

5 TASK B3 – REVIEW DESIGN BASIS ACCIDENT DOSE ANALYSIS 5-1
- 5.1 INTRODUCTION/TASK OBJECTIVE 5-1
- 5.2 SOURCE TERM METHODOLOGY 5-1
- 5.3 EVALUATION APPROACH 5-1
- 5.4 RESULTS SUMMARY 5-2
- 5.5 IMPACT ON PLANT LICENSING BASIS 5-2

MASTER TABLE OF CONTENTS (cont.)

5.6 CONCLUSIONS 5-2
5.7 REFERENCES 5-2

6 TASK B4 – IMPACT ON THE LOCA M&E ANALYSIS FOR LARGE DRY CONTAINMENTS 6-1
6.1 INTRODUCTION & TASK OBJECTIVE 6-1
6.2 LOCA MASS AND ENERGY RELEASE ANALYSES 6-1
6.3 CONTAINMENT ANALYSIS RESULTS 6-2
6.4 CONCLUSIONS 6-2

7 TASK B5 – IMPACT ON THE LOCA M&E ANALYSIS FOR ICE CONDENSER CONTAINMENT 7-1
7.1 INTRODUCTION/TASK OBJECTIVE 7-1
7.2 IMPACT TO CONTAINMENT PRESSURE M&E ANALYSIS FOR ICE CONDENSER CONTAINMENT 7-1
7.3 STRATEGIES FOR DELAYING CONTAINMENT SPRAY ACTUATION 7-1
7.4 IMPACT ON PLANT LICENSING CRITERIA 7-1
7.5 CONCLUSIONS 7-2

8 TASK B6 – IMPACT ON CONTAINMENT SUMP CHEMISTRY 8-1
8.1 OBJECTIVE 8-1
8.2 IMPACT ON SUMP PH AND IODINE REMOVAL 8-1
8.2.1 Addition of Water Without Boron 8-1
8.2.2 Addition of Water With Boron 8-2
8.3 CONSIDERATION OF SAFETY INJECTION FLOW REQUIREMENTS 8-2
8.4 CONCLUSIONS 8-2
8.5 REFERENCES 8-3

9 TASK B7 – DETERMINE THE OPTIMAL RATE OF ADDITION (CE PLANT ONLY) 9-1
9.1 INTRODUCTION/TASK OBJECTIVE 9-1
9.2 DISCUSSION 9-1
9.3 CONCLUSION 9-1

10 TASK B8 – SECURING ONE TRAIN OF HPSI BEFORE AND AFTER TRANSFER TO RECIRCULATION 10-1
10.1 INTRODUCTION 10-1
10.2 CRITERIA FOR SECURING ONE TRAIN 10-2
10.3 RESTART CRITERIA 10-4
10.4 IMPACT ON CORE COOLING OF A SINGLE FAILURE AFTER SECURING ONE TRAIN 10-4
10.5 IMPACT ON EPG SER COMMITMENTS AND NUREG 0737 REQUIREMENTS 10-5
10.6 CONCLUSIONS 10-5

MASTER TABLE OF CONTENTS (cont.)

11 TASK B9 – SECURING ONE TRAIN OF LPSI BEFORE AND AFTER RECIRCULATION ACTUATION (CE NSSS ONLY) 11-1
- 11.1 INTRODUCTION 11-1
- 11.2 PROCEDURE CHANGES 11-1
- 11.3 IMPACT ON CORE COOLING OF A SINGLE FAILURE AFTER SECURING ONE TRAIN 11-1
- 11.4 IMPACT ON EPG SER COMMITMENTS AND NUREG 0737 REQUIREMENTS 11-2
- 11.5 CONCLUSIONS 11-2

12 TASK B10 – SECURING CSS PRIOR TO AND AFTER RECIRCULATION ALIGNMENT 12-1
- 12.1 INTRODUCTION/ TASK OBJECTIVE 12-1
- 12.2 CRITERIA FOR REDUCING/SECURING SPRAY AND THE IMPACT OF MISDIAGNOSIS 12-1
- 12.3 APPROPRIATE RESTART CRITERIA 12-2
- 12.4 IMPACT ON CONTAINMENT PRESSURE/TEMPERATURE RESULTS 12-2
- 12.5 IMPACT ON OFF-SITE DOSE OF A SINGLE FAILURE AFTER SECURING SPRAY 12-2
- 12.6 IMPACT ON PLANT LICENSING BASES 12-2
- 12.7 IMPACT ON EPG SER COMMITMENTS AND NUREG 0737 REQUIREMENTS 12-2
- 12.8 CONCLUSIONS 12-2

13 TASK B11 – EVALUATE THE IMPACT ON OPERATOR RESPONSE TIMES 13-1
- 13.1 INTRODUCTION/TASK OBJECTIVE 13-1
- 13.2 OPERATOR RESPONSE TIME OF SECURING ONE TRAIN (HPSI, LPSI, OR CS) EARLY 13-1
- 13.3 IMPACT ON OPERATOR RESPONSE TIME EVALUATIONS 13-2
- 13.4 CONCLUSIONS 13-3

14 TASK B12 – REVIEW THE NUREG-1431 AND 1432, STANDARD TECHNICAL SPECIFICATIONS FOR WESTINGHOUSE AND COMBUSTION ENGINEERING PLANTS BASES 14-1
- 14.1 INTRODUCTION/TASK OBJECTIVE 14-1
- 14.2 SECURE ONE OR TWO CONTAINMENT SPRAY PUMP(S) BEFORE RECIRCULATION ALIGNMENT 14-1
  - 14.2.1 TS 3.6.6 (A and B) Containment Spray and Cooling Systems 14-1
  - 14.2.2 TS 3.6.7 Spray Additive System (Atmospheric and Dual) 14-2
- 14.3 MANUALLY ESTABLISH ONE TRAIN OF CONTAINMENT SUMP RECIRCULATION PRIOR TO AUTOMATIC ACTUATION 14-2
  - 14.3.1 TS3.3.4 ESFAS Instrumentation Recirculation Actuation Signal 14-2

MASTER TABLE OF CONTENTS (cont.)

14.4 TERMINATE ONE TRAIN OF HPSI/HIGH-HEAD INJECTION AFTER RECIRCULATION ALIGNMENT 14-3
14.5 TERMINATE LPSI/RHR PUMP PRIOR TO RECIRCULATION ALIGNMENT 14-3
14.6 REFILL REFUELING WATER STORAGE TANK 14-3
14.7 INJECT MORE THAN ONE RWT/RWST VOLUME FROM REFILLED RWT/RWST OR BY BYPASSING RWT/RWST 14-3
14.7.1 TS 3.3.11 PAM Instrumentation 14-3
14.8 PROVIDE MORE AGGRESSIVE COOLDOWN AND DEPRESSURIZATION FOLLOWING A SMALL BREAK LOCA 14-4
14.8.1 TS 3.4.3 RCS Pressure and Temperature (P/T) Limits 14-4
14.9 PROVIDE GUIDANCE ON SYMPTOMS AND IDENTIFICATION OF CONTAINMENT SUMP BLOCKAGE 14-5
14.10 DEVELOP CONTINGENCY ACTIONS IN RESPONSE TO: CONTAINMENT SUMP BLOCKAGE, LOSS OF SUCTION, AND CAVITATION 14-5
14.11 TERMINATE ONE TRAIN OF HPSI/HIGH-HEAD INJECTION PRIOR TO RECIRCULATION ALIGNMENT 14-5
14.12 DELAY CONTAINMENT SPRAY ACTUATION FOR SMALL BREAK LOCA IN ICE CONDENSER PLANTS 14-5
14.13 CONCLUSION 14-5

15 TASK C1 – IDENTIFY RISK IMPACT OF ERG/EPG CHANGES (PRA EVALUATION) 15-1
15.1 PROVIDE GUIDANCE ON SYMPTOMS AND IDENTIFICATION OF CONTAINMENT SUMP BLOCKAGE AND DEVELOP CONTINGENCY ACTIONS (COA 8 AND 9) 15-1
15.2 PROVIDE GUIDANCE ON SYMPTOMS AND IDENTIFICATION OF CONTAINMENT SUMP BLOCKAGE AND DEVELOP CONTINGENCY ACTIONS AND TERMINATE ONE TRAIN OF INJECTION AFTER RECIRCULATION ALIGNMENT (COA 3, 8 AND 9) 15-2
15.3 TERMINATE ONE TRAIN OF INJECTION AFTER RECIRCULATION ALIGNMENT, REFILL THE REFUELING WATER STORAGE TANK, AND INJECT MORE THAN ONE VOLUME RWST VOLUME (COA 3, 5, AND 6) 15-2
15.4 TERMINATE ONE TRAIN OF INJECTION PRIOR TO RECIRCULATION ALIGNMENT, REFILL THE REFUELING WATER STORAGE TANK, AND INJECT MORE THAN ONE VOLUME RWST VOLUME (COA 10, 5, AND 6) 15-3
15.5 MANUAL TRANSFER OF ONE ECCS TO THE CONTAINMENT SUMP PRIOR TO AUTOMATIC RECIRCULATION ALIGNMENT, REFILL THE REFUELING WATER STORAGE TANK, AND INJECT MORE THAN ONE VOLUME RWST VOLUME (COA 2, 5, AND 6) 15-4
15.6 SECURE ONE CONTAINMENT SPRAY PUMP BEFORE RECIRCULATION ALIGNMENT, PROVIDE GUIDANCE ON SYMPTOMS AND IDENTIFICATION OF CONTAINMENT SUMP BLOCKAGE, TERMINATE LPSI/RHR PUMP PRIOR TO RECIRCULATION ALIGNMENT, REFILL THE REFUELING WATER STORAGE TANK, AND INJECT MORE THAN ONE VOLUME RWST VOLUME (COA 1, 4, 8, 5, AND 6) 15-5

MASTER TABLE OF CONTENTS (cont.)

16 TASK D3 – IMPACT ON EOP SETPOINTS 16-1
16.1 INTRODUCTION/TASK OBJECTIVE 16-1
16.2 IDENTIFY IMPACTS TO EOP SETPOINTS AS A RESULT OF ERG CHANGES 16-1
16.3 GENERIC EVALUATION OF IMPACT ON SETPOINT UNCERTAINTIES 16-1
16.4 CONCLUSIONS 16-2

17 TASK E3 – DEVELOP THE TECHNICAL BASES FOR ANY NEW EPG ACTION VALUES THAT MAY BE REQUIRED 17-1

18 TASK E4 – CONDUCT TABLE-TOP REVIEW 18-1

19 TASK E5 – CONDUCT VALIDATION ON FULL SCOPE SIMULATOR 19-1

APPENDIX A CANDIDATE OPERATOR ACTION (COA) EVALUATIONS A-1
A1a-CE – Candidate Operator Action 1A – Combustion Engineering Plants Operator Action to Secure One Spray Pump A-1
A1a-W – Candidate Operator Action 1A – Westinghouse Plants Operator Action to Secure One Spray Pump A-8
A1a-Ice Addendum – Candidate Operator Action 1A – Westinghouse Ice Condenser Plants Operator Action to Secure One Spray Pump A-15
A1b – Candidate Operator Action 1B Operator Action to Secure Both Spray Pumps A-21
A2 – Candidate Operator Action 2 Manually Establish One Train of Containment Sump Recirculation Prior to Automatic Actuation A-28
A3-CE – Candidate Operator Action 3 – Combustion Engineering Plants Terminate One Train of HPSI/High-Head Injection After Recirculation Alignment A-32
A3-W – Candidate Operator Action 3 – Westinghouse Plants Terminate One Train of Safety Injection After Recirculation Alignment A-40
A4 – Candidate Operator Action 4 Early Termination of One LPSI/RHR Pump Prior to Recirculation Alignment A-47
A5 – Candidate Operator Action 5 Refill of Refueling Water Storage Tank A-52
A6 – Candidate Operator Action 6 Inject More Than One RWST Volume From a Refilled RWST or by Bypassing the RWST A-60
A7 – Candidate Operator Action 7 Provide More Aggressive Cooldown and Depressurization Following A Small Break LOCA A-73
A8-CE – Candidate Operator Action 8 – Combustion Engineering Plants Provide Guidance on Symptoms and Identification of Containment Sump Blockage A-76
A8-W – Candidate Operator Action 8 – Westinghouse Plants Provide Guidance on Symptoms and Identification of Containment Sump Blockage A-82
A9-CE – Candidate Operator Action 9 – Combustion Engineering Plants Develop Contingency Actions in Response to: Containment Sump Blockage, Loss of Suction, and Cavitation A-86

MASTER TABLE OF CONTENTS (cont.)

A9-W – Candidate Operator Action 9 – Westinghouse Plants Develop Contingency Actions in Response to: Containment Sump Blockage, Loss of Suction, and Cavitation A-92
A10 – Candidate Operator Action 10 Early Termination of One Train of HPSI/High-Head Injection Prior to Recirculation Alignment (RAS) A-104
A11 – Candidate Operator Action 11 Prevent or Delay Containment Spray for Small Break LOCAs (<1.0 Inch Diameter) in Ice Condenser Plants A-110

APPENDIX B LOCA ANALYSES IN SUPPORT OF RESOLUTION OF THE SUMP BLOCKAGE ISSUE B-1
B.1 INTRODUCTION B-1
B.2 RELAP5 DATABASE B-1
B.3 ACCIDENT SCENARIOS ANALYZED B-1
B.4 LOCA ANALYSIS RESULTS B-2
B.5 CONCLUSIONS B-4

VOLUME 2 – PROPOSED CHANGES TO WESTINGHOUSE EMERGENCY RESPONSE GUIDELINES

1 INTRODUCTION 1-1

VOLUME 3 – PROPOSED CHANGES TO CEN-152 (COMBUSTION ENGINEERING EMERGENCY PROCEDURE GUIDELINES)

1 INTRODUCTION 1-1

2 TASK E5 – FULL SCOPE SIMULATOR VALIDATION OF POTENTIAL EPG CHANGES TO ADDRESS NRC BULLETIN 2003-1 RECOMMENDATIONS 2-1
2.1 INTRODUCTION/TASK OBJECTIVE 2-1
2.2 VALIDATION SCENARIOS 2-1
2.3 VALIDATION GUIDELINES 2-2
2.4 RESULTS 2-2
2.5 CONCLUSIONS 2-6

3 EMERGENCY PROCEDURE GUIDELINES 3-1

1 INTRODUCTION

Volume 3 of this report contains the following documents:

- V&V Simulator Scenarios for CEN-152 Containment Sump Blockage Interim Compensatory Measures
- Combustion Engineering Emergency Procedure Guidelines (EPGs) and their Bases documents

The following sections describe these documents concerning the proposed changes to CEN-152.

2 TASK E5 – FULL SCOPE SIMULATOR VALIDATION OF POTENTIAL EPG CHANGES TO ADDRESS NRC BULLETIN 2003-1 RECOMMENDATIONS

2.1 INTRODUCTION/TASK OBJECTIVE

After changes to the EPGs/emergency operating procedures (EOPs) have been developed, they must undergo a process of validation/verification. This process is used to establish the accuracy of information and/or instructions, to determine that the procedures can be accurately and efficiently carried out, and to demonstrate that the procedures are adequate to mitigate particular transients and accidents. Both technical and human engineering adequacy should be addressed in the validation/verification process.

Validation/verification may be accomplished in a number of ways. Some of these are as follows:

- Exercising EPGs on either a plant-specific simulator or a generic simulator
- Control room walk-through
- Desk top reviews

By verifying that EPGs/EOPs can be successfully used by operators during simulated events, assurance is provided that the same holds true should a real emergency occur. In essence, validation is a verification of the EPGs/EOPs during dynamic conditions. The validation should be performed by operating crews using the EPGs/EOPs during simulated events. The usefulness of the EPGs/EOPs is determined by direct observation and debriefings.

Validation of "Potential EPG Changes to address NRC Bulletin 2003-01 Recommendations" (PA-SEE-085) (CEN-152, Revision 5.3 draft, dated January 20, 2004) was conducted on Calvert Cliffs Nuclear Power Plant (CCNPP) simulator on February 17, and 18, 2004. The validation was conducted by CCNPP licensed reactor operators and staff of the Procedures Control Group, as well as Procedure Working Group (PWG) representatives from the Westinghouse Electric Company, Ft. Calhoun Station, Palisades Plant, and Millstone Point. Refer to Table 1 for a complete list of attendees.

2.2 VALIDATION SCENARIOS

Before performing the EPG validation, it was first necessary to construct accident scenarios. In developing simulator scenarios to be used in the validation, the following general guidance was considered:

- The number of scenarios should be sufficient to test each affected EPG (at least two).
- All flow paths through the EPGs should be exercised.
- All steps expected to be performed in the control room should be exercised.
- Any discrepancies identified during the validation process must be resolved.

The scenarios developed for this validation were constructed by a collaborative effort between Westinghouse Electric Company engineers, Calvert Cliffs Procedure Control Group, and Calvert Cliffs Simulator Instructors. The scenarios used for this validation are included in this volume.

Table 1 Attendance List		
Name	**Affiliation**	**Phone**
Robert Bleacher	Calvert Cliffs	(410) 495-2150
David Ford	Calvert Cliffs	(410) 495-5205
Chris Furaro	Calvert Cliffs	(410) 496-5901
Steve McCord	Calvert Cliffs	(410) 495-4706
Bob Luikens	Fort Calhoun Station	(402) 533-6779
Peter Dellarco	Millstone Point Unit 2	(860) 447-1791 x4452
Bob Tucker	Palisades	(269) 764-2214
Denis Baker	V. C. Summer	(803) 931-5676
Joe Congdon	Westinghouse	(860) 731-6705
Bob Fuld	Westinghouse	(860) 731-6168
Paul Kramarchyk	Westinghouse	(860) 731-6719

2.3 VALIDATION GUIDELINES

Applicable portions (pages 79, 101, and 102) of Calvert Cliffs EOP/AOP Writer's Guide (Revision 8) were used to provide general validation guidance.

2.4 RESULTS

The following is a brief description of issues that were raised during the validation. Note that the guidelines step numbers referenced below relate to the EPG guidelines that were validated (CEN-152, Interim Revision 5.3 draft, dated January 20, 2004). The step numbers in the post-validation draft (dated March 3, 2004) have changed in many instances.

LOCA Step 13, Early Termination of Spray

In the course of the validation (Scenario 2), we discovered that the operator needed instructions sooner in the Functional Recovery Guideline (FRG) to terminate a spray pump (CTPC-3 step 2). When the FRG was entered (multiple events), containment temperature and pressure control (CTPC) was determined to be not in jeopardy or challenged; therefore, it was a lower priority for the operator than inventory control (IC) and heat removal (HR). In order to receive any benefit in delaying the time to recirculation actuation signal (RAS) by securing a spray pump, it must be undertaken early in the event as soon as plant conditions warrant. Therefore, the validation and verification (V&V) team decided that CTPC-3 step 2 should also be located following IC-2 step 3.

The team also recognized that it would be good to predetermine the optimal strategy for securing pumps. This applies to the early termination of the containment spray (CS) pump and stopping of a high-pressure safety injection (HPSI) pump post-RAS. Therefore, the operator would know in advance which pumps would be secured first. It should be noted that this was not an issue with the operators in

the validation. The bases for CS pump and HPSI pump termination will be enhanced with the following guidance. Select the preferred CS train (A or B) and the preferred HPSI train (A or B) to be secured first when the termination criteria are satisfied. Consider such factors as: pump power supplies, suction valve and piping configuration, and sump design (split versus common). An optimal configuration would include one CS pump and one HPSI pump with the same power supply, with a common suction line and common sump penetration or sump section. In this way, the reliability of the standby pumps will be increased.

LOCA Step 14, Containment Spray Termination Criteria (also in CTPC-3)

In substep a), members pointed out that "CSAS" should have brackets around it. The ESFAS signals that need to be reset vary from plant to plant. Some plants require that SIAS also be reset in order to reset CS.

LOCA Step 17, Commence a Cooldown (also in HR-2)

It was determined that the technical bases for this step (and HR-2 step 5) needed to be clarified to ensure that the importance of steam generator cooldown versus reactor coolant system (RCS) cooldown. The intent of this loss-of-coolant accident (LOCA) step is to ensure that deliberate action is taken by the operator to remove stored energy from the steam generators. As long as the operator has the ability to feed and steam the steam generator, then steam generator heat removal is always beneficial to the overall event mitigation strategy. It will support RCS depressurization to SDC entry conditions, especially in the case of a small-break LOCA. In the case of a large-break LOCA, this action will help recouple the RCS to the steam generators and promote reflux boiling (two-phase natural circulation). Lowering RCS pressure will also limit the associated break flow (loss of RCS inventory) by reducing the stored energy in the plant.

The validation illustrated that a conflict may arise for the operator in implementing the cooldown strategy. The initial uncontrolled cooldown of the reactor vessel is beyond operator control. The influence of cool SI flow on cold leg RTDs is beyond operator control. Compliance with TS RCS cooldown rates is not possible until the system stabilizes. Steam generator cooldown can be controlled by the operator. PTS is not a concern as long as the RCS is not allowed to rapidly repressurize. Reactor vessel wall delta-temperature stresses will dissipate with time. Then a controlled cooldown within the TS limits can be initiated. A "controlled" cooldown implies that the operator is in control of the cooldown; that is, that the cooldown is within the designed reset capabilities of MSIS and SIAS, or that the operator has the ability to stop or maintain a given pressure and temperature band. The intent of this step should not imply that a controlled cooldown is what is required.

LOCA Step 24, Line Up for RWT Refill or Alternate RCS Injection (also in IC-2)

No change in the instruction. However, it was suggested that the bases be clarified by removing the qualifier to facilitate refilling "quickly" after RAS. Also, the bases should be edited to ensure that the intent is clear. This is a preemptive or precautionary action to address prerequisites only. It does not entail actually moving water.

LOCA Step 38, RAS Initiation Criteria (also in IC-2, HR-2, and HR-3)

The team observed that an additional instruction should be included. After switching to containment sump recirculation, it is likely that containment pressure will increase and settle out at a new equilibrium temperature because of changes in the temperature of the injection/spray water. For plants with a relatively low CS actuation setpoint, the increase in containment pressure may be sufficient to re-actuate CS and start the idle pump(s). This is undesirable because it goes against strategies to minimize flow through the sump screens after RAS and avoid equipment operations that would increase the potential for debris transport and accumulation on the sump screens. We need to ensure that all idle CS pumps do not auto start. Therefore, a new substep will be added to the RAS initiation instruction to ensure that the auto-start function is disabled.

LOCA Step 40, Post-RAS HPSI Stop Criteria (also in IC-2, HR-2, and HR-3)

No change as a result of the validation. There was a discussion about considering rewording this step to make it an all encompassing reduction in flow through the sump versus just stopping one HPSI pump. After a closer review, it was decided that early termination of one (or more) CS pumps was already covered. Also, the CS reset instruction is available to secure the remaining CS pump prior to (or after) RAS if the criteria are satisfied. Therefore, it was decided not to change this step and leave it focused on stopping a HPSI pump.

When incorporating changes for the post V&V version, it was discovered that this step should appear in HR-3 as well as HR-2. Also, the HR-2 draft had it located after the "Hot and Cold Leg Injection" step instead of the previous step, "HPSI Pump Minimum Flow Criteria." HR-2 was changed to be consistent with the LOCA guideline.

LOCA Step 41, Refill the RWT (also in IC-2)

No change as a result of the validation.

LOCA Step 42, Monitor for Loss of ECCS Pump Suction (also in IC-2)

As a result of the validation, we made two enhancements to this proposed step. First, we wanted to ensure that the operator goes to the FRG as soon as erratic pump behavior becomes apparent and the operator suspects that sump blockage has increased to the point that it is difficult to maintain required NPSH and necessary to secure the CS pump to protect the operating HPSI pump. Therefore, contingency action a.1.3 was moved to the instruction side, step c. Secondly, the contingency actions associated with the HPSI pump were improved. In the event that pump performance does not improve following securing the CS pump, the guidance was changed to direct the operator to reduce SI flow to the minimum required for pump protection, verses just throttle back. Assuming the pump is then operating satisfactorily, the operator could gradually increase flow as much as allowed by available pump suction. If pump performance does not improve at minimum flow, the operator would immediately secure the pump.

IC-2 Step 2.b.1.4, Optimize SI

During the validation, an observer indicated that this contingency action to "Start additional SI pumps as needed…" may be confusing by appearing to conflict with new instructions to secure one HPSI pump after RAS. After closer review, it is determined that there is no conflict with the overall strategy. Before RAS, the operator would start the standby HPSI pump. Post-RAS, with only one HPSI pump operating and no indication of sump blockage, the operator would start the standby pump. With indication of sump blockage, the operator would not based on guidance provided in post-RAS instructions to "Monitor for loss of ECCS pump suction." Therefore, no change to this contingency action is recommended.

IC-2 Step 3, Early Termination of Spray

The "Early Spray Termination" instruction was added to IC-2 as discussed in the first item (LOCA Step 13).

IC-2 Step 16.a, Monitor for Loss of ECCS Pump Suction

As a result of the validation, it was decided that the underlined text to "Refer to the CTPC success path in use" was not correct. In these circumstances (indication of sump blockage), we want the CS pumps secured regardless. Core cooling has precedence over the containment. Therefore the "refer to" was deleted.

IC Continuing Actions

An observer requested that a few words be added at the beginning of the IC Continuing Actions to remind the EOP writer to coordinate with the TSC (if manned) in executing the CAs along with the SAMGs. The following was added:

> "The EPGs typically do not address specific beyond design basis events. The safety function based functional structure of the EPGs provides the best overall approach to respond to and mitigate the consequences of all events. Implementation of many of the following strategies requires close coordination with the TSC and concurrent implementation of the Severe Accident Management Guidelines (SAMGs). Refer to reference 48 and plant specific SAMGs for additional guidance."

IC-CA 2, Maximize RCS Cooldown

Emphasis change to focus on steam generator heat removal. Refer to third item, "LOCA Step 17, Commence a Cooldown" for details. Bases for new CA written accordingly.

IC-CA 6, Line Up an Alternate Injection Source

During the validation, the operators pointed out that the instruction directs that the operator line up "<u>any</u> available borated water source." A likely first choice may be the concentrated BA storage tanks. The instruction conflicts with other instructions associated with the boron precipitation issue in the reactor vessel. Therefore, the operator may not be inclined to use this source. To accommodate the boric acid

precipitation issue, consider diluting the BASTs by batching straight DI water prior to injecting to the RCS. Ensure adequate mixing. The bases were changed accordingly.

IC-CA 8, Establish Minimum SDC Entry Conditions

There was considerable discussion about implementing this option. The group raised several issues that should be addressed and considered prior to attempting it. Therefore, implementation of this option deserves careful consideration before launching into it. For example: 1) it may be difficult to make up for core boiloff once SDC is in service and, thus, maintain RCS level equal to or greater that the center line of the hot leg, 2) if RCS is at saturated conditions and not subcooled, pump cavitation may make it difficult to maintain suction, 3) system alignment to support SDC may make it necessary to enter high radiation areas (potential for failed fuel), 4) the SDC alignment will impact the availability of one CS flow path and one HPSI flow path, and 5) once into it, it may be very difficult to back out because of local high radiation areas.

These issues were included and addressed to a degree in the bases document. In addition, it was believed that this should be a last option; therefore, it was relocated to the end of the continuing actions.

IC-CA 9, Attempt to Discharge the SITs

The group believed that the 'IF' statement (if pressurizer pressure is greater that SIT pressure) at the beginning of the instruction was not needed. Also, they believed that the strategy should include ensuring that the SIT outlet isolations were first closed and then discharging the SITs one at a time in a controlled manner. The strategy was included in the bases.

IC-CA 10 and 11, Injecting from a Refilled RWT or an Alternate Source

The group believed that requiring concurrence for management and the TSC was not justified and should be removed.

2.5 CONCLUSIONS

The validation was successful. The proposed changes were found to be acceptable by the validation team. A post-validation draft of CEN-152, Revision 5.3 has been prepared. It incorporates the V&V changes and enhancements that are described in Section 2.4. The new draft of the EPGs and Bases documents will be reviewed by the validation team and the entire CE PWG membership for their concurrence and approval.

3 EMERGENCY PROCEDURE GUIDELINES

Only those chapters that have been changed for the post-validation version of CEN-152, Interim Revision 5.3 are included in the volume. They are as follows:

- Loss of Coolant Accident ORG (LOCA)
  LOCA Bases Document

- Inventory Control Success Path (IC)
  IC Bases Document

- Heat Removal Success Path (HR)
  HR Bases Document

- Containment Temperature and Pressure Control (CTPC) Success Path
  CTPC Bases Document

- Long Term Actions (LTA)
  LTA Bases Document

These EPG changes have been implemented in accordance with the EPG Maintenance Program. Refer to CR 5045 on the EPG website for details. CR 5045 and Interim Change 5.3 in its entirety may be viewed and downloaded from the EPG website following final approval by the Procedure Working Group (PWG). Implementation is planned for March 31, 2004.

V&V Simulator Scenarios for CEN-152
Containment Sump Blockage
Interim Compensatory Measures

V&V Simulator Scenarios for CEN-152
Containment Sump Blockage
Interim Compensatory Measures

Purpose: The purpose of the following simulator exercises is to evaluate interim compensatory measures (procedure changes) to CEN-152 Emergency Operating Guidelines which may be implemented in response to NRC Bulletin 2003-01.

Definitions:

- *Interim Compensatory Measure* — EPG procedure step added or revised in accordance with NRC Bulletin 2003-01. Interim Compensatory Measures are indicated with a bold arrow, thus (➔).
- *SIM OP* — simulator operator (training dept. rep.)

Scenario No. 1. — Large Break LOCA without loss of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump does not block.
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢LOCA

Event No.	Scenario Outline	Notes and Observer Comments
1)	Initial Condition: no. 12 BOC, 100% power (eq. xenon, full power history)	
2)	**SIM OP:** **Actuate LOCA** **res001 (038) RCS Cold Leg 12B Rupture**	
3)	Reactor Trip	Operators carry out Standard Post Trip Actions.
4)	**SIM OP:** **Transfer 1/3 RWT to containment sump to hasten RAS.**	

Scenario No. 1. — Large Break LOCA <u>without</u> loss of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump does not block.
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢LOCA

Event No.	**Scenario Outline**	**Notes and Observer Comments**
5)	ESF Actuation – All ESF equipment operates per design (no failures)	Operators diagnose LOCA event and implement LOCA procedure.
6)	➔ LOCA Step 13 Early Termination of Containment Spray pump(s)	
7)	➔ LOCA Step 14 Containment Spray Termination Criteria	
8)	➔ LOCA Step 17 Controlled cooldown	
9)	➔ LOCA Step 24 Line up for RWT Refill or alternate RCS Injection	
10)	Recirculation Actuation Signal (RAS) Occurs	
11)	➔ LOCA Step 40 Post RAS HPSI stop criteria (RAS + 40 minutes)	Operator leaves one HPSI pump running, stop ALL other HPSI pumps.
12)	➔ LOCA Step 41 Refill RWT	
13)	➔ LOCA Step 42 Monitor for loss of ECCS pump suction	
14)	End of scenario: Core conditions stable on RAS.	

Scenario No. 2. — Large Break LOCA <u>with</u> loss of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump Blocks immediately after Post RAS HPSI Stop (interim compensatory measure, LOCA Step 40).
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢LOCA ➢FRG

Event No.	**Scenario Outline**	**Notes and Observer Comments**
1)	Initial Condition: no. *66, large break LOCA just before RAS *new initial condition by Bob Bleacher	
2)	ESF Actuation – All ESF equipment operates per design (no failures)	Operators diagnose LOCA event and implement LOCA procedure.
3)	➔ LOCA Step 13 Early Termination of Containment Spray pump(s)	
4)	➔ LOCA Step 14 Containment Spray Termination Criteria	
5)	➔ LOCA Step 17 Controlled cooldown	
6)	➔ LOCA Step 24 Line up for RWT Refill or alternate RCS Injection	
7)	Recirculation Actuation Signal (RAS) Occurs	
8)	➔ LOCA Step 40 Post RAS HPSI stop criteria (RAS + 40 minutes)	Operator leaves one HPSI pump running, stop ALL other HPSI pumps.
9)	➔ LOCA Step 41 Refill RWT	
10)	➔ LOCA Step 42 Monitor for loss of ECCS pump suction	

Scenario No. 2. — Large Break LOCA <u>with</u> loss of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump Blocks immediately after Post RAS HPSI Stop (interim compensatory measure, LOCA Step 40).
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢LOCA ➢FRG

Event No.	Scenario Outline	Notes and Observer Comments
11)	**SIM OP** **Actuate Containment Sump Blockage si011(291) ramp to 100% (sump remains blocked for the remainder of the scenario, no operator actions will unblock the sump)**	
12)	➔ LOCA Step 42 Stop ALL CS pump(s), AND observe if HPSI pump performance improves.] <u>Notify</u> [Plant management]	Stop ALL Containment Spray Pumps
13)	➔ LOCA Step 42 Operators secure HPSI pump due to loss of containment sump suction.	Stop HPSI Pump.
14)	➔ LOCA Step 42 Contingency Action <u>GO TO</u> the FRG	Go to FRG.

Scenario No. 2. — Large Break LOCA <u>with</u> loss of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump Blocks immediately after Post RAS HPSI Stop (interim compensatory measure, LOCA Step 40).
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢LOCA ➢FRG

Event No.	**Scenario Outline**	**Notes and Observer Comments**
15)	Operators leave LOCA and enter FRG due to failed Safety Function Status Check, as noted here: <u>Inventory Control, Condition 2</u> a. SI flow is within [SI flow delivery curves] — *FAILED* b. [The required number of charging pumps are in operation] c. Reactor vessel level is greater than [top of active fuel region]	Failed safety function: <u>Inventory Control</u>
16)	Enter FRG	Operators implement Functional Recovery Guideline
17)	FRG Entry Procedure, Step 8 "*Perform Safety Function Status Checks.*"	Operators perform FRG Safety Function Status Checks
18)	FRG Entry Procedure, Step 9 "*Perform ALL the following in the order listed:* • *Instructions for success paths for safety functions that are in jeopardy are the first priority.* • *Instructions for success paths for safety functions that are challenged are second priority.* • *Instructions for all other success paths for safety functions are third priority.*"	Operators identify <u>Inventory Control</u> as high priority safety function in jeopardy.
19)	Operators enter FRG, IC-2 RCS Inventory Control	

Scenario No. 2. — Large Break LOCA with loss of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump Blocks immediately after Post RAS HPSI Stop (interim compensatory measure, LOCA Step 40).
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢LOCA ➢FRG

Event No.	Scenario Outline	Notes and Observer Comments
20)	➔ FRG IC-2, Step 10 **Line up for RWT Refill or alternate RCS Injection** Prepare for alternate RCS Injection by performing ANY of the following: a. Initiate actions to make up to the RWT. b. Initiate actions to lineup to inject directly to the RCS bypassing the RWT.	This step same as LOCA Step 24 above.
21)	➔ FRG IC-2, Step 14 **Post RAS HPSI stop criteria**	This step same as LOCA Step 40 above.
22)	➔ FRG IC-2, Step 15 **Refill RWT** Commence refilling the RWT.	This step same as LOCA Step 41 above. The simulator will model refill via CVCS. Other methods will not be modeled. The RWT inventory can be increased to simulate a non-modeled refill method.
23)	➔ FRG IC-2, Step 16 **Monitor for loss of ECCS pump suction**	This step same as LOCA Step 42 above.
24)	Operators enter IC-2 Continuing Actions	
25)	➔ FRG IC-2, Continuing Actions, Step 2 **Maximize RCS Cooldown**	

Scenario No. 2. — Large Break LOCA <u>with</u> loss of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump Blocks immediately after Post RAS HPSI Stop (interim compensatory measure, LOCA Step 40).
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢LOCA ➢FRG

Event No.	**Scenario Outline**	**Notes and Observer Comments**
26)	➔ FRG IC-2, Continuing Actions, Step 3 **Depressurize RCS**	
27)	➔ FRG IC-2, Continuing Actions, Step 4 **Maximize Containment Cooling**	
28)	➔ FRG IC-2, Continuing Actions, Step 5 **Refill RWT**	
29)	➔ FRG IC-2, Continuing Actions, Step 6 **Line up an Alternate injection source**	
30)	➔ FRG IC-2, Continuing Actions, Step 7 **Attempt to reestablish SI pump suction from Containment Sump**	
31)	➔ FRG IC-2, Continuing Actions, Step 8 **Establish minimum SDC Entry Requirements**	

Scenario No. 2. — Large Break LOCA <u>with</u> loss of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump Blocks immediately after Post RAS HPSI Stop (interim compensatory measure, LOCA Step 40).
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢LOCA ➢FRG

Event No.	**Scenario Outline**	**Notes and Observer Comments**
32)	➔ FRG IC-2, Continuing Actions, Step 9 **Attempt to Discharge SITs**	
33)	➔ FRG IC-2, Continuing Actions, Step 10 **Inject Refilled RWT to RCS**	
34)	➔ FRG IC-2, Continuing Actions, Step 11 **Inject Alternate Source to RCS**	
	End of scenario.	

Scenario No. 3. — Small Break LOCA with Excess Steam Demand Event (ESDE) and Loss Of Offsite Power (LOOP)
Description: multiple event accident to force enter FRG from Rx Trip SPTA.
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢FRG

Event No.	Scenario Outline	Notes and Observer Comments
1)	Initial Condition: no. 12 BOC, 100% power (eq. xenon, full power history)	
2)	**SIM OP:** • **Actuate LOCA rcs001 (039) Controlled leak from RCS 0-10,000 gpm (set to 5000 gpm)**	LOCA
3)	Reactor Trip	Operators carry out Standard Post Trip Actions.
4)	**SIM OP:** • **Actuate LOOP swyd002 (149)**	
5)	**SIM OP:** • **Actuate ESDE ms016 (113) 11/12 SG Safety Valve Fails Open**	Loss Of Offsite Power
6)	**SIM OP:** **Transfer 1/3 RWT to containment sump to hasten RAS.**	Steam Generator Safety Valve Fails Open
7)	ESF Actuation – All ESF equipment operates as expected (both diesels operate normally)	Operators diagnose multiple accident event and enter FRG.
8)	Enter FRG	Operators implement Functional Recovery Guideline

Scenario No. 3. — Small Break LOCA with Excess Steam Demand Event (ESDE) and Loss Of Offsite Power (LOOP)
Description: multiple event accident to force enter FRG from Rx Trip SPTA.
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢FRG

Event No.	**Scenario Outline**	**Notes and Observer Comments**
9)	FRG Entry Procedure, Step 8 "*Perform Safety Function Status Checks.*"	Prior to RAS — Operators perform FRG Safety Function Status Checks
10)	FRG Entry Procedure, Step 9 "*Perform ALL the following in the order listed:* • *Instructions for success paths for safety functions that are in jeopardy are the first priority.* • *Instructions for success paths for safety functions that are challenged are second priority.* • *Instructions for all other success paths for safety functions are third priority.*"	Prior to RAS — No safety functions in jeopardy.
11)	Recirculation Actuation Signal (RAS) Occurs	
12)	**SIM OP** **Actuate Containment Sump Blockage si011(291) ramp to 100% (sump remains blocked for the remainder of the scenario, no operator actions will unblock the sump)**	
13)	**Perform IC-2** **RCS Inventory Control with Safety Injection**	Perform IC-2

Scenario No. 3. — Small Break LOCA with Excess Steam Demand Event (ESDE) and Loss Of Offsite Power (LOOP)
Description: multiple event accident to force enter FRG from Rx Trip SPTA.
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢FRG

Event No.	Scenario Outline	Notes and Observer Comments
14)	➔ FRG IC-2, Step 10 **Line up for RWT Refill or alternate RCS Injection** Prepare for alternate RCS Injection by performing ANY of the following: a. Initiate actions to make up to the RWT. b. Initiate actions to lineup to inject directly to the RCS bypassing the RWT.	
15)	➔ FRG IC-2, Step 14 **Post RAS HPSI stop criteria**	
16)	➔ FRG IC-2, Step 15 **Refill RWT** Commence refilling the RWT.	The simulator will model refill via CVCS. Other methods will not be modeled. The RWT inventory can be increased to simulate a non-modeled refill method.
17)	➔ FRG IC-2, Step 16 **Monitor for loss of ECCS pump suction**	
18)	Operators enter IC-2 Continuing Actions	
19)	➔ FRG IC-2, Continuing Actions, Step 2 **Maximize RCS Cooldown**	

Scenario No. 3. — Small Break LOCA with Excess Steam Demand Event (ESDE) and Loss Of Offsite Power (LOOP)
Description: multiple event accident to force enter FRG from Rx Trip SPTA.
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢FRG

Event No.	Scenario Outline	Notes and Observer Comments
20)	➔ FRG IC-2, Continuing Actions, Step 3 **Depressurize RCS**	
21)	➔ FRG IC-2, Continuing Actions, Step 4 **Maximize Containment Cooling**	
22)	➔ FRG IC-2, Continuing Actions, Step 5 **Refill RWT**	
23)	➔ FRG IC-2, Continuing Actions, Step 6 **Line up an Alternate injection source**	
24)	➔ FRG IC-2, Continuing Actions, Step 7 **Attempt to reestablish SI pump suction from Containment Sump**	
25)	➔ FRG IC-2, Continuing Actions, Step 8 **Establish minimum SDC Entry Requirements**	

Scenario No. 3. — Small Break LOCA with Excess Steam Demand Event (ESDE) and Loss Of Offsite Power (LOOP)
Description: multiple event accident to force enter FRG from Rx Trip SPTA.
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢FRG

Event No.	Scenario Outline	Notes and Observer Comments
26)	➔ FRG IC-2, Continuing Actions, Step 9 **Attempt to Discharge SITs**	
27)	➔ FRG IC-2, Continuing Actions, Step 10 **Inject Refilled RWT to RCS**	
28)	➔ FRG IC-2, Continuing Actions, Step 11 **Inject Alternate Source to RCS**	
29)	**Perform CTPC-3** **Containment Temperature and Pressure Control with Containment Spray**	Perform CTPC-3
30)	➔ FRG CTPC-3, Step 2 **Early Termination of Containment Spray pump(s)**	
31)	**Perform HR-2** **RCS and Core Heat Removal via SG with SIS in operation**	Perform HR-2
32)	➔ FRG HR-2, Step 47 **Post RAS HPSI stop criteria**	
33)	➔ FRG HR-2, Step 48 **Monitor for loss of ECCS pump suction**	

Scenario No. 3. — Small Break LOCA with Excess Steam Demand Event (ESDE) and Loss Of Offsite Power (LOOP)
Description: multiple event accident to force enter FRG from Rx Trip SPTA.
EOP Sequence: Rx Trip (SPTA) ➢Diagnostics ➢FRG

Event No.	Scenario Outline	Notes and Observer Comments
34)	**Perform Long Term Actions**	Perform Long Term Action
35)	➔ LTA, Step 5 **Shutdown Cooling Entry Conditions** End of scenario.	

Scenario No. 4. — Large Break LOCA <u>with</u> partial blockage of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump partially Blocks immediately after Post RAS HPSI Stop (interim compensatory measure, LOCA Step 40)
Best Estimate Plant Response Model Tests
Description: The purpose of this simulator session is to test plant response for various post accident conditions and compare with best estimate models.
EOP Sequence: LOCA

Event No.	Scenario Outline	Notes and Observer Comments
1)	Initial Condition: no. *66, large break LOCA just before RAS *new initial condition by Bob Bleacher	
2)	Recirculation Actuation Signal (RAS) Occurs	
3)	➔ LOCA Step 40 Post RAS HPSI stop criteria (RAS + 40 minutes)	Operator leaves one HPSI pump running, stop ALL other HPSI pumps.
4)	➔ LOCA Step 41 Refill RWT	
5)	**SIM OP** **Actuate Containment Sump Blockage si011(291) ramp to 25% adjust for effect (25-29%)**	
6)	➔ LOCA Step 42 Monitor for loss of ECCS pump suction	
7)	➔ LOCA Step 42 Stop ALL CS pump(s),AND observe if HPSI pump performance improves.] Throttle SI Injection flow. Stop the HPSI pump Notify [Plant management]	Stop ALL Containment Spray Pumps Recover HPSI flow via throttling.

Scenario No. 4. — Large Break LOCA <u>with</u> partial blockage of containment sump
Description: Best Estimate Case, No Failed Diesel, Containment Sump partially Blocks immediately after Post RAS HPSI Stop (interim compensatory measure, LOCA Step 40)
Best Estimate Plant Response Model Tests
Description: The purpose of this simulator session is to test plant response for various post accident conditions and compare with best estimate models.
EOP Sequence: LOCA

Event No.	**Scenario Outline**	**Notes and Observer Comments**
	End of scenario.	

- **Loss of Coolant Accident ORG (LOCA)**

  LOCA Bases Document

- **Inventory Control Success Path (IC)**

  IC Bases Document

- **Heat Removal Success Path (HR)**

  HR Bases Document

- **Containment Temperature and Pressure Control (CTPC) Success Path**

  CTPC Bases Document

- **Long Term Actions (LTA)**

  LTA Bases Document

LOSS OF COOLANT ACCIDENT RECOVERY GUIDELINE

Prepared by
Westinghouse Electric Company LLC

for the
Westinghouse Owners' Group

Revision 5.3

Effective Date
March 31, 2004

1.0 PURPOSE

This guideline provides operator actions which must be accomplished in the event of a Loss of Coolant Accident (LOCA). The actions in this guideline are necessary to ensure that the plant is placed in a stable, safe condition. The goals of this guideline are to mitigate the effects of a LOCA, isolate the break (if possible), and establish long term core cooling using the safety injection system or the shutdown cooling system. This guideline achieves these goals while maintaining continuous adequate core cooling and minimizing radiological releases to the environment. This guideline provides technical information to be used by utilities in developing a plant specific procedure.

End of Section 1.0

2.0 ENTRY CONDITIONS

If a LOCA is evident, as indicated by **ANY** of the following plant conditions:

- Pressurizer level low (for a break in the pressurizer, the level may be high).
- Safety injection system actuated automatically.
- Rise in containment pressure, temperature, radiation, humidity and containment sump level.
- High quench tank level, temperature, or pressure.

AND ONE of the following is true:

- The Standard Post Trip Actions have been performed [Mode 1 or Mode 2]
- [SIAS has **NOT** been blocked] [Mode 3 or Mode 4]

THEN ENTER the LOCA Recovery Guideline.

End of Section 2.0

3.0 EXIT CONDITIONS

1. The diagnosis of a Loss of Coolant Accident is **NOT** confirmed.

   or

2. **ANY** of the Loss of Coolant Accident Safety Function Status Check acceptance criteria are **NOT** satisfied.

   or

3. The Loss of Coolant Accident EPG has accomplished its purpose by satisfying **ALL** of the following:

   - All Safety Function Status Check acceptance criteria are being satisfied.
   - Shutdown Cooling System Entry Conditions are satisfied

     or

     The break has been isolated

     or

     RCS is in long term core cooling
   - An appropriate, approved procedure to implement exists or has been approved by the [Plant Technical Support Center or the Plant Operations Review Committee].

End of Section 3.0

4.0 INSTRUCTIONS/CONTINGENCY ACTIONS

	INSTRUCTIONS	CONTINGENCY ACTIONS
* 1.	**Confirm Diagnosis {law1loca}**	
	Confirm the diagnosis of a LOCA:	
	a. Verify Safety Function Status Check Acceptance criteria are satisfied.	a.1 Re-diagnose the event and GO TO **ONE** of the following: • The appropriate Optimal Recovery Guideline • The Functional Recovery Guideline
	[b. Sample Steam Generators for activity.]	[b.1 Monitor other indications for SGTR.]
* 2.	**Classify Event {law34loca}**	
	Ensure the Emergency Plan is implemented and the event is being classified.	
3.	**Implement Placekeeping {law35loca}**	
	Open the placekeeper and note the time of the [event or EOP entry].	
* 4.	**Verify SIAS Actuation {pk20loca}**	
	IF pressurizer pressure is less than [SIAS setpoint], **THEN** ensure SIAS is actuated.	

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 5. **Optimize SI {pk8loca}**	
IF SIAS is present, **THEN:**	
a. Ensure SI pumps have started.	
b. Verify SI flow within [SI flow delivery curves]. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.	b.1 Take steps to restore SI flow: 1. Ensure electrical power to SI pumps and valves. 2. Ensure correct SI valve lineup. 3. Ensure operation of necessary auxiliary systems. 4. Start additional SI pumps as needed until SI flow is within [SI flow delivery curves].
[c. Start idle charging pumps.]	
* 6. **RCP Trip Strategy {pk12loca}**	
IF pressurizer pressure is less than [SBLOCA plateau pressure], **AND** SIAS is actuated, **THEN**:	
a. Ensure **ONE** RCP in each loop is stopped.	
b. **IF** RCS subcooling is less than [minimum RCS subcooling], **THEN** ensure all RCPs are stopped.	
* 7. **Verify RCP Operating Limits {pk19loca}**	
IF RCPs are operating, **THEN** verify RCP operating limits are satisfied.	7.1 Stop RCPs which do **NOT** satisfy RCP operating limits.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
8. **Isolate the LOCA {jc4loca}**	
Isolate the LOCA:	
a. [**IF** pressurizer pressure is less than [expected PORV closure pressure], **THEN** verify PORVs are closed].	a.1 Close the associated PORV block valve(s).]
b. Ensure letdown containment isolation valve is closed.	
c. Ensure RCS sampling containment isolation valves are closed.	
d. Verify **BOTH** of the following conditions exist: • NO CCW high radiation alarm • NO CCW Surge Tank high level alarm	d.1 **IF** RCS to CCW leak is evident, **THEN**: 1. Locate the leak. 2. Isolate the leak. 3. **IF** CCW was isolated to any operating RCP, **THEN** secure the affected RCP(s).

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 9. **Verify LOCA Not Outside Containment {pk41loca}**

IF LOCA is outside of containment as indicated by **ANY** of the following:

- Auxiliary building radiation monitor alarm
- Unexplained rise in auxiliary building sump levels

THEN:

a. Locate and isolate the leak.

[b. Isolate the auxiliary building.]

[c. Initiate actions to makeup to the RWT]

d. Ensure CIAS is initiated.

e. Notify [plant management]

10. **Place hydrogen monitors in service {pk42loca}**

Place the hydrogen monitors in service.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 11. **Ensure Containment Isolation and Cooling {jc1loca}**	
IF ANY of the following conditions exist: • Containment pressure is greater than [CIAS setpoint] • [Containment area radiation monitor greater than {alarm setpoint}]	
THEN:	
a. Ensure CIAS is initiated.	
b. Ensure all available containment emergency cooling systems are operating.	a.1 Ensure the required valves are closed.
c. Ensure all available normal containment equipment cooling and air recirculation systems are operating.	
* 12. **Ensure Containment Spray Actuation {jc2loca}**	
IF containment pressure is greater than [CSAS setpoint], **THEN**:	
a. Ensure CSAS is initiated.	
b. Ensure that each containment spray system is delivering at least [design flowrate] to containment spray headers.	

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 12A **[Early Termination of Containment Spray pump(s)]** [**IF** CS pumps are operating **AND ALL** of the following conditions are satisfied: • Containment pressure is less than [containment design pressure], • [The required number of containment cooling fans are in operation], • Safety injection is actuated and flow within [SI delivery curves], **THEN** stop one CS pump at a time until only one pump remains in operation: a. Stop Containment Spray Pump. b. Verify containment pressure maintained less than [containment design pressure].]	12A.1 [Take action to restore full CS flow to containment. a) Start CS pump(s).]

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 12B **Containment Spray Termination Criteria {jc9loca}**

IF CS pump(s) are operating
AND ALL of the following conditions are satisfied:

- Containment pressure is less than [CSAS reset pressure] and stable or lowering
- Containment Spray is **NOT** required for Containment cooling
- Containment Spray is **NOT** required for iodine removal

THEN stop Containment Spray:

a) Reset [CSAS].

b) Stop the Containment Spray Pump.

c) Close the Containment Spray Header Isolation Valve.

d) Align the system for automatic CSAS operation.

* 13. **Protect Main Condenser {jc14loop}**

IF offsite power has been lost,
THEN take steps to protect the Main Condenser:

[a. Ensure MSIVs are closed.]

[b. Ensure steam generator blowdown is isolated.]

14. **LOCA Condition, Isolated {pk44loca}**

IF the LOCA is isolated,
THEN GO TO step 53.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
15. **Steam Generator ~~Controlled~~ cooldown {law2locaSG}** Commence steam generator ~~a~~ cooldown using the Turbine Bypass Valves.	15.1 Cooldown steam generator using the Atmospheric Dump Valves.
* 16. **Depressurize RCS to SDC Entry Conditions {law4loca}** Depressurize the RCS to [SDC Entry Conditions]: a. Operate main or auxiliary pressurizer sprays. b. **IF** HPSI throttle criteria are met, **THEN:** 1) Control charging and letdown. 2) Throttle HPSI flow as necessary.	
* 17. **Bypass automatic MSIS and SIAS Initiation {law12sgtrhr2}** As cooldown and depressurization proceed, lower or bypass automatic initiation setpoints: a. **IF** MSIS is **NOT** present, **THEN** lower or bypass the automatic initiation setpoint for MSIS. b. **IF** SIAS is **NOT** present, **THEN** lower or bypass the automatic initiation setpoint for SIAS.	

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 18. **HPSI Throttle Criteria {law10loca}**

IF HPSI pumps are operating,
AND ALL of the following conditions are satisfied:

- RCS subcooling is greater than or equal to [minimum RCS subcooling]
- Pressurizer level is greater than [minimum level for inventory control] and **NOT** lowering
- At least one steam generator is available for RCS heat removal with level being maintained or restored to [normal control band].
- Reactor vessel level is greater than [top of the hot leg nozzles]

THEN throttle HPSI flow or stop one HPSI pump at a time.

* 19. **HPSI Pump Restart Criteria {law9loca}**

IF ANY of the HPSI throttle criteria can **NOT** be maintained,
THEN:

a. Raise HPSI flow.

b. Start HPSI pumps as necessary.

* 20. **LPSI Pump Stop Criteria {law13loca}**

IF pressurizer pressure is greater than [LPSI pump shutoff head] and controlled,
THEN:

a. Stop the LPSI pumps.

b. Close the LPSI injection valves.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

21. **LPSI Pump Restart Criteria {law33loca}**

IF pressurizer pressure lowers to less than [LPSI pump shutoff head],
AND BOTH of the following conditions are satisfied:

- LPSI pumps have been stopped,
- RAS has **NOT** occurred

THEN:

a. Start LPSI pumps as necessary.

b. Open the LPSI injection valves.

* 21A **[Line up for RWT Refill or alternate RCS Injection]**

[Prepare for alternate RCS Injection by performing **ANY** of the following:

a. Initiate actions to make up to the RWT.

b. Initiate actions to lineup to inject directly to the RCS bypassing the RWT.]

* 22. **Restore Letdown {law39loca}**

IF letdown is isolated,
AND BOTH of the following conditions exist:

- HPSI throttle criteria are met
- Letdown is needed or desired

THEN restore letdown.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 23. **Ensure Charging and SI flow are Maintaining Pressurizer Level in the expected post-trip band {law7loca}** **IF** HPSI throttle criteria are met, **THEN** maintain pressurizer level within [expected post-trip band]: a. Charge via normal path and letdown.	a.1 Charge to the RCS via the HPSI header.
b. Throttle HPSI flow as necessary.	

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 24. **Maintain RCS within Post Accident PT Limits {pk7loca}**

Maintain the RCS less than the upper limits of the [Post Accident PT curves]:

a. Operate main or auxiliary pressurizer sprays.

b. **IF** HPSI throttle criteria are met, **THEN**:

1) Control charging and letdown.

2) Throttle HPSI flow as necessary.

26.1 **IF** the RCS is oversubcooled, **OR** pressurizer pressure exceeds the limits of [Post Accident PT curves], **THEN** take steps to restore subcooling or pressure to within the appropriate limit:

a. Stop the cooldown.

b. Depressurize the RCS using main or auxiliary pressurizer spray.

c. **IF** HPSI throttle criteria are met, **THEN**:

1) Control charging and letdown.

2) Throttle HPSI flow as necessary.

26.2 **IF** the cooldown rate is greater than [Post Accident cooldown rate limit], **THEN** take steps to restore the cooldown rate to within its limit:

a. Stop the cooldown as necessary.

b. Maintain the plant in a stable pressure-temperature configuration.

c. Continue the plant cooldown within [Post Accident cooldown rate limit].

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 25. **Ensure SG level being restored to Normal Control Band {law22loca}**
Ensure at least one steam generator has level being maintained or restored to [normal control band].

* 26. **Ensure Adequate Condensate Inventory {law6loca}**

Ensure the condensate inventory is greater than the minimum required. REFER TO Figure 13.14, Feedwater Capacity Vs Time Remaining Until Shutdown Cooling, and Figure 13.15, Feedwater Required for Removal of Sensible Heat.

* 27. **Void Elimination {jc13loca}**

IF the RCS fails to depressurize **AND** voiding is suspected, **THEN** take steps to mitigate voiding:

a. Ensure minimum letdown, or letdown is isolated.

b. Stop depressurizing the RCS.

c. Take steps to eliminate the void:

1) Raise and lower the RCS pressure within the [Post Accident PT limits] with **ANY** of the following:

- Pressurizer heaters and spray
- HPSI and charging pumps

2) Operate the reactor vessel head vents as necessary.

3) Monitor Pressurizer level and Reactor Vessel level for RCS inventory trends.

30.1 **IF** depressurization to the SDC entry conditions is **NOT** possible, **AND** voiding is suspected in the steam generator tubes, **THEN**:

a. Steam the suspected steam generator using **ONE** of the following methods:

- Turbine Bypass System
- Atmospheric Dump Valves

b. Feed and bleed the suspect steam generator using feedwater and SG blowdown to maintain level within [normal control band].

c. Monitor Pressurizer level and Reactor Vessel level for RCS inventory trends.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 28. **Restore Offsite Power {law42loca}** **IF** offsite power has been lost **AND** resources permit, **THEN** restore power to plant distribution and station loads. REFER TO [applicable operating instructions].	
* 29. **Verify Single Phase Natural Circulation {pk21loca}** **IF** NO RCPs are operating, **THEN** verify natural circulation flow in at least one loop by **ALL** of the following: • Loop delta T less than [normal full power delta T] • Hot and cold leg temperature constant or lowering • RCS subcooling greater than or equal to [minimum RCS subcooling] based on [representative] CET temperature • [NO abnormal difference] between Thot RTDs and [representative] CET temperature	32.1 Ensure proper control of steam generator feeding and steaming.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 30. **Ensure Heat Removal Under Two Phase Natural Circulation {pk3loca}** **IF** NO RCPs are operating, **AND** single phase natural circulation can **NOT** be maintained, **THEN** ensure **ALL** of the following conditions exist: • All available charging pumps are operating • SI flow is within the [SI flow delivery curves], REFER TO Figure 13.13. SI Flow Delivery Curves • At least one steam generator is available for RCS heat removal with level being maintained or restored to [normal control band]. • [Representative] CET temperature is [**NOT** superheated]	

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 31. **RCP Restart Criteria {pk10loca}**

IF RCP restart is desirable,
THEN ensure RCP restart criteria are met:

a. Verify single phase natural circulation has been established for the preceding [20 minutes] in the loop selected for RCP restart.

b. Verify RCS pressure and temperature are [within the Post Accident PT curves] limits for RCP operation. REFER TO Figure 13.8, Post Accident PT Curves.

c. Verify the duration of [CCW] interruption to RCPs is within limits for RCP restart. REFER TO RCP technical manual.

d. Verify RCP seal pressures and temperatures are within limits. REFER TO RCP technical manual.

e. Verify RCP auxiliaries are operating properly to support RCP operation:

f. [Verify the RCS conditions are within the RCP start limits of plant technical specifications].

g. Ensure at least one steam generator is maintaining RCS heat removal with level within [normal control band].

h. Ensure pressurizer level is within [RCP restart level control band].

i. Ensure electrical power is available to the RCPs.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 32. **RCP Start {pk11loca}** **IF** RCP restart is desired, **AND** RCP restart criteria are satisfied, **THEN** take steps to restart an RCP in each loop: a. Maintain pressurizer level within [RCP restart level control band]: 1) Operate available charging pumps as needed to control pressurizer level. 2) **IF** RCS pressure is less than [HPSI pump shutoff head], **THEN** operate HPSI pumps as needed to control pressurizer level. b. Start the first RCP in the operating loop. c. Start the second RCP in the opposite loop to the running RCP. d. Verify RCS pressure and temperature are [within the Post Accident PT curves] limits for RCP operation. REFER TO Figure 13.8, Post Accident PT Curves.	d.1 **IF** RCP NPSH is **NOT** within limits, REFER TO Figure 13.8, Post Accident PT Curves, **THEN** stop the RCPs.
e. Operate charging and HPSI pumps until HPSI throttle criteria are met.	
* 33. **Charging Pump Suction Sources {pk1loca}** [**IF** the charging pumps are taking suction from a concentrated borated water source, **THEN** align suction to the RWT or other suitable source within [1 hour] after the start of the Loss of Coolant Accident].	

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 34. **Ensure Adequate Suction for SI Pumps {jc12loca}**

Confirm LOCA is inside containment:

a. Verify containment sump level is rising as the RWT level drops.

37.1 [Confirm LOCA is outside containment].

37.2 Initiate actions to makeup to the RWT].

37.3 Verify CIAS.

37.4 Notify [plant management].

* 35. **RAS Initiation Criteria {law26loca}**

IF the break is inside containment,
AND RWT level is less than [RAS setpoint],
THEN ensure proper recirculation actuation:

a. Ensure that RAS is initiated.

b. Ensure that both LPSI pumps are stopped.

c. Ensure that ESF pump suction has shifted to the containment sump.

d. Ensure that RWT outlet valve(s) to the SIS are closed.

e. Ensure that HPSI minimum recirculation flow valves are closed.

[f. **IF** charging pump suction is aligned to the RWT,
THEN disable all charging pumps.]

[g. Ensure that the auto-start function for all idle CS pumps is disabled.]

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
36. **Containment Spray Termination Criteria {jc9loca}** Relocated to Step 12B per CR 5045.	
* 37. **HPSI Pump Minimum Flow Criteria {law 8loca}** **IF** RAS is present, **THEN** verify that HPSI flow is greater than [minimum required HPSI pump flowrate].	39.1 Stop **ONE** HPSI pump at a time until [minimum required HPSI pump flowrate] is met.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS

* 37A **Post RAS HPSI stop criteria**

IF RAS is present,
AND ALL of the following conditions exist,

- **BOTH** HPSI trains are in operation,
- HPSI flow rate is within the [SI flow delivery curves], REFER TO Figure 13.13. SI Flow Delivery Curves
- [Representative] CET Temperature [less than superheat],
- Reactor Vessel level is greater than [bottom of the hot leg].
- Time from reactor shutdown is greater than [time for successful 15 minute operator response],

THEN stop one HPSI pump at a time until only one pump is in operation.

a) Stop one HPSI pump.

b) Verify SI flowrate greater than [SI flow delivery curves], REFER TO Figure 13.13. SI Flow Delivery Curves

c) Verify [Representative] CET Temperature less than [superheat],

d) Verify Reactor Vessel level greater than [top of active fuel].

* 37B **Refill RWT**

Commence refilling the RWT.

CONTINGENCY ACTIONS

37A.1 **IF ANY** of the HPSI Stop criteria can **NOT** be maintained,
THEN:
1. Start HPSI pumps as necessary.
2. Raise HPSI flow as necessary.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 37C **Monitor for loss of ECCS pump suction**

IF RAS is present
AND a lost of ECCS pump suction is indicated by **ANY** of the following exist::

- [Lower or unstable SI or CS flow]
- [Lower or unstable HPSI or CS pump discharge pressure]
- [Lower or unstable HPSI or CS pump suction pressure]
- [Lower or unstable HPSI or CS pump motor current]
- [Increased HPSI or CS pump noise]

THEN take actions to prevent HPSI and CS pump damage,
AND maintain adequate core cooling by performing **ALL** of the following in the order listed:

a) Stop **ALL** CS pump(s).

b) Observe if HPSI pump performance improves.

c) Notify [Plant management]

d) GO TO the FRG.

b.1 **IF** HPSI pump performance does not improve,
THEN perform **ALL** of the following:

1) Throttle SI flow to achieve the [minimum required HPSI pump flowrate].

2) **IF** pump performance does NOT improve,
THEN stop the pump.

3) **IF** pump performance improves,
THEN gradually increase SI flow to achieve the maximum available and continue to monitor.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 38. **SIT Isolation and Venting {law17loca}**

WHEN Pressurizer Pressure is less than [SIT isolation pressure] and controlled,
THEN isolate or depressurize the SITs as necessary to prevent SIT injection.

* 39. **LTOP Initiation Criteria {jc5loca}**

WHEN [LTOP enabling criteria] are met,
THEN initiate low temperature over-pressurization protection.

* 40. **Hot and Cold Leg Injection {jc3loca}**

IF elapsed time from the start of the LOCA is between [2 and 4 hours]
AND ANY of the following conditions exist:

- RCS subcooling is less than [minimum RCS subcooling] based on [representative] CET temperature
- Pressurizer level is less than [minimum for inventory control]
- Reactor vessel level is less than [top of the hot leg nozzles]

THEN establish simultaneous hot and cold leg injection.

* 41. **Operate H2 Recombiners {law24loca}**

IF containment hydrogen concentration is greater than [minimum detectable concentration],
AND less than [lower flammability concentration for hydrogen],
THEN operate hydrogen recombiners.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 42. **Monitor Containment Radiation {loca}**

Monitor containment radiation levels:

a. Provide input for the [TSC] to evaluate the impact of potential environmental release.

b. **IF** containment radiation levels are high, **THEN** consider operating the Iodine Removal System.

* 43. **Operate H2 Purge System {law23loca}**

Operate the H2 purge system as directed by the Technical Support Center.

* 44. **Reset Safety Systems {law36loca}**

IF ANY safety signals have initiated,
AND are no longer needed,
THEN reset the appropriate signals.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 45. **SDC Entry Conditions {law29loca}**

IF ALL of the following SDC entry conditions are established:

- Pressurizer level is greater than [heater cutoff setpoint]
- RCS subcooling is greater than or equal to [minimum RCS subcooling]
- Pressurizer pressure is less than [SDC entry pressure]
- RCS Th is less than [SDC entry temperature]
- RCS activity will **NOT** result in unacceptable radiological consequences outside containment,

THEN GO TO SDC operating instructions.

46. **Maintain Long Term Cooling {loca}**
IF SDC entry conditions can **NOT** be established,
THEN maintain long term cooling.

47. **LOCA Condition, Isolated {loca}**

IF the LOCA is isolated,
THEN perform Steps 53 through 77.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 48. **HPSI Throttle Criteria {law10loca}**

IF HPSI pumps are operating,
AND ALL of the following conditions are satisfied:

- RCS subcooling is greater than or equal to [minimum RCS subcooling]
- Pressurizer level is greater than [minimum level for inventory control] and **NOT** lowering
- At least one steam generator is available for RCS heat removal with level being maintained or restored to [normal control band].
- Reactor vessel level is greater than the [top of the hot leg nozzles]

THEN throttle HPSI flow or stop **ONE** HPSI pump at a time.

* 49. **HPSI Pump Restart Criteria {law9loca}**

IF ANY of the HPSI throttle criteria can **NOT** be maintained,
THEN:

a. Raise HPSI flow.

b. Start HPSI pumps as necessary.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 50. **LPSI Pump Stop Criteria {law13loca}**

IF pressurizer pressure is greater than [LPSI pump shutoff head] and controlled,
,
THEN:

a. Stop the LPSI pumps.

b. Close the LPSI injection valves.

* 51. **LPSI Pump Restart Criteria {law33loca}**

IF pressurizer pressure lowers to less than [LPSI pump shutoff head]
AND BOTH of the following conditions are satisfied:

- LPSI pumps have been stopped,
- RAS has **NOT** occurred

THEN:

a. Start LPSI pumps as necessary.

b. Open the LPSI injection valves.

* 52. **Restore Letdown {law39loca}**

IF letdown is isolated,
AND BOTH of the following conditions exist:

- HPSI throttle criteria are met
- letdown is needed or desired

THEN restore letdown.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS

* 53. **Verify RCS is Not Water Solid {law40loca}**

Verify the RCS is **NOT** in a water solid condition:

a. Verify that RCS inventory or temperature changes DO NOT produce exaggerated or severe pressure response.

b. Verify that **ANY** of the following conditions exist:

- Pressurizer level less than 100%
- RVLMS less than 100%

CONTINGENCY ACTIONS

58.1 Maintain the RCS within [Post Accident PT limits]:

a. Control RCS temperature.

b. **IF** HPSI throttle criteria are met,
THEN:

1) Control charging and letdown.

2) Throttle HPSI flow as necessary.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 54. **Draw a Bubble in RCS {law41loca}**

IF it is desired to draw a bubble in the pressurizer,
THEN adjust Pressurizer conditions as necessary:

a. Energize available pressurizer heaters.

b. **IF ANY** of the following conditions exist:

- Both SG pressures can be maintained less than RCS pressure
- At least one RCP is running

THEN take actions to reduce RCS pressure:

1) **IF** HPSI termination criteria are met,

THEN;

a) Control charging and letdown.

b) Throttle HPSI flow as necessary.

2) Cooldown the RCS to within [Post-Accident PT curves]

c. **IF** a bubble forms in the RVUH region, **THEN** Control charging, letdown and HPSI to maintain Reactor Vessel level above [top of the hot leg nozzles].

d. Continue efforts to draw a bubble in the pressurizer.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 55. **Ensure Charging and SI flow are Maintaining Pressurizer Level in the expected post-trip band {law7loca}** **IF** HPSI throttle criteria are met, **THEN** maintain pressurizer level within [expected post-trip band]: a. Control charging and letdown. b. Throttle HPSI flow as necessary.	

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS

* 56. **Maintain RCS within Post Accident PT Limits {pk7loca}**

Maintain the RCS less than the upper limits of the [Post Accident PT curves]:

a. Operate main or auxiliary pressurizer sprays.

b. **IF** HPSI throttle criteria are met, **THEN**:

1) Control charging and letdown.

2) Throttle HPSI flow as necessary.

CONTINGENCY ACTIONS

60.1 **IF** the RCS is oversubcooled, **OR** pressurizer pressure exceeds the limits of [Post Accident PT curves], **THEN** take steps to restore subcooling or pressure to within the appropriate limit:

a. Stop the cooldown.

b. Depressurize the RCS using main or auxiliary pressurizer spray.

c. **IF** HPSI throttle criteria are met, **THEN**:

1) Control charging and letdown.

2) Throttle HPSI flow as necessary.

60.2 **IF** the cooldown rate is greater than [Post Accident cooldown rate limit], **THEN** take steps to restore the cooldown rate to within its limit:

a. Stop the cooldown as necessary.

b. Maintain the plant in a stable pressure-temperature configuration.

c. Continue the plant cooldown within [Post Accident cooldown rate limit].

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 57. **Ensure SG Level being restored to Normal Operating Band {law22loca}**

Ensure at least one steam generator has level being maintained or restored to [normal control band].

* 58. **Evaluate Need for Cooldown {pk4esde}**

Evaluate the need for a plant cooldown based on **ALL** of the following:

- Plant status
- Auxiliary systems availability
- Available condensate inventory. REFER TO Figure 13.14, Typical Feedwater capacity vs Time Remaining Until Shutdown Cooling and Figure 13.15, Typical Feedwater Required for Removal of Sensible Heat.

59. **Cooldown Not Desired {esde}**

IF a plant cooldown is **NOT** desired, **THEN**:

a) Maintain the plant in a stabilized condition.

b) GO TO an appropriate procedure.

* 60. **Borate the RCS {law27loca}**

Borate the RCS until [adequate Shutdown Margin] is established.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

61. **Controlled cooldown {law2loca}**

Cooldown using the Turbine Bypass Valves.

* 62. **Depressurize RCS to SDC Entry Conditions {law4loca}**

Depressurize the RCS to [SDC Entry Conditions]:

a. Operate main or auxiliary pressurizer sprays.

b. **IF** HPSI throttle criteria are met, **THEN**:

1) Control charging and letdown.

2) Throttle HPSI flow as necessary.

* 63. **Bypassing automatic MSIS and SIAS Initiation {law12loca}**

As cooldown and depressurization proceed, lower or bypass automatic initiation setpoints:

a. **IF** MSIS is **NOT** present, **THEN** lower or bypass the automatic initiation for MSIS (low SG Pressure).

b. **IF** SIAS is **NOT** present, **THEN** lower or bypass the automatic initiation for SIAS (low PZR Pressure).

CONTINGENCY ACTIONS

65.1 Cooldown using the Atmospheric Dump Valves.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

* 64. **Void Elimination {jc13loca}**

IF the RCS fails to depressurize
AND voiding is suspected,
THEN take steps to mitigate voiding:

a. Ensure minimum letdown, or letdown is isolated.

b. Stop depressurizing the RCS.

c. Take steps to eliminate the void:

1) Raise and lower the RCS pressure within the [Post Accident PT limits] with **ANY** of the following:

- Pressurizer heaters and spray
- HPSI and charging pumps

2) Operate the reactor vessel head vents as necessary.

3) Monitor Pressurizer level and Reactor Vessel level for RCS inventory trends.

* 65. **Restore Offsite Power {law42loca}**

IF offsite power has been lost
AND resources permit,
THEN restore power to plant distribution and station loads. REFER TO [applicable operating instructions].

CONTINGENCY ACTIONS

68.1 **IF** depressurization to the SDC entry conditions is **NOT** possible,
AND voiding is suspected in the steam generator tubes,
THEN:

a. Steam the suspected steam generator using **ONE** of the following methods:

- Turbine Bypass System
- Atmospheric Dump Valves

b. Feed and bleed the suspect steam generator using feedwater and SG blowdown to maintain level within [normal control band].

c. Monitor Pressurizer level and Reactor Vessel level for RCS inventory trends.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 66. **Verify Single Phase Natural Circulation {pk21loca}**	
IF NO RCPs are operating, **THEN** verify natural circulation flow in at least one loop by **ALL** of the following: • Loop delta T less than [normal full power delta T] • Hot and cold leg temperature constant or lowering • RCS subcooling greater than or equal to [minimum RCS subcooling] based on [representative] CET temperature • [No abnormal difference] between Thot RTDs and [representative] CET temperature	70.1 Ensure proper control of steam generator feeding and steaming.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 67. **RCP Restart Criteria {pk10loca}**

IF RCP restart is desirable,
THEN ensure RCP restart criteria are met:

a. Verify single phase natural circulation has been established for the preceding [20 minutes].

b. Verify RCS pressure and temperature are within [Post Accident PT curves] limits for RCP operation. REFER TO Figure 13.8, Post Accident PT Curves.

c. Verify the duration of [CCW] interruption to RCPs is within limits for RCP restart. REFER TO [RCP technical manual].

d. Verify RCP seal pressures and temperatures are within limits for RCP restart. REFER TO [RCP technical manual].

e. Verify RCP auxiliaries are operating properly to support RCP operation.

f. [Verify the RCS conditions are within RCP start limits of plant technical specifications].

g. Ensure at least one steam generator is maintaining RCS heat removal with level within [normal control band]

h. Ensure pressurizer level is within [RCP restart level band].

i. Ensure electrical power is available to the RCPs.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 68. **RCP Start {pk11loca}**	
IF RCP restart is desired, **AND** RCP restart criteria are satisfied, **THEN** take steps to restart an RCP in each loop:	
a. Maintain pressurizer level within [RCP restart level control band]:	
1) Operate available charging pumps as needed to control pressurizer level.	
2) **IF** RCS pressure is less than [HPSI pump shutoff head], **THEN** operate HPSI pumps as needed to control pressurizer level.	
b. Start first RCP in operating loop.	
c. Start second RCP in the opposite loop to the running RCP.	
d. Verify RCS pressure and temperature are within [Post Accident PT curves] limits for RCP operation. REFER TO Figure 13.8, Post Accident PT Curves.	d.1 **IF** RCP NPSH is **NOT** within limits, REFER TO Figure 13.8, Post Accident PT Curves, **THEN** stop the RCPs.
e. Operate charging and HPSI pumps until HPSI throttle criteria are met.	
* 69. **SIT Isolation and Venting {law17loca}**	
WHEN Pressurizer Pressure is less than [SIT isolation pressure] and controlled **THEN** isolate or depressurize the SITs as necessary to prevent SIT injection.	

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 70. **LTOP Initiation Criteria {jc5loca}**

WHEN [LTOP enabling criteria] are met,
THEN initiate low temperature over-pressurization protection.

* 71. **Reset Safety Systems {law36loca}**

IF ANY safety signals have initiated,
AND are no longer needed,
THEN reset the appropriate signals.

* 72. **SDC Entry Conditions {law 29loca}**

WHEN ALL of the following SDC entry conditions are established:

- Pressurizer level is greater than [heater cutoff setpoint]
- RCS subcooling is greater than or equal to [minimum RCS subcooling]
- Pressurizer pressure is less than [SDC entry pressure]
- RCS Th is less than [SDC entry temperature]
- RCS activity will **NOT** result in unacceptable radiological consequences outside containment

THEN GO TO SDC operating instructions.

The LOCA Guideline has accomplished its purpose if the plant is in a condition where all of the Safety Function Status Check acceptance criteria are being satisfied, and the RCS is either in long term core cooling (i.e. recirculation through the SI), the break has been isolated, or SCS entry conditions are satisfied. Further recovery actions must be identified by the [Plant Technical Support Center].

End of Section 4.0

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

5.0 SAFETY FUNCTIONS STATUS CHECKS

SAFETY FUNCTION:

1. **Reactivity Control {pk15loca}**

ACCEPTANCE CRITERIA:	**CRITERIA SATISFIED**
a. Reactor power is lowering and [SUR negative]. or Reactor power is less than [maximum expected reactor power 15 minutes after shutdown], and stable or lowering,	☐ ☐ ☐ ☐ ☐
b. No more than [one full length CEA] is **NOT** inserted, or boration is in progress greater than [nominal capacity of one charging pump], or [adequate shutdown margin] is established.	☐ ☐ ☐ ☐ ☐

SAFETY FUNCTION:

2. **Maintenance of Vital Auxiliaries (AC and DC electrical Power) {pk13loca}**

ACCEPTANCE CRITERIA:

CRITERIA SATISFIED

a. At least one vital [4.16 kV] AC bus is ~~available~~energized. ☐ ☐ ☐ ☐ ☐

b. At least one train of vital DC power is energized~~available~~. ☐ ☐ ☐ ☐ ☐

c. At least one train of 120 VAC instrument power is ~~available~~energized. ☐ ☐ ☐ ☐ ☐

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

SAFETY FUNCTION:

3. **RCS Inventory Control {law30loca}**

----------NOTE----------

Meeting the provisions of Condition 1 or Condition 2 will satisfy the Safety Function

---

ACCEPTANCE CRITERIA:	**CRITERIA SATISFIED**
Condition 1:	
a. Pressurizer level is greater than [minimum level for inventory control]	☐ ☐ ☐ ☐ ☐
b. RCS subcooling is greater than or equal to [minimum RCS subcooling]	☐ ☐ ☐ ☐ ☐
c. Reactor vessel level is greater than [top of the hot leg nozzles]	☐ ☐ ☐ ☐ ☐
or	
Condition 2:	
a. SI flow is within [SI flow delivery curves]	☐ ☐ ☐ ☐ ☐
b. [The required number of charging pumps are in operation]	☐ ☐ ☐ ☐ ☐
c. Reactor vessel level is greater than [top of active fuel region]	☐ ☐ ☐ ☐ ☐

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

SAFETY FUNCTION:

4. **RCS Pressure Control {jc8loca}**

----------NOTE----------

Meeting the provisions of Condition 1 or Condition 2 will satisfy the Safety Function

---

ACCEPTANCE CRITERIA:	**CRITERIA SATISFIED**
Condition 1:	
a. Pressurizer pressure is within [Post-Accident PT curves]	☐ ☐ ☐ ☐ ☐
or	
Condition 2:	
a. SI flow is within [SI flow delivery curves]	☐ ☐ ☐ ☐ ☐
b. [The required number of charging pumps are in operation]	☐ ☐ ☐ ☐ ☐

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

SAFETY FUNCTION:

5. **Core Heat Removal {pk45loca}**

ACCEPTANCE CRITERIA:	**CRITERIA SATISFIED**
a. Th RTD and [representative] CET temperatures [less than superheated].	☐ ☐ ☐ ☐ ☐

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

SAFETY FUNCTION:

6. **RCS Heat Removal {pk14loca}**

ACCEPTANCE CRITERIA:	**CRITERIA SATISFIED**
a. Level in at least one Steam Generator is within [normal control band] or Feedwater is restoring level in at least one Steam Generator to [normal control band]	☐ ☐ ☐ ☐ ☐
b. RCS [Tave or Tc] is stable or lowering	☐ ☐ ☐ ☐ ☐

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

SAFETY FUNCTION:

7. **Containment Isolation {jc6loca}**

----------NOTE----------

Meeting the provisions of Condition 1 or Condition 2 will satisfy the Safety Function

---

ACCEPTANCE CRITERIA:	**CRITERIA SATISFIED**
Condition 1:	
a. NO steam plant activity monitor [alarms] or unexplained rise	☐ ☐ ☐ ☐ ☐
b. Containment pressure is less than [CIAS setpoint]	☐ ☐ ☐ ☐ ☐
c. [NO containment area radiation monitor greater than the [alarm setpoint] or unexpected rise.]	☐ ☐ ☐ ☐ ☐
or	
Condition 2:	
a. NO steam plant activity monitor [alarms] or unexplained rise	☐ ☐ ☐ ☐ ☐
b. CIAS is present	☐ ☐ ☐ ☐ ☐

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

SAFETY FUNCTION:

8. **Containment Temperature and Pressure Control {jc6loca}**

----------NOTE----------

Meeting the provisions of Condition 1 or Condition 2 will satisfy the Safety Function

---

ACCEPTANCE CRITERIA:	**CRITERIA SATISFIED**
Condition 1:	
a. Containment temperature is less than [saturated vapor temperature corresponding to CSAS setpoint]	☐ ☐ ☐ ☐ ☐
b. Containment pressure less than [CSAS setpoint]	☐ ☐ ☐ ☐ ☐
or	

SAFETY FUNCTION:

8. **Containment Temperature and Pressure Control {jc6loca}**

----------NOTE----------

Meeting the provisions of Condition 1 or Condition 2 will satisfy the Safety Function

---

ACCEPTANCE CRITERIA:	**CRITERIA SATISFIED**
Condition 2:	
a. The required number of containment spray systems are in operation or The required number of containment emergency cooling systems are in operation or The required combination of containment spray systems and containment emergency cooling systems are in operation	☐ ☐ ☐ ☐ ☐
b. Containment pressure is less than [containment design pressure]	☐ ☐ ☐ ☐ ☐

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

SAFETY FUNCTION:

9. **Containment Combustible Gas Control{law31loca}**

----------NOTE----------

Meeting the provisions of Condition 1, Condition 2, or Condition 3 will satisfy the Safety Function

---

ACCEPTANCE CRITERIA:	**CRITERIA SATISFIED**
Condition 1:	
a. Hydrogen concentration is less than [minimum detectable concentration].	☐ ☐ ☐ ☐ ☐
or	
Condition 2:	
a. [All available hydrogen recombiners are energized]	☐ ☐ ☐ ☐ ☐
b. Hydrogen concentration is less than [lower flammability concentration].	☐ ☐ ☐ ☐ ☐
or	
Condition 3:	
a. [Hydrogen purge system is operating].	☐ ☐ ☐ ☐ ☐

End of Section 5.0

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

6.0 SUPPLEMENTARY INFORMATION

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (Reference 34).
2. All available indications should be used to aid in the evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (References 24).
3. If there is a high radioactivity level in the reactor coolant system, then circulation of this fluid through the SDC or the CVCS may result in high area radioactivity readings in the [auxiliary building]. The activity level of the RCS should be determined prior to initiating SCS or letdown flow (Reference 12).
4. For small breaks in the RCS where the steam generators are important for heat removal, one steam generator must be used for this purpose even if primary to secondary leaks are detected. Use the unaffected steam generator, or the least affected steam generator, if both have primary to secondary leaks (Reference 9).
5. The operator should be cautioned against prematurely initiating a RAS. This manual action should not be taken unless an automatic RAS is required and an adequate containment sump level exists (indicative of LOCA inside containment).
6. If the initial cooldown rate exceeds Technical Specification Limits, then there may be a potential for Pressurized Thermal Shock (PTS) of the reactor vessel. The initial uncontrolled cooldown of the reactor vessel is beyond control of the operator. The influence of cool SI flow on cold leg RTDs is also beyond control of the . Compliance with Technical Specification RCS cooldown limits is not possible until the system stabilizes. PTS is not a concern as long as the RCS is not allowed to rapidly repressurize. Reactor vessel wall delta-temperature stresses will dissipate with time. Then a controlled cooldown within the TS limits can be initiated (~~Post Accident Pressure/Temperature Limits should be maintained within the limits of~~ Figure 5-1) (Reference 8).
7. Minimize the number of auxiliary spray cycles whenever the temperature differential between the spray water and the pressurizer is greater than the [post accident upper subcooled limit] (200°F) in order to minimize the increase in the spray nozzle thermal stress accumulation factor. Every such cycle must be recorded in accordance with Technical Specification Limitations (References 10 & 25).

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

8. High containment temperature conditions may adversely impact the accuracy of instruments whose transmitters are located inside containment (e.g. pressurizer level and pressure, steam generator pressure and level, RCS loop RTDs) and may impact the continued availability of equipment located in containment.
9. Verification of an RCS temperature response to a plant change during natural circulation cannot be accomplished until approximately [5 to 15] minutes following the action due to increased loop cycle times (References 11 & 12).
10. Water solid operation of the pressurizer should be avoided unless [minimum RCS subcooling] cannot be maintained in the RCS (Figure 5-1). If the RCS is solid, closely monitor any makeup or draining, and any system heatup or cooldown, to avoid any unfavorable rapid pressure excursions.
11. Hot leg and cold leg RTD temperature indication may be influenced by charging pump or SI injection water temperatures. Use multiple RTD indications [and/or CET indications] for temperature when injection is occurring (Reference 11).
12. During the process of establishing entry conditions (RCS pressure and temperature) for SDC operation, it may be necessary to eliminate or reduce the size of the steam void in the reactor head. Ensure sufficient condensate availability to continue steam generator heat removal until the RCS pressure and temperature are reduced sufficiently, and SCS operation is accomplished (Reference 11).
13. When a void exists in the reactor vessel, and RCPs are not operating, the RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the RVLMS. The indicated level also differs for different RVLMS designs under these conditions. Information concerning reactor vessel liquid inventory trending may still be discerned. However, the operator is cautioned not to rely solely on the RVLMS indication when RCPs are operating (Reference 15).
14. For those plants which use the Containment Spray System (CS) in conjunction with the Iodine Removal System (IRS), operation of the CS may be desirable in the event of an iodine buildup in containment. Since iodine may be released to the containment atmosphere at various times following event initiation.
15. Small breaks located at the top of the pressurizer [e.g. stuck open PORV or safety relief valve] will result in flashing and steam production in the reactor vessel and hot legs. This steam will flow towards the break through the pressurizer surge line and oppose the draining of the pressurizer liquid. Thus, the liquid level in the pressurizer may increase or exhibit erratic behavior due to the competing steam-water counter current flow condition. A similar behavior may be observed if the break is in the surge line.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

16. Operation of any equipment in the containment building when containment hydrogen concentration ≥ [lower flammability concentration] should consider the possibility of hydrogen ignition (Reference 16). Consideration should be given to the following:
    a. The importance to safety of equipment operation,
    b. The urgency of equipment operation,
    c. The use of alternative equipment located outside containment,
    d. The current hydrogen level and the anticipated time to reduce H_2 ≤[lower flammability concentration].
17. Combustion Engineering plants are designed with redundant electrical equipment. Therefore, the loss of one vital AC or DC bus will not prevent the operators from performing the actions of this guideline. However, it is desirable to have a complete complement of electrical equipment to mitigate and to recover from an event. Therefore, the operators should attempt to restore electrical power to any lost vital AC or vital DC bus(es).
18. During recirculation, at least one HPSI pump should be operating at all times unless HPSI termination criteria are met.
19. If restarting Reactor Coolant Pumps (RCPs), consideration should be given to choosing pump combinations which will maximize pressurizer spray flow.
20. Operators should be aware of the status of CCW supply to the RCPs and, if CCW has been isolated, should restore CCW if possible and desired. This is particularly true for plants which receive a CIAS for a low pressurizer pressure condition.
21. If pressurizer pressure is less than the PSV reset value and greater than the SIAS setpoint, and the operator suspects that a PSV is not fully closed, then pressurizer pressure may be intentionally lowered in an attempt to reset the PSV. When doing so, pressurizer pressure should be maintained greater than the SIAS setpoint and the minimum required subcooling shall be maintained.
22. Before starting a RCP the operator should ensure that the pressurizer is at saturation conditions to support restart of the RCP. If a RCP is started with the pressurizer not at saturation conditions because of refill, RCS pressure may rapidly drop below minimum pressure to operate the pumps as a result of an out-surge.

End of Section 6.0

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

Loss of Coolant Accident Recovery Bases

Characterization of a LOCA

A LOCA is an accident which is caused by a break in the reactor coolant system (RCS) pressure boundary. The break can be as large as a double ended guillotine break in the hot leg or as small as a break which results in a loss of RCS fluid at a rate that is just in excess of the available charging capacity of the plant.

Small and large break LOCAs differ in their effect on the post-LOCA RCS heat removal process. For a large break, the only path necessary for RCS heat removal in both the short and long term is the break flow with core boiloff. For small breaks, heat removal via the flow out the break is not sufficient to provide cooling and, therefore, steam generator heat removal is required. The guidelines take this into account with the decisions which must be made. Although distinct small and large break LOCA information is contained in the bases section of this guideline, the action steps to be used during the actual emergency do not require the operator to distinguish between break sizes.

A LOCA is characterized by an initial decrease In RCS pressure and inventory. Subsequent RCS inventory and pressure response depends on the size of the break. For large breaks inside containment, an increase in containment temperature and pressure occurs relatively soon after the LOCA. However, a small LOCA or stuck open PORV may not be detectable on containment temperature and pressure instruments in the short term. The actions taken by the operator during a LOCA, and more detailed descriptions of LOCA response, are provided in the following sections.

Safety Functions Affected

The LOCA primarily affects RCS inventory and pressure control, and RCS and core heat removal. To a lesser degree, reactivity control, containment isolation, and containment temperature and pressure control are also affected. All safety functions should be monitored to assure public safety or to detect failures which might lead to unsafe conditions.

RCS inventory control is initially lost since the break flow rate exceeds the available charging pump capacity. For small breaks, RCS inventory control is regained via injection from the high pressure safety injection (HPSI) pumps and the charging pumps. It is maintained in the long-term by injection from these pumps. For large breaks, inventory control is regained through the injection of water into the RCS by the safety injection tanks (SITs) and the low pressure safety injection (LPSI) pumps. It is maintained in the long-term through the recirculation of sump water through the RCS by the HPSI pumps. Note that for large breaks, the RCS may not totally refill and pressurizer level may not be regained. If the large break is unisolable, continuous injection is required to make up for the loss out the break and to prevent boron precipitation.

Loss of Coolant Accident Recovery Bases

RCS pressure control is initially lost as the RCS depressurizes because of the loss of inventory out the break. For large breaks, the RCS depressurizes in 10 seconds to 3 minutes to pressures typically below 300 psia. In the case of the largest breaks, the RCS pressure will reach equilibrium with containment pressure, and will be nearly equal to that pressure. Because of the size of the break, the operator never regains direct control of RCS pressure and the RCS remains depressurized. For small breaks, the RCS depressurizes during the short-term (10 to 30 minutes) to an equilibrium condition with the steam generators. It then continues to depressurize as the operator cools down the steam generators. Pressure control is regained when the safety injection system (SIS) refills the RCS and pressurizer level is regained. Once pressure control is regained, subsequent small break post-LOCA operator actions which are associated with pressure control are (1) decreasing RCS pressure by means of auxiliary sprays, (2) controlling HPSI pumps and charging, (3) heat removal via the steam generators in order to establish shutdown cooling entry conditions and, (4) isolating or depressurizing the SITs. For small break LOCAs, during the period of time when the RCS is refilling (pressure control has not yet been achieved), there may be significant voiding in the RCS. The voided areas may be located in the reactor vessel head region [as indicated by the RVLMS], the RCS loops, or the steam generator u-tubes, and may be made up of steam or non-condensable gases. Steam voids may occur from fluid flashing in local hot spots within the RCS. This voiding is not a problem as long as heat removal is not inhibited or the ability to reduce primary pressure is not greatly reduced. The presence of small amounts of non-condensable gases may be present from sources such as gases evolving from the primary coolant and pressurizer vapor space. [If their presence is detected in the RCS the reactor vessel head vent may be operated. The presence of non-condensable gases in the steam generator tubes is characterized by a decrease in primary to secondary heat removal capability. RCS heat removal is not jeopardized by the presence of non-condensables until a significant number of steam generator tubes are blocked. A significant number of tubes will not be blocked unless there is considerable oxidation of fuel cladding, and this is not expected for the small break LOCA, unless significant core uncover occurs.

There are two paths initially available for RCS heat removal: heat transfer to the secondary side via the steam generators, and heat transfer via the fluid flowing out the break. Large break LOCAs have sufficient fluid flowing out the break to provide adequate heat removal without relying on steam generators. Small break LOCAs do not have sufficient fluid flowing out of the break to provide adequate heat removal. Therefore, steam generator heat removal is required in addition to break flow for adequate heat removal. Because the LOCA ORG does not distinguish between large and small break LOCAs, steam generator heat removal capability is required at all times during a LOCA.

Loss of Coolant Accident Recovery Bases

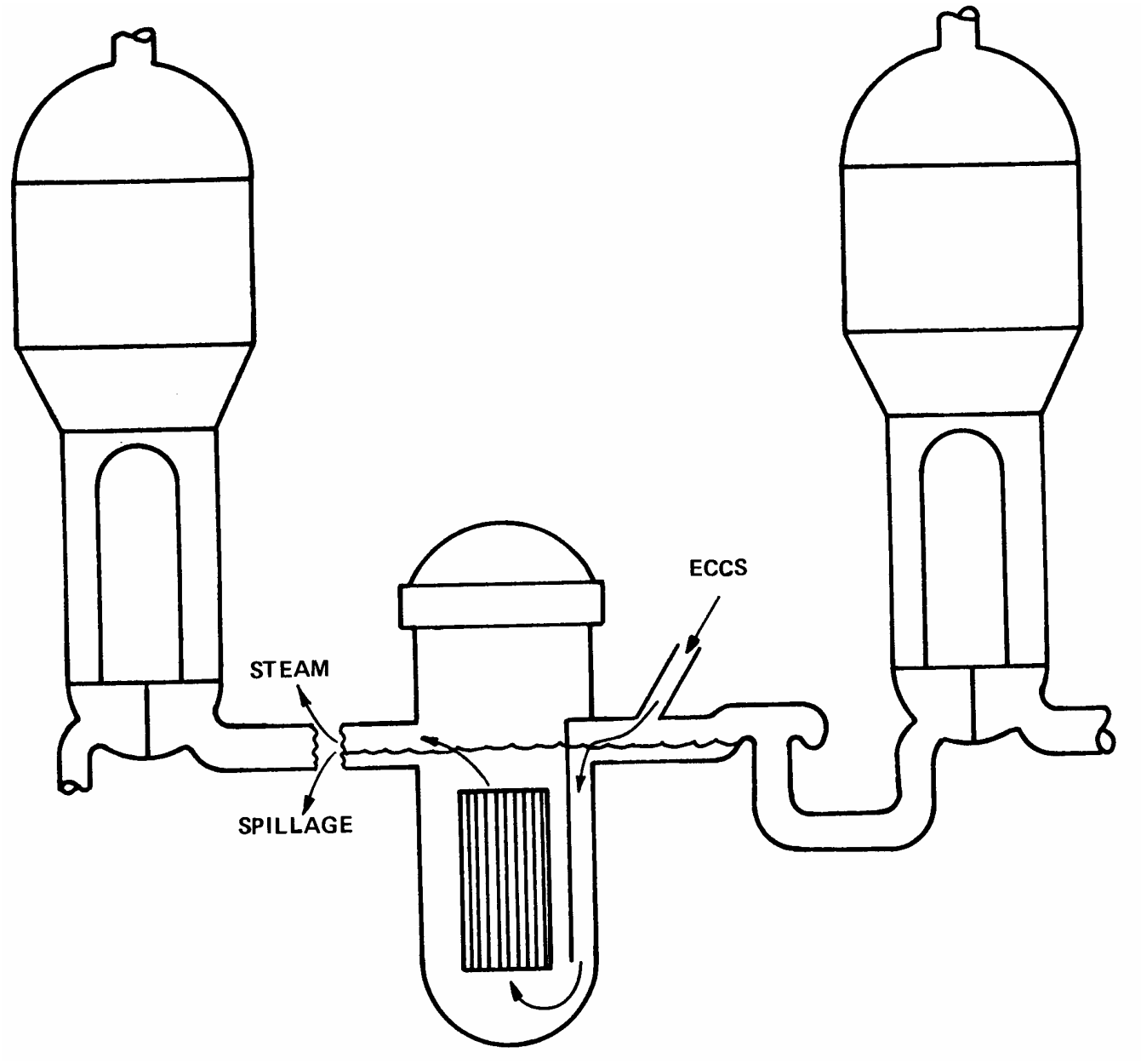
The large break LOCA heat removal process is not complex. For cold leg breaks the SIS refills the reactor vessel (RV) and provides only enough fluid to the core to match boil off. The excess injected fluid spills out of the cold leg break. The steam from core boil off passes out the hot leg and through the steam generators on its way out the cold leg break. For the hot leg break, the injected water builds up in the cold legs and provides the core with water for boil off heat removal and some single phase cooling. In the long term, heat removal is provided by simultaneous hot and cold leg injection. This process provides heat removal for either hot or cold leg large break LOCAs while providing the added benefit of ensuring adequate flushing of the RV to avoid buildup of non-volatile materials produced in the boil off cooling process. Figures 5-1 and 5-2 illustrate the heat removal process for large break LOCAs.

The small break LOCA heat removal process is more complex than that described above for the large break. In the short-term, after the RCPs are tripped, core heat removal is maintained by natural circulation. Since the break is not large enough to adequately remove the heat, heat removal via a steam generator is required. This requires that the operator maintain feedwater (either main or auxiliary) to the steam generators and control steam flow from the steam generators via the turbine bypass system or the atmospheric dump valves: Figures 5-3 and 5-4 illustrate the heat removal process for typical small break LOCAs. The typical percentage of required RCS heat removed by the steam generators for various break sizes is illustrated in Figures 5-5 and 5-6.

The small break natural circulation process can take different forms. These forms include single phase natural circulation and a more complex two phase natural circulation. The simplest form of natural circulation is single phase, liquid cooling. Single phase natural circulation is possible for cases where RCS inventory and pressure are controlled. Single phase cooling transports heat using the same flow path involved in forced circulation cooling with the liquid density difference between SG and RV driving the flow. Two phase natural circulation involving steam and water is more complex and can take several forms, which depends on the amount of decay heat, the amount of inventory and pressure control degradation, the break size and the status of the SIS and the steam generators. One form of two phase natural circulation is known as reflux. In the reflux process, steam leaves the core region and travels to the steam generator via the hot leg; the steam is condensed in the steam generator before reaching the top of the "U" tubes and flows back to the core via the hot leg where it is once again turned to steam. Another two phase natural circulation process is similar to reflux but differs in that the steam from the core goes past the steam generator "U" bend and is condensed in the tubes on the cold leg side; thus condensate flows back to the core via the cold leg. A combination of the two processes is also possible.

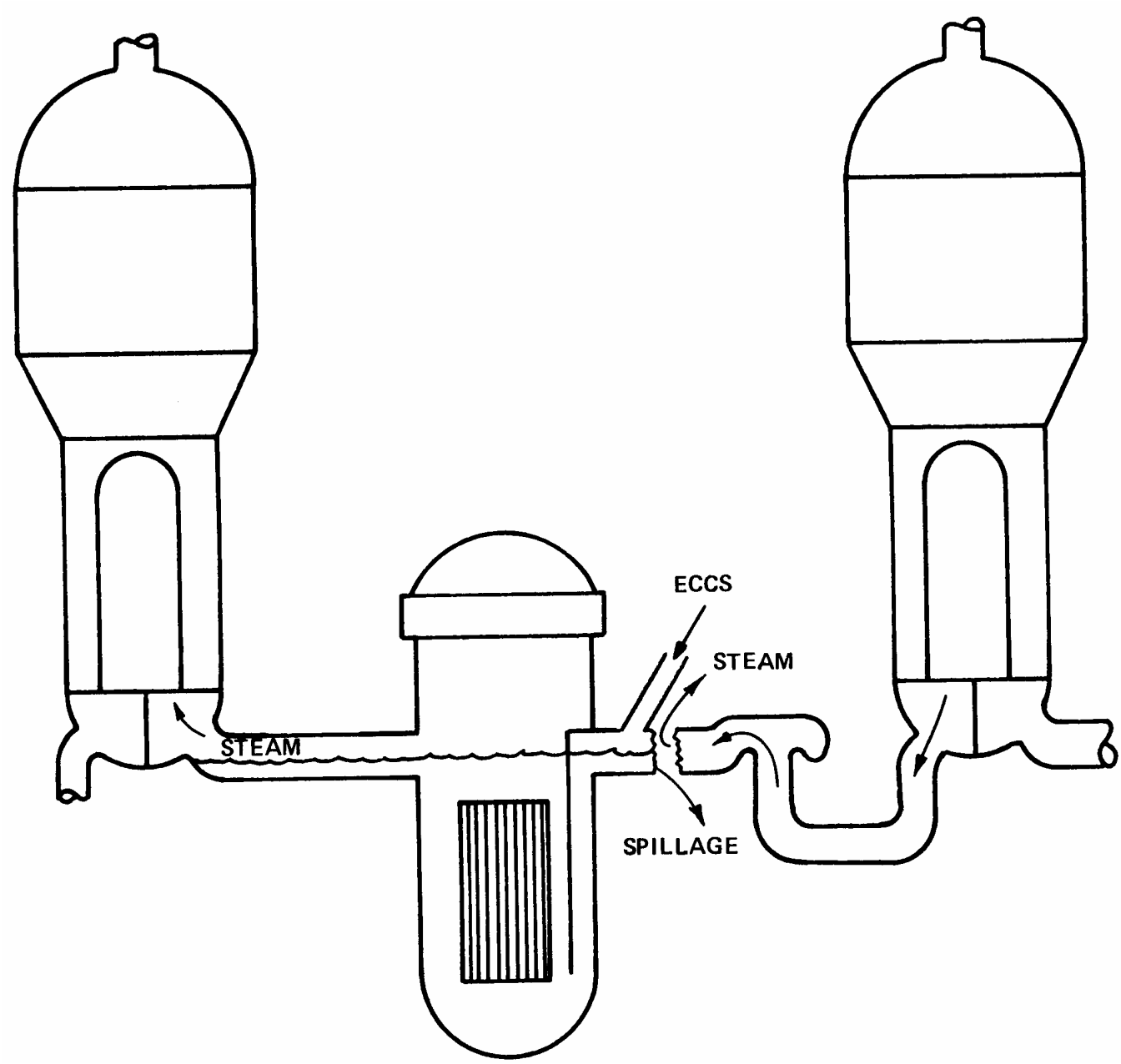
Loss of Coolant Accident Recovery Bases

FIGURE 5-1
HEAT REMOVAL VIA LARGE HOT LEG BREAK



Loss of Coolant Accident Recovery Bases

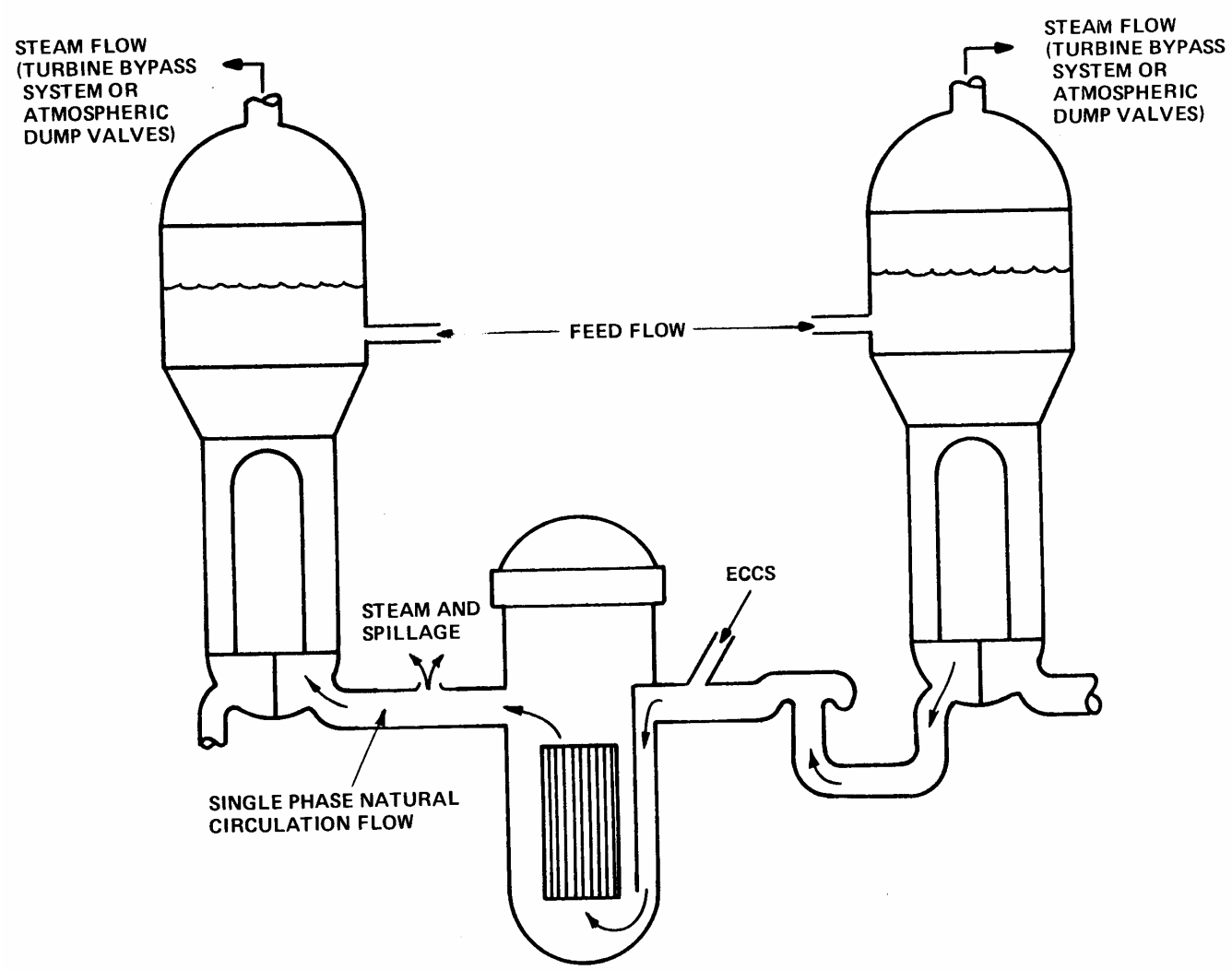
FIGURE 5-2
HEAT REMOVAL VIA LARGE COLD LEG BREAK



Loss of Coolant Accident Recovery Bases

FIGURE 5-3

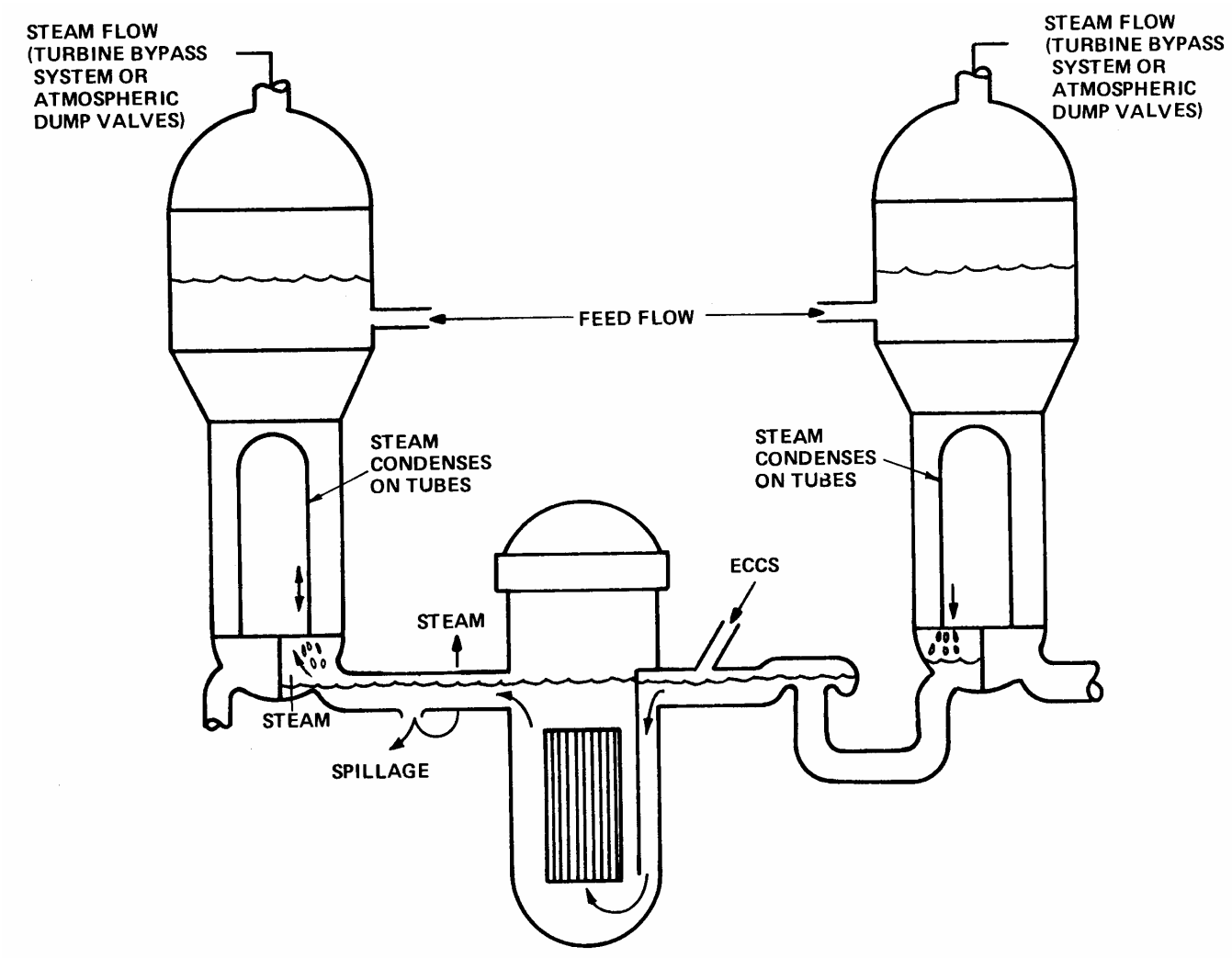
HEAT REMOVAL VIA SMALL BREAK (RCS FILLED)



Loss of Coolant Accident Recovery Bases

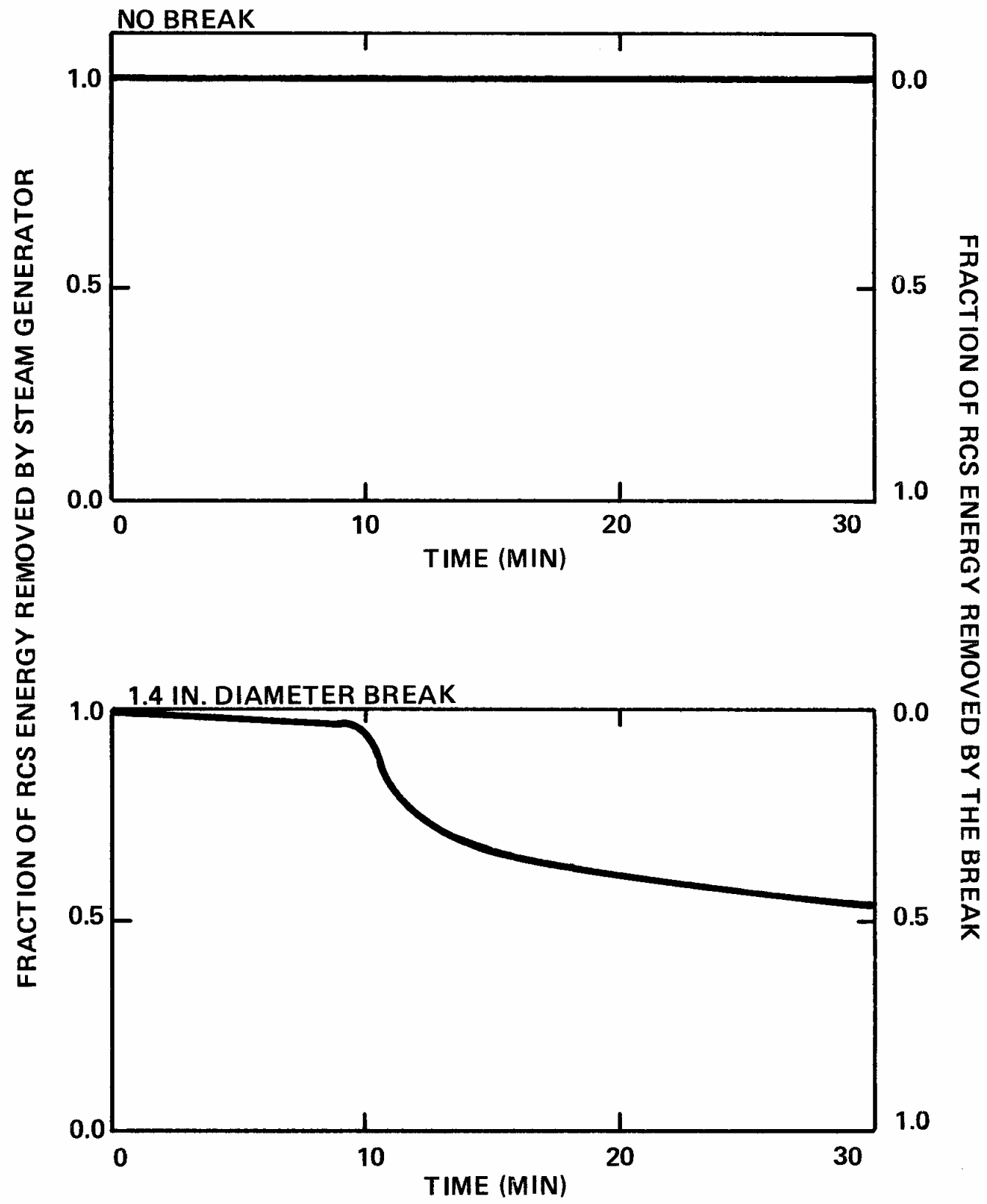
FIGURE 5-4

HEAT REMOVAL SMALL BREAK (REFLUX COOLING)



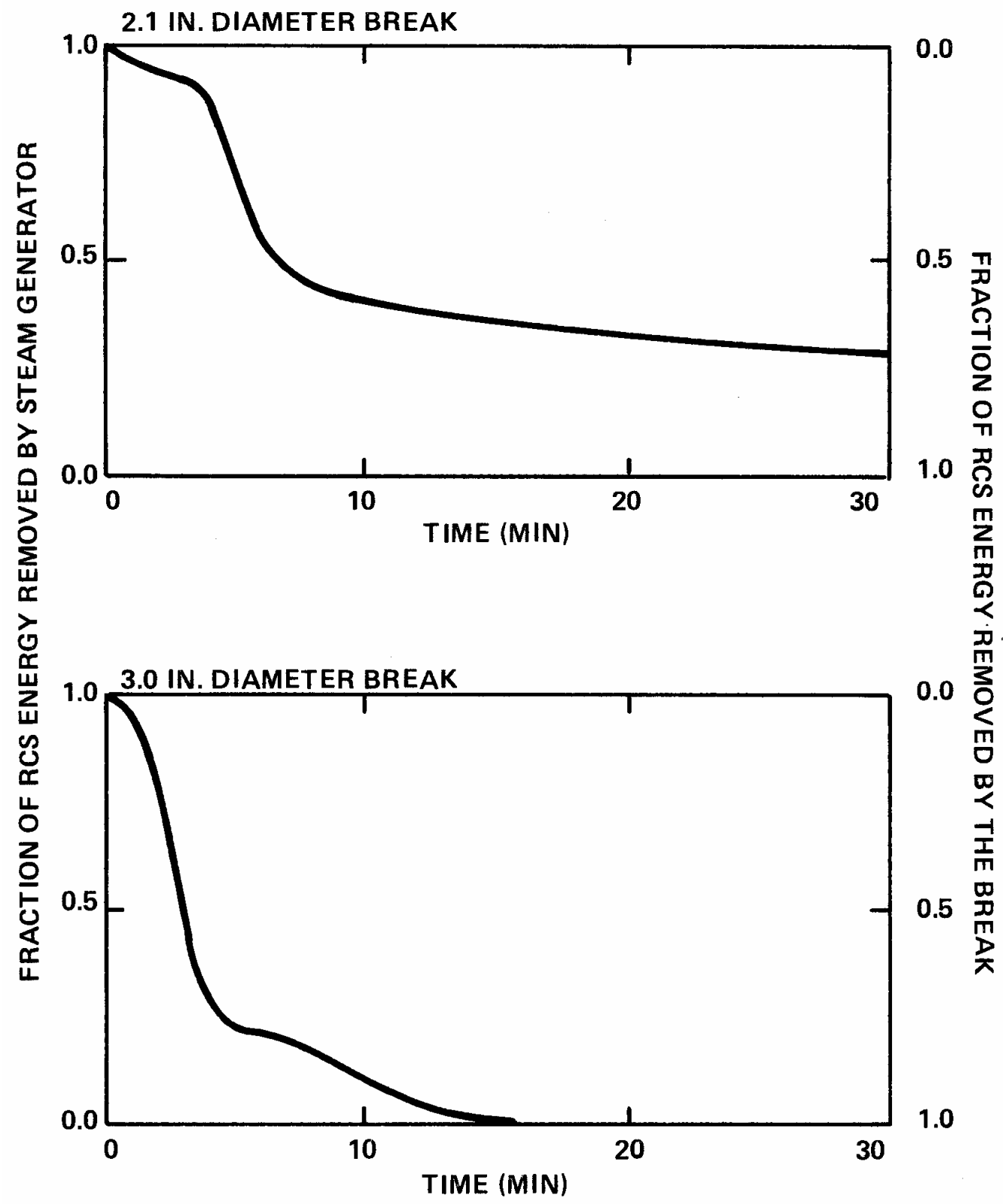
Loss of Coolant Accident Recovery Bases

FIGURE 5-5
BREAK DIAMETER VS % OF DECAY HEAT REMOVED
BY STEAM GENERATORS



Loss of Coolant Accident Recovery Bases

FIGURE 5-6
BREAK DIAMETER VS % OF DECAY HEAT REMOVED
BY STEAM GENERATORS



The operator has adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, and loop Delta T can be used along with other information to confirm that the single phase natural circulation process is effective. The natural circulation processes involving two phase cooling are complex and varied enough so that RCS loop Delta T may not be a meaningful indication of adequate natural circulation cooling. The guidelines are written to alert the operator to use explicit acceptance criteria for natural circulation only when RCS Inventory and pressure are controlled.

For cases where two phase natural circulation cooling is the heat removal process, the operator relies upon maintaining the steam generator heat removal process and the strict rules that require the SIS to remain operating to restore inventory control. In addition, the core exit thermocouple temperature and TN temperature indication are important in monitoring heat removal during two phase natural circulation cooling. As long as these temperatures remain within acceptable limits they indicate that heat removal and inventory functions are being satisfied.

The time frame for the transition' from single phase liquid natural circulation cooling to the reflux mode is determined by the relative size of the small break. The operator should be aware that this transition may cause confusing temperature indications as the RCS loop Delta Ts readjust to reflect the transition in progress. The emphasis in the guideline is to continue the steam generator heat removal process, continue restoring inventory control, and to continue monitoring the core exit thermocouples to confirm the heat removal process is adequate.

Once RCS pressure and temperature are reduced, RCS heat removal is provided by the shutdown cooling system-if possible. [In the event that liquid inventory in the steam generators is not adequate to remove decay heat, a source of feedwater is unavailable, and the SCS is inoperable, the operator is instructed to Implement the Functional Recovery Guideline because a multiple casualty condition Is in effect (LOCA and Loss of All Feedwater). Specific guidance for Initiating once-through-cooling is provided here. As discussed previously, although steam generator heat removal is only required for the small break LOCA event, the LOCA EPG does not require the operator to distinguish between large and small break LOCAs so the action is taken whenever SG heat removal capability is lost.

Short-term reactivity control is accomplished by the negative moderator effects for large breaks and by the reactor trip for small breaks. The reactor trip decreases core heat generation to decay heat levels which aids in the control of heat removal. Long-term reactivity control is accomplished through injection of borated water by the safety injection system and the charging pumps (when available).

Containment isolation occurs either automatically, or is performed manually after an evaluation of the plant conditions (containment temperature, pressure, and activity level; and for plants which generate a CIAS on SIAS, [pressurizer pressure]).

Loss of Coolant Accident Recovery Bases

If the LOCA occurs inside containment, then containment temperature and pressure control can be accomplished by various combinations of containment fan coolers (in the emergency mode) and/or the containment spray system. These systems act to remove heat from the containment atmosphere, thus reducing the temperature and pressure.

Containment Combustible Gas Control may become a concern due to hydrogen generated during LOCA events. The ultimate goal of the Containment Combustible Gas Control safety function is to prevent a hydrogen burn from causing containment pressure to reach or exceed containment design pressure. Preferentially this is accomplished by operation of the hydrogen recombiner. If recombiner operation is not possible or sufficient, the a hydrogen purge may be performed if deemed necessary by the [Plant Technical Support Center]. These actions are performed to prevent or minimize the release of fission products to the environment.

Three significant sources of hydrogen exist during LOCA events. These are:

(1) <u>Metal-water reactions involving zircalloy or stainless steel in the RCS</u>

These reactions take place at high temperatures during the core uncover phase of a LOCA. Thus, hydrogen generated will be released to the containment atmosphere if the primary break is inside containment. The amount of hydrogen produced depends on the duration of core uncover and the maximum core temperature reached.

(2) <u>Radiolysis of water by fission product decay</u>

As a result of the decay of the fission products, water molecules in the RCS and in the RCS fluid which has been released into the containment may be broken down into hydrogen and oxygen. The gases are released to the containment atmosphere. This is a slow process but over a period of time can be the most significant source of hydrogen. It may take [12 to 16] days for hydrogen concentration to reach 4%. The rate of buildup will increase with an increase of fission products in the RCS.

(3) <u>Corrosion of aluminum and zinc by the containment sprays</u>

The reaction between the aluminum and zinc materials in the containment with the borated spray solution generates hydrogen. The reactions occur at higher rates with increasing temperatures. Hydrogen may be generated in this way during the first hours of a LOCA event.

Figure 5-7 provides the results of a typical safety analysis calculation of the hydrogen concentration for a large break LOCA event. The initial increase in hydrogen concentration is due to the metal-water reactions and the corrosion reactions. The long term Increase is due to the radiolysis of water.

The containment hydrogen concentration can be reduced by recombining hydrogen and oxygen to form water. The hydrogen recombiners do this by raising the temperature of the air passing through them to the point where the recombination reaction takes place. [Electric heating elements are used to heat the incoming mixture, while flow through the units is provided by natural circulation.]

Since the recombination rate (cubic feet of hydrogen removed per hour) depends on the hydrogen concentration in the atmosphere, use of the recombiners will result in an exponential decrease in the hydrogen concentration. Typically, one recombiner will remove hydrogen at a rate that is compatible with the long term hydrogen generation rate following a large break LOCA due to radiolysis of reactor coolant water.

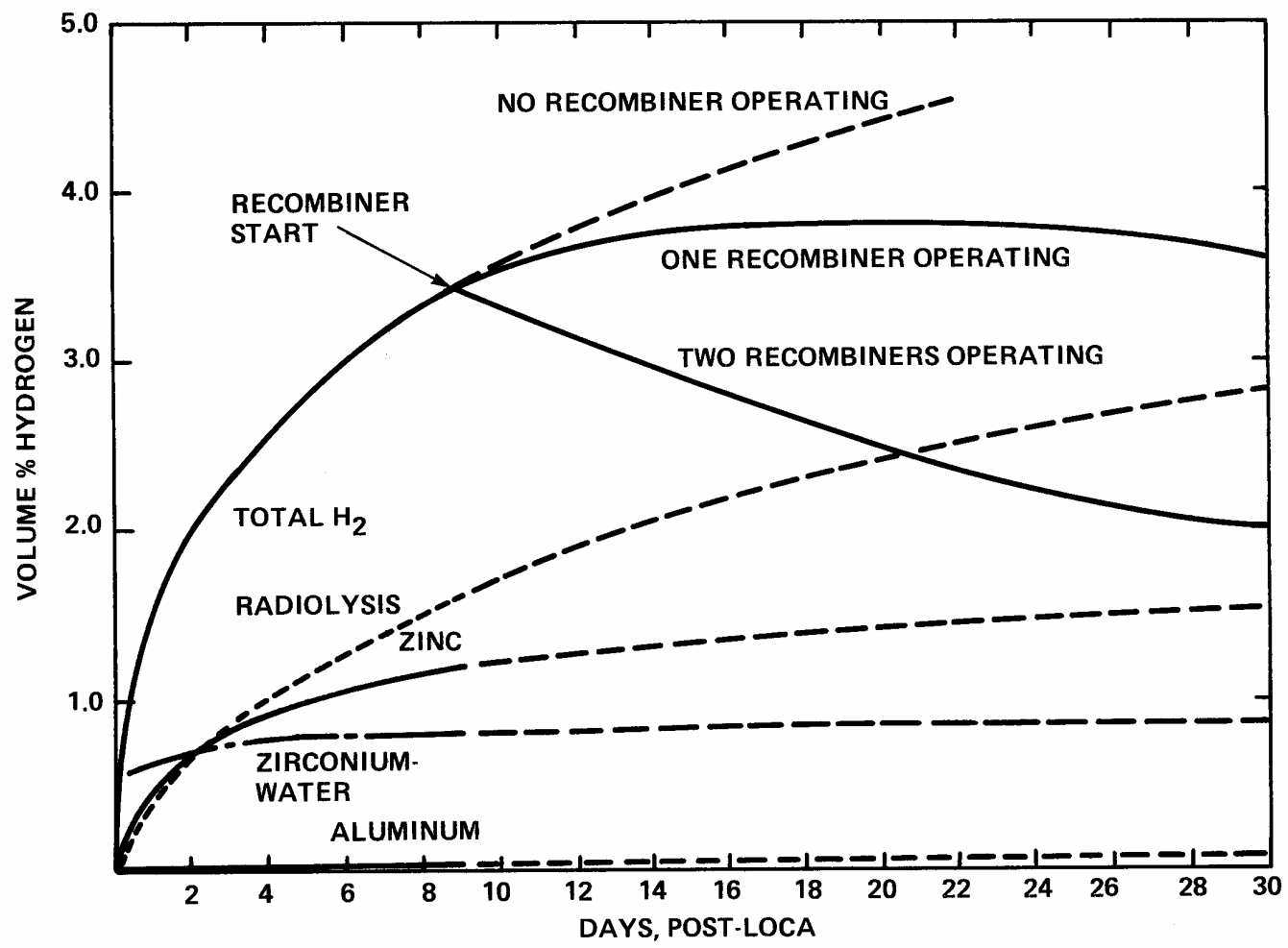
Figure 5-7 provides typical curves showing the effect of one and two recombiners that are started nine days after the LOCA.

The containment hydrogen concentration can also be reduced by purging the containment atmosphere with fresh air. The hydrogen purge system accomplishes this by providing controlled intakes and exhausts to the containment atmosphere. This method of hydrogen control is utilized after the [Plant Technical Support Center] has evaluated several factors - including the expected effects of a hydrogen burn.

The hydrogen removal rate (cubic feet of hydrogen removed per hour) depends on the purge system flow rate, the containment free volume, and the containment hydrogen concentration. Typically, the hydrogen purge system will remove hydrogen at a rate that is comparable with the long term hydrogen generation rate following a large break LOCA. Higher purge rates will result in higher removal rates. The hydrogen purge rate can be approximated by the hydrogen removal rate of one recombiner as shown in Figure 5-7.

Loss of Coolant Accident Recovery Bases

FIGURE 5-7
TYPICAL HYDROGEN CONCENTRATION BUILDUP AND
REMOVAL FOLLOWING A LARGE BREAK LOCA



Trending of Key Parameters (Representative of small break LOCAs)

Reactor Power (Figure 5-8)

A reactor trip will occur on thermal margin/low pressure, and reactor power will be decreasing as a result of the reactor trip. Additional negative reactivity insertion will be provided by moderator voiding, and boron addition by charging pump and/or SIS flow.

RCS Temperature (Figures 5-9, 5-10)

Following the reactor trip, RCS temperature initially decreases for all size LOCAs due to the reduction in heat input into the RCS, and due to the heat removed out the break and by the steam generators.

Pressurizer Pressure (Figure 5-11)

Pressurizer pressure initially decreases due to the loss of coolant and reactor power reduction following reactor trip.

Pressurizer Level (Figure 5-12)

Pressurizer level may decrease or increase. For breaks not located in the pressurizer, the pressurizer will empty and, depending on the size of the break, not refill during the course of the accident. Breaks located in the pressurizer may lead to increased pressurizer level since water from the hot leg flows into the pressurizer surge line while significant voiding of the RCS loop is occurring. If there is a break on or near the pressurizer level instruments, this may cause this instrument to be grossly inaccurate and misrepresent pressurizer level (high or low).

For small break LOCAs where the pressurizer refills as a result of safety injection, pressurizer level may not be representative of RCS inventory or core coverage. As indicated above, the depressurization associated with a leak in the RCS will usually result in the formation of voids in

RCS hot spots (reactor vessel head, hot legs, S/G tube bundle). The growth or persistence of these voids, after refill of the pressurizer by the SIS, may cause pressurizer level to increase or remain constant in spite of continuing loss of inventory through the break.

Loss of Coolant Accident Recovery Bases

Reactor Vessel Level (Figure 5-13)

Some degree of voiding is expected for LOCAs; but the extent and duration is largely dependent on break size and location. Most small break (58) LOCA events will not result in core uncover without some other failure occurring concurrently. Some small breaks can lead to some core uncover. However, when HPSI delivery is established, the core will be covered. For very small breaks, the RCS will repressurize to slightly below the shut-off head of the HPSI pumps and voiding will not uncover the core. For large breaks, the RCS saturates almost immediately and voids start to form. Core uncover is expected in the short term but RCS pressure decrease is also very rapid and SIS flow restores core cooling.

Steam Generator Pressure (Figure 5-14)

Steam generator pressure may increase or remain constant in the short-term if the break is small. However, for all sized LOCAs, steam generator pressure will usually decrease in the long term as a result of operator action.

Steam Generator Level (Figure 5-15)

Steam generator level will decrease rapidly following the reactor trip and then increase to the hot standby level. Level may then remain constant or increase somewhat based on automatic or manual control of feedwater.

Loss of Coolant Accident Recovery Bases

FIGURE 5-8

REPRESENTATIVE SMALL BREAK LOCA REACTOR POWER

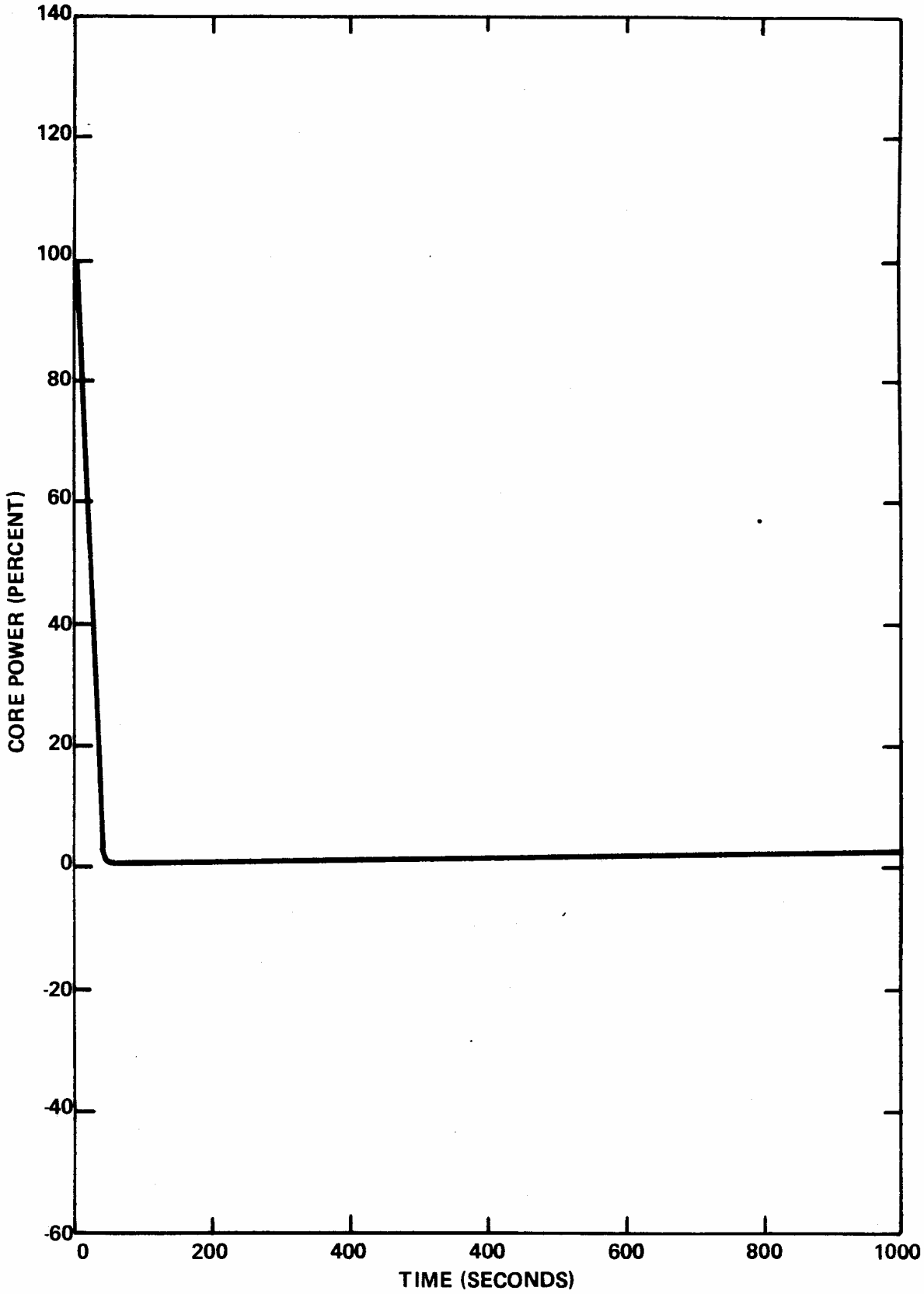
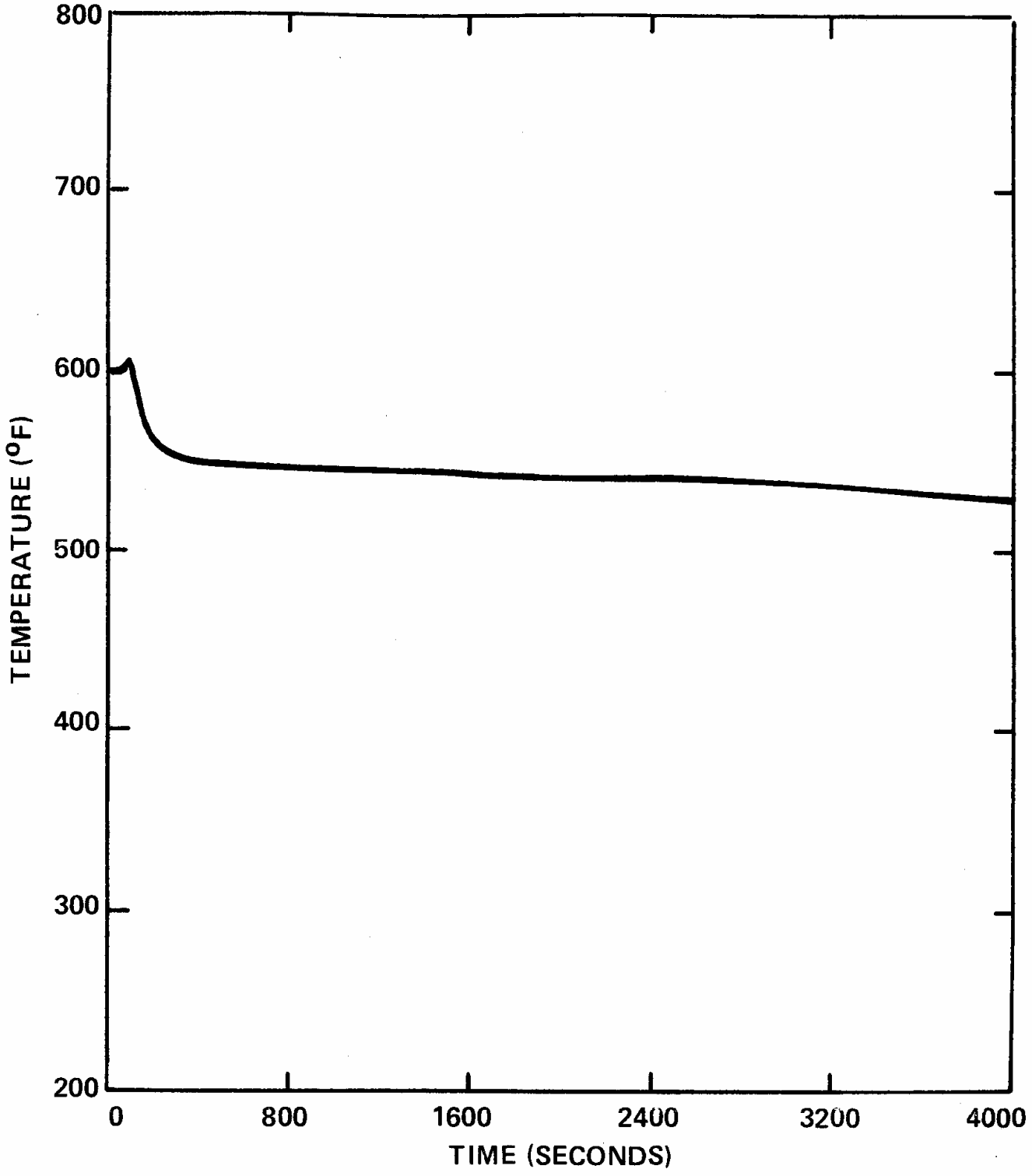


FIGURE 5-9

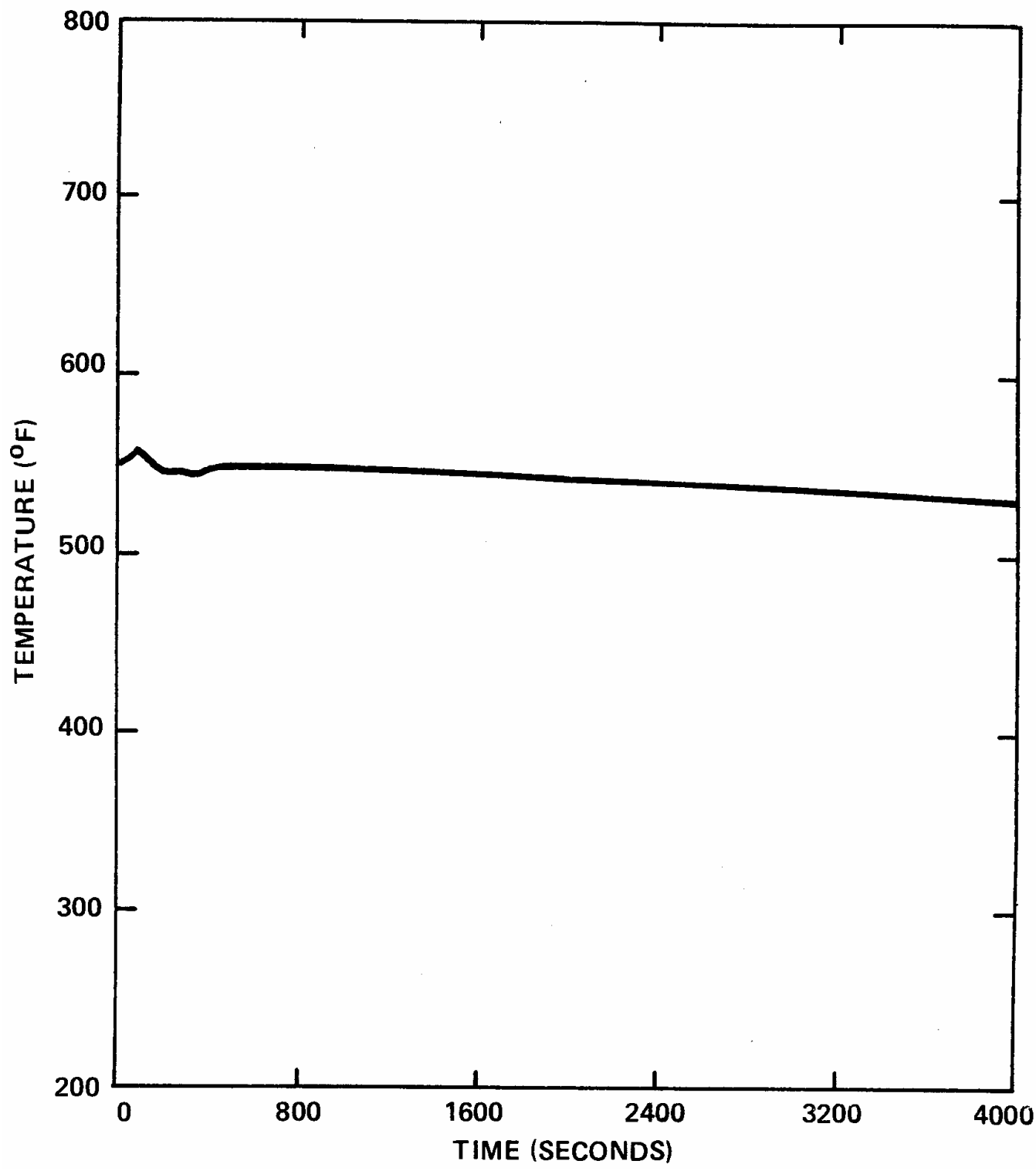
REPRESENTATIVE SMALL BREAK LOCAL RCS HOT LEG TEMPERATURE



Loss of Coolant Accident Recovery Bases

FIGURE 5-10

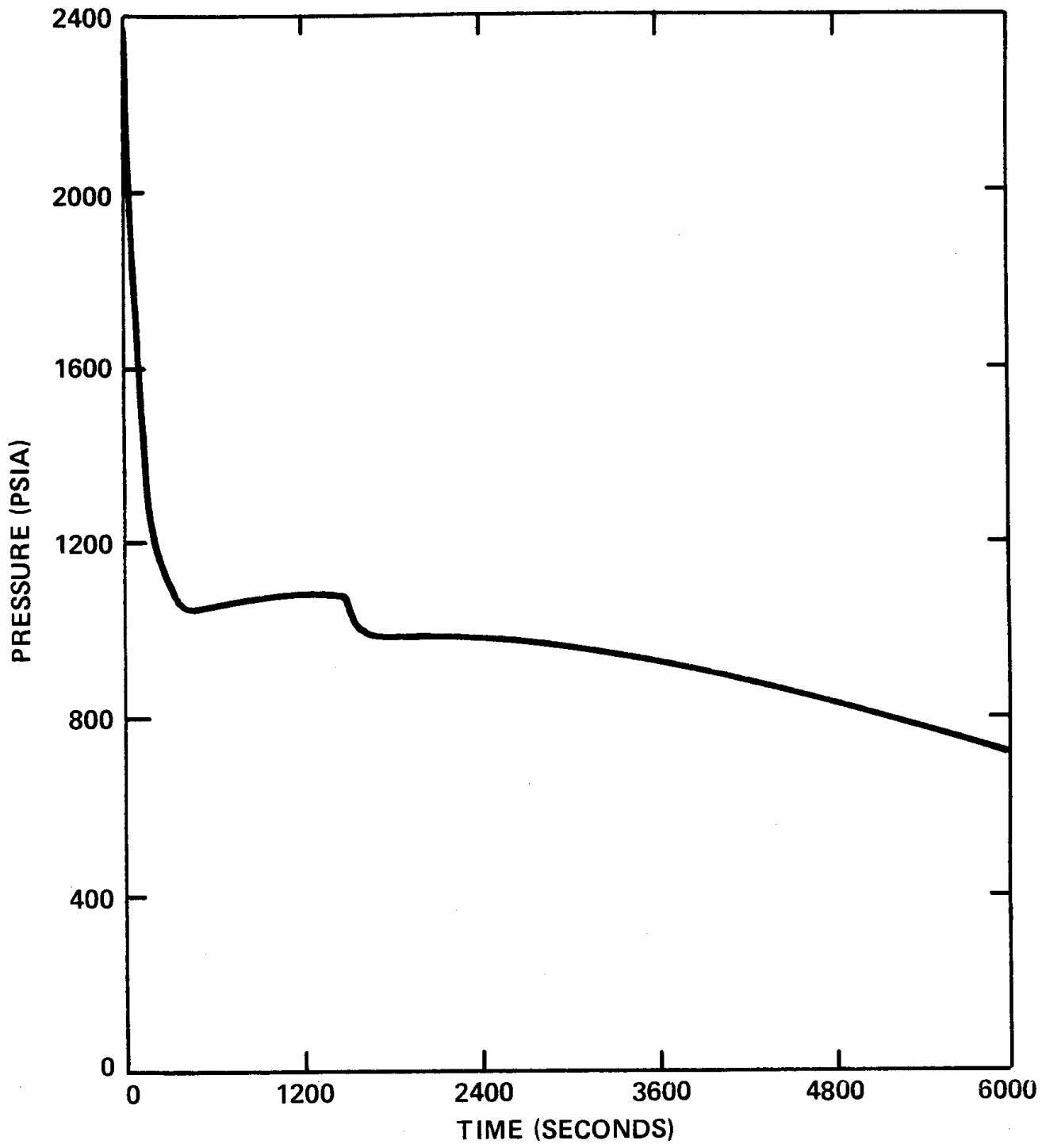
REPRESENTATIVE SMALL BREAK LOCA RCS COLD LEG TEMPERATURE



Loss of Coolant Accident Recovery Bases

FIGURE 5-11

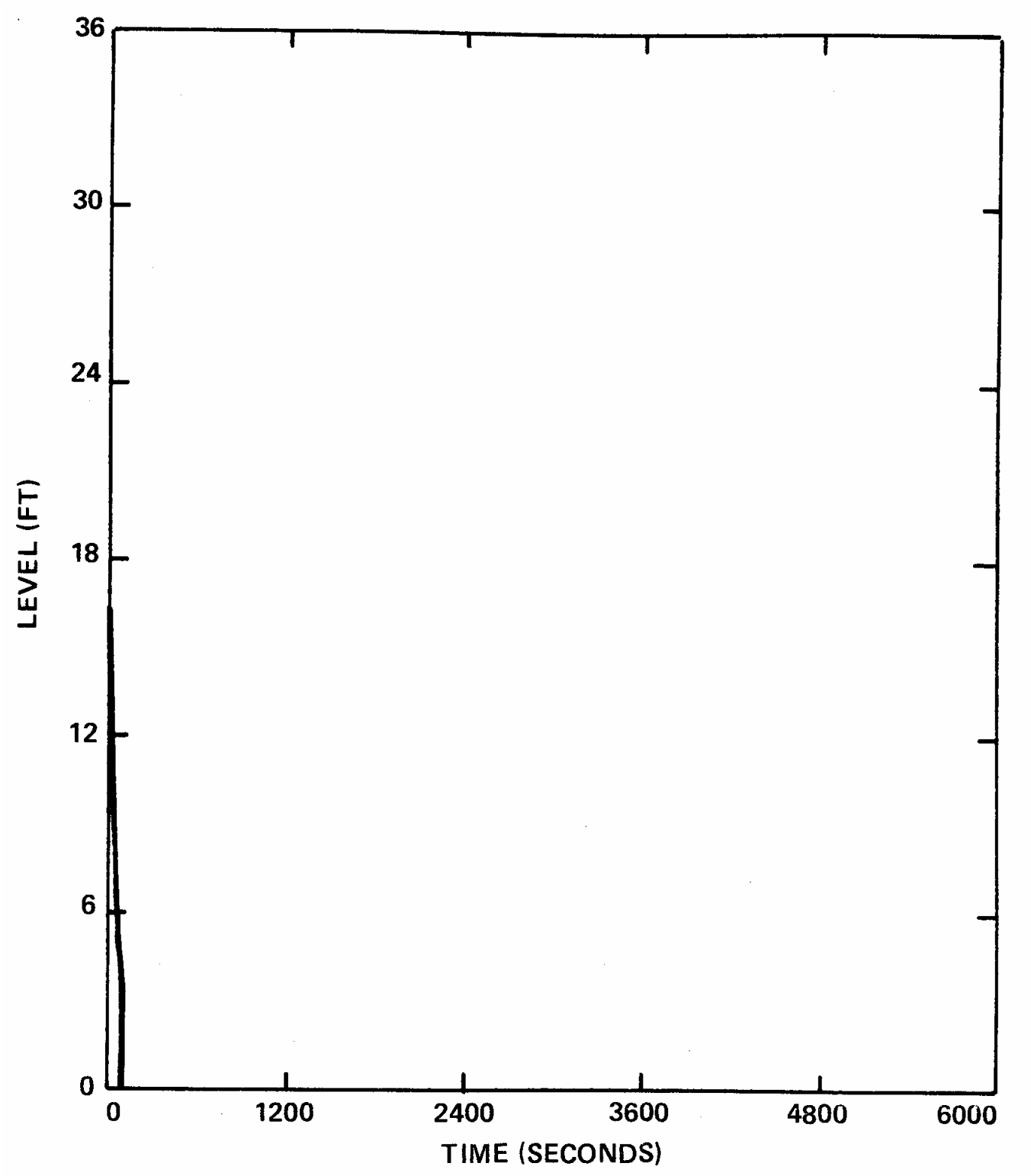
REPRESENTATIVE SMALL BREAK LOCA PRESSURIZER PRESSURE



Loss of Coolant Accident Recovery Bases

FIGURE 5-12

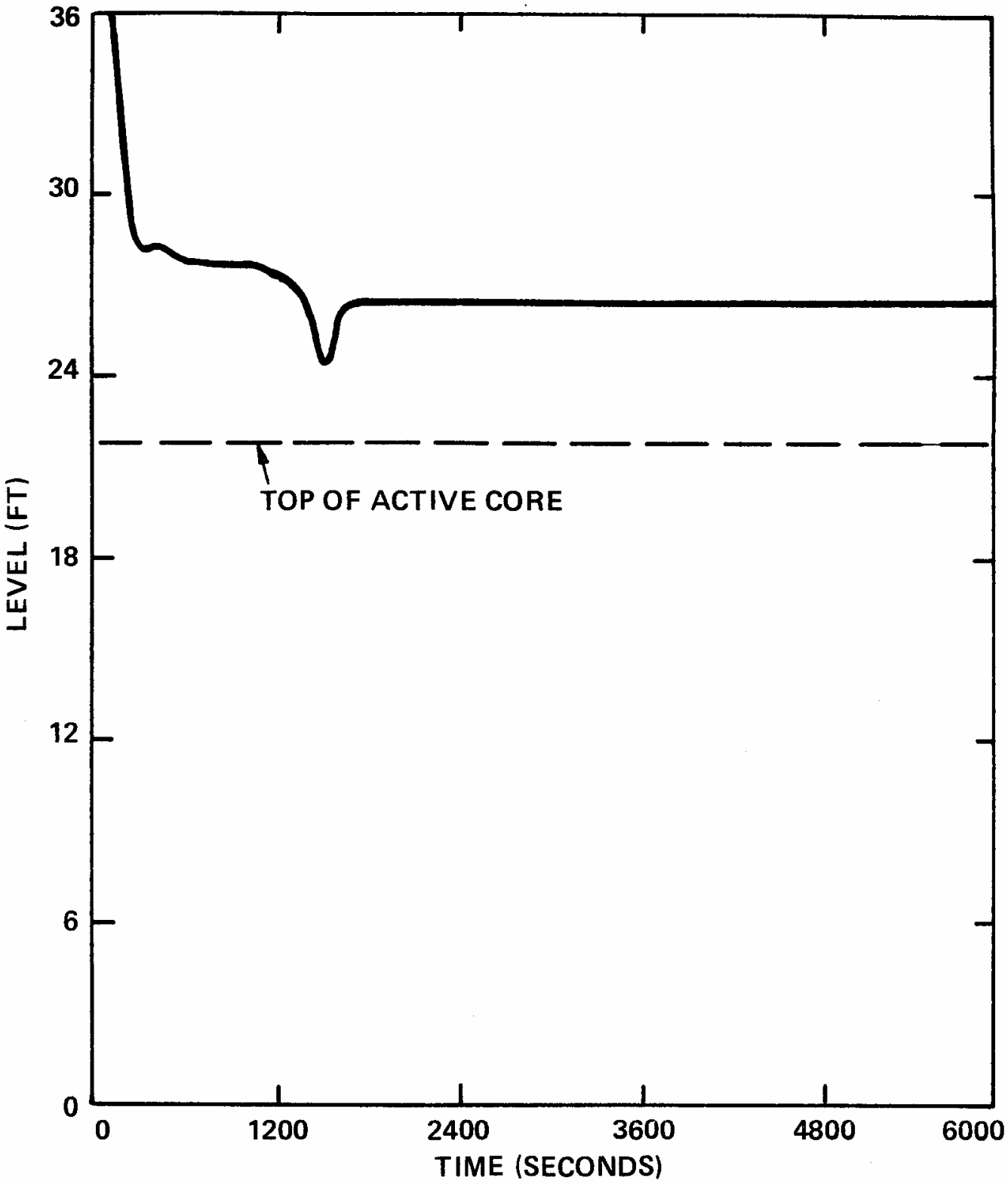
REPRESENTATIVE SMALL BREAK LOCA PRESSURIZER LEVEL



Loss of Coolant Accident Recovery Bases

FIGURE 5-13

REPRESENTATIVE SMALL BREAK LOCA REACTOR VESSEL LEVEL



Loss of Coolant Accident Recovery Bases

FIGURE 5-14

REPRESENTATIVE SMALL BREAK LOCA
STEAM GENERATOR SECONDARY SIDE PRESSURE

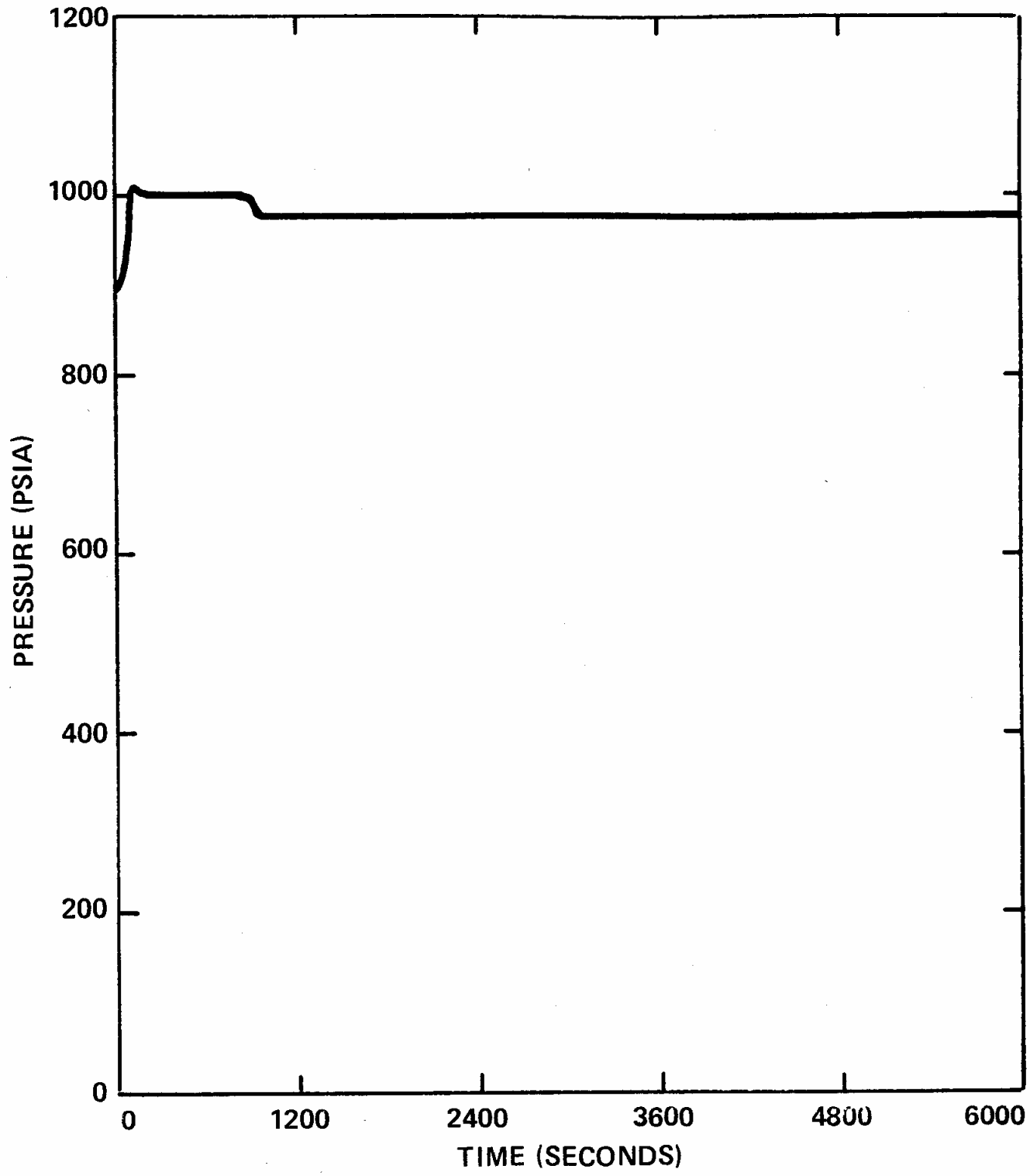
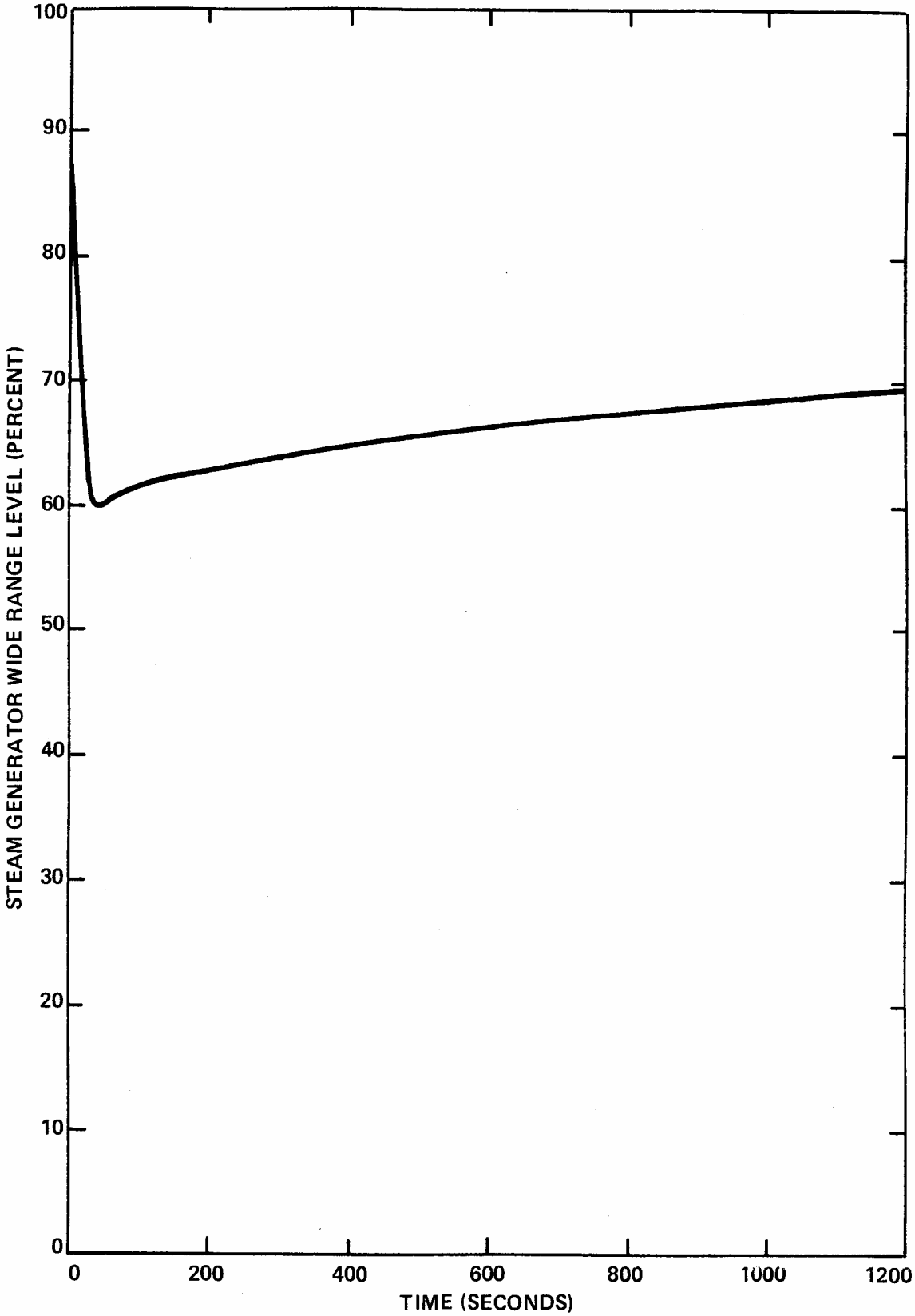


FIGURE 5-15
REPRESENTATIVE SMALL BREAK LOCA
STEAM GENERATOR WIDE RANGE LEVEL



Loss of Coolant Accident Recovery Bases

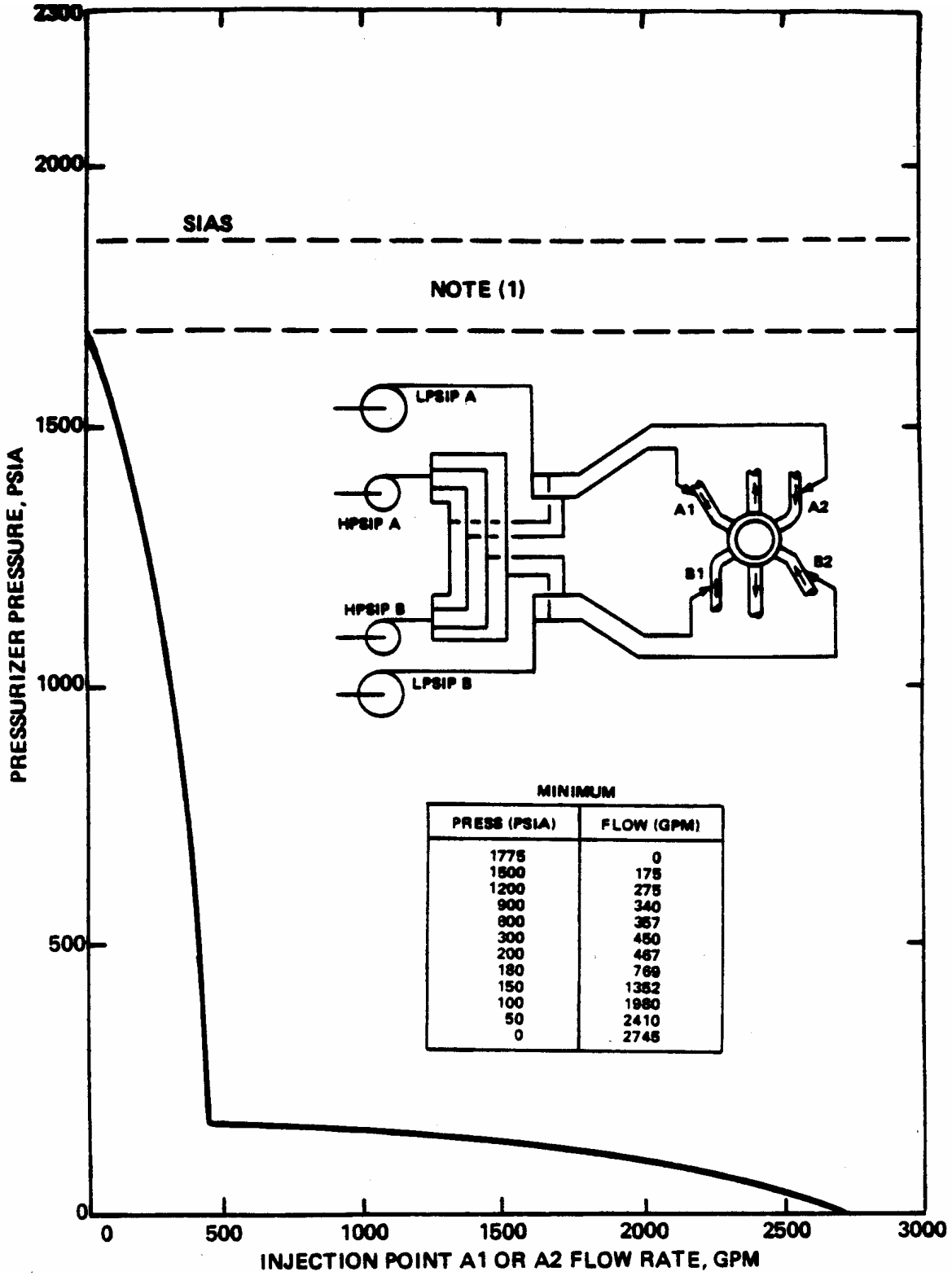
Guideline Strategy and Information Flow

Prior to implementing the actions provided in the LOCA Recovery Guideline, the operator would have performed the Standard Post Trip Actions and diagnosed the event. In the LOCA Recovery Guideline, the operator begins using the Safety Function Status Check to confirm that the plant is recovering. The next steps can be broken into six major recovery actions.

The six major recovery actions bring the plant to a stable condition which can be maintained indefinitely. The first major action consists of maximizing safety injection flow into the RCS and attempting to isolate the source of the leak. This step reduces the risk of core uncover and facilitates recovery from the LOCA. The second and third major actions apply to the situation when the leak has been isolated. The second major action involves regaining control of the RCS pressure and inventory and maintaining sufficient RCS heat removal. The third major action is to perform a controlled cooldown to the SCS entry conditions. The fourth through sixth major recovery actions are applicable to the situation when the leak cannot be isolated. The fourth major action involves a rapid plant cooldown using the steam generators. This step is particularly important for small breaks which require the SGs to remove the core decay heat. The fifth major recovery action is the commencement of post-LOCA Long Term Cooling (LTC). Safety injection flow is switched to simultaneous hot/cold leg injection from the normal cold leg injection. Also, the suction for the charging pumps is switched to the [refueling water tank] for boron concentration control. The sixth major action is a determination of whether SCS operation Is appropriate (small breaks) or whether simultaneous hot/cold leg injection In a recirculation mode should be continued (large breaks).

A detailed chart illustrates the recovery guideline strategy and lists the guideline steps which correspond to each strategy objective. Refer to Figure 5-19 (Reference 15.2).

FIGURE 5-16
TYPICAL SAFETY INJECTION DELIVERY CURVES
NO FAILURES



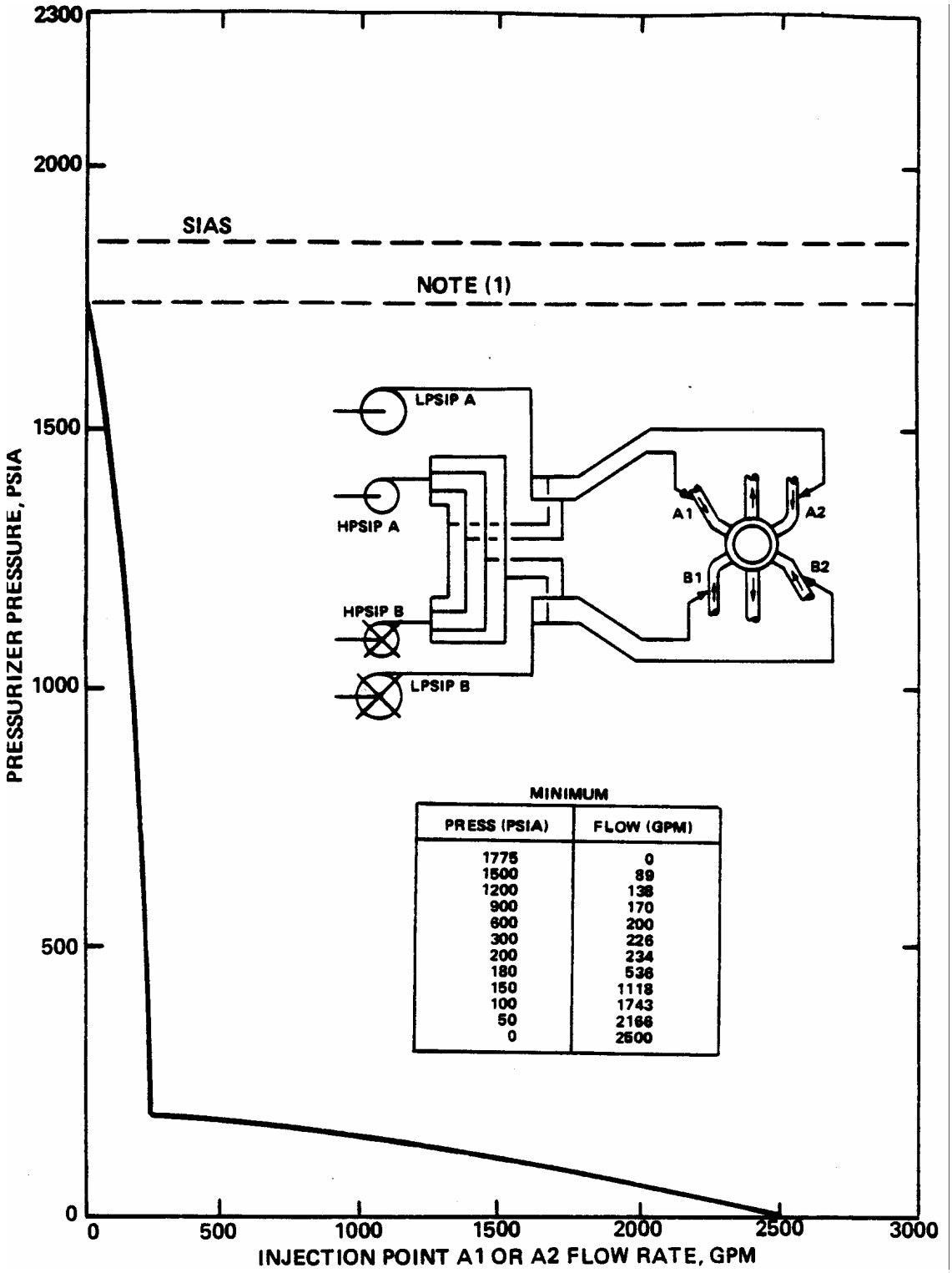
MINIMUM

PRESS (PSIA)	FLOW (GPM)
1775	0
1500	175
1200	275
900	340
600	357
300	450
200	467
180	769
150	1352
100	1980
50	2410
0	2745

Note: (1) Below SIAS Pressure, Safety Injection System (SIS) pumps will be operating, but there will be no injection flow until system pressure falls below the shutoff head pressure of any HPSI SIS Pump

Loss of Coolant Accident Recovery Bases

FIGURE 5-17
TYPICAL SAFETY INJECTION DELIVERY
FAILURE CONDITION - LOSS OF ONE EMERGENCY GENERATOR



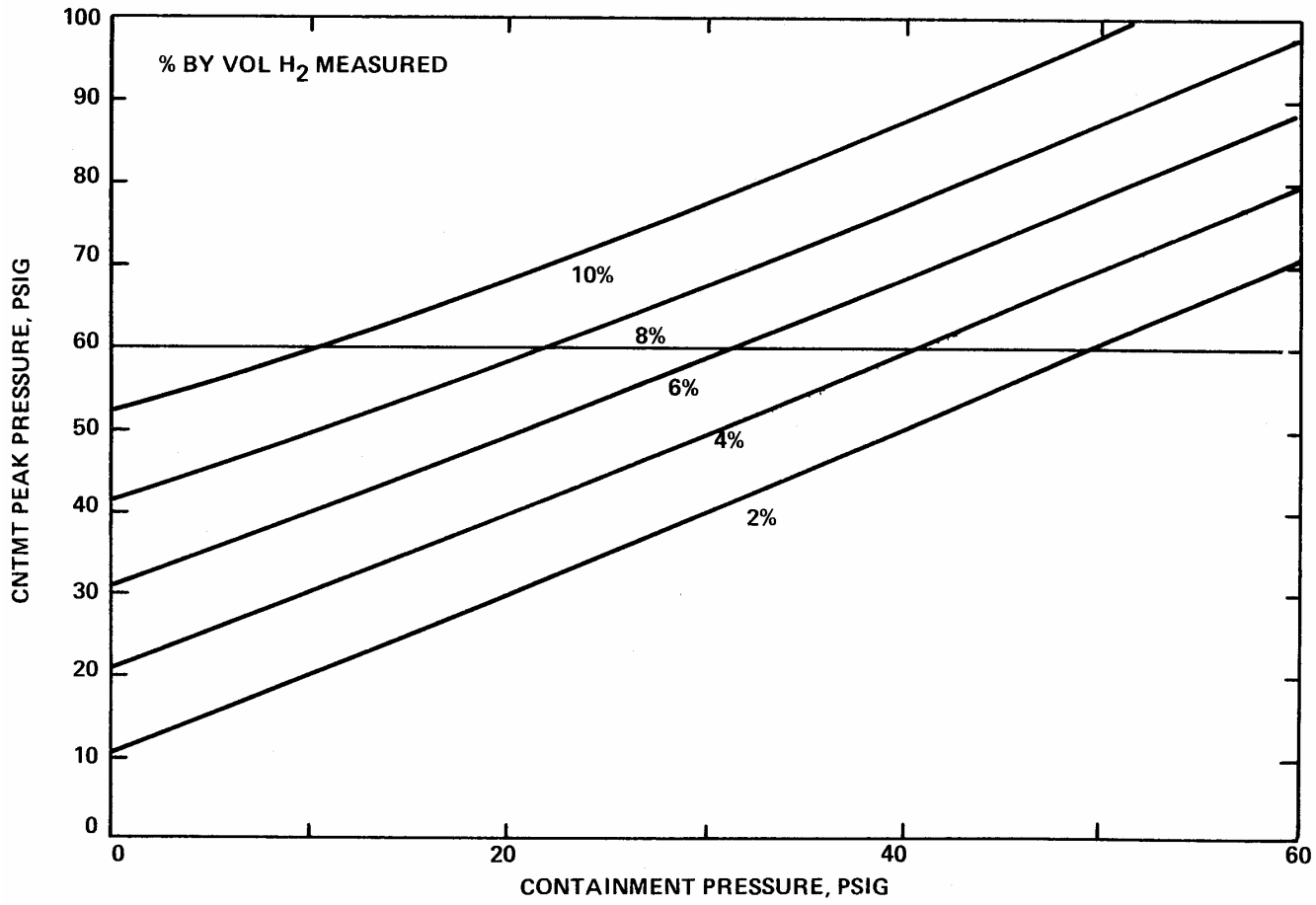
MINIMUM

PRESS (PSIA)	FLOW (GPM)
1775	0
1500	89
1200	138
900	170
600	200
300	226
200	234
180	536
150	1118
100	1743
50	2166
0	2500

Note: (1) Below SIAS Pressure, Safety Injection System (SIS) pumps will be operating, but there will be no injection flow until system pressure falls below the shutoff head pressure of any HPSI SIS Pump

FIGURE 5-18

POST H_2 BURN CHARACTERISTICS



Loss of Coolant Accident Recovery Bases

Bases for Operator Actions

The operator actions are directed at placing the plant in a safe, stable condition. One of two paths is followed, depending upon whether or not the break has been isolated.

Step Number 1 Confirm Diagnosis

Intent

The intent of this step is to confirm the diagnosis of the event.

Method

The Safety Function Status Checks and steam generator activity are used to confirm the diagnosis. Note that steam generator samples should only be taken for LOCA, SGTR, ESDE and FRG, if a means to sample is available. If it is not possible to sample the steam generators, then monitor for other indications of SGTR to confirm the diagnosis.

The diagnosis of a Loss of Coolant Accident should be confirmed by comparing control board parameters [or the Safety Parameter Display System (SPDS)] to the acceptance criteria in the Safety Function Status Check to ensure that all safety functions are being satisfied. The Safety Function Status Checks confirm that the diagnosis is correct and that the procedure and plant are adequately responding to the diagnosed event, or that event re-diagnosis must be performed. In particular, the operator should note the status of RCS subcooling, containment radiation and steam plant activity. These parameters provide a means of discriminating between a LOCA, SGTR and ESDE.

- For a LOCA, the RCS may reach saturation conditions and the containment activity monitors may be alarming but steam plant activity monitors should not be alarming.
- For a SGTR, steam plant activity monitors should have shown (or are showing) an increasing trend and may be alarming, but containment activity monitors should not be alarming.
- For an ESDE, neither steam plant or containment activity monitors should be alarming, and subcooling should be increasing. For plants which exhibit SG tube leakage, however, steam plant or containment activity monitors may alarm during ESDEs.

Sampling both steam generators for activity will assist in confirming the diagnosis. There should be no unexplained increase in secondary system activity during a LOCA (indicative of an SGTR).

If the initial diagnosis of is confirmed, then the operator is directed to continue the instructions of this guideline. If a different event has occurred, then the LOCA guideline is exited and the actions of the appropriate guideline must be implemented.

The symptoms of LOCA, SGTR, and ESDE are similar and this step allows the operator to implement the proper procedure if the event has been misdiagnosed.

(continue)

(continued)

If a single event cannot be diagnosed, or if actions to recover a safety function do not immediately produce the appropriate response, the operator is directed to exit the guideline and to implement the Functional Recovery Guideline. The Functional Recovery Guideline is purely safety function based and will ensure that all safety functions are addressed regardless of what event(s) is occurring.

The operator should stay in this guideline under any of the following conditions:

1. If the operator is certain (upon re-diagnosis) that the event in progress is <u>only</u> a LOCA.
2. If the operator is aware that some equipment failure caused the failure of the Safety Function Status Check and only a LOCA is in progress.
3. If immediate operator action produces immediate response toward satisfying the failed safety function.

Note that if it is not possible to sample the steam generators, then the operator should monitor for other indications of SGTR to confirm the diagnosis.

Otherwise, the operator must go to the FRG.

<u>Sequence</u>

This step is the first step in the procedure. It is considered important to confirm the diagnosis to ensure that the correct Optimal Recovery Guideline is in use. The step is continuously applicable to ensure that throughout the event that the this remains true.

<u>Plant Parameters</u>

None

Loss of Coolant Accident Recovery Bases

Step Number 2 Classify the Event

Intent

The intent of this step is ensure that the Emergency Plan has been implemented and the event is being classified.

Method

The Emergency Plan is implemented for any unplanned reactor trip. Emergency Plan implementation gains additional support for the control room staff, and ensures that the health and safety of the public is being protected by independently checking plant status. It also ensures that pertinent information is provided to the appropriate personnel and agencies. This step supports the notification time requirements for local and federal agencies.

Sequence

Positioning this step within the procedure ensures timely notification of the appropriate personnel and agencies as specified in the Emergency Plan and implementing procedures.

Plant Parameters:

None

Loss of Coolant Accident Recovery Bases

Step Number 3 Implement Placekeeping

Intent

The intent of this step is to ensure that the placekeeper be put into use and the time this EPG is entered is noted.

Method

The placekeeper provides the instructions for ensuring that the time of the event is recorded, and for tracking the status of steps in the procedure. Recording the entry time facilitates event documentation and reconstruction during the post trip review, and is used for time dependent steps. The step tracking section provides the operator with an easy means with which to track completion of each step, and may be used to update the crew on initiated and completed steps in the procedure during a briefing. It also provides the function of a table of contents fro returning to steps which may have been bypassed because the conditions were not yet satisfied.

Sequence

This step is placed early in the procedure to ensure that the placekeeper in put in use in a timely manner.

Plant Parameters

None

Step Number 4 Verify SIAS Actuation

Intent

The intent of this step is to ensure that a [SIAS] has actuated if pressurizer pressure is equal to or less than the [SIAS setpoint]. If a [SIAS] has not automatically actuated then the operator should manually actuate it.

Method

The purpose of this step is to check that Engineered Safety Actuation Systems (ESAS) which actuate on low pressurizer pressure have actuated when pressurizer pressure lowers to less than the low pressurizer pressure setpoint. The exact method of SIAS verification should be determined on a plant specific basis.

If SIAS has not automatically actuated then the operator should manually actuate SIAS. The exact method of manual SIAS actuation should be determined on a plant specific basis.

Sequence

The step is generally placed early in a procedure whenever a SIAS is believed to be necessary, or a SIAS is a plausible consequence of the accident event.

Plant Parameters

Pressurizer pressure is less than or equal to the SIAS setpoint

The engineering limit is based on the Technical Specification setpoint for SIAS. The operational limit, nominally [1600 psia] is the same as the engineering limit. The engineering limit establishes the decreasing pressurizer pressure value for SIAS.

Loss of Coolant Accident Recovery Bases

Step Number 5 Optimize SI

Intent

The intent of this step is to ensure that SI flow is within the limits of the design basis SI flow. That is, SI flow should be in accordance with the SI delivery curves (Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure) for the given RCS pressure and the number of running SI pumps. Typical SI system design provides two redundant trains of SI, but only one train operation is necessary to meet the intent of the this step. Therefore, it may be optimum for RCS inventory recovery purposes to have two SI trains in operation delivering flow in accordance with the two pump curve, but one train in operation (one SI pump running with flow in accordance with the one pump curve) is acceptable.

Method

After a SIAS the Safety Injection (SI) system flow rate to the RCS is a function of pressurizer pressure. This flow can be predicted using standard fluid flow calculations. The SI flow delivery curves are the results of these fluid flow calculations and can be used by the operator to determine if the SI system is performing as designed and delivering the expected flow to the RCS. Therefore, unless SI flow is deliberately throttled, SI delivery flow should always be greater than or equal to the pump curve. Therefore, SI flow within the one pump curve while two SI pumps are operating is not considered an acceptable configuration, and the problem should be investigated to determine the cause of the deviation and appropriate actions taken to restore SI flow within the limits of the curve. Deviations from the SI delivery curves may be due to valve misalignments, SI pump problems, etc.

It must be noted, however, that the safety injection flow can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and stop or throttle SI flow when SI stop and throttle criteria are met.

[Start idle charging pumps], is a plant specific RCS inventory restoration action that may be implemented depending on the design basis and the normal equipment response to a SI actuation.

(continue)

If SI flow is not within the SI flow curve then the operator is directed to perform any of the following to restore SI flow:

- Ensure electrical power to SI pumps and valves. This step ensures that pumps and valves which actuate on a SIAS have not tripped on overload and the electrical bus which supplies the loads is still available.
- Ensure correct SI valve lineup have been established. The operator should observe control board indications and ensure that a flowpath exists from the RWT to the RCS.
- Ensure auxiliary systems are in operation which are vital to the proper operation of the SI pumps. The operator ensures the necessary systems are inservice to support the SI pumps.
- The operator is directed to start additional HPSI pumps as needed to ensure SI flow is within the [SI flow delivery curves]. The operator ensures that the pumps that are not running have electrical power, are lineup properly and that auxiliary systems are available to the pumps. Additional HPSI pumps provide additional water to satisfy RCS inventory control sooner.

Sequence

This step should be located shortly after any event sequence where a SIAS is likely.

Plant Parameters

Safety Injection flow within the SI delivery curves
The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

Step Number 6 RCP Trip Strategy

Intent

The intent of this step is to implement a RCP trip strategy that takes into account the potential adverse effects of operating RCPs during a LOCA.

Method

An RCP Trip 2 / Leave 2 strategy has been developed which requires that only two RCPs be running in opposite loops if pressurizer pressure lower to less than the [maximum pressure plateau for SBLOCA] following a SIAS, and RCS subcooling less than the [minimum RCS subcooling].

The LOCA operational strategy directs the operator to trip two RCPs (in opposite loops) if pressurizer pressure is less than the [maximum pressure plateau for SBLOCA]. This action may have already been taken in the Standard Post Trip Actions, and in such case the operator would simply verify that two RCPs (in opposite loops) have been tripped. If RCP NPSH is less than adequate, the operational strategy directs the operator to ensure that all four RCPs are tripped.

Verification of RCP operating limits is covered by the following instruction. If minimum NPSH or [minimum RCS subcooling] (which ever is most limiting) is satisfied, the other two RCPs remain in operation unless one or more of the RCP operating requirements, (e.g. temperatures, seal flow oil pressures, motor amperage) are not satisfied. In such cases, any pump which does not satisfy these requirements would be tripped. If the operator cannot confirm that a LOCA has occurred, and the FRG is entered, the RCP trip strategy is identical to that described above.

The Trip 2 / Leave 2 strategy has two main goals. First, it maintains forced RCS circulation for non-LOCA depressurization events, and for LOCA events in which the rate of RCS inventory loss is not unduly exacerbated by leaving two RCPs in service. Second, it ensures that all four RCPs are tripped for LOCAs in which the RCS leak rate may challenge RCS heat removal capability if forced circulation is continued.

For a reactor trip in which RCS pressure remains below the [maximum pressure plateau for SBLOCA] (but in which the NPSH criteria is satisfied), the Trip 2 / Leave 2 strategy results in a manual trip of two RCPs in opposite loops. It has been demonstrated that the plant can be maintained in a safe condition, regardless of event diagnosis, with two RCPs operating under these conditions. Two RCPs are tripped at this time to reduce the potential for RCS inventory loss should a LOCA diagnosis (i.e. with RCP NPSH less than adequate) be confirmed. This strategy provides the operators with maximum flexibility for plant control while still ensuring a conservative approach to event recovery.

If the LOCA or Functional Recovery procedure is implemented when no charging pumps are available and no significant RCS leak exists, stopping the second two RCPs with pressurizer pressure at the [maximum pressure plateau for SBLOCA] would severely inhibit the operator's ability to reduce RCS pressure to the point where HPSI pumps could restore the RCS inventory, since neither main nor auxiliary spray would be available.

(continue)

(continued)

Conversely, continuing to run two RCPs for LOCAs in which the RCS Inventory loss is great enough to challenge the subcooling margin acceptance criteria carries a separate risk. Under these conditions, forced circulation tends to increase the total RCS inventory loss. Shortly after NPSH is lost, it is likely that the remaining RCPs will have to be tripped, due to loss of subcooling margin, at a time when the RCS inventory is less than it would have been, had the RCPs been turned off earlier in the transient.

The technical justification for the RCP Trip 2 / Leave 2 strategy found in CEN-268 (reference 22) suggests that a more appropriate point to stop the second two RCPs is when the existence of a LOCA has been conclusively demonstrated by maximum subcooling being less than the [minimum RCS subcooling] value. This position have been reviewed, and deemed acceptable by the NRC.

Sequence

This step should be placed early in the procedure to ensure the RCP trip strategy is employed in a timely fashion.

Plant Parameters

Pressurizer pressure is less than the maximum pressure plateau for SBLOCA

The engineering limit is based on establishing a generic plant condition at which the first two RCPs are tripped as part of the trip two/leave two (T2/L2) RCP trip strategy. The maximum pressure plateau for SBLOCA was selected because it is: consistent with a LOCA event, deterministic (the value can be determined for each plant via analysis), and easily recognizable once determined. The goal of the T2/L2 RCP trip strategy is to take advantage of the operational flexibility gained from continued RCP operation; while addressing the important concern of preparing the RCS for a particular LOCA event where continued RCP operation may result in increase inventory loss. The nominal SBLOCA pressure plateau is generally near the HPSI pump shutoff head (1300 psi).

RCS Subcooling is less than the minimum RCS subcooling based on representative CET temperature

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Step Number 7 Verify RCP Operating Limits

Intent
The intent of this step is to verify that RCPs are operating within their acceptable operating conditions.

It is important to verify RCP operating limits in the EPGs given the off-normal conditions of the RCS so that any RCP that is not operating within their operating limits is stopped prior to being damaged.

Method
RCP operating limits are plant specific. Typically, operating limits may include the following: NPSH requirements, bearing temperatures, seal flow, oil pressures, motor amperage, vibration, etc.

Any RCPs which do not satisfy the operating limits, either directly or by referencing the applicable operating instructions, should be stopped.

Sequence
This step should follow T2/L2 step to evaluate whether RCPs left running are within limits.

Plant Parameters
None

Loss of Coolant Accident Recovery Bases

Step Number 8 Isolate the LOCA

Intent
The intent of this step is to isolate potential sources of RCS leakage which can be rapidly and remotely isolated, to minimize RCS inventory losses.

Method
The following guidance is provided to isolate the leak:

a. [The PORVs are not expected to open during a LOCA. Therefore, if they are open and pressurizer pressure is below the [expected PORV closure setpoint], then the PORVs should be closed. However, there is no way for the operator to manually close the PORVs, Therefore, If the PORVs do not indicate closed or there is evidence that they are not fully closed, then the operator should close the PORV block valves.]

b. Letdown is isolated to isolate a break and to preclude loss of RCS inventory to the CVCS. The operator should first close letdown containment isolation valves from the Control Room. If necessary, the operator may direct that letdown be isolated locally

c. RCS sampling should be terminated and all sampling lines should be isolated. If necessary, this isolation should be performed manually. Isolating RCS sample lines minimizes RCS inventory losses and minimizes the possibility of inadvertent personnel exposure, if there is a break in the sample system.

d. RCS to CCW leakage should be detected by the CCW high radiation alarm or abnormal trend. A rise in CCW surge tank level, indicated by high level alarms or abnormal trend, may also be an indication of reactor coolant to CCW in-leakage. A higher CCW heat load, possibly caused by high containment temperatures will also cause surge tank level to rise to the point where an abnormally high level rise may possibly be discerned. If RCS to CCW leakage is evident, then an attempt at locating and isolating the leak should be made.

If there are other plant specific systems which could isolate the LOCA, then they should be listed.

Sequence
This step is located directly after a LOCA is diagnosed and SI is actuated and RCPs are tripped.

(continue)

Plant Parameters:

Pressurizer pressure less than the expected PORV closure pressure

The engineering limit is based on the expected PORV closure pressure, nominally [2340 psia]. The engineering limit is plant specific and depends on the detailed design of the valves and their controls. Typically, the closure pressure is several percent below the opening pressure, to minimize valve cycling near the opening pressure. It is also desirable for the closure pressure to be below the RCS high pressure alarm setpoint.

Loss of Coolant Accident Recovery Bases

Step Number 9 Verify LOCA Not Outside Containment

Intent

The intent of this step is to determine if the LOCA is outside of containment, and to provide the operator with direction regarding systems that should be considered when attempting to isolate a LOCA outside containment.

A LOCA outside of containment is a very low probability event. But if it does occur, and appropriate actions are not taken, the consequences can be severe due to the limited ability to make up to the RWT. The actions taken should control and limit the release of fission products to the environment.

Method

The operator is directed to check for indications of abnormal radiation levels and contamination outside containment. If a break occurs in a system connected to the RCS such as the CVCS, auxiliary building radiation levels and sump levels will increase. The spread of contamination outside of containment will be apparent by increases in airborne activity as well as area radiation levels in adjoining buildings.

The operator is directed to locate the leak (by observing the indication from the radiation monitors, sump level alarms and local indications of the leak). The operator should then use operating experience to isolate the leak in the best possible way. CIAS is initiated as an attempt to quickly isolate a leak in a process line connected to the RCS. The actions taken will limit the release of radionuclides to the environment and minimize the loss of RCS inventory.

The operator is directed to initiate actions to makeup to the RWT to attempt to maintain level greater than the RAS setpoint. If the leak is outside of containment, then the RCS inventory loss will not be collected in the containment emergency sump and will not be available as a suction source for SI flow following a RAS. Actions should therefore be taken to maintain RWT levels above the [RAS setpoint] to preclude a loss of RCS makeup.

If the LOCA is outside of containment, [Management] must be notified immediately to initiate actions to provide additional makeup to the RWT for alternate sources.

Sequence

This step is placed after attempts to isolate the LOCA are complete.

(continue)

Plant Parameters

Refueling Water Storage Tank level less than the RAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for RAS, [nominally 10%]. The intent of the application is to prompt the operator to verify that RAS occurred automatically or to manually initiate RAS if it did not. The upper allowable value for this trip is set low enough to ensure RAS does not initiate before sufficient water is transferred to the containment sump. Premature recirculation could damage or disable the recirculation system if recirculation begins before the sump has enough water to prevent air entrainment in the suction. The lower allowable value is high enough to transfer suction to the containment sump prior to emptying the RWT and to prevent air entrainment during the transfer. Switchover from RWT to the Containment sump must occur before the RWT empties to prevent damage to the ECCS pumps and a loss of core cooling capability. For similar reasons, switchover must not occur before there is sufficient water in the Containment sump to support pump suction.

Step Number 10 Place hydrogen monitors in service

Intent

The intent of this step is to place the hydrogen monitors in service.

Method

Subsequent operator actions and performance of the containment combustible gas control portion of the Safety Function Status Check will require measurement of the containment hydrogen concentration. The hydrogen monitors should be placed in service in order to enable the operator to monitor containment hydrogen concentration.

Sequence

Placed at the top EOP to ensure the ability to monitor H2 early in the procedure.

Plant Parameters

None

Loss of Coolant Accident Recovery Bases

Step Number 11 Ensure Containment Isolation and Cooling

Intent

The purpose of this step is to prevent direct communication between the containment atmosphere and the environment by ensuring containment isolation, and to ensure that containment cooling systems are functioning as designed.

High pressure in the containment may pose a threat to containment integrity. Furthermore, high containment temperature adversely impacts the accuracy of instruments whose transmitters are located inside containment (e.g., pressurizer level and pressure, steam generator pressure and level, RCS loop RTDs) and may impact the continued availability of equipment located in containment.

Method

If containment pressure is greater than the [CIAS setpoint], then the operator is directed to perform the following:

a. Verify CIAS [and CCAS for those plants that have a Containment Cooling Actuation System] occurs automatically at the appropriate setpoint. [The plant-specific method for ensuring adequate containment isolation should be inserted here]. These signals ensure that the minimum equipment included in the accident analysis is functioning. If containment isolation does not occur automatically, then the operator should manually initiate CIAS and ensure that the required valves are closed. The intend of the second part of the contingency is to have the operator quickly check CIAS/CCAS component status indication in the control room to verify components are in the required position. Manually repositioning individual components to the required position may be performed in parallel with subsequent procedure steps. Operators should be alert to the loss of auxiliaries to containment (in particular [component cooling water and letdown]) which may occur as a result of containment isolation actuation.

b. [CIAS setpoint] is also the setpoint for automatic initiation of containment emergency cooling. The containment fan coolers are designed as a means of cooling the containment atmosphere to reduce the containment building pressure and thus reduce the leakage of airborne and gaseous radioactivity. [Typically, at this setpoint, the normal cooling fans are automatically shifted to slow speed and standby fans started while the fan cooler cooling water is maximized.]

c. Normal containment cooling and air recirculation systems are verified to be operating. The operator ensures normal containment ventilation is operating to maximize the recirculation of the containment atmosphere. This recirculation will minimize the possibility of local accumulation of hydrogen developing.

(continue) (continued)

This will also help in removing heat from the containment and may help to provide for earlier termination of containment spray.

Sequence

This action is taken after the operator determines that the LOCA is inside containment. In an ESDE it is done after the affected SG has been isolated and RCS temperature and pressure are stabilized.

Plant Parameters

Containment pressure greater than the [CIAS] setpoint

The bases for the engineering limit is the same as the bases for the technical specification setpoint for [CIAS], nominally [4.0 psig]. The operational limit is the same as the engineering limit. The engineering limit establishes the increasing containment pressure value at which automatic controls activate to isolate [and cool] the containment, independent of operator action. The intent of the application is to prompt the operator to verify automatic Containment Isolation actuation and to manually initiate Containment Isolation and Emergency Cooling if they did not actuate when required.

Containment area radiation monitors greater than the alarm setpoint

The engineering limit is the alarm setpoint, which is based on the minimum detectable radiation levels above background. The intent of the application is to determine if containment isolation is necessary and/or if containment integrity is being maintained, and to confirm that the radiation alarm is consistent with the diagnosed event. The operator is expected to routinely monitor and trend radiation and radioactivity levels, and be alert to unexplained changes. In the context of the EOPs, increases in containment area radiation may be indicative of a LOCA, core uncovery and core damage, or another containment radiation anomaly that must be investigated further to determine its full meaning and implications to plant safety.

Step Number 12 Ensure Containment Spray Actuation

Intent

The intent of this step is to ensure that the containment spray system is activated to mitigate the containment pressure transient.

The Containment Spray system is designed to maintain containment pressure below design pressure, and provide a redundant means for containment heat removal to the containment cooling fans (which were ensured to be operating in the previous step). In addition, the containment spray water is used for scrubbing the iodine from the containment atmosphere, thereby minimizing radioactivity release to the environment.

If containment spray is actuated, there may be a need for the use of hydrogen recombiners. Therefore, for plants which utilize external hydrogen recombiners, the appropriate personnel should be directed to begin preparations to make the recombiners available and aligned for use. Use of the recombiners may be required by subsequent steps in order to satisfy the combustible gas control safety function (Reference 16).

When containment sprays are actuated, the conditions created in the containment may generate Hydrogen. Hydrogen may be generated by the reaction of boric acid (from containment spray flow) and metals in the containment. Aluminum and zinc are two metals which are reactive with boric acid. The reaction rates of boric acid and aluminum and zinc are a function of temperature. Therefore, if the containment spray system has been spraying boric acid onto zinc and aluminum surfaces in a high temperature environment, then conditions exist for the generation of hydrogen in the containment.

Method

a. The containment spray system is automatically actuated at a containment pressure of [CSAS setpoint] or greater. If containment pressure reaches [CSAS setpoint], then the operator should verify actuation. If CSAS does not actuate automatically, then the operator should manually actuate CSAS.

b. Following CSAS, both containment spray systems should start and deliver design flowrate to each containment spray header. The operator should verify that CS header flowrate is as expected to confirm proper pump operation and correct valve line up.

Sequence

Once it is determined that the LOCA is inside containment, and containment pressure is greater than the CSAS setpoint, the Containment Spray System must be verified to be in operation. [Some plants have external hydrogen recombiners that require considerable preparation to make ready for operation. If this is the case, preparations should start early in the procedure.

(continue)

(continued)

Plant Parameters

Containment Pressure greater than the CSAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for CSAS, nominally [10.0 psig]. The operational limit is the same as the engineering limit. The engineering limit establishes the increasing containment pressure at which automatic containment pressure/temperature controls activate to remove heat from the containment atmosphere, thereby ensuring that containment pressure remains below design pressure, independent of operator action. The intent of the application is to prompt the operator to verify automatic Containment Spray actuation or to manually initiate CSAS if it did not actuate when required.

Containment Spray pump flow at design flowrate

The engineering limit is based on the minimum required Containment spray flow needed to remove the design basis Containment heat load assumed in the accident analyses for LOCA or MSLB DBA. Containment spray flow in each header equal to or greater than the engineering limit ensures that each spray header is providing 50% of design requirements for containment heat removal. The intent of the operational limit is to provide the operator with criteria for verification that adequate containment spray flow exists after CS system actuation and to prompt the operator to investigate possible causes of degraded system flow if it is below the expected value.

Loss of Coolant Accident Recovery Bases

Step Number 12A Early Containment Spray Termination Criteria

Intent

The intent of this step is to secure unneeded containment spray pumps as early as possible after it has been confirmed that they have performed their safety function (Reference 48). The overall objective is to:

- Reduce the demand on the RWT,
- Delay the time to the start of containment recirculation during small breaks,
- Reduce the flow rate to the sump when containment recirculation begins,
- Reduce the pressure differential across the sump screens if there is a build up of debris.

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action if it is determined to be risk beneficial with respect to containment sump blockage.]

A large break LOCA will reach peak containment pressure and temperature within five minutes. As the break size decreases the time to reach peak conditions will increase but the magnitude of the peaks will decrease. This makes it easier for the active heat removal systems to accomplish their safety functions. During a large break LOCA, securing the spray pumps has only a small effect on the time to RAS actuation. Smaller breaks commensurately increase this time interval. Verifying that containment temperature and pressure have peaked and are decreasing ensures that enough time has elapsed for containment spray to have accomplished its safety function prior to securing spray pump(s).

Proper operation of safety injection ensures that no core damage has occurred. If core damage has not occurred, there is no source term, so that containment spray is not required to meet the dose source term assumptions. Under these conditions, securing containment spray will not affect the analysis of record dose calculation. However, the requirement for containment spray for Iodine removal is a plant specific criterion.

Securing the containment spray pumps leaves the containment fan coolers (CFCs) as the only active containment heat removal system. A loss of offsite power has the potential to reduce this containment heat removal capability by half. The CFC effectiveness defines how much time is available to restart the idle spray pump in the event that the operating pump fails. For the Reference CE Plant, time is infinite because soon after blowdown 2 of 4 CFCs can continue to reduce containment pressure and temperature after switching to containment recirculation. Analysis shows that the CFCs will maintain containment pressure and temperature control. Failure of half the CFCs does not challenge the containment pressure and temperature safety functions. Plant specific implementation of this step should include loss of one train of CFCs while containment spray pumps are secured. The results should demonstrate there is adequate time to start an idle spray pump and maintain the pressure and temperature below the current peak values in the analyses of record (AOR)

Method

a. Specify the criteria for early termination of containment spray.
    - Both (all required) containment spray trains are operating as per design. That is, all required pumps started and associated discharge valves opens on the appropriate ESFAS signal(s). Both trains are delivering design flow rate,

- Containment pressure has peaked and is now less than [containment design pressure] and lowering,
- The required combination of one containment spray train and containment emergency fan coolers is in operation. 'Required' is defined as having sufficient capacity to provide 100% of containment design cooling,
- Safety Injection has actuated and flow is within the delivery curves. Verifying proper operation of safety injection confirms that no core damage has occurred. Therefore, containment spray would not be required to meet the dose source term assumptions, i.e. iodine removal,
- Containment spray is not required to maintain containment temperature less than the [EEQ requirement]. The maximum containment temperature limit associated with Equipment Environmental Qualification (EEQ) is a plant specific requirement,
- Then:
  1) Secure one containment spray train at a time until the minimum required combination of containment spray trains and containment emergency fan coolers is in operation.
  2) If containment pressure can not be controlled and maintained below containment design pressure, restart the idle train(s) as necessary.

b. Predetermine the optimal strategy for securing pumps. Select the preferred CS train (A or B) and the preferred HPSI train (A or B) to be secured first when the termination criteria are satisfied. Consider such factors as: pump power supplies, suction valve and piping configuration and sump design (split vs. common). An optimal configuration would include one CS pump and one HPSI pump with the same power supply, with a common suction line and common sump penetration or sump section. In this way the reliability of the standby pumps is enhanced.

Sequence

This instruction should be located early in the procedure after verification that containment spray has actuated per design.

Plant Parameters

Containment pressure is less than [containment design pressure]

The engineering limit is based on the containment design pressure. This limit is consistent with the FSAR design criteria and the limiting pressure assumed in the accident analysis for high energy line releases inside containment.

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

Loss of Coolant Accident Recovery Bases

Step Number 12B Containment Spray Termination Criteria

Intent

The intent of this step is to specify when and how the containment spray system should be secured following a valid actuation by the CSAS. The step is intended to allow stopping containment spray if it is no longer needed. The actions direct stopping one train at a time. This method gives the crew time to evaluate the response of containment conditions to stopping containment spray. If it is found that containment conditions are not responding favorably, then containment spray may continue in accordance with the cooling requirements necessary to maintain acceptable containment conditions.

Method

It is desirable to secure containment spray flow as soon as it can be determined that it is no longer required for any of the reasons described below. Prolonged operation of sprays into the containment increases the probability of electrical grounds, shorts and other equipment malfunctions occurring.

Containment spray system operation may be terminated when all of the following conditions are satisfied:

1. The Containment Spray pumps are operating and delivering water to the spray headers inside containment. It is assumed that containment spray was initiated on a valid CSAS signal or because the CSAS setpoint had been exceeded.
2. Containment pressure has been reduced to less than the CSAS reset pressure and is under control (stable) or lowering. This provides some assurance that containment spray is no longer required. If containment pressure is stable below the CSAS setpoint, it should also be at a low value. Otherwise, if it is just below the CSAS setpoint, it may barely be keeping up with the heat generation, and CSAS will probably reinitiate shortly after termination.
3. The containment spray flow is no longer required for containment cooling. This determination is made by evaluating the availability and operability of all normal and emergency containment cooling systems. There should be compelling evidence that the available containment heat removal systems will be able to effectively control containment pressure and avoid repressurization.
4. Spray flow is no longer required for iodine removal. The following factors should be considered when making this determination: 1) the quantity of radioactive iodine in the containment atmosphere, 2) the severity of fission product release to the containment atmosphere, 3) the integrity of the containment boundary and, 4) the length of time that the iodine cleanup system has been in service.

   (continue)

(continued)

The containment [high range] radiation monitors are used to ensure that radiation levels inside containment have lowered and are trending in the conservative direction and that containment spray is no longer needed for iodine removal. If the TSC is manned and the containment high range radiation alarms are actuated when this step is reached, they may still suggest that containment sprays be terminated (as long as all of the other criteria are met) after determining that the radiological consequences would remain acceptable.

Once the decision to secure containment sprays has been made, one train should be secured at a time. Prior to securing the second train, the operator should verify that containment pressure and temperature remain under control (stable) or continue to lower. The spray pump is secured first, followed by closing the containment spray header isolation valve. This sequence ensures that the spray pump is not operated without a flow path. The Containment Spray System should then be realigned for automatic operation so it will automatically actuate if containment pressure rises to the CSAS setpoint.

Sequence

This step should be located soon after instructions to verify containment spray actuation.

Plant Parameters

Containment pressure less than the CSAS reset pressure

The bases for the engineering limit is the same as the bases for the technical specification value for resetting the Containment Spray Actuation System (CSAS), nominally [7.0 psig]. The reset value represents the containment pressure at which the Containment Spray System may be secured, the CSAS logic may be reset, and the Containment Spray System may be returned to a normal standby configuration. The intent of this instrument application is to restore containment spray to a standby status as soon as possible to minimize the effects of the spray on equipment inside containment, but not so early so as to unnecessary challenge to the actuation logic and actuate CSAS.

Loss of Coolant Accident Recovery Bases

Step Number 13 Protect the Main condenser

Intent

The intent of this step is to prevent overpressurizing the Main Condenser in the absence of condenser cooling water. This step also ensures that the operator has control of RCS cooldown rate and SG inventory.

Method

The operator closes the MSIVs to isolate the major main steam supply to the condenser and steam generator blowdown. Note that up-stream main steam traps and MSIV bypass valves may also be isolated on a plant specific bases as time permits. The substeps are bracketed to permit each plant to do what ever is necessary to prevent overpressurizing the main condenser.

Sequence

This step is located just prior to the RCS heat removal steps of the procedure. It may be located earlier, if necessary, on a plant specific bases.

Plant Parameters

None

Loss of Coolant Accident Recovery Bases

Step Number 14 LOCA Condition Isolated

Intent
The intent of this step is to direct the operator to the series of steps that address the LOCA Isolated condition.

Method
At this point in the guideline, the operator will pursue one of two strategy paths, LOCA isolated or LOCA NOT isolated. If the LOCA has not been isolated, the operator is directed to follow the path which contains recovery actions for the LOCA NOT isolated condition. If the leak or rupture has been isolated, the operator is directed to perform the LOCA Isolated steps aimed at stabilizing the plant.

Sequence
This step is placed after the major mitigating actions are taken and the operator is ready to begin taking actions to prepare the plant for longer term stability, such as plant cooldown and entry to shutdown cooling.

Plant Parameters
None

Step Number 15 Cooldown Steam Generators

Intent

The intent of this step is to ensure steam generators are available for RCS heat removal. If steam generators are cooled below RCS temperature, then the RCS will “see” the steam generator as a heat sink. Steam generators can provide RCS heat removal indefinitely as long as sufficient feedwater is supplied and a controllable steam release path is available. In addition, as the RCS is cooled and depressurized to SDC entry conditions, SDC may be used for long term heat removal.

During a large break LOCA, break flow cools the core. Steam Generators are decoupled from the rest of the RCS and are not the primary means of core heat removal. ECCS in-flow down the vessel wall and flow out the break is the dominant cooling mechanism. The operator has little control over reactor vessel cooldown rate because of uncontrolled cooldown and the impact of SI flow on indicated Tcold. The operator may be prompted to stop steaming the steam generators because of large uncoltrolled cooldown. However, it is still important to remove stored energy from the SGs for the reasons described above. Recall that in a LBLOCA the SGs are uncoupled from the RCS. During a small or medium size LOCA, SG heat removal is also important to lower Pressurizer pressure to ensure that the HPSI pumps are able to inject into the RCS. If a smaller break size holds Pressurizer pressure above HPSI shutoff head, it is important to maintain RCS heat removal via the steam generators, and to maintain forced circulation, if possible, using the RCP trip two / leave two strategy.

A conflict may arise for the operator in implementing the SG cooldown strategy. The initial uncontrolled cooldown of the reactor vessel is beyond his control. The influence of cool SI flow on cold leg RTDs is beyond his control. Compliance with TS RCS cooldown rates is not possible until the system stabilizes. SG cooldown can be controlled by the operator. PTS is not a concern as long as the RCS is not allowed to rapidly repressurize. Reactor vessel wall delta-temperature stresses will dissipate with time. Then a controlled cooldown within the TS limits can be initiated. A ‘controlled’ cooldown implies that the operator is in control of the cooldown, i.e., that the cooldown is within the designed reset capabilities of MSIS and SIAS, or that the operator has the ability to stop or maintain a given pressure and temperature band.

A plant cooldown will change the reactivity conditions in the reactor core. Therefore, whenever a cooldown is performed the crew must consider the effects of the cooldown on reactivity control and take appropriate actions to maintain the [reactor shutdown]. This may include borating and sampling the RCS, both, prior to and during the cooldown. This step assumes that emergency boration will be in progress due to SIAS and therefore no direction is given to commence boration.

Method

Two methods are provided for accomplishing this task; the turbine bypass valves, and the atmospheric dump valves. If the main condenser is available, the turbine bypass valves is the preferred method. Use of the turbine bypass valves conserves secondary inventory and provides for greater control over possible releases from the steam generators to the atmosphere. However, if systems are not available to support this method, or for some other reason it is not desired, then the Atmospheric dump valves may be used.

Sequence

For events in which reducing the energy from the RCS, in particular from the steam generators, is a high priority, this action would be placed early in the sequence of events. Reducing the energy in the RCS helps minimize the loss of inventory associated with either a primary or secondary system break. It supports re-coupling the SGs with the RCS and depressurizing the RCS to SDC entry conditions. However, the replenishment of RCS inventory is normally of higher importance therefore this step would normally follow those steps.

Plant Parameters

None

Step Number 16 Depressurize RCS to SDC Entry Conditions

Intent

The intent of this step is to provide direction to depressurize the RCS to Shutdown Cooling entry conditions.

Method

For small break LOCAs, especially where RCS inventory and pressure are controlled, a deliberate depressurization of the RCS will be necessary to permit entry into shutdown cooling. This step directs a depressurization to [SDC entry pressure] and [SDC temperature]. It provides the available depressurization success paths, depending on existing plant conditions. For large breaks, all that may be required to depressurize to or below [SDC entry pressure] is throttling of SI flow (if SI termination criteria are met), or action may not be necessary at all.

a. If available, main or auxiliary pressurizer sprays may be used to depressurize the RCS.

b. If HPSI throttle/stop criteria are met, charging pumps may be stopped as necessary to aid in depressurization. Charging pumps are operated to provide inventory throughout the cooldown as well as to provide auxiliary spray as needed. Letdown should not be required during a cooldown, but may be used to aid in inventory control, and thus RCS depressurization provided HPSI throttle/stop criteria are satisfied.

c. If the HPSI pumps are in service, they may be throttled one at a time, if the stop/throttle criteria are satisfied.

Sequence

This step is sequenced after the immediate actions to control inventory and isolate the leak have been completed. It is important to reduce RCS pressure to limit the loss of inventory from the primary system.

Plant Parameters

Pressurizer pressure less than the Shutdown Cooling entry pressure

The upper engineering limit is based on the shutdown cooling system design pressure. The shutdown cooling system may be placed in operation when the RCS has been depressurized to the point that the shutdown cooling system will not be exposed to pressures greater than its design pressure. The operational limit, nominally [300 psia] (including the instrument uncertainties) should be less than the setpoint of the permissive interlock which prevents opening of the shutdown cooling suction line isolation valves.

RCS hot leg temperature less than the Shutdown Cooling entry temperature]

The upper engineering limit is based on the design temperature of the shutdown cooling system components, nominally [300]°F. The shutdown cooling system may be placed in operation when hot leg temperature is less than [300]°F.

Step Number 17 Bypassing automatic MSIS and SIAS Initiation

Intent

The intent of this step is to ensure that MSIS and SIAS do not actuate unnecessarily and complicate the event.

Method

During a controlled cooldown and depressurization, automatic operation of MSIS and SIAS is not wanted when it is not needed. Therefore, SIAS (low PZR Pressure) and MSIS (low SG Pressure) must be [blocked, bypassed, or lowered], if they have not actuated automatically, as the cooldown proceeds to ensure that automatic actuation does not occur unnecessarily. The preferred method for RCS cooldown is using the turbine bypass system, but an unnecessary MSIS would interrupt this flowpath and force the operator to either reset the MSIS or use the ADVs. An unnecessary SIAS would start both emergency diesel generators, [start emergency containment cooling], isolate letdown and commence emergency boration.

"CONTROLLED COOLDOWN: The operator is in control of the cooldown, i.e., the cooldown is within the designed reset capabilities of MSIS and SIAS, or the operator has the ability to stop or maintain a given pressure and temperature band."

Sequence

This step is sequenced after the directions to commence a cooldown.

Plant Parameters

None

Step Number 18 HPSI Throttle Criteria

Intent

The intent of this step is to establish the conditions that must be met before HPSI flow can be reduced following a SIAS actuation.

Method

After SIAS actuation, two full trains of SI must remain in operation at full flow, until all HPSI throttle criteria are met. For most LOCAs, the HPSI pumps will run continuously for a long period of time while RCS inventory, pressure, and heat removal control are being regained. In some cases, control of these three safety functions is not regained during the accident (i.e., large break LOCA) and the HPSI pumps run for the duration of the event recovery. Throttling of HPSI is expected when the SIAS was spurious, the leak rate can be accommodated by HPSI and charging when RCS pressure lowers, or after the leak is isolated.

HPSI throttle criteria are as follows:

a. RCS subcooling is greater than the [minimum RCS subcooling] of the RCS P/T curve. T hot should be used to determine RCS subcooling if RCPs are operating. Representative CET temperature should be used if natural circulation is in progress. Because of the location of the CETs inside the ICI tubes, the CETs are exposed to a mixture of core exit fluid and core bypass fluid during forced circulation. Since the core bypass fluid is cooler than the core exit temperature, it is common that CET temperature reads somewhat less than the loop T hot RTD. When natural circulation is in progress the CETs provide the best indication of fluid conditions adjacent to the core. The CETs do not rely on loop flow (as do the RTDs) for detecting fluid conditions adjacent to the core. With no flow in the loops, the loop RTDs may not provide adequate indication of core fluid conditions.

   Establishing the [minimum required subcooling] ensures that the fluid surrounding the core is subcooled, and provides sufficient margin for reestablishing HPSI flow if the minimum value can not be maintained. Voids (e.g. saturated conditions) may exist in some parts of the RCS (e.g., reactor vessel head). In themselves, this is not a major problem, provided that the voids do not interfere with core heat removal.

b. Pressurizer level is greater than the [minimum level for inventory control] and not lowering. A pressurizer level greater than the [minimum level for inventory control] and not lowering, in conjunction with criterion (a), is an indication that RCS inventory control is established.

c. At least one steam generator is available for RCS heat removal. A steam generator is considered available for RCS heat removal if: 1) level is being maintained or restored to the [normal control band], 2) capable of being supplied with feedwater, and 3) is capable of being steamed. Feedflow may be provided by main or auxiliary feedwater. Steaming capability includes controlled steaming by: 1. turbine bypass valves, 2. atmospheric dump valves, 3. main steam safety valves.

   (continue)

(continued)

The steam generator must be available to remove heat because the HPSI will no longer be adequate to remove decay heat from the core. Now the RCS must perform that function and there must be a means of removing heat from the RCS.

d. Reactor vessel level is greater than the [top of the hot leg nozzles] using RVLMS. This provides an extra margin of core coverage, taken in conjunction with the above criterion, and serves as an additional indication that adequate RCS inventory control has been established].

The operator should realize that when HPSI is throttled, the core and RCS are going to heat up until the steam generator heat removal (RCS heat removal) can be increased by the operator. Depending upon how long the adjustment takes, the RCS fluid could expand appreciably, thereby further complicating the event recovery.

If all of the HPSI throttle criteria are met, then the operator may either throttle the HPSI injection valves or stop the HPSI pumps as necessary, provided the previously stated criteria remain met.

Sequence

This step is sequenced commensurate with the expected condition of the Inventory Control and Pressure Control Safety Functions. For example, in the LOCA ORG the step is sequenced early in the section associated with actions to be taken after the LOCA is isolated. In SGTR it is positioned after the steps which address isolating the affected steam generator and controlling the level which are of a higher priority for this event.

Plant Parameters

RCS subcooling is greater than the [minimum RCS subcooling]

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

(continue)

Pressurizer level greater than the [minimum level for inventory control]

The lower engineering limit corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The lower operational limit, nominally [35"], is approximately ([10%]) of a typical Combustion Engineering Pressurizer's range, and was chosen as the lower limit to account for some instrument and process fluid uncertainties. The lower limit is based on the lowest indication, approximately [2%] that with confidence reflects an actual Pressurizer level. Instrument uncertainties, assumed to be ± 8%, were conservatively applied to the engineering limit, yielding the lower operational limit of [10%].

Steam Generator level within the [normal control band]

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that, 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

Step Number 19 HPSI Pump Restart Criteria

Intent

The intent of this step is to ensure that all available trains of HPSI are restored to operation if any of the HPSI throttle criteria can not be met.

Method

After the HPSI throttle/stop criteria are met and HPSI is throttled or the HPSI pumps are stopped, the operator must monitor RCS inventory and pressure control. If any of the throttle/stop criteria cannot be maintained, the operator must raise HPSI flow and/or start HPSI pumps as necessary to regain the safety functions and once again meet the HPSI throttle/.stop criteria. It should be noted that this approach differs from the one that used to require full SI flow to be e-established. Industry operating experience has shown that blindly re-establishing full SI flow is unnecessary and can further complicate event recovery. Therefore, that method of re-establishing HPSI flow is no longer used.

Sequence

This step is sequenced immediately after the HPSI throttle criteria.

Plant Parameters

None

Step Number 20 LPSI Pump Stop Criteria

Intent

The intent of this step is to prevent damaging the LPSI pumps as a result of extended operation without adequate flow through the pump.

Method

If the RCS pressure is greater than the shutoff head, the pumps will not deliver any flow to the RCS. Therefore, they should be secured. In order to minimize the time of operation at shutoff head, they should be stopped if the pressurizer pressure rises to greater than [LPSI pump shutoff head] and is controlled. The pump is secured first, followed by closing the injection valves. This sequence is intended to minimize the time of operation with no flow. The LPSI injection valves are closed to prevent unintentionally cross-connecting the HPSI system to the LPSI system in the event of a leaking check valve in a LPSI pump discharge line.

Sequence

This step is sequenced after the HPSI pump termination criteria. It is sequenced early in the procedure but after immediate actions are taken to respond to the event.

Plant Parameters

Pressurizer pressure greater than the LPSI pump shutoff head

The engineering limit is the shutoff head of the LPSI pump, nominally [200 psia]

Step Number 21 LPSI Pump Restart Criteria

Intent

The intent of this step is to ensure that two complete trains of LPSI are restored to operation if any LPSI stop criteria can not be met.

Method

Once the LPSI pumps have been stopped and the injection valves have been closed, if the LPSI stop criteria cannot be maintained, the LPSI injection valves must be opened and the LPSI pumps must be restarted to ensure that adequate inventory and pressure control are maintained. The intent is to have one LPSI pump operating in each train with both cold leg injection valves fully open (not throttled). Once inventory control has been regained, and the LPSI stop criteria met, then LPSI pumps may be once again stopped.

This does not apply to the situation where pressurizer pressure has purposefully been reduced to less than [LPSI pump shutoff head] in a controlled manner to get the plant to SDC conditions. This does not apply when pressurizer pressure is less than [LPSI pump shutoff head] and the LPSI pumps were secured in response to RAS initiation.

Sequence

This step is sequenced immediately after the LPSI Stop criteria.

Plant Parameters
None

Loss of Coolant Accident Recovery Bases

Step Number 21A Line up for RWT Refill or Alternate RCS Injection

Intent

The intent of this step is to initiate early action to line up to refill the RWT or lineup alternate sources for RCS injection bypassing the RWT. This is a preemptive/precautionary move to take reasonable prerequisite actions that would better position the plant to initiate RWT refill after RAS or alternate RCS injection if sump recirculation capability should subsequently be lost (Reference 48).

Possible sources of borated water for RWT refill or alternate RCS injection include:

- Normal make up water via plant specific chemical addition system,
- Reprocessed reactor coolant via plant specific liquid waste processing and recovery system,
- Spent Fuel Pool,
- Adjacent unit RWT,
- Other plant specific sources

The specific prerequisites selected for inclusion in this instruction are plant specific. Detailed guidance should be preplanned and available in an appropriate plant procedure or guideline. Prerequisites may include such things as: reviewing preplanned guidance, activating necessary support from other organizations (Chemistry, Maintenance, Health Physics, and Security etc.), sampling, removing flanges or installing other mechanical modifications, staging temporary pumps and hoses, staging and mixing solutions of borated water, flushing lines, starting a valve line-up, etc.

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action in their EOPs if it is determined to be risk beneficial with respect to containment sump blockage.]

Method

a. Initiate actions to make up to the RWT or,
b. Initiate actions to lineup to inject directly to the RCS bypassing the RWT.

Sequence

This is a floating step. For concerns associated with sump blockage, starting RWT refill as early as possible after RAS produces the greatest benefit. Therefore, refill prerequisites and line up should be started as soon as circumstances allow and resources are available because they may take considerable time. During a large break LOCA RAS could occur within 20 to 30 minutes.

Plant Parameters

None

Loss of Coolant Accident Recovery Bases

Step Number 22 Restore Letdown

Intent

The intent of this step is to restore letdown so that it is available to support a cooldown, if necessary.

Method

Letdown is needed to support inventory/pressure control, especially when the RCS is water-solid. Therefore, if needed or desired, it should be restored as soon as possible. To do so, may require SIAS & CIAS to be blocked and reset. Plant specific administrative procedures must be followed when blocking and resetting these signals. However, if it can not be restored at the time or it may take considerable time to get letdown back, then the operator may restore letdown anytime conditions permit and when assistance is available.

If letdown is isolated and all of the following conditions exist, then the operator should attempt to restore letdown:

1) HPSI stop/throttle criteria are met, RCS inventory must be conserved. Any deliberate action to remove inventory from the RCS is not allowed if control of RCS inventory has not been achieved.
2) If it is needed or desired as deemed by [operations supervisor]. The operator should not attempt to restore letdown if the LOCA has been isolated and placing letdown in service will result in an uncontrolled loss of RCS inventory.

If letdown is not be needed for inventory control (i.e. facilitate maintain pressurizer level), it may be desired for other evolution's such as RCS chemistry control. If there is no current need or desire for letdown, then it does not have to be restored at this point.

RCS activity may be higher than normal due to the event in progress. Restoring letdown could create unacceptable radiological consequences in adjacent areas outside containment that may complicate access to the affected areas.

Sequence`

This step is sequenced after the major mitigation steps.

Plant Parameters

None

Step Number 23 Maintain Pressurizer Level

Intent

The intent of this step is to ensure that the Inventory Control Safety Function is being adequately addressed.

Method

If HPSI throttle/stop criteria are not met by the time this step is reached in the procedure, as would be the case in a large break LOCA and certain size small break LOCAs, all available charging and SI flow must be directed to the RCS . Once HPSI has restored pressurizer level to greater than the minimum valid indicated level, then the operator ensures that the charging pumps and letdown are maintaining pressurizer level within the [expected post-trip band]. If the HPSI throttle criteria are met, then HPSI pumps may be throttled or stopped as necessary to maintain level within the [expected post-trip band].

It may be necessary to exceed the upper pressurizer level if the operator is attempting to restore RCS subcooling as indicated in the safety injection termination criteria since pressurizer heaters may be unavailable and water-solid operation may be necessary to restore subcooling.

Sequence

This step is located after the event is under control to establish RCS inventory control prior to cooldown.

Plant Parameters

Pressurizer level within the [expected post-trip band]

The upper engineering limit is based on engineering judgment to: 1) avoid water-solid conditions, 2) provide sufficient steam space to ensure pressure control using sprays, and 3) bound the highest pressurizer levels observed in best estimate analysis. The lower engineering limit is nominally [2%]. The lower operational limit, nominally [35"] corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The upper operational limit, nominally [245"] corresponds to the highest level judged to provide sufficient steam space to ensure pressure control using Pressurizer sprays without immediately bringing the plant to a water-solid condition. In the EPGs, the RCS is not considered water-solid if there is evidence of a steam void anywhere in the RCS, i.e. in the pressurizer, the reactor vessel head, or in the steam generator tubes. Pressurizer level between [35" to 245"] defines an acceptable transient control band following a reactor trip. Ultimately, level should be restored to the normal control band. Level in the transient band is indicative of RCS inventory control via a saturated bubble in the Pressurizer. It provides the operator with information to support the continued operability of the Pressurizer.

Step Number 24 Maintain RCS within Post Accident PT Curve Limits

Intent

The intent of this step is to direct the operator to maintain the RCS within the limits of the post accident PT curve.

Method

Maintaining RCS conditions within the acceptable limits of the post accident PT curve ensures that: 1) the [post accident cooldown rate] is not exceed; 2) that the core is covered by subcooled fluid; and 3) minimizes the concern for pressurized thermal shock by staying within the [post accident upper subcooled limit]. This is accomplished by controlling pressurizer heaters, main or auxiliary spray, charging and letdown, and HPSI flow (if HPSI throttle/stop criteria are met).

If subcooling or cooldown rate limits are not within the post accident PT curve, then the operators should take actions to restore the RCS to within the PT limits. The contingency actions provide typical solutions for out-of-limit PT conditions. Depending on the situation, the operator should perform any of the given actions appropriate to the problem. Out-of-limit conditions and the appropriate operator response should be address in operator training.

If the RCS is oversubcooled, the operator is directed to take the following actions to alleviate the problem:

- Stop the cooldown. The operator will stop the cooldown to stop the temperature decrease from increasing subcooling.
- Depressurize the RCS. The operator will use main or auxiliary spray to reduce pressure, thereby reducing RCS subcooling.
- If HPSI throttle/stop criteria are met, control charging, letdown, and HPSI. If HPSI throttle/stop criteria are met, the operator will increase letdown (if available), stop charging as necessary and throttle/stop HPSI to reduce inventory and pressure and help reduce subcooling. However, the operator must maintain the plant within the HPSI throttle/stop criteria or re-initiate HPSI flow.
- If in the process of the RCS becoming oversubcooled, the RCS has exceeded its cooldown rate limit, the operator must stop the cooldown and maintain the plant in a stable pressure and temperature configuration (soak) until the cooldown rate is once again within limits. Once the RCS cooldown rate is back within its limits the cooldown can resume.

(continue)

PT curve background

Due to variations in reactor vessel design, thermal transient history, and neutron fluence, [Post Accident PT curves] should be developed on a plant specific basis. These curves should address the following items:

1) The plant conditions or transients that invoke the applicability of these curves, i.e. when do the curves become the controlling document regarding the limits of the PT operating point and cooldown rate? Traditionally this has been an initial transient cooldown that results in lowering Tc to less than 500°F, but this may need adjustment depending on a particular plant's reactor vessel history.

2) The specific plant indications that should be used to locate the operating point within the curves. These indications should be identified for a variety of likely RCS flow and inventory conditions, for example: full forced flow, single phase natural circulation, and two phase natural circulation.

3) The applicable cooldown rates, how the cooldown rate should be measured, and any soak requirements.

4) Minimum and maximum subcooling limits.

5) RCP NPSH operating space for various pump configurations.

6) Shutdown cooling entry conditions and operating limits.

7) Any Low Temperature Over Pressure (LTOP) considerations that may apply.

Sequence

This step is continuously applicable to enforce the limits of the post accident PT curve throughout execution of the EPG.

Plant Parameters

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

Step Number 25 Ensure SG Level is being restored to normal control band

Intent

The intent is to ensure an adequate RCS heat sink is available via a SG since some LOCAs with small break flow still require a SG heat sink. The instruction states that at least one SG level should be restore to and maintained within the [normal control band] with main or auxiliary feedwater. This level provides adequate heat removal capability under forced flow and natural circulation conditions. The reason the step specifies level being restored by 'main or auxiliary feedwater" is because sometimes level can rise due to a heatup of the steam generator or due to steam generator swell. This step requires the operator to verify that main or aux feedwater is flowing to the steam generator(s) to restore level and that the level rise is not from another heatup or swell.

In general, it is desirable to restore SG level to the normal band. During a LOCA it is assumed that the operator will not encounter problems restoring SG level. But during large break LOCA conditions and certain size small break LOCAs, immediate and aggressive recovery of SG level to the [normal control band] may exacerbate an already rapid cooldown rate due to SI flow into the RCS. Therefore, the operator should be aware of the potential for overcooling due to excessive feed to the steam generators. Due to the low probability of the large break LOCA occurring and considering the generic EPG strategy that does not require the operator to distinguish between break sizes, feeding up the steam generators under these conditions is a worth risk. Therefore, the operator is directed to feed up steam generators even if a large break LOCA or a large small break LOCA has occurred and the cooldown rate is being exacerbated. However, the operator should limit the feedwater flowrate under these conditions to just what is necessary to refill the steam generators.

Method

At least one steam generator level is restored to and maintained in the [normal control band] using main or auxiliary feedwater.

Sequence

This step is sequenced early in the procedure, after the initial mitigation. It is important to the RCS Heat removal safety functions.

Plant Parameters

Steam Generator level within the [normal control band]

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Loss of Coolant Accident Recovery Bases

Step Number 26 Ensure Adequate Condensate Inventory

Intent

The intent of this step is to determine if there is sufficient condensate inventory available to maintain hot standby within technical specification allowable time limitations, if it is necessary to re-fill the CST, or if a cooldown to SDC conditions must be initiated.

Method

The available condensate inventory should be continually monitored, and replenished from available sources as necessary to provide a source for a secondary heat sink. Examples of alternate sources of condensate are non-seismic tanks, fire mains, lake water supplies, portable tanks, etc. Alternate sources of feedwater may be identified and cited in the procedure as considered necessary. The amount of condensate required to either maintain the plant at hot standby conditions or during a cooldown may be determined from plant specific figures.

The step refers to two figures which can be used to determine the amount of condensate required based on the existing temperature and the time after shutdown. The existing temperature provides for determining the inventory required based on the sensible heat that must be removed. The time after shutdown provides a basis for determining the inventory required based on the decay heat remaining in the plant assuming that the event occurred from a stable full power configuration. Each of the figures should assume a nominal leakage from the systems based on plant experience.

Additional allowances should be included to accommodate the time required to actually transition to forced cooling by the SDC system.

Sequence

This step is sequenced early enough in the guideline to ensure sufficient time for actions which may be necessary to replenish the inventory from normal or alternate sources.

Plant Parameters

None

Step Number 27 Void Elimination

Intent

The intent of this step is to eliminate voids in the RCS that may prevent lowering RCS pressure to SDC entry conditions.

Method

The operator should continuously monitor for the presence of voids in the reactor coolant system. If voiding is suspected, then the operator should proceed as follows:

The operator is directed to: Ensure minimum letdown, or letdown is isolated. If voiding is occurring, the continued net loss of inventory from the RCS may make the situation worst. If desired, letdown may be throttled to a minimum flow value instead of securing it completely, provided charging is maintained to ensure a net gain in RCS inventory while performing the void elimination procedure. Throttling verses securing may be preferred if a plant is concerned about thermal shocking letdown components such as the heat exchangers.

The operator is directed to stop attempting to depressurize the RCS. Depressurization activities will only make the situation worst by enlarging the void.

There are two primary methods which have been demonstrated successful for eliminating voiding in the RCS. They are: 1) cycling RCS pressure, and 2) operating the RV vent valves. One alternate method is available which is specifically directed at eliminating voiding in steam generator tubing.

Pressurizing and depressurizing the RCS within the limits [Post Accident PT limits] may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In the case of a void in the reactor vessel, the pressurization/ depressurization cycle will produce a fill and drain of the reactor vessel to help eliminate the void. Operation of the RV vent valves may also be used to reduce or eliminate a void in the head. The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) and the SIS/charging system (alternative method).

If indications of RCS voiding continue, and voiding is suspected to exist in the steam generator tubes, then actions to cool the steam generator and eliminate the voiding can be performed. This determination can be made by observing if saturated temperature in the steam generator is greater than RCS temperature. The suspected steam generator can then be cooled by performing any combination of the following : 1) blow down to lower steam generator level below the top of the tube bundle, 2) feed to add cool water and restore level, 3) steam to the condenser or to the atmosphere.

Monitor Pressurizer Level and the RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

Continue void elimination procedures until either the voiding is eliminated or the attempts have proved unsuccessful.

(continue)

Sequence

This step should be located soon after commencing plant cooldown.

Plant Parameters

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

Step Number 28 Restore Offsite Power

Intent

The intent of this step is to restore offsite power as conditions and resources permit.

Method

The method for restoration of offsite power are plant specific. This action is necessary to re-energize vital and non-vital equipment and restore the plant to a normal configuration. This step has been placed the procedure at a location where it is expected that control of the plant has most likely been re-gained. The operator will begin to concentrate on restoring the plant to a more normal configuration. As part of these efforts the operator will need to restore any vital and non-vital buses that may have been lost due to the loss of offsite power. This will aid in event recovery and help to ensure a smother transition out of the EPGs.

Sequence

This step is sequenced after the major mitigation steps.

Plant Parameters

None

Step Number 29 Verify Single Phase Natural Circulation

Intent

The intent of this step is to verify natural circulation flow is established and is supporting RCS heat removal. After RCPs are tripped, natural circulation RCS flow should develop within 5-15 minutes (longer if the plant tripped from a low power level). Natural circulation flow will continue as long as RCS pressure and inventory control are maintained, and at least one steam generator is available for RCS heat removal.

Method

Natural circulation flow is determined by a combination of factors. The factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. These density differences occur when primary to secondary heat removal through the steam generator tubes is utilized. Figure [10-7] illustrates that a reactor vessel upper head void and natural circulation flow can occur at the same time.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

1. Loop delta T less than [normal full power delta T]. This ensures by plant design that the Power/Flow ratio remains less than 1.0. A Power/flow ratio of less than 1.0 ensures that heat can be removed from the RCS during the establishment of natural circulation. Initially, T hot may increase causing the lop delta to rise, but once natural circulation is established the loop delta T will drop.

   During the initial development of the natural circulation acceptance criteria there was no maximum delta-T criterion. Operators would observe T hot rising fairly rapidly and would interpret this as being a failure of natural circulation to develop. They would increase the steam generator feeding and steaming rate in an attempt to establish natural circulation. Unfortunately, this would only exacerbate the problem because T hot would have to increase more to cause enough of a density difference to start full-flow natural circulation. Therefore, it was determined that when both steam generators were available, if the operator did nothing but ensure normal steaming and feeding, the core delta-T never exceeded the full-power delta-T. In addition, with both steam generators available, it was determined that if the full-power delta-T was exceeded, natural circulation flow would be inadequate. Therefore, it was decided that full-power delta-T should be added as a maximum limit for the plant to stay within for adequate single phase natural circulation.

   (continue)

(continued)

It should be noted, however, that at the start of natural circulation or even during a natural circulation cooldown, If an asymmetric steam generator plant cooldown is initiated, the full-power delta-T value may be briefly exceeded. This is acceptable as long as the least affected steam generator remains operable. Eventually the delta-T will fall below the full-power delta-T limit and this acceptance criterion will be passed.

2. Hot and cold leg temperature constant or dropping. This is direct feedback to the operator as to how RCS heat removal is progressing. Initially T hot will increase but as natural circulation is established T hot turn and both T hot and T cold will be decrease until the point at which they become constant.

3. RCS is greater than or equal to the [minimum RCS subcooling] based on CET temperature. Adequate subcooling ensures that an adequate amount of fluid in its desired status is available to remove decay heat. During natural circulation CET subcooling should be used to determine if adequate subcooling exist. The CETs do not rely on loop flow (as do the RTDs) for detecting fluid conditions adjacent to the core any would therefore be the most accurate indication of core temperature.

4. No abnormal difference between T hot RTDs and CET temperature. Hot leg RTD temperatures should be consistent with the [representative CETs]. The intent is to observe that *same temperature* fluid is moving from the core to the hot leg. Therefore, adequate natural circulation flow is indicated by the [representative CET] temperature being approximately equal to the hot leg RTD temperatures. An abnormal difference between Th and [representative CET] could be any difference greater than [10°F], and would indicate possible blockage in the RCS loop or uncoupling on the core and the loops.

If the RCS does not indicate natural circulation is in progress, operators should ensure that the systems and safety functions needed to support natural circulation are available and functioning properly. Specifically, the operator should ensure that RCS heat removal is available via a SG, and that heat removal is being controlled by steam generator feeding and steaming.

<u>Sequence</u>

This step is usually put after the evaluation of restarting RCPs, after the initial event mitigation steps are initiated. Or, may be used whenever the need to ensure proper natural circulation flow occurs.

(continue)

(continued)

Plant Parameters

RCS Loop delta T less than normal full power delta T

The engineering limit is based on the normal full power delta T. The intent of the engineering limit is to provide a value that enables the operators to assess the status of single phase liquid natural circulation flow in at least one RCS loop. Under single phase natural circulation flow, the operating loop delta-T should be less than the normal full power delta-T. A loop delta-T less than the full power delta-T ensures that the [power/flow] ratio is within the nominal thermal hydraulic parameters for the RCS (i.e., the power to flow ratio is less than that for full power operation).

RCS subcooling is greater than the [minimum RCS subcooling]

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

No abnormal difference between Thot RTDs and representative CET temperature

The engineering limit is based on engineering judgment. The operational value is nominally [+/-10 °F]. The intent of the engineering limit is to provide an approximate operational value that can be used, in conjunction with other indications, to assess the status of single phase liquid natural circulation flow in at least one RCS loop. Under single phase natural circulation flow, core exit thermocouple temperatures should be consistent with the operating loop hot leg temperature. Approximate agreement between hot leg temperature and CET is corroborative evidence that there is fluid communication (flow) between the core and at least one hot leg.

Step Number 30 Ensure Heat Removal Under Two Phase Natural Circulation

Intent

The intent of this step is to monitor the effectiveness of core heat removal during two phase natural circulation cooling. Under two phase natural circulation the operational imperatives are to: 1) use every available means to fill the RCS and restore single phase (liquid) natural circulation; 2) to ensure an effective heat sink is available to the RCS; and 3) monitor core exit temperatures to determine the effectiveness of core heat removal.

During a LOCA, the natural circulation process can take different forms. These forms include single phase natural circulation and a more complex two phase natural circulation. The simplest form of natural circulation is a single phase liquid convective cooling. Single phase natural circulation is the most probable mode when RCS inventory control and pressure control maintain the RCS hot leg completely flooded and subcooled. Single phase natural circulation cooling removes core decay heat using the same flow path as forced circulation cooling. The motive force for single phase natural circulation is the liquid density difference between the warmer column of water from the core to the SG (Th), and the cooler column from the SG back to the reactor vessel.

Two phase natural circulation is more complex and can take several forms. The characteristics of two phase natural circulation depend on the amount of decay heat, the amount of inventory, pressure control degradation, RCS leak rate, the status of Safety Injection, and the operability of the steam generators.

One form of two phase natural circulation is known as reflux. The reflux process occurs with a partially voided hot leg: where steam leaves the core region, travels to the steam generator U-tubes, condenses, and the condensate flows back to the core via the hot leg where the cycle begins again. Another form of two phase natural circulation is similar to reflux, except the steam from the core goes over the top of the steam generator U-tube bend and is condensed on the cold leg side. In this mode the condensate flows back to the core via the cold leg. A combination of the two processes is also possible.

Method

RCS loop delta-T and loop temperature trend information can be used along with other corroborating parameters to confirm the effectiveness of single phase (liquid) natural circulation.

Because the two phase natural circulation processes is more complex, loop delta-T is not an indicator of effective natural circulation cooling. Therefore, in cases where two phase natural circulation cooling is the principal core heat removal process, other parameters and plant conditions must be used.

(continue)

(continued)

The following methods and bases meet the intent of this step:

Charging pumps operating and SI flow [within the SI delivery curves], ensure that a deliberate effort is being made to replenish RCS inventory. SI flow alone is acceptable to satisfy the intent of the step if no charging pumps are available and SI flow is in accordance with the SI flow delivery curve of Figure 13.13.

At least one steam generator is maintaining RCS heat removal with [minimum level for 1/3 tube coverage], ensures that an effective heat sink is available to the RCS. This includes heat removal via SG safety valves if necessary.

One-third tube area coverage is the minimum level, a higher level is preferred (100% tubes covered) during reflux boiling.

[Representative CET temperature is **NOT** superheated], ensures superheated conditions do not exist in the core region. Representative CET not superheated is the best available indication that the core is covered and that core heat removal is effective (ref. 9). If the core is uncovered, the CET would rise rapidly into the superheated region.

Sequence

This step is placed last in a series of steps regarding RCS flow and core cooling status. Since two phase natural circulation is one of the more complex, and least preferred, methods of core cooling, the steps preceding this step deal with RCP operation, RCP restart, and single phase (liquid) natural circulation. If the previous steps flow conditions do not apply, then guidance is provided for two phase natural circulation.

Plant Parameters

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

Steam Generator level greater than minimum level for heat removal

The engineering Limit: is the minimum steam generator level in at least one SG that will support RCS heat removal during forced flow or natural circulation conditions. The intent of this step is to ensure that an effective steam generator heat sink is available. One-third tube coverage is accepted as a conservative minimum level for RCS heat removal, although a lower SG level may be acceptable on a plant specific basis as long as there is supporting technical justifications.

(continue)

(continued)

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

Step Number 31 RCP Restart Criteria

Intent

The intent of this step is to ensure the RCS and the RCP(s) selected for restart are in the proper condition to support RCP restart and operation. This step is only applicable if RCP restart is desired.

In general, forced circulation is normally the preferred mode of core cooling because it provides more responsive control of RCS temperature and pressure. But the need for forced circulation operation must be weighed against any potential risks of RCP operation. Once RCPs have been stopped, restarting of RCPs should be considered a major plant evolution and given considerable thought before restart is attempted. In addition to the RCP restart criteria given in the instruction the following items should be considered when deciding whether RCP restart is desirable: 1) the effectiveness of RCS heat removal using natural circulation, and 2) the need for main pressurizer spray capability.

Under some LOCA events there is a span of time during which steam generated in the core is condensed in the steam generator tubes. The steam generated in the core is largely devoid of boric acid which remains dissolved in the highly borated liquid in the core. The condensate formed from this steam is also largely devoid of dissolved boric acid. This process, called reflux boiling, serves to transfer heat from the core to the steam generators when the primary side liquid level falls below the top of the steam generator tubes.

A core reactivity problem may occur if unborated condensate, which has accumulated in the cold leg side of the RCS, returns to the reactor core without sufficient mixing with the highly borated water in the RCS. Therefore, single phase natural circulation must have been established for the preceding 20 minutes in the loop selected for RCP restart to prevent unborated condensate from entering the core before mixing with the rest of the inventory in the RCS. Twenty minutes is considered a conservative nominal loop transient time for natural circulation flow (ref. 41).

Method

Verify single phase natural circulation has been established for the preceding 20 minutes in the loop selected for RCP restart.

Verify RCS pressure and temperature are within the [Post Accident PT curve] limits for RCP operation, REFER TO Figure 13.8. This substep is a check to see that RCS pressure and temperature conditions will support RCP restart. The [Post Accident PT curve] should include RCP operation curves that ensure RCP NPSH and reactor core subcooling requirements are within their limits. Minimum RCS subcooling should be based on [representative CET] temperature.

In addition, to checking the RCS [Post Accident PT curve], the operators should be aware that the pressurizer water and steam space may not have reached equilibrium saturation conditions if there was a large level change (rise) a short time ago. This may result in the pressurizer being much less able to mitigate the pressure effects of a significant outsurge.

(continue)

(continue)

Verify the duration of [CCW] interruption to RCPs is within limits for RCP restart, REFER TO [RCP technical manual]. This substep prompts the operator to check that any cooling interruption to RCPs is within limits that allow for RCP restart. Each plant should establish guidelines for RCP restart after cooling interruption. The guidelines should be based on RCP vendor information and other appropriate sources.

Verify RCP seal pressures and temperatures are within limits for RCP restart, REFER TO [RCP technical manual]. This substep prompts the operator to check that RCP seal conditions are within limits that allow for RCP restart. Each plant should have guidelines for limiting RCP seal conditions based on RCP vendor information and other appropriate sources.

Verify the following RCP auxiliaries are operating properly to support RCP operation: oil lift system, bearing and motor cooling systems. This substep is an additional reminder to specifically check that the RCP oil lift system, and bearing and motor cooling systems are operating properly. There should be no bearing and motor cooling systems high temperature alarms on the selected RCPs.

[Verify RCS conditions are within the RCP start limits of plant technical specifications]. Plant technical specification typically provide LCO requirements regarding RCP restart and: RCS and steam generator Delta T, pressurizer pressure, and pressurizer level. These limits and their bases should be reviewed for applicability prior to RCP restart.

Ensure that at least one steam generator is controlling RCS heat removal with level being maintained within [normal control band]. The basic intent of this substep is to ensure that an effective heat sink is available prior to starting an RCP. One-third tube coverage is generally considered adequate to remove decay heat either via natural circulation or forced flow conditions. However, to be consistent with general SG level recovery guidance used throughout the EPGs, the operator is instructed to ensure SG level is within the [normal control band]. It is recognized that SG level in the [normal control band] is more than the minimum required level for RCS heat removal.

Use of SG safeties is generally considered an acceptable method for RCS heat removal, although not a preferred method because of the loss of RCS temperature control and the inability to cooldown. Therefore, starting RCPs while on the SG safeties should only be done after a through review of the likely affects of RCP restart, and a determination that these affects are manageable within the context of current plant status. The intent here is to maximize the reasonable options available to the operator and allow RCP restart and operation while on SG safeties.

There are some predictable affects of transitioning from natural circulation to forced flow while on the SG safeties. From best estimate analysis it's assumed that post trip RCS heat removal via SG safeties is likely to be a cyclical evolution where the SG safety valve opens periodically removing heat and then shuts. The period of the cycling (the time between safety valve lifts) is determined by heat removal requirements. While heat removal from the RCS is through the SG safeties, RCS Tc will seek a temperature just slightly higher than the corresponding saturation temperature for the lowest SG safety valve lift pressure. Therefore, under natural circulation, with a much wider delta T than forced flow, there will be a higher overall effective RCS temperature than under forced flow conditions.

(continue)

(continued)

During the initial moments after starting a RCP, Tave will drop as the core delta T collapses with the subsequent change in pressurizer level. The additional heat input from the RCPs may raise the cycle rate of the SG safeties (lift, blowdown and close), but should not appreciably change the RCS temperature at which the SG safety lifts. These affects should be considered before starting an RCP while on the SG safety valves.

A pressurizer level [within the RCP restart level band] provides a minimum level to help mitigate the effects of RCS void collapse during RCP restart. And, a maximum level to keep a pressurizer steam space available for slight raise in RCS temperatures. Plant technical specifications typically address this topic and should be consulted when determining the plant specific RCP restart level band.

Ensure electrical power is available to the RCPs. This substep directs the operator to evaluate the availability and reliability of RCP power supplies, and to ensure their readiness to support RCP restart.

[RCP technical manual] is used generically to mean plant specific RCP technical information.

Sequence

This step should be placed just before actual RCP restart.

Plant Parameters

Pressurizer pressure within RCP NPSH limits

The engineering Limit is based on the reactor coolant pump suction pressure that meets or exceeds the minimum NPSH and pump seal pressure requirements. The engineering limit is intended on preserving RCP operability. Operation of the RCPs must be constrained to ensure that adequate net positive suction head (NPSH) is available to preclude pump cavitation and damage. The RCP seals also require a minimum suction pressure for reliable long-lived service. These pump suction pressure requirements are established by the pump vendor.

Steam Generator level within the normal control band

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

(continue)

(continued)

Pressurizer level in the restart level control band

Establishing pressurizer level within the required restart level band provides a minimum level, nominally [200"] to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. The upper engineering limit is based on TS RCP restart requirements which will ensure that there is still sufficient steam space to ensure pressure control using Pressurizer sprays, and preclude a large pressure surge in the RCS following restart. The lower engineering limit is based on keeping the pressurizer heaters covered to preserve normal means of RCS pressure control following RCP restart. The pressurizer heaters maintain RCS pressure to keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow.

Loss of Coolant Accident Recovery Bases

Step Number 32 RCP Start

Intent

The intent of this step is to take final actions in preparation for RCP restart, start the selected RCPs, and monitor plant response and RCP operation after RCP start.

Method

A pressurizer level [within the RCP restart level band] provides a minimum level to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. Plant technical specifications typically address this topic and should be consulted when determining the plant specific RCP restart level band.

Starting the first RCP in the 'operating loop' means to start the first RCP a loop with natural circulation flow, i.e., the loop being used for heat removal. This limits the potential of forcing relatively dilute reactor coolant, in a non-operating loop, directly into the core without the benefit of mixing during loop transit.

Starting one RCP in opposite loops provides forced circulation through the core, better cooling of the RV head region, the capability for the use of normal pressurizer spray, condenses RCS steam voids, and removes non-condensable gases from the SG tubes. Further, starting a RCP in each loop simplifies RCS temperature control and facilitates a plant cooldown. RCP operation should be limited to one reactor coolant pump in each loop to minimize heat input to the RCS (Reference 22).

Plant technical specification typically provide LCO requirements regarding RCP restart and: RCS and steam generator Delta T, pressurizer pressure, and pressurizer level. These limits and their bases should be reviewed for applicability prior to RCP restart.

Verify RCS pressure and temperature are within the [Post Accident PT curve] limits for RCP operation, REFER TO Figure 13.8. This substep is a check to see that RCS pressure and temperature conditions are responding favorably to RCP restart and will support continued operation of RCPs. The [Post Accident PT curve] should include RCP operation curves that ensure RCP NPSH and reactor core subcooling requirements are within their limits. Minimum RCS subcooling should be based on [representative CET] temperature.

In addition to the conditions stated above, plant specific RCP operating limits should be verified immediately after restart as well as closely monitoring RCP operation while they are in operation.

Operating charging and HPSI pumps until HPSI throttle criteria are met ensures that pressurizer heaters remain covered in the event of RCS void collapse after RCP restart.

(continue)

(continued)

If steam voids are present in the RCS during RCP restart, pressurizer level and pressure may lower due to steam void condensation. Depending on the void volume, there is a potential to drain the pressurizer. The operator should be mindful of this affect and immediately commence restoring pressurizer level using charging and HPSI pumps if void collapse is suspected. This issue should be addressed in operator training.

Sequence

This step should immediately follow the RCP restart criteria step.

Plant Parameters

Pressurizer level in the restart level control band

Establishing pressurizer level within the required restart level band provides a minimum level, nominally [200"] to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. The upper engineering limit is based on TS RCP restart requirements which will ensure that there is still sufficient steam space to ensure pressure control using Pressurizer sprays, and preclude a large pressure surge in the RCS following restart. The lower engineering limit is based on keeping the pressurizer heaters covered to preserve normal means of RCS pressure control following RCP restart. The pressurizer heaters maintain RCS pressure to keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow.

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

Step Number 33 Charging Pump Suction Sources

Intent

The intent of this step it to realign the charging pumps from a high concentration borated water source to a less concentrated source (not dilute pure water) to reduce the effects of boric acid precipitation in the core which may occur due to boil off during a large break LOCA.

For large breaks, the reactor vessel refills only to the elevation of the break. Borated water is injected into the reactor vessel via the charging and safety injection pumps and steam is boiled away. This may result in boric acid being concentrated in the reactor vessel. Switching suction of the charging pump to a dilute source helps limit the excessive buildup of boric acid in the reactor vessel while still allowing for sufficient long-term reactivity control.

The degree to which this step is applicable depends on the plant specific borated water source arrangement. Some plants may not have alternate sources with significantly different boron concentrations. Under no circumstances should this step be construed to imply the use of any borated water source that would compromise reactor shutdown status or the reactivity safety function.

Method

The degree to which this step is applicable depends on the plant specific borated water source arrangement. Some plants may not have alternate sources with significantly different boron concentrations. Under no circumstances should this step be construed to imply the use of any borated water source that would compromise reactor shutdown status or the reactivity safety function.

Sequence

Consideration of switching charging pump suction sources should be done after a SIAS and prior to hot-leg injection.

Plant Parameters

Align suction to the RWT or other suitable source within [1 hour]

One hour is based on engineering judgment. The intent is to limit the problem of boron precipitation in the core. One hour is approximately one-half the minimum time before hot-leg injection is required (hot-leg injection is nominally required 2-4 hr. after the event). Each plant should consult their plant specific boron precipitation calculations and determine what methods, if any, should be employed to mitigate the effects of boron precipitation post accident. The time frame basically depends on the quantity of borated water that has been transferred. Quantity depends on concentration and flow rate (number of charging pumps operating). Each plant should develop minimum and maximum times. Minimum is based on quantity necessary to achieve SDM. Maximum is based on avoiding boric acid participation in the core.

Loss of Coolant Accident Recovery Bases

Step Number 34 Ensure Adequate Suction for SI Pumps after RAS

Intent

The intent of this step is to verify that RWT water is exiting from the RCS rupture and ending up in the containment sump. This is necessary to ensure an adequate source of water when RAS initiates.

Method

If the LOCA is located inside containment, a lowering trend of RWT level should correspond to an rising trend of containment sump level. If a lowering trend in RWT level cannot be correlated to an rising containment sump level, then the LOCA is probably outside of containment.

The contingency actions direct the operator to verify that the LOCA is outside containment, initiate CIAS, initiate actions to start normal makeup and notify [plant management].

A LOCA outside of containment may result in insufficient water in the containment sump to support HPSI pump operation following a RAS. The operator should initiate actions to makeup to the RWT via the normal means. However, this method of makeup may be much slower that the drain down to the RCS. Therefore, depending on the size of the break, initiating normal makeup may prolong the time to RAS, provide additional time to isolate the leak and more time to [align an alternate source of makeup as directed by the Technical Support Center]. This event is outside the design bases of the plant.

If possible, for LOCAs outside containment, RWT level should be maintained above the [RAS setpoint] by replenishment from available sources. This will avert an undesirable RAS, which would align the HPSI pumps to a dry containment sump and cause air binding of the pumps.

Sequence

This step is located after the SIS pumps have been started, to remind the operator to continuously watch [RWT] levels, to ensure proper activation of RAS.

Plant Parameters

Refueling Water Storage Tank level less than the RAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for RAS, [nominally 10%]. The intent of the application is to prompt the operator to verify that RAS occurred automatically or to manually initiate RAS if it did not. The upper allowable value for this trip is set low enough to ensure RAS does not initiate before sufficient water is transferred to the containment sump. Premature recirculation could damage or disable the recirculation system if recirculation begins before the sump has enough water to prevent air entrainment in the suction. The lower allowable value is high enough to transfer suction to the containment sump prior to emptying the RWT and to prevent air entrainment during the transfer. Switchover from RWT to the Containment sump must occur before the RWT empties to prevent damage to the ECCS pumps and a loss of core cooling capability. For similar reasons, switchover must not occur before there is sufficient water in the Containment sump to support pump suction.

Step Number 35 RAS Initiation Criteria

Intent

The intent of this step is to ensure that RAS is initiated when required and that the associated equipment and systems function as designed.

Method

For breaks located inside containment, if the refueling water tank level lowers to [RAS setpoint], then the operator should perform the following:

a. The operator first verifies that RAS has automatically initiated. If it did not, then the operator should manually initiate RAS. Recirculation is actuated either automatically or manually in order to maintain a continuous flow of safety injection fluid to the RCS (required for inventory control) and a continuous flow of containment spray water (required for containment temperature and pressure control).

b. The operator then verifies that the LPSI pumps stop, since (by design) they are not required for RAS. If they do not stop, the operator should secure them.

c. The operator then verifies that the ESF pump suction valves from the containment sump are open. This will provide a suction flowpath for the operating ESF pumps. If the valves do not open automatically, then the operator should open them.

d. After verifying (a) through (e), the operator should close the RWT outlet valves one at a time. In addition, for events where high containment pressure is present, the check valves in the RWT outlet line may be forced shut and the RWT fluid will remain unavailable while the containment is pressurized.

e. The operator then ensures that the HPSI pump minimum recirculation flow valves are closed to prevent contaminated containment sump water from returning to the RWT.

[f. All charging pumps are [disabled] to prevent low suction pressure trip while charging pumps are taking suction on RWT post RAS. [disabled] in this context is the plant specific method to prevent use or auto-start of charging pumps after RAS. Generally, the term “pull-to-lock” conveys the intent, but plant specific terms should be used.]

[g. The auto-start function for all idle CS pumps and associated discharge valve should be disabled when RAS is initiated. The [CSAS] signal may have been reset and aligned for auto actuation prior to RAS. Post RAS, automatic actuation should be disabled. The purpose of this action is to prevent an unintended start of CS pumps that were intentionally secured earlier in the procedure. As a result of switching to containment sump recirculation, containment pressure may temporarily spike before settling out at a new equilibrium value. For plants with a relatively low CS actuation setpoint, the increase in containment pressure may be sufficient to re-actuate CS and start idle pumps (open discharge valve). This is undesirable because it goes against strategies to minimize flow through the sump screens after RAS and avoid equipment operations that would increase the potential for debris transport and accumulation on the sump screens.]

(continue)

(continued)

Sequence

This step is sequenced after the step to monitor the RWT level and is fairly late in the steps. Reaching the RAS setpoint should take some time and therefore this step should not have to be early in the sequence.

Plant Parameters

Refueling Water Storage Tank level less than the RAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for RAS, [nominally 10%]. The intent of the application is to prompt the operator to verify that RAS occurred automatically or to manually initiate RAS if it did not. The upper allowable value for this trip is set low enough to ensure RAS does not initiate before sufficient water is transferred to the containment sump. Premature recirculation could damage or disable the recirculation system if recirculation begins before the sump has enough water to prevent air entrainment in the suction. The lower allowable value is high enough to transfer suction to the containment sump prior to emptying the RWT and to prevent air entrainment during the transfer. Switchover from RWT to the Containment sump must occur before the RWT empties to prevent damage to the ECCS pumps and a loss of core cooling capability. For similar reasons, switchover must not occur before there is sufficient water in the Containment sump to support pump suction.

Step Number 36 Relocated to Step 12B per CR 5045.

Step Number 37 HPSI Pump Minimum Flow Criteria

Intent

The intent is to ensure that after RAS has actuated, sufficient flow is maintained through each high pressure safety pump such that damage to the pump does not occur (since the HPSI mini-flow recirc valves are closed after RAS).

After the switch to recirculation, the HPSI pump flows are monitored in order to ensure that HPSI pump minimum flow requirements per pump) for pump protection are met. One HPSI pump should be left operating at all times, unless the termination criteria are met. In addition, pumps may be restarted as necessary to meet other procedural requirements as long as the minimum flow criteria are met.

Method

The operator checks HPSI flow greater than the [minimum required HPSI pump flow] to be assured that HPSI pump minimum flow requirements are met. The exact method used to accomplish this is plant specific.

A check may also be made that HPSI pumps are not in a runout condition at this time. Pump discharge pressure and pump amp's are used for this indication.

The primary concern is hydraulic instability and damage to pump components including the pump seals as the result of heat buildup in low flow conditions. As the heating effects can be cumulative and are dependent on temperature, pressure and flow conditions, an exact time to failure is not possible. However, generally manufacturers will specify minimum flow rates for various lengths of time at which pump damage is not anticipated.

Another consideration is the accuracy of the instrument used to determine the total flow as well as individual pump flow. The minimum flow based on the accuracy of the instrumentation may be higher than required to actually preclude pump damage.

Sequence

This step is sequenced after the step for verifying recirculation actuation. It ensures that sufficient flow is maintained through the HPSI pumps after the recirculation minimum flow line is isolated. Pump damage is not expected to be imminent with flow less than the minimum required. That is, as noted above, damage is dependent on several variables in particular the time at the flow condition. Except in extremely low flow conditions and excluding air binding of a pump it can be assumed that low flow for up to two hours can be accommodated. These are general statements and specific manufacturers recommendations should be adhered to.

(continue)

Plant Parameters

Minimum required HPSI pump flowrate

The engineering limit is based on the minimum required flowrate through a HPSI pump that will avoid pump damage during continuous minimum flow operation, nominally [30 gpm]. The intent of the operational limit is to ensure that the HPSI pump is secured when the flowrate through the pump decreases to less than the minimum required for continuous minimum flow operation. This will ensure continued operability and availability of the HPSI pumps by avoiding over heating and subsequent pump damage.

Loss of Coolant Accident Recovery Bases

Step Number 37A Post RAS HPSI Stop Criteria

Intent

The intent of this step is to permit securing one HPSI pump following RAS if two HPSI trains are not needed for core heat removal. This action reduces the total ECCS flow through the containment sump screens in order to reduce debris buildup on the screens. It also establishes a protected train for use at a later time if needed. This instruction is applicable post RAS only. It does not replace or alter the standard HPSI stop/throttle criteria which are available before and after RAS.

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action in their EOPs if it is determined to be risk beneficial with respect to containment sump blockage.] (Reference 48)

Method

a. Verify both HPSI trains are in operation. It is assumed that they are operating normally and delivering design flow rate to the core as determined by the [SI flow delivery curves]. With both trains in service at this time after the trip, there may be more safety injection flow than is needed to cool the core. Therefore, it is likely that one HPSI pump may be secured. The adequacy of core heat removal is made by assessing core conditions, i.e. representative CET Temperature less than [superheat], and reactor vessel level greater than [bottom of the hot leg]. To ensure that there will be sufficient time for the operator to recognize and respond to a failure of the remaining operating pump, an additional criteria based on the time from shutdown is also included. The time requirement is based on the time for successful fifteen minute operator response which is a typical time needed to complete of a round of safety function status checks.

b. If these conditions are met, then one HPSI pump may be secured. The other pump is then monitored to ensure continued normal operation. If at any time, any of the termination criteria can not be maintained, the standby pump must be restarted or flow increased as necessary to ensure adequate core cooling is maintained.

c. Predetermine the optimal strategy for securing pumps. Select the preferred CS train (A or B) and the preferred HPSI train (A or B) to be secured first when the termination criteria are satisfied. Consider such factors as: pump power supplies, suction valve and piping configuration and sump design (split vs. common). An optimal configuration would include one CS pump and one HPSI pump with the same power supply, with a common suction line and common sump penetration or sump section. In this way the reliability of the standby pumps is enhanced.

Alternate Methods

Post-RAS, some plants require subcooled injection to the suction of the HPSI pumps to maintain sufficient NPSH and prevent cavitation. By design, the subcooled injection is provided by the containment spray pumps since containment spray is cooled via CCW in the spray/SDC HTX. The cumulative effect of running one HPSI pump and one containment spray pump post-RAS may increase the total flow through the containment sump screens.

(Continue)

(Continued)

For plants requiring containment spray flow injection to the HPSI pumps, the need for subcooled flow may be reduced if HPSI pump discharge flow is also reduced proportionately. This will reduce the overall flow through the sump screens. Therefore, some plants may find it more beneficial to throttle both HPSI pumps post-RAS versus securing one HPSI. This is an acceptable alternate method of reducing flow through containment sump screens if plant staff has determined an overall beneficial effect. However, if this method is use, consider the following:

1. One HPSI pump at design flow (not throttled) is within the design bases and flow loss out the break is considered in the safety analyses.
2. If HPSI is throttled, core conditions must be monitored closely since there is no way to determine the proportion of flow actually reaching the core.
3. If diesel failure occurs and the subsequent loss of one HPSI pump, operators must promptly adjust throttling flow to ensure sufficient core cooling with the remaining running HPSI pump.

Sequence

This step is sequenced after verifying that HPSI pump flow is greater than the minimum required to protect the pump. It is a continuously applicable step that may be used at any time that the relative criteria are satisfied.

Plant Parameters

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and to corroborate core covered or core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower indicating limit, RVLMS level indication, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to cover the core, support adequate core cooling, and prevent core damage.

Reactor Vessel level greater than the top of active fuel region

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the active fuel. However, the lowest sensor in the Reactor Vessel Level Monitoring System (RVLMS) is typically located just above the top of the fuel alignment plate. Nominal operating value is the lowest-reading sensor in the RVLMS.

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

(continue)

(continued)

Supplemental Information from an engineering evaluation performed on this strategy (Reference 48)

Advantages

In order for the operator to secure one train of HPSI after initiating sump recirculation it is assumed that two trains of HPSI are in operation at the time of RAS and running normally; in addition, other specific criteria are met. During large break LOCA, all of the standard HPSI stop/throttle criteria may not be met. Yet, it may still be preferable to stop one HPSI pump after RAS, if the plant-specific risk of containment sump blockage is significant. Since most plants only require one HPSI pump to meet licensing requirements, securing all but one HPSI pump after RAS still provides adequate core cooling consistent with the analytical bases. In addition, the normal HPSI Stop/Throttle criteria are still available to the operator prior to and after RAS.

Securing one HPSI pump reduces the total flow through the sump screens and thereby reduces the rate of debris transport to the screen surface and reduces the risk of blockage. The amount and size of debris collected at the containment sump screens is a function of screen size, the flow volume through the screens and the overall inflow to the containment sump. Greater volumetric flow is more likely to “sweep” debris to the containment sump screens and thereby increase the risk of blockage. The flow contribution of one HPSI pump is relatively small (less than 1/10) compared to containment spray pump. However, any flow reduction should reduce the risk of blockage.

PWR sump screens were typically designed assuming relatively small structural loads from the differential pressure associated with 50% debris blockage. Consequently, PWR sump screens may not be capable of accommodating the substantial structural loadings that may occur due to debris beds that cover the entire screen surface. Inadequate structural reinforcement of a sump screen may result in its deformation, damage, or failure, which could allow large quantities of debris to be ingested into the HPSI and Containment Spray System piping, pumps, and other components, potentially leading to clogging and failure. Reducing both the risk and rate of sump blockage lowers the risk of containment sump screen failure and potential failure of operating HPSI and Containment Spray pumps.

Securing one HPSI pump post RAS provides additional assurance that the secured pump will not be damaged due to debris ingestion or loss of NPSH, thereby preserving one operable HPSI pump for later use.

Some plants have separate sumps for each ECCS train. In this case securing flow from one train will preserve the other sump for use in the event that the in-service sump screens become blocked. In addition, operation of the single screen might reduce the amount of free debris available to block the other screen. Therefore, operating a single sump may extend recirculation capability, preserving the second sump screen by sacrificially clogging the first.

(continue)

Disadvantages

Stopping one (1) HPSI pump during recirculation mode may slightly increase the required NPSH for the remaining running HPSI pump due to the increase in flow through the running pump. During two pump operation all HPSI flow must pass through common loop headers into the cold leg. When one HPSI pump is stopped, the reduction in overall flow also reduces the line-loss to the cold leg and thus flow will increase slightly for the remaining running HPSI pump. This increase in flow will result in a slight increase in required NPSH. This should not present a problem since the required NPSH for one HPSI pump operation is already accounted for in system design.

Typical plant licensing bases show adequate core cooling with one HPSI pump after recirculation actuation. However, since deliberate manual securing of one HPSI pump is not considered a "failure," licensees may be required to show acceptable consequences with failure of the running HPSI pump after manually stopping one of two HPSI pumps. This would mean an interruption of HPSI flow until the operator could restart the previously secured HPSI pump. Since current licensing analysis does not account for an interruption in HPSI flow due to single failure, plant specific 10 CFR 50.59 evaluation may be required to determine the acceptability of securing one HPSI pump after recirculation actuation. Best estimate analyses have been performed to determine the time after trip when the decay heat level is low enough, such that, failure of "the one" running high pressure injection pump will result in approximately 15 minutes of reaction time before core temperature begins to rise. Fifteen minutes was selected so that loss of the one remaining high pressure injection pump will allow one Safety Function Status Check interval for the operator to recognize the loss of injection flow and take corrective action to restore core cooling. Best estimate analyses show that at 40 minutes after trip there is approximately 15 minutes of operator reaction time before core temperatures begin to rise.

Details of this analysis are contained in Reference 48, Appendix B. Since 40 minutes is an approximate value, each plant should complete a similar plant specific best estimate analysis.

By the time that the operator is expected to reach this step (up to 1 hour post-event), the injection flow required for decay heat removal may only be 200 – 300 gpm. This will make it difficult to balance the required flow between the four injection points (50 – 75 gpm each), because SI cold leg injection flow instrument uncertainties for a harsh environment may exceed this amount. This reality supports the strategy of stopping one pump, as opposed to the strategy of throttling flow to match decay heat.

Loss of Coolant Accident Recovery Bases

Step Number 37B Refill Refueling Water Storage Tank (RWT)

Intent

The intent of this step is to initiate action to start refilling the RWT as soon as possible after RAS. The possible sources of borated water available for RWT refill include:

- Normal make up water via plant specific chemical addition system,
- Reprocessed reactor coolant via plant specific liquid waste processing and recovery system,
- Spent Fuel Pool,
- Adjacent unit RWT,
- Other plant specific sources

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action in their EOPs if it is determined to be risk beneficial with respect to containment sump blockage.]

Method

Initiate plant specific actions to refill the RWT.

Sequence

This is a floating step. For concerns associated with sump blockage, starting RWT refill as early as possible after RAS produces the greatest benefit. Therefore, the refill prerequisites and line up should be started as soon as circumstances allow and resources are available because it may take considerable time.

Plant Parameters

None

Loss of Coolant Accident Recovery Bases

Step Number 37C Monitor for loss of ECCS pump suction

Intent

This instruction is applicable when ECCS pumps are operating in the sump recirculation mode (Reference 48). The overall objectives are to assist the operator in recognizing the onset of sump blockage, take immediate action to reduce recirculation flowrate, protect the operating HPSI pump and then transition to the FRG for contingency actions. It is assumed that the operator has previously secured unneeded CS pumps taking suction from the containment sump. It is expected that typically one CS and one HPSI pump will be operating taking a suction from the containment sump post RAS. The goal of the overall sump blockage strategy (LOCA and FRG) is to:

1. Monitor key parameters associated with containment sump blockage,
2. Identify symptoms indicative of degraded ECCS pump performance,
3. Implement a preemptive strategy to minimize the risk of a loss of core cooling
4. Provide compensatory actions to respond to a single pump failure,
5. Provide compensatory actions to restore core cooling in the event of loss of ECCS sump as a viable suction source.

Parameters that may be available and useful in monitoring for sump blockage:

1. *Containment wide range level indication
2. *Cold leg HPSI injection flowrate
3. *CS pump flowrate
4. *HPSI pump discharge pressure
5. *CS pump discharge pressure
6. HPSI and CS pump motor current
7. *[HPSI, LPSI and CS pump suction pressure]
8. *Containment narrow range pressure
9. [other plant specific indications]

*To the greatest extent possible, uses existing alarms, SSPDS and the plant computer to trend key parameters and alert operators to deviations from the nominal post RAS base line. From a human performance standpoint, it is not realistic to expect the operator to monitor these indications closely over the period of several hours without aids such as trending or alarms. They need some automated tool to give them a “poke” when conditions start to deviate from the norm. An example of an existing alarm at some plants that may be useful is the SDC pump discharge pressure alarm. It will come in as suction pressure decreases. When the pump is secured this sensor indicates pump suction pressure, which is suction pressure to the operating HPSI pump. The potentially useful alarms will differ from plant to plant.

Expected trends and possible anomalies

Normal Trend:

Once in service, a baseline ‘normal’ trend for each pump should be established. Assuming no changes in system configuration, expect all parameters to be similarly affected by changes in containment pressure and sump water temperature.

(continue)

(continued)

Containment water level should remain relatively constant after the RWT is transferred to containment. Unexpected increase in sump level may indicate in-leakage from component cooling water or essential service water systems. Lowering sump level may indicate an ECCS leakage outside containment, or pooling inside containment due to blocked choakpoints along the return path to the containment sump.

Degradation of single pump:

Individual pump mechanical degradation would be indicated by unexpected reduction or erratic behavior in pump [flowrate, discharge pressure and motor current]. Concurrently, other pumps operating on the same suction source would continue to trend as expected.

Blockage of sump screens:

The containment sump screens are designed to filter out debris and provide adequate suction flow to the ECCS pumps. Debris buildup on sump screens will impair suction flow return to the ECCS pumps. Typical containment sump screens are designed for 50% debris blockage and still deliver design rated flow. Debris blockage in excess of design (50% screen area) will adversely affect ECCS pump performance and may result in loss of NPSH, severe cavitation, and potential pump failure. All ECCS pumps taking suction directly from a common sump will be affected. (If ECCS pumps are connected in series, the pump taking suction directly on the containment sump will be affected before the downstream pump.) Minor Head loss (3 to 5%) should have minimal affect on pump performance. Moderate Head loss (10 to 20%) may be accompanied by noticeable reductions in flow and discharge pressure. A large Head loss (25% and more) will result in significant flow reduction, unstable pump operation and eventually cavitation will occur. Cavitation will be result in increased pump noise.

Failure of sump screens:

If the sump screens experience a large buildup of debris, a high differential pressure may result in screen failure. If the screens fail, the pumps will ingest debris. Blockage of small internal passages and mechanical binding may occur. The pump will behave erratically, performance will decline and it will ultimately fail. Multi-stage, high pressure injection pumps are more susceptible to damage from debris ingestion than low pressure single stage pumps. Ingested debris may also cause downstream valves to fail due to blockage between the valve disc and seat.

<u>Method</u>

a. Monitor of all available indications for signs of a loss of ECCS pump suction, i.e. sump blockage, as indicated by any of the following (listed in order of likely occurrence):
   a) [Unstable or lower than expected HPSI or CS flow]
   b) [Unstable or lower than expected HPSI or CS pump discharge pressure]
   c) [Lower than expected HPSI or CS pump suction pressure, low suction pressure alarm]
   d) [Unstable or lower than expected HPSI or CS pump motor current]
   e) [ncreased HPSI or CS pump noise]
   f) [other plant specific indications]

(continue)

(continued)

b. If there are indications of a reduction in NPSH or pump performance, the operator should review parameter trends and attempt to diagnose what is happening. For example: an individual pump in distress, a valve or system component failure or sump screen blockage. Accurate diagnosis of these occurrences under accident conditions is difficult and will require the operator to rely heavily on knowledge, experience and training. None of the available indications will provide a 100% conclusive diagnoses. Nevertheless, time is of the essence. If the operator is fairly certain that a loss of suction is taking place, he must act quickly to avert equipment damage and avoid inadequate core cooling.
c. Stop all Containment Spray pumps still in operation. The purpose of this action is to reduce the demand on the sump to a minimum and protect the remaining HPSI pump and buy some time to implement the FRG. Core heat removal takes precedence over the containment safety functions.
d. The operator should then notify plant management of the loss of sump suction and impending loss of recirculation capability, and transition from the LOCA guideline to the FRG. Since this event is beyond design bases, the FRG is the appropriate place to be, regardless of whether or not the loss of suction (blockage) is believed to be total at this point or not. Once blockage starts, it is unlikely that it will improve on its own. The buildup will continue until the screens are totally blocked or the screens fail.
e. The operator should monitor the remaining HPSI pump performance closely. If pump performance does not improve, throttle HPSI flow to the to the [minimum required HPSI pump flowrate] for pump protection. If pump performance still does not improve, stop the pump. If the pump is operating satisfactory at minimum flow, flow may be gradually increased as needed to achieve the maximum available and continue to monitor.

Additional Guidance on Compensatory Actions

Actions to avert ECCS pump damage:

As stated earlier, the best overall strategy to reduce the risk of sump screen blockage, loss of all ECCS pump capability and loss of core cooling, is to stop unneeded HPSI and CS pumps as soon as possible and place them in standby. To the extent possible, this should have been done prior to getting to this step. System alignment should not be changed, so that the possibility of realignment failures is avoided. This strategy reduces the demand on the containment sump and establishes reliable backup capability. If this strategy is used, the post RAS lineup would then consist of one operating HPSI pump aligned to inject to the RCS, and possibly one CS pump operating in recirculation mode to remove heat from the containment sump water. Note that CS and the SDC heat exchanger may not be needed for long term cooling. Without spray recirculating and cooling the sump, water in the sump will reach saturated conditions and create steam. The energy in the steam is then removed from the containment atmosphere by the CFCs and transferred to CCW. Thus decay heat may be removed without spray and heat exchangers.

Some plants may also align the CS pump discharge to provide suction to the HPSI pump. Piggyback operation increases the reliability of HPSI pumps by having only the most robust pumps aligned directly to the containment sump.

(continue)

(continued)

Actions to restore ECCS flow in the event of ECCS pump failure:

With the preemptive strategy discussed above in use, if an individual ECCS pump fails or is diagnosed to be seriously degraded due to reasons other than sump blockage, the pump should be stopped and the standby pump placed in service after performing the necessary verifications to avoid a possible common cause failure.

Actions to mitigate increasing screen blockage:

If there are indications of increasing sump screen blockage, consider reducing the flow demand through the sump screens to as little as possible consistent with adequate core cooling. For example, consider intermittent operation of ECCS pumps based on reactor vessel level (core covered), containment conditions, and sump water temperature. Permit bulk temperature to rise to [just below the maximum]. Also, consider going to a piggy back alignment (if possible) in order to insulate the HPSI pump from damage due to possible Head loss. Throttle HPSI flow or intermittently operate the HPSI pump as needed to maintain core heat removal, until an alternate RCS injection source is available.

Sequence

This step is a continuously applicable step and is located directly after RAS initiation.

Plant Parameters

Minimum required HPSI pump flowrate

The engineering limit is based on the minimum required flowrate through a HPSI pump that will avoid pump damage during continuous minimum flow operation, nominally [30 gpm]. The intent of the operational limit is to ensure that the HPSI pump is secured when the flowrate through the pump decreases to less than the minimum required for continuous minimum flow operation. This will ensure continued operability and availability of the HPSI pumps by avoiding over heating and subsequent pump damage.

Actions to maintain or restore core cooling if the containment sump is blocked (Addressed in detail by FRG IC-2 Continuing actions):

Containment: Ensure all available normal and emergency containment cooling units are in operation to maximize containment heat removal and support indirect cooling of the RCS and reactor core. Without spray and SDC heat exchangers, water in the sump will reach saturated conditions and create steam. Steam energy is removed by the CFCs and transferred to CCW. Thus decay heat is removed without spray and heat exchangers.

Steam Generators: Take maximum advantage of steam generators as a heat sink. RCS heat removal can be accomplished via single phase heat transfer to the steam generators or two phase reflux cooling. Ensure adequate steam generator level and control steam flow to maintain steam generator temperature lower than the RCS, i.e., ensure steam generator is heat sink, not heat source. Continue rapid cooldown and depressurize the RCS using the secondary system to reduce break flow (RCS mass loss), and thereby reduce the need for ECCS makeup flow.

(continue)

(continued)

Shutdown Cooling: If RCS conditions permit, consider placing the SDC system in service as follows. The reactor vessel level must be stable and equal or greater than [mid-level on the hot leg] to ensure adequate pump suction. It is not necessary that pressurizer level be above the heaters. The RCS will likely be saturated, so care must be taken to initiate flow slowly and minimize pump cavitation.

Borated Water alternate Source: Commence RCS injection of borated water from an alternate source (non-RWT). Since the RWT may still be empty in the early stages of a sump blockage event, bypassing the RWT using an existing plant specific source may be the preferred success path. Success of refilling and using a refilled RWT requires that a HPSI, LPSI or charging pump be available. The suction sources, pumps and necessary alignments are plant specific.

Step Number 38 SIT Isolation and Venting

Intent

The intent of this step is to prevent unnecessary injection of the Safety Injection Tank (SIT) water volume and possible injection of the SIT cover gas during a cooldown. Do not isolate SITs until it is confirmed that RCS pressure is under control and no LOCA event requiring SIT injection is in progress. If injected into the RCS, nitrogen gas could cause the steam generator tubes to become gas bound, thereby reducing their effectiveness as a heat sink.

Method

When pressurizer pressure reaches [SIT isolation pressure] the SITs should be isolated by closing their discharge valves and depressurized to prevent an undesired injection of water or the nitrogen cover gas into the RCS as RCS pressure is reduced during a cooldown.

Sequence

This step is sequenced after instructions to cooldown/depressurize the RCS. Ensure that no LOCA event is in progress prior to SIT isolation by verifying RCS inventory and pressure are under control. As there is no urgency to perform this step until the SIT pressure is approached. Even then, it will take some time for the entire SIT volume to be injected and N2 injection to be a real possibility.

Plant Parameters

Pressurizer pressure less then the SIT isolation pressure

The engineering Limit is based on the maximum Safety Injection Tank (SIT) pressure, nominally [250 psia]. The SITs are isolated and vented to prevent SIT discharge of water or nitrogen gas into the RCS during a plant cooldown/depressurization. For plants with high pressure SITs, this may be necessary to allow the plant to be brought to shutdown cooling system entry conditions.

Step Number 39 LTOP Initiation Criteria

Intent

The intent of this step is to ensure Low Temperature Overpressure Protection is initiated when required.

Low Temperature overpressurization protection (LTOP) is instituted at a temperature of [LTOP enabling criteria] to protect against subjecting the RCS pressure boundary to high pressure at low temperature, which could lead to brittle fracture.

Method

When [LTOP enabling criteria] are met, the operator initiates low temperature overpressurization protection.

Sequence

This step is to be located late in the procedure, after the plant has been cooled to the greatest extent possible using the steam generators..

Plant Parameters

RCS temperature less than the LTOP enabling criteria

The engineering limit is based on the LTOP enabling temperature found in technical specifications, nominally [285°F]. This operational limit is intended to ensure that low temperature overpressurization protection (LTOP) is lined up at the required cold leg temperature to protect against subjecting the RCS pressure boundary to low temperature brittle fracture.

Step Number 40 Hot and Cold Leg Injection

Intent

The intent of this step is to avoid concentrating boric acid in the reactor vessel and possible boron precipitation in the core which could restrict coolant flow through the core. This phenomena may occur if there is a large break in the hot leg and RV level can not be regained.

Method

During a large break LOCA on one of the RCS cold legs, it is assumed that all of the SI flow from the injection point associated with that cold leg goes directly out the break. In addition, some of the fluid injected into the other cold legs is directed out the break such that the water flowing to the core is just enough to make up for boil-off. Over time, this boiling in the core could concentrate the boric acid to the point where it begins to plate out on core surfaces and begins to interfere with adequate core heat removal. Therefore, the mode of SI flow is switched from “cold leg only “ to “simultaneous hot and cold leg injection sometime into the event.

In this mode of operation, the HPSI pump discharge is aligned so that the total injection flow is divided equally between the hot and cold legs. Injecting to both sides of the reactor vessel will ensure that fluid from the reactor vessel (where the boric acid is being concentrated) flows out the break (regardless of the break location) and is replaced with a dilute solution of borated water from the other side of the reactor vessel.

The operator should not line up hot and cold leg injection before [2 hours] have elapsed after the start of the LOCA. The purpose of this requirement is to ensure the borated water injected to the hot leg is not entrained in the steam being released from through the break. Hence, possibly diversion of borated water from the reactor vessel is avoided. [2 hours] after start of the LOCA, core decay heat generation will have dropped sufficiently and there will not be insufficient steam velocity to entrain the borated water being injected to the hot leg. The operator should line up hot and cold leg injection no later than [4 hours] after start of the LOCA to ensure that the concentration of boric acid in the reactor vessel is terminated well before the potential for boric acid precipitation occurs. The time frame is plant specific and depends on source tank concentration assumed in associated analysis.

Simultaneous hot and cold leg injection is not required for small break LOCAs because the buildup of boric acid is terminated when the RCS is refilled. Once the RCS is refilled, the boric acid is dispersed throughout the RCS via natural circulation.

If entry into shutdown cooling is anticipated before the [4 hour] limit, and the criteria for entry are met, then the realignment to hot/cold leg injection is unnecessary (Reference 17)

(continue)

(continued)

After the [specified time period] following a LOCA, if any of the following RCS inventory parameters are in jeopardy, simultaneous hot and cold leg injection should be initiated:

1. RCS subcooling is less than [minimum RCS subcooling], based on CET temperature. If subcooling has not been re-gained, the RCS inventory and pressure control parameters, needed to preclude boron precipitation, do not exist. CETs are used because it is not expected that the core and loops would be coupled such that T hot could be used. In addition, the CETs are more accurate in natural circulation then the T hot RTDs.
2. Pressurizer level is less than [minimum level for inventory control]. If subcooling is greater than the minimum required and pressurizer level is greater than the minimum required, this is a good indication that the loops are re-filled. However, if pressurizer level is less than the minimum required, it is not certain how full the RCS is, and therefore, simultaneous hot and cold leg injection would be required.
3. RVLMS is [less than top of the hot leg nozzles]. If RVLMS does not indicate that RV level is greater than the top of the hot leg nozzles, the RCS loops are not filled and simultaneous hot and cold leg injection must be initiated to preclude boron precipitation.

Sequence

This step is placed in the guideline at the point necessary to implement the boron precipitation strategy.

(continue)

(continued)

Plant Parameters:

RCS Subcooling is less than the required minimum subcooling based on representative CET temperature

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Pressurizer level greater than the minimum level for inventory control

The lower engineering limit corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The lower operational limit, nominally [35"], is approximately ([10%]) of a typical Combustion Engineering Pressurizer's range, and was chosen as the lower limit to account for some instrument and process fluid uncertainties. The lower limit is based on the lowest indication, approximately [2%] that with confidence reflects an actual Pressurizer level. Instrument uncertainties, assumed to be ± 8%, were conservatively applied to the engineering limit, yielding the lower operational limit of [10%].

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that, 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

Loss of Coolant Accident Recovery Bases

Step Number 41 Operate H2 Recombiners

Intent

The intent of this step is to ensure that the H2 recombiners are placed in operation as soon as H2 starts to build up in containment and before the hydrogen concentration reaches the flammability limit.

Method

Although hydrogen is not flammable until it achieves a concentration of at least [lower flammability concentration for hydrogen], it is prudent to reduce hydrogen to as low a concentration as possible (i.e., less than [minimum detectable concentration for hydrogen].). Such action minimizes the possibility of reaching the flammability limit and the resultant hydrogen burn if it is ignited.

If the hydrogen concentration in containment reaches [minimum detectable concentration], then the hydrogen recombiners should be run until hydrogen concentration is reduced to less than [minimum detectable concentration for hydrogen]. The recombiners take a finite time to reach operating temperature, so no lowering of measured hydrogen concentration should be expected before this time.

Sequence:

This hydrogen analyzers are placed in service and external recombiners are made ready early in the procedure. It will take some time to get valid sample information and to reach minimum detectable concentration. Therefore, this step can be located later in the procedure.

Plant Parameters:

Containment hydrogen concentration greater than minimum detectable concentration for hydrogen

The engineering limit establishes a nominal value for hydrogen that is high enough to be within the limits of detectability, yet low enough to permit the operator to take corrective action prior to the hydrogen concentration reaching hazardous levels (i.e. the flammability limit), nominal [0.5%].

Containment hydrogen concentration less than the lower flammability concentration for hydrogen

The engineering limit is based on ensuring the containment hydrogen concentration remains less than the lower flammable concentration following a DBA, nominally [4.0%] v/o. The intent of this application is to prevent a containment-wide hydrogen burn to avoid exceeding the containment pressure and temperature assumed in the safety analysis and minimize damage to safety-related equipment located in containment.

Step Number 42 Monitor Containment Radiation

Intent
The intent of this step is to monitor containment radiation levels in order to provide the [Plant Technical Support Center] input to evaluate the environmental impact of any planned, or unplanned releases.

[Removal of iodine from the containment atmosphere may be desirable in order to minimize the activity released to the environment in the event of a hydrogen purge].

Method
Monitor containment radiation levels.

Sequence
Place after cooldown/RAS step.

Plant Parameters
None

Step Number 43 Operate H2 Purge System

Intent

The intent of this step is direct the crew to consult the Technical Support Center for guidance regarding operation of the H2 purge system (both starting and stopping) since this may involve the potential for a limited release while venting containment to the environment using the purge system.

Method

The Technical Support Center is responsible for evaluating conditions in containment, and if necessary, to recommend operating the hydrogen purge system.

The following factors should be considered in the evaluation:

a. Containment Hydrogen Concentration

b. Containment Pressure

c. Expected Effects of a Hydrogen Burn

If a hydrogen burn is not expected to threaten containment integrity, then radioactive releases to the environment could be minimized or avoided if a burn were allowed to occur rather than purging. In contrast, if a hydrogen burn is expected to result in containment pressure exceeding its design value, a continuous, unisolable release to the environment could occur. Figure 5-18 is available to assist in evaluating the expected effects of a hydrogen burn. Existing containment pressure and containment concentration are determined and, using Figure 5-18, the expected post-burn containment pressure can also be determined. If the post-burn pressure is expected to be less than containment design pressure, then a hydrogen purge may not be necessary. Containment conditions must still be monitored and evaluated to ensure that expected post-burn pressure will remain below design pressure. Conditions to monitor include: rate of rise of hydrogen concentration, hydrogen Recombiner availability/capability, and rate of increase of containment pressure.

If the expected post-burn pressure would exceed containment design pressure, then a hydrogen purge may be necessary to ensure continue containment integrity. The recommendation to purge will be made by the Technical Support Center and the following factors should be considered:

Containment Atmosphere Radiation Levels -- This factor affects the offsite dose that would result from venting the containment using the purge system. Whether or not offsite doses would be within acceptable limits has to be considered.

Rate of Change of Hydrogen Concentration -- The rate of change of hydrogen concentration is an important factor to consider in the evaluation of whether or not to purge. If hydrogen concentration is increasing rapidly and expected post-burn containment pressure would exceed design pressure, then a hydrogen purge may be required to be performed expeditiously to maintain containment integrity in the event of a hydrogen burn.

(continue)

(continued)

Conversely, if hydrogen concentration is lowering and expected post-burn containment pressure would slightly exceed design pressure, then it may be prudent to allow hydrogen concentration to lower to an acceptable level instead of purging.

Hydrogen Recombiner Availability/Capability -- This factor is related to factor e) discussed above. If hydrogen recombiners are not available (not on-site or not operable), then purging will be the sole means of hydrogen control available. Recombiner capability relates to whether or not hydrogen recombiners are lowering containment hydrogen concentration, maintaining constant hydrogen levels, or incapable of keeping up with the hydrogen generation rate.

Rate of Change of Containment Pressure -- Existing containment pressure and existing containment hydrogen concentration are used to determine expected post-burn containment pressure. The rate of change of hydrogen concentration has been discussed. The discussion of the rate of change of containment pressure is similar. If containment pressure is increasing and expected post-burn pressure is above design pressure, then efforts to make available all containment temperature/pressure control equipment should be made and a hydrogen purge may be necessary depending on factors d), e), and f). Conversely, if expected post-burn pressure would exceed design pressure but containment temperature/pressure control equipment are now lowering containment pressure, then a hydrogen purge may not be necessary. Again, this decision would made by also considering factors d), e), and f.)

When deciding to secure the hydrogen purge system, the following factors should be considered: 1) the concentration of hydrogen in containment and the threat of hydrogen ignition, 2) the concentration of other radioactive nuclides in the containment atmosphere being released along with the hydrogen, 3) the efficiency and effectiveness of the purge operation, 4) resultant offsite exposure to the public, 5) the urgency to gain access to containment. The recommendation to stop the containment hydrogen purge should be made by the Plant Technical Support Center.

(continue)

(continued)

Sequence

This step is sequenced early in the LOCA procedure. However, it is placed after those steps associated with the initial response to the event which address A LOCA in containment would effect hydrogen concentration and buildup based on the extent of the leak, what is taking place within the primary system and the core, and the reaction of the various materials within the containment to the coolant accumulating. While the buildup may not be quick or severe, this step notes that the TSC will be evaluating any buildup and that they might recommend using the purge system to alleviate a hydrogen buildup problem.

Plant Parameters

None

Loss of Coolant Accident Recovery Bases

Step Number 44 Reset Safety Systems

Intent

The intent of this step is to secure or restore safety systems that have actuated because they were needed, but are no longer needed.

Method

The operator is directed to restore safety systems to normal standby status using plant specific procedures. It is best to place the plant in as normal a configuration as possible prior to exiting the procedure. This is especially important if the operator will be exiting to a normal operating procedure which would not expect ESFAS signals to be present.

Sequence

This step is located at this position within the LOCA procedure because it is least important in carrying out the LOCA strategy and all other LOCA instructions have been taken.

Plant Parameters

None

Loss of Coolant Accident Recovery Bases

Step Number 45 SDC Entry Conditions

Intent

The intent of this step is to establish shutdown cooling entry conditions once the required conditions are established.

Method

This step represents the final preparations for placing the plant on shutdown cooling (SDC). The following conditions should exist prior to establishing SDC. It is implied that, all of the entry conditions are stable or trending to further within the entry conditions.

a. Pressurizer level control should be established and verified by a level greater than [Heater cutoff setpoint]. This ensures that the heaters will be available for pressure control once shutdown cooling is established and verifies adequate inventory control for SDC operation.

b. RCS subcooling should be at least the [required minimum subcooling]. This ensures that the RCS coolant is in the required state to support SDC operation and ensures pressurizer level is a good indication of inventory control.

c. RCS pressure should be at or below the [SDC entry pressure] to protect the integrity of shutdown cooling piping, which is not rated for the higher pressures which could exist in the RCS.

d. RCS hot leg temperature should be at or below the [SDC entry temperature] due to shutdown cooling system design.

e RCS activity level should be at or below acceptable limits. Before the shutdown cooling system is operated, the RCS activity levels must be considered since the RCS fluid will now be circulated outside of the containment building. Establishing the plant on shutdown cooling will result in the RCS coolant outside containment. If high activity is present. Such circulation has the potential for release to the environment. If the potential for significant releases exists, it may be more desirable to continue using the established method of cooling the plant. In addition, access to equipment where the coolant will be circulated must also be considered.

Sequence

This step is sequenced after the safety functions are under control. It provides an exit point for the guideline.

(continue)

Plant Parameters

Pressurizer level greater than the heater cutoff setpoint

The engineering limit is based on keeping the pressurizer heaters covered to preserve the normal means of RCS pressure control following a reactor trip. The pressurizer heaters are used to maintain RCS pressure, and keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow. The heater cutoff value is nominally [100"] decreasing.

RCS subcooling is greater than the minimum RCS subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Pressurizer pressure less than the Shutdown Cooling entry pressure

The upper engineering limit is based on the shutdown cooling system design pressure. The shutdown cooling system may be placed in operation when the RCS has been depressurized to the point that the shutdown cooling system will not be exposed to pressures greater than its design pressure. The operational limit, nominally [300 psia] (including the instrument uncertainties) should be less than the setpoint of the permissive interlock which prevents opening of the shutdown cooling suction line isolation valves.

RCS hot leg temperature less than the Shutdown Cooling entry temperature]

The upper engineering limit is based on the design temperature of the shutdown cooling system components, nominally [300]°F. The shutdown cooling system may be placed in operation when hot leg temperature is less than [300]°F.

Loss of Coolant Accident Recovery Bases

Step Number 46 Maintain Long term cooling

Intent

The intent of this step is to direct the operator to maintain long term cooling if SDC entry conditions can not be established

Method

If SDC operation is determined to be appropriate, then the SDC is initiated. If the conditions can not be met or maintained, then the operators are directed maintain long term cooling. Any successful means of long term cooling is acceptable. For example; SG forced cooling, SG natural circulation, or Once-Trough-Cooling.

One of the above methods of maintaining the RCS Heat Removal safety function should be in force based on previous steps in the guideline.

Sequence

This step is sequenced after SDC entry instructions.

Plant Parameters

None

Loss of Coolant Accident Recovery Bases

Step Number 47 LOCA Condition, Isolated

Intent
The intent of this step is to direct the operator to the series of steps that address the LOCA Isolated condition.

Method
At this point in the guideline, the operator will pursue one of two strategy paths, LOCA isolated or LOCA NOT isolated. If the LOCA has not been isolated, the operator is directed to follow the path which contains recovery actions for the LOCA NOT isolated condition. If the leak or rupture has been isolated, the operator is directed to perform the LOCA Isolated steps aimed at stabilizing the plant.

Sequence
This step is placed after the major mitigating actions are taken and the operator is ready to begin taking actions to prepare the plant for longer term stability, such as plant cooldown and entry to shutdown cooling.

Plant Parameters
None

Step Number 48 SI Throttle Criteria

Intent

The intent of this step is to establish the conditions that must be met before HPSI flow can be reduced following a SIAS actuation.

Method

After SIAS actuation, two full trains of SI must remain in operation at full flow, until all HPSI throttle criteria are met. For most LOCAs, the HPSI pumps will run continuously for a long period of time while RCS inventory, pressure, and heat removal control are being regained. In some cases, control of these three safety functions is not regained during the accident (i.e., large break LOCA) and the HPSI pumps run for the duration of the event recovery. Throttling of HPSI is expected when the SIAS was spurious, the leak rate can be accommodated by HPSI and charging when RCS pressure lowers, or after the leak is isolated.

HPSI throttle criteria are as follows:

a. RCS subcooling is greater than the [minimum RCS subcooling] of the RCS P/T curve. T hot should be used to determine RCS subcooling if RCPs are operating. Representative CET temperature should be used if natural circulation is in progress. Because of the location of the CETs inside the ICI tubes, the CETs are exposed to a mixture of core exit fluid and core bypass fluid during forced circulation. Since the core bypass fluid is cooler than the core exit temperature, it is common that CET temperature reads somewhat less than the loop T hot RTD. When natural circulation is in progress the CETs provide the best indication of fluid conditions adjacent to the core. The CETs do not rely on loop flow (as do the RTDs) for detecting fluid conditions adjacent to the core. With no flow in the loops, the loop RTDs may not provide adequate indication of core fluid conditions.

   Establishing the [minimum required subcooling] ensures that the fluid surrounding the core is subcooled, and provides sufficient margin for reestablishing HPSI flow if the minimum value can not be maintained. Voids (e.g. saturated conditions) may exist in some parts of the RCS (e.g., reactor vessel head). In themselves, this is not a major problem, provided that the voids do not interfere with core heat removal.

b. Pressurizer level is greater than the [minimum level for inventory control] and not lowering. A pressurizer level greater than the [minimum level for inventory control] and not lowering, in conjunction with criterion (a), is an indication that RCS inventory control is established.

(continue)

(continued)

c. At least one steam generator is available for RCS heat removal. A steam generator is considered available for RCS heat removal if: 1) level is within the [normal control band], 2) capable of being supplied with feedwater, and 3) is capable of being steamed. Feedflow may be provided by main or auxiliary feedwater. Steaming capability includes controlled steaming by: 1. turbine bypass valves, 2. atmospheric dump valves, 3. main steam safety valves. The steam generator must be available to remove heat because the HPSI will no longer be adequate to remove decay heat from the core. Now the RCS must perform that function and there must be a means of removing heat from the RCS.

d. Reactor vessel level is greater than the [top of the hot leg nozzles] using RVLMS. This provides an extra margin of core coverage, taken in conjunction with the above criterion, and serves as an additional indication that adequate RCS inventory control has been established].

The operator should realize that when HPSI is throttled, the core and RCS are going to heat up until the steam generator heat removal (RCS heat removal) can be increased by the operator. Depending upon how long the adjustment takes, the RCS fluid could expand appreciably, thereby further complicating the event recovery.

If all of the HPSI throttle criteria are met, then the operator may either throttle the HPSI injection valves or stop the HPSI pumps as necessary, provided the previously stated criteria remain met.

Sequence

This step is sequenced commensurate with the expected condition of the Inventory Control and Pressure Control Safety Functions. For example, in the LOCA ORG the step is sequenced early in the section associated with actions to be taken after the LOCA is isolated. In SGTR it is positioned after the steps which address isolating the affected steam generator and controlling the level which are of a higher priority for this event.

(continue)

(continued)

Plant Parameters

RCS subcooling is greater than the [minimum RCS subcooling]

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Pressurizer level greater than the [minimum level for inventory control]

The lower engineering limit corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The lower operational limit, nominally [35"], is approximately ([10%]) of a typical Combustion Engineering Pressurizer's range, and was chosen as the lower limit to account for some instrument and process fluid uncertainties. The lower limit is based on the lowest indication, approximately [2%] that with confidence reflects an actual Pressurizer level. Instrument uncertainties, assumed to be ± 8%, were conservatively applied to the engineering limit, yielding the lower operational limit of [10%].

Steam Generator level within the [normal control band]

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that, 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

Step Number 49 HPSI Pump Restart Criteria

Intent

The intent of this step is to ensure that all available trains of HPSI are restored to operation if any of the HPSI throttle criteria can not be met.

Method

After the HPSI throttle/stop criteria are met and HPSI is throttled or the HPSI pumps are stopped, the operator must monitor RCS inventory and pressure control. If any of the throttle/stop criteria cannot be maintained, the operator must raise HPSI flow and/or start HPSI pumps as necessary to regain the safety functions and once again meet the HPSI throttle/.stop criteria. It should be noted that this approach differs from the one that used to require full SI flow to be e-established. Industry operating experience has shown that blindly re-establishing full SI flow is unnecessary and can further complicate event recovery. Therefore, that method of re-establishing HPSI flow is no longer used.

Sequence

This step is sequenced immediately after the HPSI throttle criteria.

Plant Parameters

None

Step Number 50 LPSI Pump Stop Criteria

Intent

The intent of this step is to prevent damaging the LPSI pumps as a result of extended operation without adequate flow through the pump.

Method

If the RCS pressure is greater than the shutoff head, the pumps will not deliver any flow to the RCS. Therefore, they should be secured. In order to minimize the time of operation at shutoff head, they should be stopped if the pressurizer pressure rises to greater than [LPSI pump shutoff head] and is controlled. The pump is secured first, followed by closing the injection valves. This sequence is intended to minimize the time of operation with no flow. The LPSI injection valves are closed to prevent unintentionally cross-connecting the HPSI system to the LPSI system in the event of a leaking check valve in a LPSI pump discharge line.

Sequence

This step is sequenced after the HPSI pump termination criteria. It is sequenced early in the procedure but after immediate actions are taken to respond to the event.

Plant Parameters

Pressurizer pressure greater than the LPSI pump shutoff head

The engineering limit is the shutoff head of the LPSI pump, nominally [200 psia]

Step Number 51 LPSI Pump Restart Criteria

Intent

The intent of this step is to ensure that two complete trains of LPSI are restored to operation if any LPSI stop criteria can not be met.

Method

Once the LPSI pumps have been stopped and the injection valves have been closed, if the LPSI stop criteria cannot be maintained, the LPSI injection valves must be opened and the LPSI pumps must be restarted to ensure that adequate inventory and pressure control are maintained. The intent is to have one LPSI pump operating in each train with both cold leg injection valves fully open (not throttled). Once inventory control has been regained, and the LPSI stop criteria met, then LPSI pumps may be once again stopped.

This does not apply to the situation where pressurizer pressure has purposefully been reduced to less than [LPSI pump shutoff head] in a controlled manner to get the plant to SDC conditions. This does not apply when pressurizer pressure is less than [LPSI pump shutoff head] and the LPSI pumps were secured in response to RAS initiation.

Sequence

This step is sequenced immediately after the LPSI Stop criteria.

Plant Parameters

Pressurizer pressure greater than the LPSI pump shutoff head

The engineering limit is the shutoff head of the LPSI pump, nominally [200 psia]

Loss of Coolant Accident Recovery Bases

Step Number 52 Restore Letdown

Intent

The intent of this step is to restore letdown so that it is available to support a cooldown, if necessary.

Method

Letdown is needed to support inventory/pressure control, especially when the RCS is water-solid. Therefore, if needed or desired, it should be restored as soon as possible. To do so, may require SIAS & CIAS to be blocked and reset. Plant specific administrative procedures must be followed when blocking and resetting these signals. However, if it can not be restored at the time or it may take considerable time to get letdown back, then the operator may restore letdown anytime conditions permit and when assistance is available.

If letdown is isolated and all of the following conditions exist, then the operator should attempt to restore letdown:

1) HPSI stop/throttle criteria are met, RCS inventory must be conserved. Any deliberate action to remove inventory from the RCS is not allowed if control of RCS inventory has not been achieved.
2) If it is needed or desired as deemed by [operations supervisor]. The operator should not attempt to restore letdown if the LOCA has been isolated and placing letdown in service will result in an uncontrolled loss of RCS inventory.

If letdown is not be needed for inventory control (i.e. facilitate maintain pressurizer level), it may be desired for other evolution's such as RCS chemistry control. If there is no current need or desire for letdown, then it does not have to be restored at this point.

RCS activity may be higher than normal due to the event in progress. Restoring letdown could create unacceptable radiological consequences in adjacent areas outside containment that may complicate access to the affected areas.

Sequence

This step is sequenced after the major mitigation steps.

Plant Parameters

None

Step Number 53 Verify RCS NOT Water Solid

Intent

The intent of this step is to determine if a steam bubble exists in the RCS. Since it is expected that a steam bubble exist in the RCS, the step is worded to expect that condition.

Method

The EPGs are designed to address water solid conditions separately from non-water solid conditions. In order to initiate the appropriate actions, the operator must first evaluate the RCS to determine if a steam bubble is present or if it is water solid. The intent of this step is to aid the operator in making that determination. By definition in the EPGs, water solid conditions refer to the RCS effectively being full of subcooled water, with possible exception of some small pockets of non-condensable gases in high points of the system. Conversely, non-water solid conditions implies that there is a steam bubble somewhere in the RCS. The steam bubble could be located in the Pressurizer, RV head, or the steam generator U-tubes. Therefore, in this step, the operator is prompted to look at all RCS indications that may provide evidence that the RCS is not in a water solid condition. The following is a minimum list of RCS indications that should be considered:

Pressurizer level less than 100%

Pressurizer level indicating on scale, i.e., < 100%, is a good indication that there is a saturated steam-water interface in the Pressurizer. Indicated level may not be representative of actual level, if instrument uncertainties are not considered, if the instrument has decalibrated due to a change in temperature, if a LOCA or leak is located in the top of the Pressurizer, or if harsh containment conditions have exaggerated instrument uncertainties in a non-conservative direction. All available channels of level instrumentation should be checked to corroborate the level reading. One channel of level indication should not be relied upon alone to confirm the existence of a steam bubble in the Pressurizer. Pressurizer level alone should not be relied upon to confirm that the RCS is not solid. RVLMS, the indications of saturated conditions in the RCS and RCS pressure response, must also be considered.

RVLMS less than 100%

RVLMS may be used to identify or corroborate a bubble in the RV head region. Level indication alone may not confirm that the bubble is saturated steam. [Head temperature] and Pressurizer pressure can be used to validate that saturated conditions exists.

(continue)

No exaggerated or severe pressure response

Observation of an abnormal or exaggerated Pressurizer pressure response do to operation of heaters, changes in RCS inventory, or changes in RCS temperature are good indicators the RCS is solid. Operator training and simulator exercises should emphasize recognition of normal pressure response (with steam bubble) versus abnormal pressure response (water-solid).

The contingency action is intended to guide the operator in controlling the RCS while it is water solid. The goal of the step is to maintain the RCS within the limits of the P/T curves by controlling RCS temperature and pressure. When the RCS is intact and water-solid, the RCS pressure is sensitive to changes in RCS inventory. If the RCS is intact and inventory and temperature are not controlled carefully, there is a potential for a pressure excursion which could over pressurize the RCS, resulting in challenging the PSVs, or pressurized thermal shock of the RCS.

RCS pressure changes may result from changes in the heat input or removal from the RCS. Therefore, changes in steam generator feed rate and steaming rate should be slow and deliberate, and require the operator to be constantly aware of the effect of the change in Pressurizer pressure.

The operator must also anticipate an exaggerated Pressurizer response when starting or stopping charging pumps, when increasing or decreasing letdown flow, when starting or stopping HPSI pumps, when throttling SI flow, when securing RCP bleedoff, when initiating or securing sampling, and when isolating RCS leak paths. For best control, changes should be made slowly, allowing time to monitor the effect of the actions taken. Multiple or simultaneous changes should be avoided.

Water solid operations may continue as required within the guidelines described above, depending on plant conditions and the event recovery strategy. As long as the operators have established control of RCS temperature and inventory, there is no urgency to re-establish a bubble in the Pressurizer. In fact, the operators may conclude that it does not make sense to intentionally draw a bubble, and instead they may choose to proceed with the cooldown with the existing conditions.

Sequence

This step is sequenced after the major mitigation steps.

Plant Parameters

Reactor Vessel is full

The engineering limit is the highest elevation in the interior Reactor Vessel Head. The intent of the operational limit is to detect voiding in the Reactor Vessel Head when the attempts are made to depressurize the RCS and system pressure fails to respond as expected.

Loss of Coolant Accident Recovery Bases

Step Number 54 Draw PZR Bubble

Intent

This step is intended to provide guidance for drawing a bubble in the RCS. The ideal location for drawing an RCS bubble is in the pressurizer. Therefore, the step guidance focuses on restoring a bubble in the pressurizer. However, it is acceptable to draw a bubble in the pressurizer or reactor vessel (RV) head. A bubble in the RV head is not a problem as long as it does not interfere with natural circulation flow, i.e. remains above the hot leg nozzles.

Method

Prior to drawing a bubble in the pressurizer, certain activities or combination of activities are necessary to establish a bubble in the pressurizer. [To do so, may require SIAS & CIAS to be blocked and reset. Plant specific administrative procedures must be followed when blocking and resetting these signals.] The activities are:

1. heating the water in the pressurizer to saturation temperature for the pressure desired,
2. lowering the RCS pressure to the saturated conditions by
   a) removing inventory via letdown flow and/or
   b) reducing inventory volume via RCS heat removal, and
3. continuing to remove inventory or reduce inventory volume in the RCS in order to lower water level in the Pressurizer to an acceptable reading.

The most effective method of drawing a bubble is to initiate a cooldown. Commencing a cooldown is usually appropriate whether it is desired to draw a bubble or not. A bubble will ultimately form in the pressurizer, RV head, or SG U-tubes by simply cooling down and allowing the RCS to depressurize, without any other action. A bubble will form quicker in the pressurizer or RV head if letdown can be established and maximized. The probability of a bubble forming in the pressurizer is increased if the pressurizer heaters are energized. Once heat removal is established, the cooldown happens slowly and the plant is easily controlled. It will take a considerable amount of time to draw a bubble, depending on the initial conditions and the combination of activities used to draw the bubble. A bubble may form in the RV head before forming in the pressurizer. This is not a problem as long as it does not impede natural circulation flow. A bubble will form with or without RCPs operating. It will form quicker with an RCP running, due to the increased heat removal.

a. The procedure for drawing a bubble starts with energizing all available pressurizer heaters. Heaters will increase the likelihood that the bubble will form in the pressurizer.

b. Efforts should be made to minimize the probability of void formation in the steam generator U-tubes. Drawing a bubble in the tubes of a steam generator will aid in RCS pressure control but may interfere with accurately monitoring RCS inventory. The purpose of this step is to avoid operating without the ability to accurately monitor RCS inventory. Therefore, this sub-step provides direction to maintain the operating SG

(continue)

pressure less than RCS pressure and the isolated SG pressure approximately equal to or less than RCS pressure. By doing so, the operating SG steam space, and consequently the top portion of the U-tubes, will be the coolest part of the RCS, thus preventing void formation. Under these conditions, it is unlikely that voids should form in the tubes of the isolated SG. If an RCP is still in operation, void accumulation in the top of the U-tubes will not occur.

Pressurizer pressure should be reduced by establishing letdown flow greater than a combination of charging and HPSI flows. HPSI stop/throttle criteria must be met prior to throttling SI or stopping HPSI pumps or charging pumps. RCS cooldown, within Technical Specification limits, should be initiated using both steam generators, if available.

c) If a bubble forms in the RV upper head region, then the RVLMS level must be maintained above the top of the hot leg for proper inventory control and optimum core heat removal. The pressurizer heaters should remain operating (if available until a bubble forms in the pressurizer). Then the bubble in the RVUH can be eliminated and the plant can return to a more normal means of pressure control.

Sequence

This step is sequenced after the major mitigation steps and after the step to determine if the RCS is water solid.

Plant Parameters

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that, 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

Loss of Coolant Accident Recovery Bases

Step Number 55 Maintain pressurizer level

Intent

The intent of this step is to ensure that the Inventory Control Safety Function is being adequately addressed.

Method

If HPSI throttle/stop criteria are not met by the time this step is reached in the procedure, as would be the case in a large break LOCA and certain size small break LOCAs, all available charging and SI flow must be directed to the RCS . Once HPSI has restored pressurizer level to greater than the minimum valid indicated level, then the operator ensures that the charging pumps and letdown are maintaining pressurizer level within the [expected post-trip band]. If the HPSI throttle criteria are met, then HPSI pumps may be throttled or stopped as necessary to maintain level within the [expected post-trip band].

It may be necessary to exceed the upper pressurizer level if the operator is attempting to restore RCS subcooling as indicated in the safety injection termination criteria since pressurizer heaters may be unavailable and water-solid operation may be necessary to restore subcooling.

Sequence

This step is located after the event is under control to establish RCS inventory control prior to cooldown.

Plant Parameters

Pressurizer level within the [expected post-trip band]

The upper engineering limit is based on engineering judgment to: 1) avoid water-solid conditions, 2) provide sufficient steam space to ensure pressure control using sprays, and 3) bound the highest pressurizer levels observed in best estimate analysis. The lower engineering limit is nominally [2%]. The lower operational limit, nominally [35"] corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The upper operational limit, nominally [245"] corresponds to the highest level judged to provide sufficient steam space to ensure pressure control using Pressurizer sprays without immediately bringing the plant to a water-solid condition. In the EPGs, the RCS is not considered water-solid if there is evidence of a steam void anywhere in the RCS, i.e. in the pressurizer, the reactor vessel head, or in the steam generator tubes. Pressurizer level between [35" to 245"] defines an acceptable transient control band following a reactor trip. Ultimately, level should be restored to the normal control band. Level in the transient band is indicative of RCS inventory control via a saturated bubble in the Pressurizer. It provides the operator with information to support the continued operability of the Pressurizer.

Step Number 56 Maintain RCS within [Post Accident PT Curve] Limits

Intent

The intent of this step is to direct the operator to maintain the RCS within the limits of the post accident PT curve.

Method

Maintaining RCS conditions within the acceptable limits of the post accident PT curve ensures that: 1) the post accident cooldown rate is not exceed, [100°F/Hr]; 2) that the core is covered by subcooled fluid; and 3) minimizes the concern for pressurized thermal shock by staying within the [post accident upper subcooled limit], [200°F]. This is accomplished by controlling pressurizer heaters, main or auxiliary spray, charging and letdown, and HPSI flow (if HPSI throttle/stop criteria are met).

If subcooling or cooldown rate limits are not within the post accident PT curve, then the operators should take actions to restore the RCS to within the PT limits. The contingency actions provide typical solutions for out-of-limit PT conditions. Depending on the situation, the operator should perform any of the given actions appropriate to the problem. Out-of-limit conditions and the appropriate operator response should be address in operator training.

If the RCS is oversubcooled, the operator is directed to take the following actions to alleviate the problem:

- Stop the cooldown. The operator will stop the cooldown to stop the temperature decrease from increasing subcooling.
- Depressurize the RCS. The operator will use main or auxiliary spray to reduce pressure, thereby reducing RCS subcooling.
- If HPSI throttle/stop criteria are met, control charging, letdown, and HPSI. If HPSI throttle/stop criteria are met, the operator will increase letdown (if available), stop charging as necessary and throttle/stop HPSI to reduce inventory and pressure and help reduce subcooling. However, the operator must maintain the plant within the HPSI throttle/stop criteria or re-initiate HPSI flow.
- If in the process of the RCS becoming oversubcooled, the RCS has exceeded its cooldown rate limit, the operator must stop the cooldown and maintain the plant in a stable pressure and temperature configuration (soak) until the cooldown rate is once again within limits. Once the RCS cooldown rate is back within its limits the cooldown can resume.

(continue)

PT curve background

Due to variations in reactor vessel design, thermal transient history, and neutron fluence, [Post Accident PT curves] should be developed on a plant specific basis. These curves should address the following items:

1) The plant conditions or transients that invoke the applicability of these curves, i.e. when do the curves become the controlling document regarding the limits of the PT operating point and cooldown rate? Traditionally this has been an initial transient cooldown that results in lowering Tc to less than 500°F, but this may need adjustment depending on a particular plant's reactor vessel history.

2) The specific plant indications that should be used to locate the operating point within the curves. These indications should be identified for a variety of likely RCS flow and inventory conditions, for example: full forced flow, single phase natural circulation, and two phase natural circulation.

3) The applicable cooldown rates, how the cooldown rate should be measured, and any soak requirements.

4) Minimum and maximum subcooling limits.

5) RCP NPSH operating space for various pump configurations.

6) Shutdown cooling entry conditions and operating limits.

7) Any Low Temperature Over Pressure (LTOP) considerations that may apply.

Sequence

This step is continuously applicable to enforce the limits of the post accident PT curve throughout execution of the EPG.

Plant Parameters

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

Step Number 57 Ensure SG Level in Normal Control Band

Intent

The intent is to ensure an adequate RCS heat sink is available via a SG since some LOCAs with small break flow still require a SG heat sink. The instruction states that at least one SG level should be restore to and maintained within the [normal control band] with main or auxiliary feedwater. This level provides adequate heat removal capability under forced flow and natural circulation conditions. The reason the step specifies level being restored by 'main or auxiliary feedwater" is because sometimes level can rise due to a heatup of the steam generator or due to steam generator swell. This step requires the operator to verify that main or aux feedwater is flowing to the steam generator(s) to restore level and that the level rise is not from another heatup or swell.

In general, it is desirable to restore SG level to the normal band. During a LOCA it is assumed that the operator will not encounter problems restoring SG level. But during large break LOCA conditions and certain size small break LOCAs, immediate and aggressive recovery of SG level to the [normal control band] may exacerbate an already rapid cooldown rate due to SI flow into the RCS. Therefore, the operator should be aware of the potential for overcooling due to excessive feed to the steam generators. Due to the low probability of the large break LOCA occurring and considering the generic EPG strategy that does not require the operator to distinguish between break sizes, feeding up the steam generators under these conditions is a worth risk. Therefore, the operator is directed to feed up steam generators even if a large break LOCA or a large small break LOCA has occurred and the cooldown rate is being exacerbated. However, the operator should limit the feedwater flowrate under these conditions to just what is necessary to refill the steam generators.

Method

At least one steam generator level is restored to and maintained in the [normal control band] using main or auxiliary feedwater.

Sequence

This step is sequenced early in the procedure, after the initial mitigation. It is important to the RCS Heat removal safety functions.

Plant Parameters

Steam Generator level within the [normal control band]

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Loss of Coolant Accident Recovery Bases

Step Number 58 Evaluate Need for Cooldown

Intent

The intent of the step is to direct the operators to evaluate whether cooldown to shutdown cooling entry conditions is needed.

Method

The factors that should be considered when determining the need to cooldown are:

Plant status: An overall assessment of plant status and pending equipment repair requirements should be performed. If the continued availability of any systems required for maintenance of hot standby is in jeopardy, a plant cooldown should be performed before the ability to cooldown is lost.

Auxiliary systems availability: Consider the availability of compressed air, cooling water systems, and the reliability of electrical power.

Condensate inventory: Figures 4 (feedwater requirements vs time to shutdown cooling) and 5 (feedwater requirements vs cooldown sensible heat removal) are used to determine the condensate inventory requirements needed to cooldown to shutdown cooling entry conditions. If the available condensate inventory is marginally adequate, a plan to replenish condensate inventory should commence immediately to avoid the possibility of running out of condensate before the shutdown cooling system can be placed into operation.

Sequence

This step is placed after the steps that mitigate the immediate effects of the accident and ensure the near term recovery and maintenance of safety functions. The decision to perform a plant cooldown is generally considered one of the first steps towards establishing long term cooling.

Plant Parameters

None

Step Number 59 Cooldown Desired

Intent

The intent of this step is to direct the operator to the appropriate steps, depending on whether a plant cooldown is desired or not.

Method

At this point in the recovery the crew has decided whether a cooldown to shutdown cooling entry conditions is necessary. This step directs the operator to continue with the actions of the guideline if it has been decided to perform a cooldown.

If it is decided that a cooldown is not necessary, the plant should be maintained in a stable condition until a decision is made to exit the LOCA ORG and go to an approved procedure.

Sequence

This step should be placed shortly after the step where the decision to perform a plant cooldown is made.

Plant Parameters

None

Step Number 60 Borate the RCS

Intent

The intent of this step is to borate the RCS to maintain the reactor shutdown and establish [adequate shutdown margin].

Method

The operator should borate the RCS to maintain the reactor shutdown and strive to establish [adequate shutdown margin] to established shutdown cooling entry conditions. Note that if a PT Curve maximum cooldown rate is maintained, all charging pumps running may not be able to keep pressurizer level constant during the initial stages of the cooldown. Therefore, pressurizer level will lower. This outsurge from the pressurizer will tend to dilute the RCS boron concentration. The possible dilution effects should be considered in determining the boration necessary.

Sequence

This step is sequenced close to initiation of the cooldown, and after other steps associate with maintaining the safety functions that can be expected to be affected by a LOCA.
Plant Parameters

Adequate shutdown margin
The intent of the engineering limit is to be in compliance with plant specific technical specification shutdown margin requirements based on moderator temperature.

Step Number 61 Controlled cooldown

Intent

The intent of this step is to initiate a controlled cooldown of the plant. This action will reduce the pressure and temperature of the plant. In the case of a LOCA, SGTR, or ESDE this limits the associated break flow by reducing the stored energy in the plant.

A plant cooldown will change the reactivity conditions in the reactor core. Therefore, whenever a cooldown is performed the operator must consider the effects of the cooldown on reactivity control and take appropriate actions to maintain the [reactor shutdown]. This may include borating and sampling the RCS, prior to and during the cooldown. This step assumes that emergency boration is in progress due to an SIAS and therefore no direction is given to commence boration.

Method

If the main condenser is available, the turbine bypass valves is the preferred method of cooling down. Use of the turbine bypass valves conserves secondary inventory and provides for greater control over possible releases from the steam generators to the atmosphere. However, if systems are not available to support this method, or for some other reason is not desired, then the Atmospheric dump valves may be used to cool down.

Sequence

For events in which reducing the energy in the RCS is of high priority, this action would be placed early in the sequence of events. Reducing the energy in the RCS helps minimize the loss of inventory associated with a break in the primary or secondary system. However, the replenishment of RCS inventory is normally of higher importance therefore this would normally follow such steps.

Plant Parameters

None

Step Number 62 Depressurize RCS to SDC Entry Conditions

Intent

The intent of this step is to provide direction to depressurize the RCS to Shutdown Cooling entry conditions.

Method

For small break LOCAs, especially where RCS inventory and pressure are controlled, a deliberate depressurization of the RCS will be necessary to permit entry into shutdown cooling. This step directs a depressurization to [SDC entry pressure] and [SDC temperature]. It provides the available depressurization success paths, depending on existing plant conditions. For large breaks, all that may be required to depressurize to or below [SDC entry pressure] is throttling of SI flow (if SI termination criteria are met), or action may not be necessary at all.

a. If available, main or auxiliary pressurizer sprays may be used to depressurize the RCS.

b. If HPSI throttle/stop criteria are met, charging pumps may be stopped as necessary to aid in depressurization. Charging pumps are operated to provide inventory throughout the cooldown as well as to provide auxiliary spray as needed. Letdown should not be required during a cooldown, but may be used to aid in inventory control, and thus RCS depressurization provided HPSI throttle/stop criteria are satisfied.

c. If the HPSI pumps are in service, they may be throttled one at a time, if the stop/throttle criteria are satisfied.

Sequence

This step is sequenced after the immediate actions to control inventory and isolate the leak have been completed. It is important to reduce RCS pressure to limit the loss of inventory from the primary system.

Plant Parameters

Pressurizer pressure less than the Shutdown Cooling entry pressure

The upper engineering limit is based on the shutdown cooling system design pressure. The shutdown cooling system may be placed in operation when the RCS has been depressurized to the point that the shutdown cooling system will not be exposed to pressures greater than its design pressure. The operational limit, nominally [300 psia] (including the instrument uncertainties) should be less than the setpoint of the permissive interlock which prevents opening of the shutdown cooling suction line isolation valves.

RCS hot leg temperature less than the Shutdown Cooling entry temperature

The upper engineering limit is based on the design temperature of the shutdown cooling system components, nominally [300]°F. The shutdown cooling system may be placed in operation when hot leg temperature is less than [300]°F.

Step Number 63 Bypass automatic MSIS and SIAS initiation

Intent

The intent of this step is to ensure that MSIS and SIAS do not actuate unnecessarily and complicate the event.

Method

During a controlled cooldown and depressurization, automatic operation of MSIS and SIAS is not wanted when it is not needed. Therefore, SIAS (low PZR Pressure) and MSIS (low SG Pressure) must be [blocked, bypassed, or lowered], if they have not actuated automatically, as the cooldown proceeds to ensure that automatic actuation does not occur unnecessarily. The preferred method for RCS cooldown is using the turbine bypass system, but an unnecessary MSIS would interrupt this flowpath and force the operator to either reset the MSIS or use the ADVs. An unnecessary SIAS would start both emergency diesel generators, [start emergency containment cooling], isolate letdown and commence emergency boration.

"CONTROLLED COOLDOWN: The operator is in control of the cooldown, i.e., the cooldown is within the designed reset capabilities of MSIS and SIAS, or the operator has the ability to stop or maintain a given pressure and temperature band."

Sequence

This step is sequenced after the directions to commence a cooldown.

Plant Parameters

None

Step Number 64 Void Elimination

Intent

The intent of this step is to eliminate voids in the RCS that may prevent lowering RCS pressure to SDC entry conditions.

Method

The operator should continuously monitor for the presence of voids in the reactor coolant system. If voiding is suspected, then the operator should proceed as follows:

a. The operator is directed to secure letdown. If voiding is occurring, the continued net loss of inventory from the RCS will only make the situation worst. If desired, letdown may be throttled to a minimum flow value instead of securing it completely, provided charging is maintained to ensure a net gain in RCS inventory while performing the void elimination procedure. Throttling verses securing may be preferred if a plant is concerned about thermal shocking letdown components such as the heat exchangers.

b. The operator is directed to stop attempting to depressurize the RCS. Depressurization activities will only make the situation worst by enlarging the void.

c. There are two primary methods which have been demonstrated successful for eliminating voiding in the RCS. They are: 1) cycling RCS pressure, and 2) operating the RV vent valves. One alternate method is available which is specifically directed at eliminating voiding in steam generator tubing.

   Pressurizing and depressurizing the RCS within the limits [Post Accident PT limits] may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In the case of a void in the reactor vessel, the pressurization/ depressurization cycle will produce a fill and drain of the reactor vessel to help eliminate the void. Operation of the RV vent valves may also be used to reduce or eliminate a void in the head. The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) and the SIS/charging system (alternative method).

d. Monitor Pressurizer Level and the RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

   (continue)

If indications of RCS voiding continue, and voiding is suspected to exist in the steam generator tubes, then the contingency actions can be used to cool the steam generator and eliminate the voiding. This determination can be made by observing if saturated temperature in the steam generator is greater than RCS temperature. The suspected steam generator can then be cooled by performing any combination of the following : 1) blow down to lower steam generator level below the top of the tube bundle, 2) feed to add cool water and restore level, 3) steam to the condenser or to the atmosphere.

Blowdown the affected steam generator will reduce level and expose the upper portion of the tube bundle. This will be effective for condensing steam voids but will not have an effect on non-condensable gases trapped in the tube bundle. A buildup of non-condensable gases in the tube bundles will not hinder natural circulation event with a large number of the tubes blocked. This is due to the small amount of heat transfer area required for the removal of decay heat.

Monitor pressurizer level and RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

Continue void elimination procedures until either the voiding is eliminated or the attempts have proved unsuccessful.

Sequence

This step should be located soon after commencing plant cooldown.

Plant Parameters

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

Loss of Coolant Accident Recovery Bases

Step Number 65 Restore Offsite Power

Intent

The intent of this step is to restore offsite power as conditions and resources permit.

Method

The method for restoration of offsite power are plant specific. This action is necessary to re-energize vital and non-vital equipment and restore the plant to a normal configuration. This step has been placed the procedure at a location where it is expected that control of the plant has most likely been re-gained. The operator will begin to concentrate on restoring the plant to a more normal configuration. As part of these efforts the operator will need to restore any vital and non-vital buses that may have been lost due to the loss of offsite power. This will aid in event recovery and help to ensure a smother transition out of the EPGs.

Sequence

This step is sequenced after the major mitigation steps.

Plant Parameters

None

Step Number 66 Verify Single Phase Natural Circulation

Intent

The intent of this step is to verify natural circulation flow is established and is supporting RCS heat removal.

Method

After RCPs are tripped, natural circulation RCS flow should develop within [5-15 minutes]. Natural circulation flow will continue as long as RCS pressure and inventory control are maintained, and at least one steam generator is available for RCS heat removal.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

- Loop delta T less than [normal full power delta T]
- Hot and cold leg temperature constant or decreasing
- RCS is equal to or greater than [the minimum RCS subcooling] based on [representative CET] temperature
- No abnormal difference [greater than 10°F] between [Th RTDs] and [representative CET]

Hot leg RTD temperatures should be consistent with the [representative CETs]. The intent is to observe that *same temperature* fluid is moving from the core to the hot leg. Therefore, adequate natural circulation flow is indicated by the [representative CET] temperature being approximately equal to the hot leg RTD temperatures. An abnormal difference between Th and [representative CET] could be any difference greater than [10°F].

Natural circulation flow is determined by a combination of factors. The factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. These density differences occur when primary to secondary heat removal through the steam generator tubes is utilized. Figure [10-7] illustrates that a reactor vessel upper head void and natural circulation flow can occur at the same time.

If the RCS does not indicate natural circulation is in progress, operators should ensure that the systems and safety functions needed to support natural circulation are available and functioning properly. Specifically, the operator should ensure that RCS heat removal is available via a SG, and that heat removal is being controlled by steam generator feeding and steaming.

Sequence

This step is usually put after the evaluation of restarting RCPs, after the initial event mitigation steps are initiated. Or, may be used whenever the need to ensure proper natural circulation flow occurs.

(continue)

Plant Parameters

RCS Loop delta T less than normal full power delta T

The engineering limit is based on the normal full power delta T. The intent of the engineering limit is to provide a value that enables the operators to assess the status of single phase liquid natural circulation flow in at least one RCS loop. Under single phase natural circulation flow, the operating loop delta-T should be less than the normal full power delta-T. A loop delta-T less than the full power delta-T ensures that the [power/flow] ratio is within the nominal thermal hydraulic parameters for the RCS (i.e., the power to flow ratio is less than that for full power operation).

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

No abnormal difference between Thot RTDs and representative CET temperature

The engineering limit is based on engineering judgment. The operational value is nominally [+/-10 °F]. The intent of the engineering limit is to provide an approximate operational value that can be used, in conjunction with other indications, to assess the status of single phase liquid natural circulation flow in at least one RCS loop. Under single phase natural circulation flow, core exit thermocouple temperatures should be consistent with the operating loop hot leg temperature. Approximate agreement between hot leg temperature and CET is corroborative evidence that there is fluid communication (flow) between the core and at least one hot leg.

Step Number 67 RCP Restart Criteria

Intent

The intent of this step is to ensure the RCS and the RCP(s) selected for restart are in the proper condition to support RCP restart and operation. This step is only applicable if RCP restart is desired.

In general, forced circulation is normally the preferred mode of core cooling because it provides more responsive control of RCS temperature and pressure. But the need for forced circulation operation must be weighed against any potential risks of RCP operation. Once RCPs have been stopped, restarting of RCPs should be considered a major plant evolution and given considerable thought before restart is attempted. In addition to the RCP restart criteria given in the instruction the following items should be considered when deciding whether RCP restart is desirable: 1) the effectiveness of RCS heat removal using natural circulation, and 2) the need for main pressurizer spray capability.

Method

Verify single phase natural circulation has been established for the preceding 20 minutes. Single phase natural circulation has been established for the preceding 20 minutes. In the course of some LOCA events there is a span of time during which steam generated in the core is condensed in the steam generator tubes. The steam generated in the core is largely devoid of boric acid which remains dissolved in the highly borated liquid in the core. The condensate formed from this steam is also largely devoid of dissolved boric acid. This process, designated as reflux boiling, serves to transfer heat from the core to the steam generators when the primary side liquid level falls below the top of the steam generator tubes.

A core reactivity problem may occur if unborated condensate, which has accumulated in the cold leg side of the RCS, returns to the reactor core without sufficient mixing with the highly borated water in the RCS. Therefore, a twenty minute delay of RCP restart is required so that any unborated water will make its initial pass through the core under the relatively slow single phase natural circulation flowrate, and thus reduce the rate of reactivity change in the core. Twenty minutes is considered a conservative nominal loop transient time for natural circulation flow (ref. 41).

Verify RCS pressure and temperature are within the [Post Accident PT curve] limits for RCP operation, REFER TO Figure 13.8. This substep is a check to see that RCS pressure and temperature conditions will support RCP restart. The [Post Accident PT curve] should include RCP operation curves that ensure RCP NPSH and reactor core subcooling requirements are within their limits. Minimum RCS subcooling should be based on [representative CET] temperature.

In addition, to checking the RCS [Post Accident PT curve], the operators should be aware that the pressurizer water and steam space may not have reached equilibrium saturation conditions if there was a large level change (rise) a short time ago. This may result in the pressurizer being much less able to mitigate the pressure effects of a significant outsurge.

(continue)

(continued)

Verify the duration of [CCW] interruption to RCPs is within limits for RCP restart, REFER TO [RCP technical manual]. This substep prompts the operator to check that any cooling interruption to RCPs is within limits that allow for RCP restart. Each plant should establish guidelines for RCP restart after cooling interruption. The guidelines should be based on RCP vendor information and other appropriate sources.

Verify RCP seal pressures and temperatures are within limits for RCP restart, REFER TO [RCP technical manual]. This substep prompts the operator to check that RCP seal conditions are within limits that allow for RCP restart. Each plant should have guidelines for limiting RCP seal conditions based on RCP vendor information and other appropriate sources.

Verify the following RCP auxiliaries are operating properly to support RCP operation: oil lift system, bearing and motor cooling systems. This substep is an additional reminder to specifically check that the RCP oil lift system, and bearing and motor cooling systems are operating properly. There should be no bearing and motor cooling systems high temperature alarms on the selected RCPs.

[Verify RCS conditions are within the RCP start limits of plant technical specifications]. Plant technical specification typically provide LCO requirements regarding RCP restart and: RCS and steam generator Delta T, pressurizer pressure, and pressurizer level. These limits and their bases should be reviewed for applicability prior to RCP restart.

Ensure that at least one steam generator is controlling RCS heat removal with level being maintained within [normal control band]. The basic intent of this substep is to ensure that an effective heat sink is available prior to starting an RCP. One-third tube coverage is generally considered adequate to remove decay heat either via natural circulation or forced flow conditions. However, to be consistent with general SG level recovery guidance used throughout the EPGs, the operator is instructed to ensure SG level is within the [normal control band]. It is recognized that SG level in the [normal control band] is more than the minimum required level for RCS heat removal.

Use of SG safeties is generally considered an acceptable method for RCS heat removal, although not a preferred method because of the loss of RCS temperature control and the inability to cooldown. Therefore, starting RCPs while on the SG safeties should only be done after a through review of the likely affects of RCP restart, and a determination that these affects are manageable within the context of current plant status. The intent here is to maximize the reasonable options available to the operator and allow RCP restart and operation while on SG safeties.

There are some predictable affects of transitioning from natural circulation to forced flow while on the SG safeties. From best estimate analysis it's assumed that post trip RCS heat removal via SG safeties is likely to be a cyclical evolution where the SG safety valve opens periodically removing heat and then shuts. The period of the cycling (the time between safety valve lifts) is determined by heat removal requirements. While heat removal from the RCS is through the SG safeties, RCS Tc will seek a temperature just slightly higher than the corresponding saturation temperature for the lowest SG safety valve lift pressure. Therefore, under natural circulation, with a much wider delta T than forced flow, there will be a higher overall effective RCS temperature than under forced flow conditions.

(continue)

(continued)

During the initial moments after starting a RCP, Tave will drop as the core delta T collapses with the subsequent change in pressurizer level. The additional heat input from the RCPs may raise the cycle rate of the SG safeties (lift, blowdown and close), but should not appreciably change the RCS temperature at which the SG safety lifts. These affects should be considered before starting an RCP while on the SG safety valves.

A pressurizer level [within the RCP restart level band] provides a minimum level to help mitigate the effects of RCS void collapse during RCP restart. And, a maximum level to keep a pressurizer steam space available for slight raise in RCS temperatures. Plant technical specifications typically address this topic and should be consulted when determining the plant specific RCP restart level band.

Ensure electrical power is available to the RCPs. This substep directs the operator to evaluate the availability and reliability of RCP power supplies, and to ensure their readiness to support RCP restart.

[RCP technical manual] is used generically to mean plant specific RCP technical information.

Sequence

This step should be placed just before actual RCP restart.

Plant Parameters

Pressurizer pressure within RCP NPSH limits

The engineering Limit is based on the reactor coolant pump suction pressure that meets or exceeds the minimum NPSH and pump seal pressure requirements. The engineering limit is intended on preserving RCP operability. Operation of the RCPs must be constrained to ensure that adequate net positive suction head (NPSH) is available to preclude pump cavitation and damage. The RCP seals also require a minimum suction pressure for reliable long-lived service. These pump suction pressure requirements are established by the pump vendor.

Steam Generator level within the normal control range

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

(continue)

Pressurizer level in the restart level control band

Establishing pressurizer level within the required restart level band provides a minimum level, nominally [200"] to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. The upper engineering limit is based on TS RCP restart requirements which will ensure that there is still sufficient steam space to ensure pressure control using Pressurizer sprays, and preclude a large pressure surge in the RCS following restart. The lower engineering limit is based on keeping the pressurizer heaters covered to preserve normal means of RCS pressure control following RCP restart. The pressurizer heaters maintain RCS pressure to keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow.

Step Number 68 RCP Start

Intent

The intent of this step is to take final actions in preparation for RCP restart, start the selected RCPs, and monitor plant response and RCP operation after RCP start.

Method

A pressurizer level [within the RCP restart level band] provides a minimum level to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. Plant technical specifications typically address this topic and should be consulted when determining the plant specific RCP restart level band.

Starting one RCP in opposite loops provides forced circulation through the core, better cooling of the RV head region, the capability for the use of normal pressurizer spray, condenses RCS steam voids, and removes non-condensable gases from the SG tubes. Further, starting a RCP in each loop simplifies RCS temperature control and facilitates a plant cooldown. RCP operation should be limited to one reactor coolant pump in each loop to minimize heat input to the RCS (Reference 22).

Plant technical specification typically provide LCO requirements regarding RCP restart and: RCS and steam generator Delta T, pressurizer pressure, and pressurizer level. These limits and their bases should be reviewed for applicability prior to RCP restart.

Verify RCS pressure and temperature are within the [Post Accident PT curve] limits for RCP operation, REFER TO Figure 13.8. This substep is a check to see that RCS pressure and temperature conditions are responding favorably to RCP restart and will support continued operation of RCPs. The [Post Accident PT curve] should include RCP operation curves that ensure RCP NPSH and reactor core subcooling requirements are within their limits. Minimum RCS subcooling should be based on [representative CET] temperature.

In addition to the conditions stated above, plant specific RCP operating limits should be verified immediately after restart as well as closely monitoring RCP operation while they are in operation.

Operating charging and HPSI pumps until HPSI throttle criteria are met ensures that pressurizer heaters remain covered in the event of RCS void collapse after RCP restart.

If steam voids are present in the RCS during RCP restart, pressurizer level and pressure may lower due to steam void condensation. Depending on the void volume, there is a potential to drain the pressurizer. The operator should be mindful of this affect and immediately commence restoring pressurizer level using charging and HPSI pumps if void collapse is suspected. This issue should be addressed in operator training.

Sequence

This step should immediately follow the RCP restart criteria step.

(continue)

(continued)

Plant Parameters

Pressurizer level in the restart level control band

Establishing pressurizer level within the required restart level band provides a minimum level, nominally [200"] to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. The upper engineering limit is based on TS RCP restart requirements which will ensure that there is still sufficient steam space to ensure pressure control using Pressurizer sprays, and preclude a large pressure surge in the RCS following restart. The lower engineering limit is based on keeping the pressurizer heaters covered to preserve normal means of RCS pressure control following RCP restart. The pressurizer heaters maintain RCS pressure to keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow.

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

Step Number 69 SIT Isolation and Venting Criteria

Intent

The intent of this step is to prevent unnecessary injection of the Safety Injection Tank (SIT) water volume and possible injection of the SIT cover gas during a cooldown. Do not isolate SITs until it is confirmed that RCS pressure is under control and no LOCA event requiring SIT injection is in progress. If injected into the RCS, nitrogen gas could cause the steam generator tubes to become gas bound, thereby reducing their effectiveness as a heat sink.

Method

When pressurizer pressure reaches [SIT isolation pressure] the SITs should be isolated by closing their discharge valves and depressurized to prevent an undesired injection of water or the nitrogen cover gas into the RCS as RCS pressure is reduced during a cooldown.

Sequence

This step is sequenced after instructions to cooldown/depressurize the RCS. Ensure that no LOCA event is in progress prior to SIT isolation by verifying RCS inventory and pressure are under control. As there is no urgency to perform this step until the SIT pressure is approached. Even then, it will take some time for the entire SIT volume to be injected and N2 injection to be a real possibility.

Plant Parameters

Pressurizer pressure less then the SIT isolation pressure

The engineering Limit is based on the maximum Safety Injection Tank (SIT) pressure, nominally [250 psia]. The SITs are isolated and vented to prevent SIT discharge of water or nitrogen gas into the RCS during a plant cooldown/depressurization. For plants with high pressure SITs, this may be necessary to allow the plant to be brought to shutdown cooling system entry conditions.

Step Number 70 LTOP Initiation Criteria

Intent

The intent of this step is to ensure Low Temperature Overpressure Protection is initiated when required.

Low Temperature overpressurization protection (LTOP) is instituted at a temperature of [LTOP enabling criteria] to protect against subjecting the RCS pressure boundary to high pressure at low temperature, which could lead to brittle fracture.

Method

When [LTOP enabling criteria] are met, the operator initiates low temperature overpressurization protection.

Sequence

This step is to be located late in the procedure, after the plant has been cooled to the greatest extent possible using the steam generators..

Plant Parameters

RCS temperature less than the LTOP enabling criteria

The engineering limit is based on the LTOP enabling temperature found in technical specifications, nominally [285°F]. This operational limit is intended to ensure that low temperature overpressurization protection (LTOP) is lined up at the required cold leg temperature to protect against subjecting the RCS pressure boundary to low temperature brittle fracture.

Step Number 71 Reset Safety Systems

Intent

The intent of this step is to secure or restore safety systems that have actuated because they were needed, but are no longer needed.

Method

The operator is directed to restore safety systems to normal standby status using plant specific procedures. It is best to place the plant in as normal a configuration as possible prior to exiting the procedure. This is especially important if the operator will be exiting to a normal operating procedure which would not expect ESFAS signals to be present.

Sequence

This step is placed late in the procedure prior to initiating Shutdown Cooling.

Plant Parameters

None

Loss of Coolant Accident Recovery Bases

Step Number 72 SDC Entry Conditions

Intent

The intent of this step is to initiate shutdown cooling once the required conditions are established.

Method

The following conditions should be exist prior to establishing SDC. It is implied that, all of the entry conditions are stable or trending to further within the entry conditions.

a. pressurizer level control should be established and verified by a level greater than [Heater cutoff setpoint].

b. RCS subcooling should be at least the [required minimum subcooling],

c. RCS pressure should be at or below the [SDC entry pressure]

d. RCS hot leg temperature should be at or below the [SDC entry temperature].

e RCS activity level should be at or below acceptable limits. Before the shutdown cooling system is operated, the RCS activity levels must be considered since the RCS fluid will now be circulated outside of the containment building. Establishing the plant on shutdown cooling will result in the RCS coolant outside containment. If high activity is present. Such circulation has the potential for release to the environment. If the potential for significant releases exists, it may be more desirable to continue using the established method of cooling the plant. In addition, access to equipment where the coolant will be circulated must also be considered.

Sequence

This step is sequenced after the safety functions are under control. It provides an exit point for the guideline.

Plant Parameters

Pressurizer level greater than the heater cutoff setpoint

The engineering limit is based on keeping the pressurizer heaters covered to preserve the normal means of RCS pressure control following a reactor trip. The pressurizer heaters are used to maintain RCS pressure, and keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow. The heater cutoff value is nominally [100"] decreasing.

(continue)

(continued)

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Pressurizer pressure less than the Shutdown Cooling entry pressure

The upper engineering limit is based on the shutdown cooling system design pressure. The shutdown cooling system may be placed in operation when the RCS has been depressurized to the point that the shutdown cooling system will not be exposed to pressures greater than its design pressure. The operational limit, nominally [300 psia] (including the instrument uncertainties) should be less than the setpoint of the permissive interlock which prevents opening of the shutdown cooling suction line isolation valves.

RCS hot leg temperature less than the Shutdown Cooling entry temperature

The upper engineering limit is based on the design temperature of the shutdown cooling system components, nominally [300]°F. The shutdown cooling system may be placed in operation when hot leg temperature is less than [300]°F.

Loss of Coolant Accident Recovery Bases

LOCA Safety Function Status Check Bases

1. Reactivity Control

Intent

The intent of the Reactivity Control safety function status check is to ensure that the reactor is shut down, and remains shut down.

Method

For all emergency events, the reactor must be shutdown. This is determined using one of two methods:

1. Reactor power lowering and a [negative startup rate] can be used in the short term, post-trip, to check that reactivity control is established.
2. Reactor power less than [maximum expected reactor power 15 minutes after shutdown], and stable or lowering is positive indication that reactivity control has been established.

Assurance must exist that the reactor will remain shutdown. Three methods exist to confirm this:

1. Requiring that no more than [one full length CEA] be stuck out (not fully inserted) ensures that the actual CEA positions are within the limits assumed in the technical specification definition of shutdown margin. The CEA positions can then be used to determine that adequate shutdown margin exists.
2. The safety analyses for a main steam line break assume that only the most reactive CEA sticks out upon a reactor trip. Therefore, if more than one CEA sticks out, the reactor must be emergency borated to restore shutdown margin.
3. Determining that [shutdown margin is adequate] directly by calculation is sufficient in itself.

Sequence

Safety Function Status Checklist

(continue)

Plant Parameters

Reactor power is less than the maximum expected reactor power 15 minutes after shutdown

The engineering limit is based on the post trip trend of reactor power following an uncomplicated trip from 100% power and extended full power operation. The intent is to provide the maximum post-trip value of reactor power that will verify successful reactivity control and confirm that the reactor is shutdown and is being maintained shutdown throughout the event.

No more than one full length CEA not inserted

The bases for the engineering limit is to ensure that the actual CEA positions are within the limits assumed in the technical specification definition of shutdown margin. The intent is to determine the status of the reactivity control safety function via CEA position. In the context of the EPGs, the purpose for determining the status of the reactivity control safety function via CEA position is to ensure sufficient shutdown margin.

[adequate shutdown margin]

The intent of the engineering limit is to be in compliance with plant specific technical specification shutdown margin requirements based on moderator temperature.

2. Maintenance of Vital Auxiliaries (AC and DC Power)

Intent

The intent of the Maintenance of Vital Auxiliaries safety function status check is to verify that electrical power is available to support and maintain control of all other safety functions.

In general, the minimum electrical power requirements needed to maintain all other safety functions are:

1) at least one vital 4.16 kV bus energized
2) at least one vital 120 V AC bus energized
3) at least one vital 125 V DC bus energized

Method

The intend of this step is accomplished by verifying:

a. at least one vital 4.16 kV AC bus is energized, and

b. at least one train of vital DC power is energized, and

c. at least one train of 120 V AC instrument power is energized.

The exact methods used to verify these criteria are plant specific.

In the case of the 4.16 kV AC bus, in addition to having the proper voltage on the bus there must also be control power available to ensure auto/remote operation of the breakers. This generally requires that the DC bus and the 4.16 kV bus be part of the same safety train.

Sequence

Safety Function Status Checklist

Plant Parameters

None

3. RCS Inventory Control

Intent

The intent of this SFSC is to provide criteria to assess whether the limits for the RCS Inventory Control safety function are being maintained.

Method

Condition 1:

Charging, letdown and Safety Injection flow must be maintaining or restoring pressurizer level to greater than the [minimum level for inventory control]. The engineering limit for this minimum level corresponds to the lowest level which can be accepted before the pressurize is considered drained. There is no upper limit on pressurizer level, since the inventory control safety function can be considered satisfied even if the pressurizer is water solid.

[Minimum RCS subcooling], coexisting with a pressurizer level within greater than the [minimum level for inventory control] indicates adequate RCS inventory control via a saturated bubble in the pressurizer. Representative CET Temperature is used to determine RCS subcooling with natural circulation flow and Th RTDs are used during forced circulation flow.

An RVLMS indication that level in the RV head is greater than the [top of the hot leg nozzles], taken in conjunction with pressurizer level and RCS subcooling, indicates that adequate RCS inventory control has been established.

Condition 2:

If pressurizer level is less than the [minimum level for inventory control], operators use reactor vessel level and the SI flow to confirm acceptable inventory control. For cases where RCS inventory has badly degraded, SI flow within the [SI delivery curves] provides implicit assurance that inventory control is being maintained with reactor vessel level greater than [top of active fuel region]. Some analysis may indicate momentary partial core uncovery. Each utility should choose a value that allows for this condition. Some plants require a certain number of charging pumps to be in operation to augment SI flow per their safety analyses. Therefore, [the required number of charging pumps in operation] is included in this condition in brackets.

Sequence

N/A The sequence of the SFSC throughout the guidelines is based on the hierarchy of safety functions. However, the process of checking the safety functions is periodic and continuous as long as a particular guideline is in use.

(continue)

(continued)

Plant Parameters

Pressurizer level greater than the minimum level for inventory control

The lower engineering limit corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The lower operational limit, nominally [35"], is approximately ([10%]) of a typical Combustion Engineering Pressurizer's range, and was chosen as the lower limit to account for some instrument and process fluid uncertainties. The lower limit is based on the lowest indication, approximately [2%] that with confidence reflects an actual Pressurizer level. Instrument uncertainties, assumed to be ± 8%, were conservatively applied to the engineering limit, yielding the lower operational limit of [10%].

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that, 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

Reactor Vessel level greater than the top of active fuel region

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the active fuel. However, the lowest sensor in the Reactor Vessel Level Monitoring System (RVLMS) is typically located just above the top of the fuel alignment plate. Nominal operating value is the lowest level sensor in the RVLMS.

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

4. RCS Pressure Control

Intent

The intent of this safety function status check is to verify RCS pressure control.

Method

Condition 1:

RCS pressure control is satisfactory if the RCS can be maintained within the post-accident PT limits utilizing pressurizer heaters and spray, charging and SI pumps. Maintaining the RCS within the limits of the Post Accident PT limits maintains the RCS subcooling necessary for single phase natural circulation flow and minimizes the possibility of PTS.

Conditions 2:

If RCS pressure can not be maintained within the post-accident PT limits, then pressure control is satisfied when two trains of SI are injecting a borated source of water into the RCS in accordance with the [SI delivery curves]. [Some plants may also require one or more charging pumps to be operating to satisfy SBLOCA analysis requirements for cases where SIAS has actuated and RCS pressure remains above the shut-off head of the HPSI pumps. In this case, the charging pumps will be the sole means of injecting water into the RCS.]

Once SIS flow has been throttled/stopped, or a RAS has occurred, then the [SI delivery curves] are no longer applicable.

Sequence

Not applicable

Plant Parameters

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

5. Core Heat Removal

Intent

The intent of this safety function status check is to verify that the Core Heat Removal safety function is satisfied.

Core exit temperatures (Th RTD and representative CET) are used to determine whether the core is covered or not. If the core is uncovered, core exit temperatures will rapidly increase to super heated range.

Method

Super-heated condition in the core can only occur with core uncovery. Core uncovery results from a loss of RCS inventory which generally results from two accident scenarios: LOCA or loss of steam generators as a heat sink. LOCA results directly in a loss of inventory. Very small break LOCAs will not result in depressurization much below the HPSI pump shutoff head. For these small break LOCAs superheat is indicative of core uncovery occurring at high pressure. For large break LOCAs which result in rapid depressurization to less than 300 psia, superheat which is indicative of core uncovery occurs at low pressure. A loss of inventory (leading to core uncovery) can also result from a loss of S/G heat sink which causes RCS pressure to rise high enough to lift the [PORVs] and pressurizer safeties. Core uncovery and, therefore, superheat on the [CETs] indicate an advanced phase in the approach to inadequate core cooling and are undesirable. If at anytime superheat is approached or indicated, the operator should review the effectiveness of earlier measures and take all possible steps to restore the inventory to at least a core covered condition as indicated by saturation or subcooling on the [CETs], Subcooled Margin Monitor, [or as an indication of core coverage on the RVLMS].

Sequence

N/A The sequence of the SFSC throughout the guidelines is based on the hierarchy of safety functions. However, the process of checking the safety functions is periodic and continuous as long as a particular guideline is in use.

Plant Parameters

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

6. RCS Heat Removal

Intent

The intent of this safety function status check is verify adequate RCS heat removal via at least one steam generator.

Although SG heat removal capability is only required for a small break LOCA, the LOCA procedure does not distinguish between large and small breaks. Therefore, SG heat removal capability is always required in the LOCA procedure. Operator training should address the need for SG heat removal capability during a small break LOCA when break flow may not be enough to remove decay heat.

Method

At least one SG with level in the [normal control band] or being restored by main or auxiliary feedwater, ensures that the in use SG has more than sufficient inventory for RCS heat removal. This level provides adequate heat removal capability under forced flow and in natural circulation conditions. The reason the check specifies level being restored by “main or auxiliary feedwater” is because sometimes level can rise due to a heatup of the steam generator or due to steam generator swell. This step requires the operator to verify that main or auxiliary feedwater is flowing to the steam generator(s) to restore level and that the level rises is not from another heatup or swell.

RCS Tc temperatures stable or lowering indicates heat is being removed from the RCS, assuming that no operator actions or plant events have caused a momentary, correctable reduction in RCS heat removal (e.g., ADV is closed automatically or manually).

Sequence

Safety Function Status Checklist

(continue)

Plant Parameters

Steam Generator level within the normal control band

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

7. Containment Isolation

Intent

The intent of this safety function status check is to confirm containment integrity exists. Consequently, radionuclides will remain in the containment building and not be released to the environment.

Method

Condition 1:

This condition addresses containment pressure less than [CIAS setpoint]. This acceptance criteria are designed to confirm that a normal containment environment exists.

a. There should be no steam plant activity alarms or unexplained rises if only a LOCA is occurring. This criterion is used as a diagnostic to verify that only a LOCA is occurring. If there is an unexplained rise in steam plant activity, or alarms are present, this would be indicative of an SGTR.

b. This criterion verifies that containment pressure is less than the [CIAS setpoint] (as would be the case for a while with a stuck open PORV). If containment pressure is greater than the CIAS setpoint this condition does not apply.

c. This criterion verifies that there are no containment area radiation alarms. Each plant should specify which monitors should be used to verify this criteria. The generic criteria addresses only high alarms on area rad monitors because they are more indicative of a LOCA inside containment, as opposed to an RCS leak. Containment atmospheric radiation monitors are generally used for leak detection. If any high rad alarms are present, this condition does not apply.

Condition 2:

If CIAS is present, then containment isolation is satisfied if no steam plant activity monitor is alarming or no unexplained rise in activity. These criteria ensure that the containment is isolated when necessary (greater than the CIAS setpoint) and that a SGTR is considered when performing Diagnostic Actions if steam plant radiation alarms are obtained.

The operator verifies that containment isolation occurs at the appropriate automatic setpoint. If containment isolation does not occur automatically then the operator should manually initiate containment isolation.

Sequence

Not applicable

(continue)

(continued)

Plant Parameters:

Containment pressure less than the [CIAS setpoint]

The bases for the engineering limit is the same as the bases for the technical specification setpoint for [CIAS/CCAS], nominally [4.0 psig]. The operational limit is the same as the engineering limit. The engineering limit establishes the increasing containment pressure value at which automatic controls activate to isolate [and cool] the containment, independent of operator action. The intent of the application is to prompt the operator to verify automatic Containment Isolation actuation and to manually initiate Containment Isolation and Emergency Cooling if they did not actuate when required.

Condenser offgas activity greater than the alarm setpoint

The engineering limit is the condenser off-gas monitor alarm setpoint, based on the minimum detectable activity. The intent of this application is to assist the operator in diagnosing a SGTR event, and to help to discriminate between a SGTR and other events that result in indications of RCS inventory loss (i.e. LOCAs and ESDEs). Operators should not overly rely on high radiation alarms to provide early warning of abnormal radiation levels. The operator should also trend radiation and radioactivity levels, and be alert to unexplained changes.

Containment area radiation monitors greater than the alarm setpoint

The engineering limit is the alarm setpoint, which is based on the minimum detectable radiation levels above background. The intent of the application is to determine if containment isolation is necessary and/or if containment integrity is being maintained, and to confirm that the radiation alarm is consistent with the diagnosed event. The operator is expected to routinely monitor and trend radiation and radioactivity levels, and be alert to unexplained changes. In the context of the EOPs, increases in containment area radiation may be indicative of a LOCA, core uncovery and core damage, or another containment radiation anomaly that must be investigated further to determine its full meaning and implications to plant safety.

(continue)

Steam plant activity greater than the alarm setpoint

The engineering limit is the alarm setpoint, which is based on the minimum detectable radiation levels above background. The intent of the application is to help the operator determine if containment isolation is necessary and/or if containment integrity is being maintained and to aid in determining if the radiation alarm is consistent with the diagnosed event. This instrument application is also used in SPTA SFSCs. The intent of this application is to assist the operator in diagnosing a SGTR event. The operator is expected to routinely monitor and trend radiation and radioactivity levels, and be alert to unexplained changes.

8. Containment Temperature and Pressure Control

Intent

The intent of this safety function status check is to verify that the containment environment is maintained within design temperature and pressure limits.
Method

Condition 1:

a. The specified containment temperature setpoint is the [saturated vapor temperature corresponding to the CSAS setpoint]. This provides an independent, approximate validation of indicated containment pressure when determining if containment spray and/or containment emergency cooling should have initiated.

b. The containment pressure setpoint is the [CSAS setpoint].

Condition 2:

If the containment temperature and pressure criteria of condition #1 are not satisfied, the operator should confirm that the required combination of equipment is in operation to ensure that 100% of the design heat load is being removed from the containment atmosphere.

a. The CTP safety function is satisfied if any of the following criteria are satisfied:

- The required number of containment spray systems are in operation.
- The required number of containment emergency cooling systems are in operation.
- The required combination of containment spray systems and containment emergency cooling systems are in operation.

b. Containment pressure is less than [containment design pressure]. The initiation of CSAS should prevent overpressurization of the containment building during the LOCA or MSLB. If containment pressure is in excess of design, the operator should proceed to the FRP. This is an indication that the plant may be headed for severe accident space.

Sequence

Not applicable

Plant Parameters

Containment atmospheric temperature less than the [saturated vapor temperature corresponding to CSAS setpoint]

The engineering limit may be based on the saturated vapor temperature corresponding to the Containment Spray Actuation (CSAS) Setpoint, or on the saturated vapor temperature derived from plant-specific computer modeling of high energy line break scenarios inside Containment corresponding to the CSAS setpoint, nominally [240 °F]. The primary purpose of this instrument application is to provide corroborative evidence that containment spray and/or containment emergency cooling should have initiated.

(continued)

Containment Pressure less than the [CSAS setpoint]

The basis for the engineering limit is the same as the basis for the technical specification setpoint for CSAS, nominally [10.0 psig]. The operational limit is the same as the engineering limit. The engineering limit establishes the increasing containment pressure at which automatic containment pressure/temperature controls activate to remove heat from the containment atmosphere, thereby ensuring that containment pressure remains below design pressure, independent of operator action. The intent of the application is to prompt the operator to verify automatic Containment Spray actuation or to manually initiate CSAS if it did not actuate when required.

Containment pressure is less than [containment design pressure]

The engineering limit is based on the containment design pressure. This limit is consistent with the FSAR design criteria and the limiting pressure assumed in the accident analysis for high energy line releases inside containment.

9. Containment Combustible Gas Control

Intent

The intent of this SFSC is to provide criteria to assess whether the Containment Combustible Gas Control safety function is being maintained.

Method

The SFSC provides three conditions of equipment operation and hydrogen concentration that are acceptable for maintenance of the CCGC SFSC.

a. The hydrogen levels are less than the [minimum detectable concentration].

b. The hydrogen is greater than or equal to [minimum detectable concentration] but less than the [lower flammability concentration], and the hydrogen recombiners should maintain the hydrogen concentration below that limit.

c. The concentration is greater than or equal to the [lower flammability concentration] and the hydrogen purge system is in operation.

The hydrogen concentration will be less than the [minimum detectable concentration] for some time into the LOCA.

If hydrogen is greater than or equal to [minimum detectable concentration], then operation of the hydrogen recombiners should maintain the hydrogen concentration below the [lower flammability concentration].

As a last resort, the hydrogen purge system can be operated (with TSC concurrence) to ensure containment combustible gas concentration is being lowered to acceptable limits.

Sequence

N/A The sequence of the SFSC throughout the guidelines is based on the hierarchy of safety functions. However, the process of checking the safety functions is periodic and continuous as long as a particular guideline is in use.

(continue)

Plant Parameters

Containment hydrogen concentration greater than minimum detectable concentration for hydrogen

The engineering limit establishes a nominal value for hydrogen that is high enough to be within the limits of detectability, yet low enough to permit the operator to take corrective action prior to the hydrogen concentration reaching hazardous levels (i.e. the flammability limit), nominal [0.5%].

Containment hydrogen concentration less than the lower flammability concentration for hydrogen

The engineering limit is based on ensuring the containment hydrogen concentration remains less than the lower flammable concentration following a DBA, nominally [4.0%] v/o. The intent of this application is to prevent a containment-wide hydrogen burn to avoid exceeding the containment pressure and temperature assumed in the safety analysis and minimize damage to safety-related equipment located in containment.

Event Strategy

This section contains the detailed LOCA operator actions strategy flow chart, Figure 5-19. The flow chart pictorially depicts the strategy around which the LOCA guideline is built. It is intended to assist the reader in understanding the intent of the guideline writer and for use in training. Operators should understand the major objectives of the guideline in order to facilitate their progress toward the guideline goals.

The strategy charts show the LOCA Recovery Guideline strategy in detail and list the guideline steps which correspond to each strategy objective. Some steps in the guideline may be performed at any time during the course of an event. Those steps which have an asterisk next to the step number can be performed at any time during the event.

Figure 5-19a
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

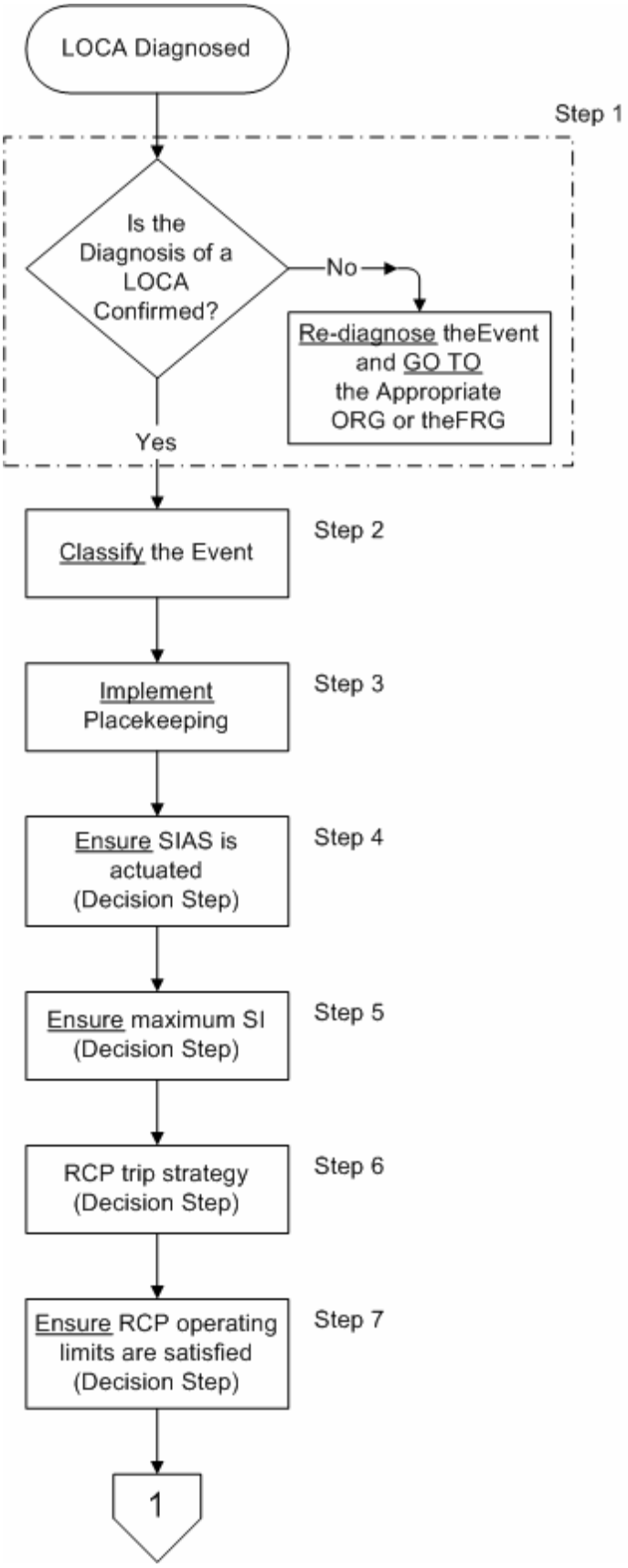


Figure 5-19b
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

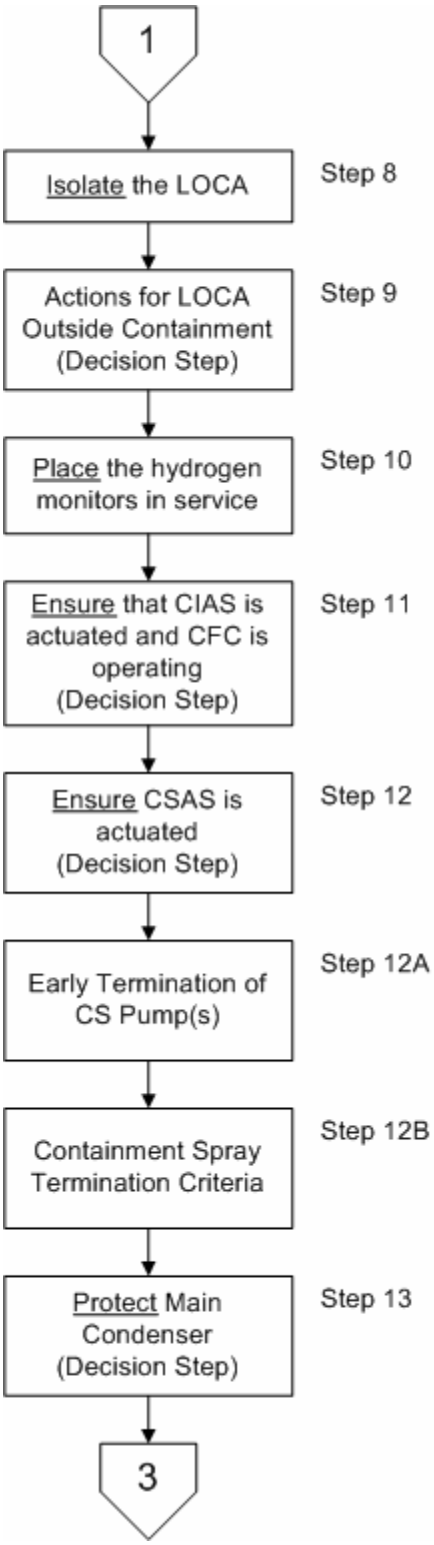


Figure 5-19c
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

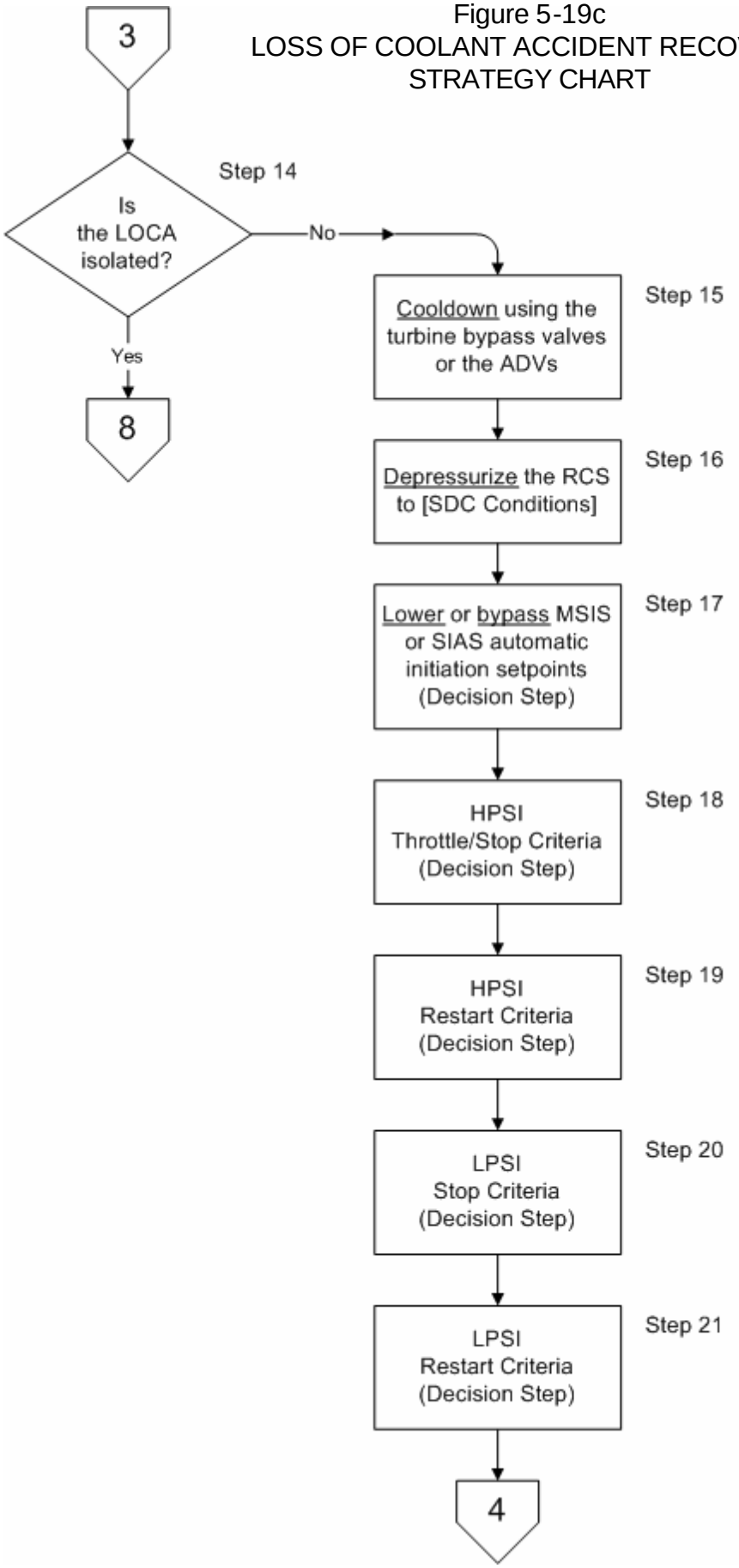


Figure 5-19d
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

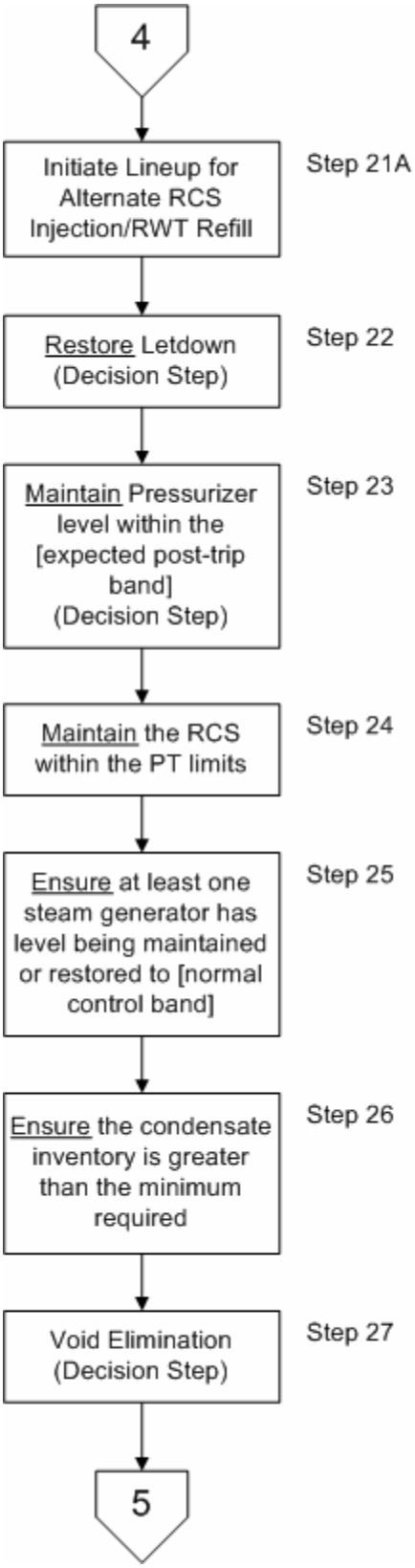


Figure 5-19e
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

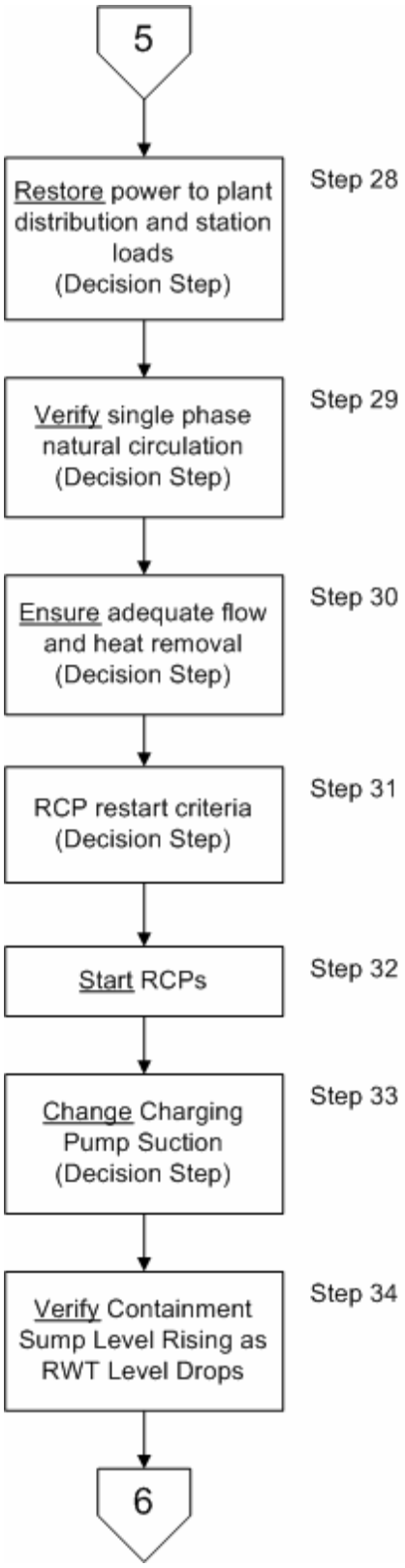


Figure 5-19f
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

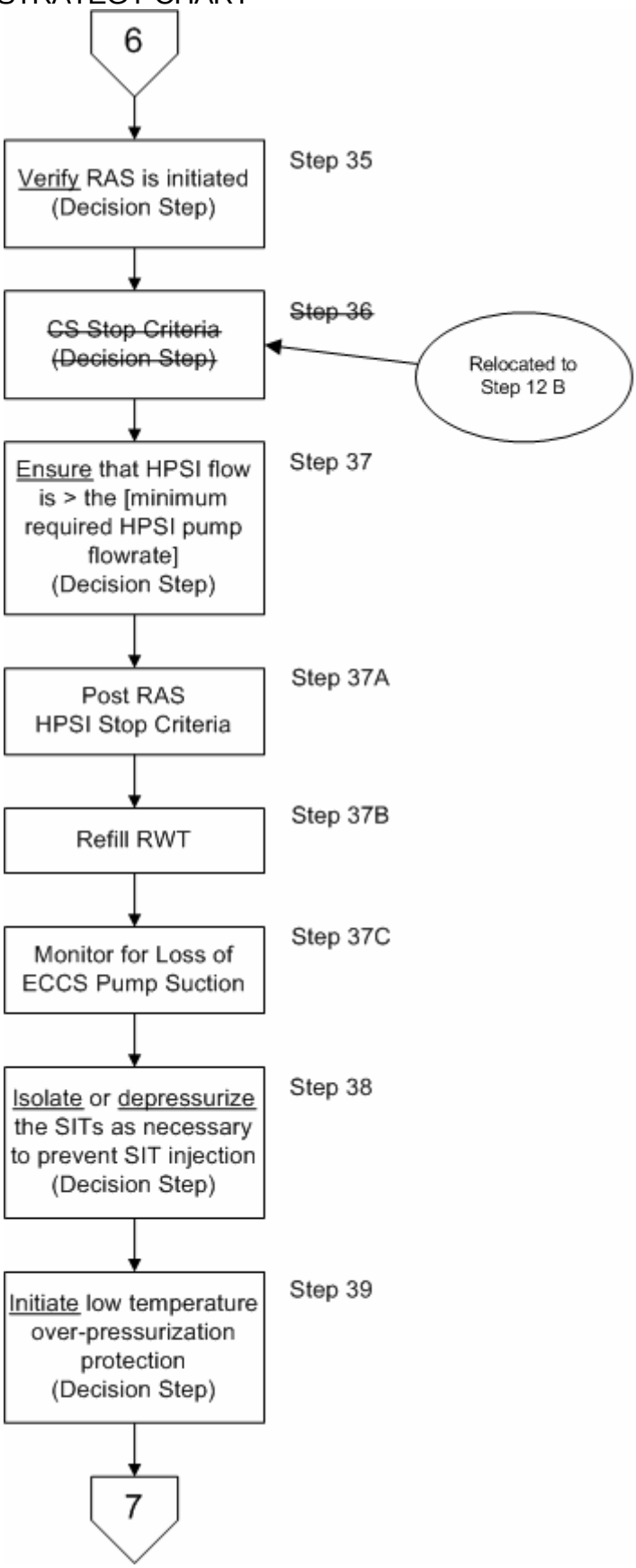


Figure 5-19g
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

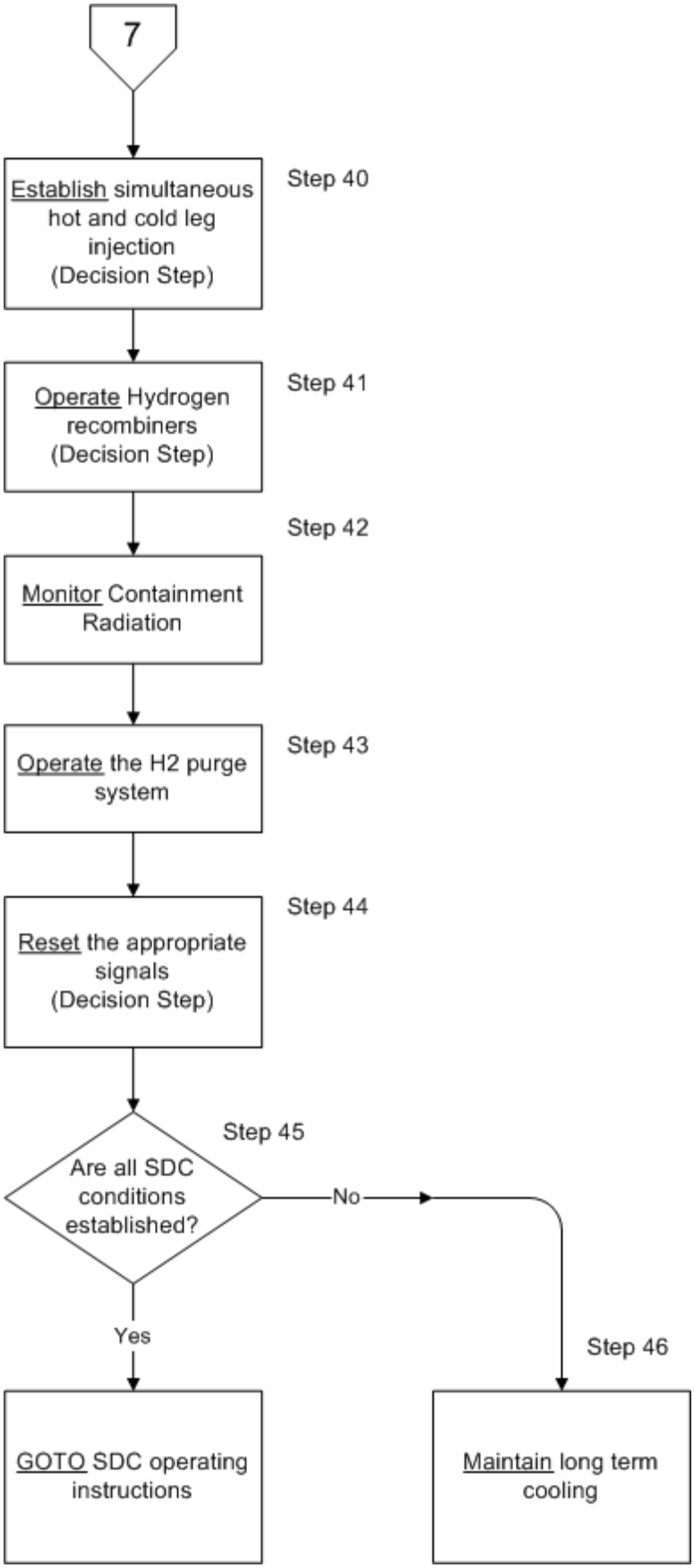


Figure 5-19h
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

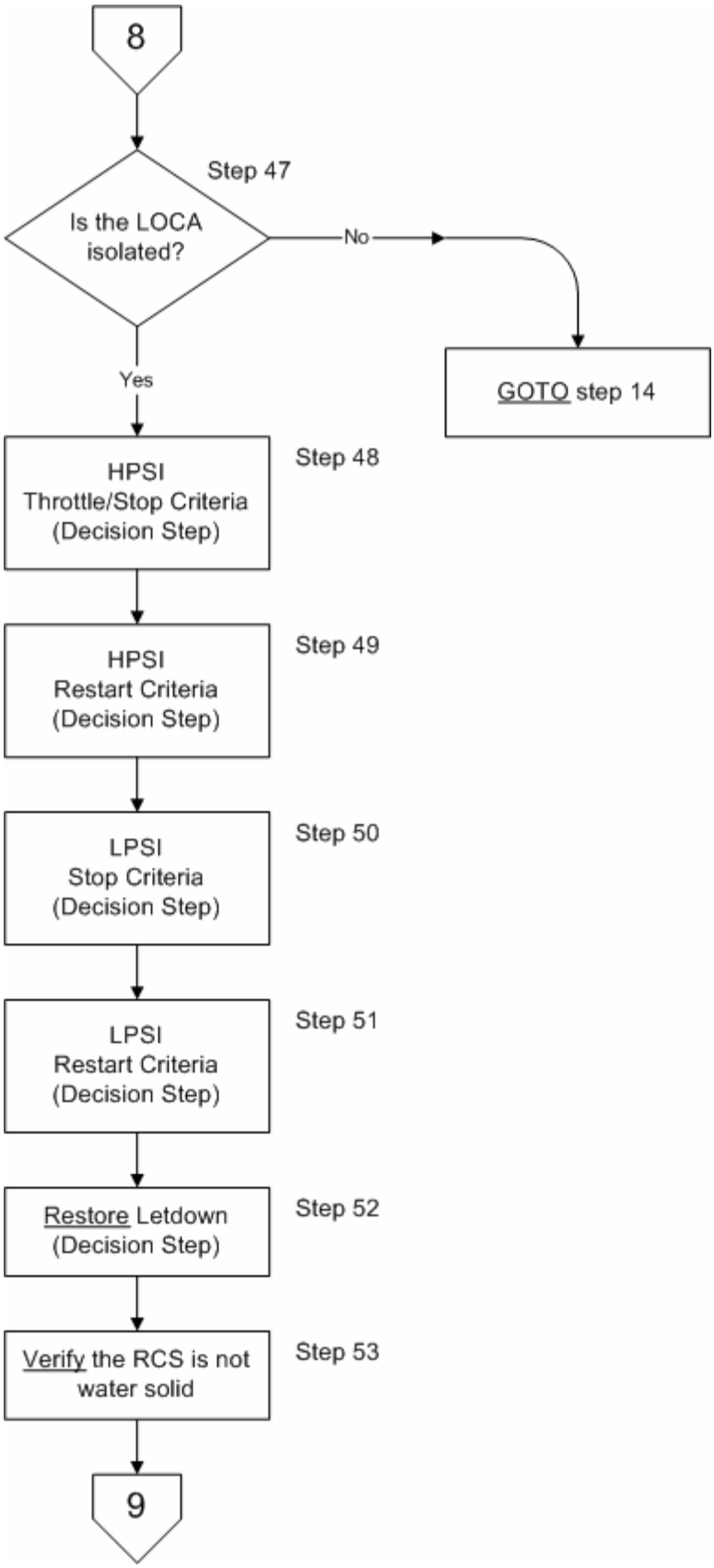


Figure 5-19i
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

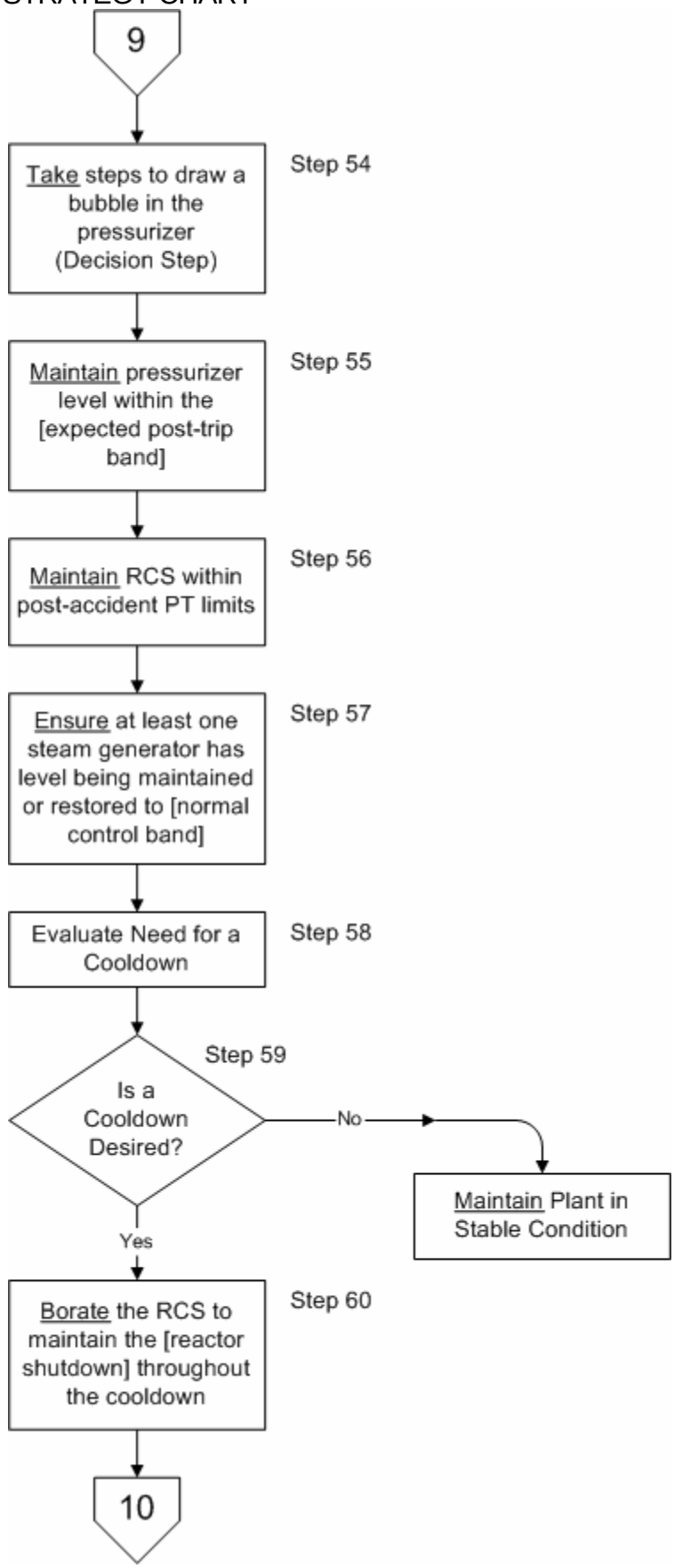


Figure 5-19j
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART

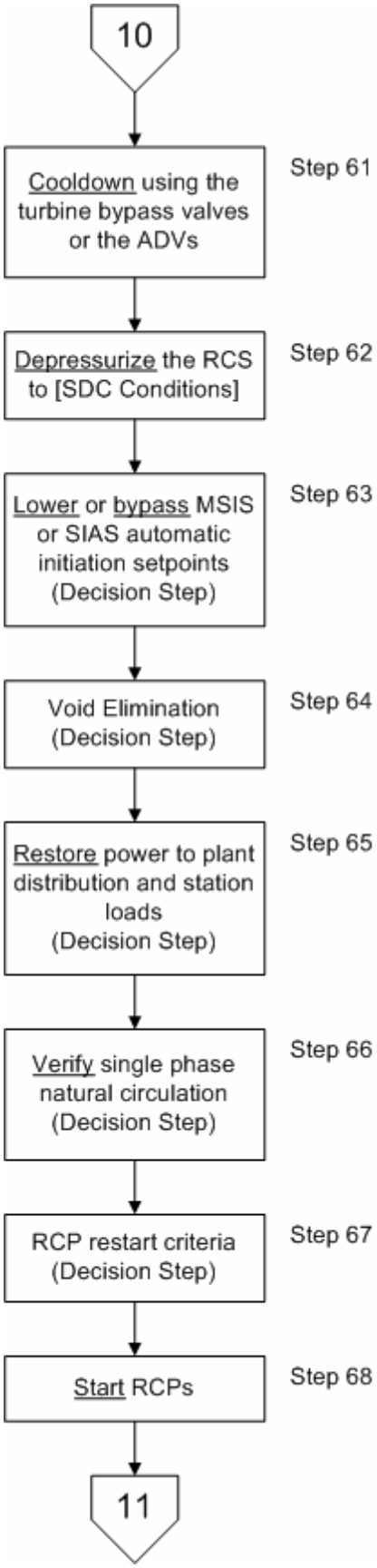
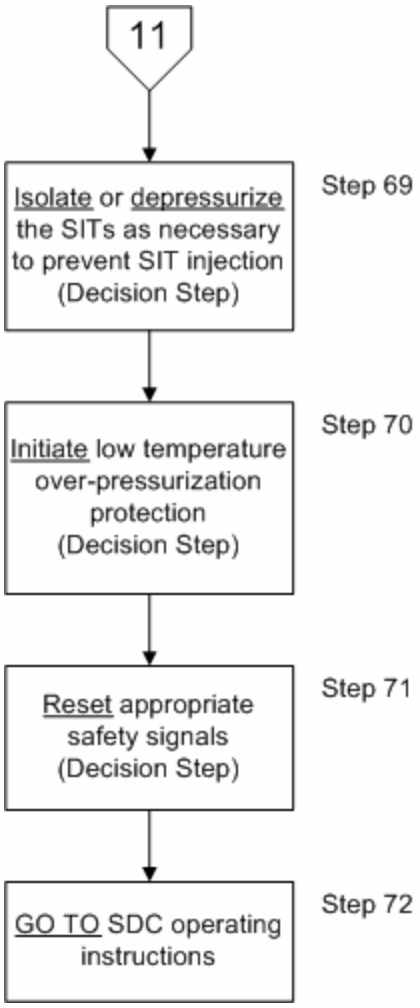


Figure 5-19k
LOSS OF COOLANT ACCIDENT RECOVERY
STRATEGY CHART



SAFETY FUNCTION: **RCS Inventory Control**
SUCCESS PATH: **CVCS; IC-1**
RESOURCE TREE: **Tree C**

INSTRUCTIONS | CONTINGENCY ACTIONS

* 1. **Protect RCP Seals {law55loopic1}**

IF Off-site power has been lost,
AND RCP seal cooling has been lost,
THEN:

[a. Isolate RCP controlled bleedoff flow.]

[b. Restore RCP seal cooling water.]

[c. Restore seal injection.]

* 2. **Minimize RCS Leakage {pk48sboic1}**

IF Station Blackout has occurred,
THEN minimize RCS leakage:

a. Ensure letdown is isolated.

[b. Ensure RCP controlled bleedoff is isolated.]

c. Ensure RCS sampling is isolated.

* 3. **Restore Letdown {law39locaic1}**

IF letdown is isolated,
AND BOTH of the following conditions exist:

- HPSI throttle criteria are met
- Letdown is needed or desired

THEN restore letdown.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. **Ensure Charging & SI flow are Maintaining Pressurizer Level in the expected post-trip band {law7ic1}** **IF** HPSI throttle criteria are met, **THEN** maintain pressurizer level within [expected post-trip band]: a. Charge via normal path and letdown.	a.1 Charge to the RCS via the HPSI header.
b. Throttle HPSI flow as necessary.	
* 5. **Ensure Adequate Suction for CVCS Pumps {ic1}** Ensure **ONE** of the following borated water sources is aligned to charging pump(s) and contains adequate inventory and boron concentration: • Volume Control Tank • Boric Acid Storage Tank • Refueling Water Storage Tank • [Spent Fuel Pool]	
* 6. **Refer to Void elimination guidance {ic1}** **IF** high Pressurizer level condition appears to be caused by RCS voiding, **THEN** take steps to eliminate the voiding. REFER TO Void Elimination instructions in the RCS and Core Heat Removal success path in use.	

* Continuously Applicable Step or Non-Sequential Step
# Hold Point step

INSTRUCTIONS		CONTINGENCY ACTIONS
* 7. **Verification of Acceptance Criteria {ic1}**		
Verify IC-1 (CVCS) is satisfied by **ALL** of the following: • Pressurizer level is greater than [minimum level for inventory control]. • RCS subcooling is greater than or equal to [minimum RCS subcooling]. • Reactor Vessel level is greater than [top of the hot leg nozzles].	7.1	**IF** the RCS Inventory Control safety function is still in jeopardy, **THEN** GO TO the next appropriate RCS Inventory Control success path.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point step

SUPPLEMENTARY INFORMATION: IC-1

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Water solid operation of the pressurizer may make it difficult to control RCS pressure, and therefore should be avoided unless [minimum RCS subcooling] cannot be maintained in the RCS. If the RCS is water solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursions.
2. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (Reference 24).
3. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (Reference 34).
4. Indications of high RCS inventory may be caused by the displacement of water from voided areas of the RCS. Operators must be aware of this and understand that operation of letdown in this situation may lower RCS pressure and, subsequently, increase RCS voiding.
5. When a void exists in the reactor vessel, and RCPs are not operating, the RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the RVLMS. The indicated level also differs from different RVLMS designs under these conditions. Information concerning reactor vessel liquid inventory trending may still be discerned. However, the operator is cautioned not to rely solely on the RVLMS indication when RCPs are operating (Reference 15).

SAFETY FUNCTION: **RCS Inventory Control**
SUCCESS PATH: **Safety Injection; IC-2**
RESOURCE TREE: **Tree C**

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. **Ensure SIAS Actuation {pk20locaic2}** Ensure SIAS is actuated.	
* 2. **Optimize SI {pk8ic2}** Optimize SI: a. Ensure SI pumps have started. b. Verify SI flow within the [SI flow delivery curves]. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.	b.1 Take steps to restore SI flow: 1) Ensure electrical power to SI pumps and valves. 2) Ensure correct SI valve lineup. 3) Ensure operation of necessary auxiliary systems. 4) Start additional SI pumps as needed until SI flow is within [SI flow delivery curves].
[c. Start idle charging pumps]	

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 3. **Depressurize RCS {law4locaic2}** **IF** high pressurizer pressure is preventing [adequate SI flow], **THEN** depressurize the RCS by **ANY** of the following: • Controlling RCS Heat Removal. REFER TO HR Success Path in use. • Controlling pressurizer heaters and main or auxiliary pressurizer spray. • **IF** HPSI throttle criteria are met, **THEN:** 1) Controlling charging and letdown. 2) Throttling HPSI flow as necessary. • Operating the [PORVs or Pressurizer vent].	
* 3.A **[Early Termination of Containment Spray pump(s)]** [**IF** CS pumps are operating **AND ALL** of the following conditions are satisfied: • Containment pressure is less than [containment design pressure], • [The required number of containment cooling fans are in operation], • Safety injection is actuated and flow within [SI delivery curves], **THEN** stop one CS pump at a time until only one pump remains in operation: a. Stop Containment Spray Pump. b. Verify containment pressure maintained less than [containment design pressure].]	3.A.1 [Take action to restore full CS flow to containment. a) Start CS pump(s).]

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 4. **Protect RCP Seals {law55loopic2}**

IF Off-site power has been lost,
AND RCP seal cooling has been lost,
THEN take steps to protect RCP seals:

[a. Isolate RCP controlled bleedoff flow.]

[b. Restore RCP seal cooling water.]

[c. Restore seal injection.]

* 5. **Minimize RCS Leakage {pk48sboic2}**

IF Station Blackout has occurred,
THEN minimize RCS leakage:

a. Ensure letdown is isolated.

[b. Ensure RCP controlled bleedoff is isolated.]

c. Ensure RCS sampling is isolated.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 6. **HPSI Throttle Criteria {law10locaic2}**

IF HPSI pumps are operating and **ALL** of the following conditions are satisfied:

- RCS subcooling is greater than or equal to [minimum RCS subcooling],
- Pressurizer level is greater than [minimum level for inventory control] and **NOT** lowering,
- At least one steam generator is available for RCS Heat Removal with level being maintained or restored to [normal control band],
- Reactor vessel level is greater than the [top of the hot leg nozzles],
- Reactivity control safety function is satisfied as defined in the acceptance criteria,

THEN throttle HPSI flow or stop one HPSI pump at a time.

* 7. **HPSI Pump Restart Criteria {law9locaic2}**

IF ANY of the HPSI throttle criteria can **NOT** be maintained,
THEN:

a. Raise HPSI flow.

b. Start HPSI pumps as necessary.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 8. **LPSI Pump Stop Criteria {law13locaic2}**

IF pressurizer pressure is greater than [LPSI pump shutoff head] and controlled,

THEN:

a. Stop the LPSI pumps.

b. Close the LPSI injection valves.

* 9. **LPSI Pump Restart Criteria {law33locaic2}**

IF pressurizer pressure lowers to less than [LPSI pump shutoff head],
AND BOTH of the following conditions are satisfied:

- LPSI pumps have been stopped,
- RAS has **NOT** occurred

THEN:

a. Start LPSI pumps as necessary.

b. Open the LPSI injection valves.

* 9A **[Line up for RWT Refill or alternate RCS Injection]**
[Prepare for alternate RCS Injection by performing **ANY** of the following:

a. Initiate actions to make up to the RWT.

b. Initiate actions to lineup to inject directly to the RCS bypassing the RWT.]

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 10. **Ensure Adequate Suction for SI Pumps {jc12locaic2}** Confirm LOCA is inside containment: a. Verify containment sump level is rising as the RWT level drops.	10.1 [Confirm LOCA is outside containment]. 10.2 [Initiate actions to makeup to the RWT]. 10.3 Verify CIAS. 10.4 Notify [plant management].
* 11. **RAS Initiation Criteria {law26locaic2}** **IF** the break is inside containment, **AND** RWT level is less than [RAS setpoint], **THEN** ensure proper recirculation actuation: a. Ensure that RAS is initiated. b. Ensure that both LPSI pumps are stopped. c. Ensure the ESF pump suction has shifted to the containment sump. d. Ensure the RWT outlet valve to the SIS is closed. e. Ensure HPSI minimum recirculation flow valves are closed. f. [**IF** charging pump suction is aligned to RWT, **THEN** disable all charging pumps.] [g Ensure that the auto-start function for all idle CS pumps is disabled.]	
* 12. **HPSI Pump Minimum Flow Criteria {law8locaic2}** **IF** RAS is present, **THEN** verify that HPSI flow is greater than [minimum required HPSI pump flowrate].	12.1 Stop one HPSI pump at a time until [minimum required HPSI pump flowrate] is met.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS

* 12A **Post RAS HPSI stop criteria**
IF RAS is present,
AND ALL of the following conditions exist,

- **BOTH** HPSI trains are in operation,
- HPSI flow rate is within the [SI flow delivery curves], REFER TO Figure 13.13. SI Flow Delivery Curves,
- [Representative] CET Temperature [less than superheat],
- Reactor Vessel level is greater than [bottom of hot leg],
- Time from reactor shutdown is greater than [time for successful 15 minute operator response],

THEN stop one HPSI pump at a time until only one pump is in operation.

a. Stop one HPSI pump.

b. Verify SI flowrate greater than [SI flow delivery curves], REFER TO Figure 13.13. SI Flow Delivery Curves.

c. Verify [Representative] CET Temperature less than [superheat].

d. Verify Reactor Vessel level greater than [top of active fuel].

* 12B **Refill RWT**

Commence refilling the RWT.

CONTINGENCY ACTIONS

12A.1 **IF ANY** of the HPSI Stop criteria can **NOT** be maintained,
THEN:

a. Start HPSI pumps as necessary.

b. Raise HPSI flow as necessary.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 12C **Monitor for loss of ECCS pump suction**

IF RAS is present
AND a lost of ECCS pump suction is indicated by **ANY** of the following exist::

- [Lower or unstable HPSI or CS flow]
- [Lower or unstable HPSI or CS pump discharge pressure]
- [Lower or unstable HPSI or CS pump suction pressure]
- [Lower or unstable HPSI or CS pump motor current]
- [Increased HPSI or CS pump noise]

THEN take actions to prevent HPSI and CS pump damage,
AND maintain adequate core cooling by performing **ALL** of the following in the order listed:

a. Stop **ALL** CS pump(s).

b. Observe if HPSI pump performance improves.

c. Notify [Plant management]

b.1 **IF** HPSI pump performance does not improve,
THEN perform **ALL** of the following:

1) Throttle SI flow to achieve the [minimum required HPSI pump flowrate].

2) **IF** pump performance does NOT improve,
THEN stop the pump.

3) **IF** pump performance improves,
THEN gradually increase SI flow to achieve the maximum available and continue to monitor.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

13. **Verification of Acceptance Criteria {ic2}**

Verify IC-2 (Safety Injection) is satisfied by **ALL** of the following:

- **IF** RAS has **NOT** occurred,
  THEN all available charging pumps are operating.
- **IF** RAS has **NOT** occurred,
  AND LPSI termination criteria are **NOT** met,
  THEN LPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.
- **IF** HPSI throttle criteria are **NOT** met,
  THEN HPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.
- RVLMS level is greater than [top of the active fuel region]

CONTINGENCY ACTIONS

13.1 **IF** the RCS Inventory Control safety function is still in jeopardy,
THEN GO TO RCS Inventory Control Continuing Actions.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

SUPPLEMENTARY INFORMATION: IC-2

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Water solid operation of the pressurizer may make it difficult to control RCS pressure, and therefore should be avoided unless [minimum RCS subcooling] cannot be maintained in the RCS. If the RCS is water solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursions.
2. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (Reference 24). Hot and cold leg RTDs may be influenced by cold SIS injection and should be checked against each other.
3. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (Reference 34).
4. The operator should be cautioned against prematurely initiating an RAS. The operator should verify that RWT level has reached [RAS setpoint] and that the containment sump has adequate fluid for SIS suction before shifting to recirculation. This manual action should not be taken unless an automatic RAS is required.
5. [Charging from the concentrated boron source should not continue past the point where boron precipitation may result, unless required for reactivity control. The specific volumes (and concentration) vs. number of charging pumps should be specified in the procedure if this concern is applicable. If boron precipitation is a concern, charging pump suction should be shifted to a lower concentration source prior to injecting a quantity of boron that may start to precipitate out in the core region].

CONTINUING ACTIONS FOR INVENTORY CONTROL

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. **Continue efforts to restore safety functions {pc4}** **IF** the RCS Inventory Control is still in jeopardy, **THEN** pursue RCS Inventory Control and other jeopardized safety functions simultaneously.	
* 2. **Evaluate RCS leakage(frg-ic-ca)** **IF** RCS leakage is evident, **THEN** take steps to isolate the leak:	
a. Ensure letdown isolation valves are closed.	
b. Ensure sample line isolation valves are closed.	
c. Verify **BOTH** of the following conditions exist: • NO CCW high radiation alarm, • NO CCW Surge Tank high level alarm.	c.1 **IF** RCS to CCW leak is evident, **THEN** locate and isolate the leak.
d. Ensure RCP controlled bleedoff line isolation valve closed.	
* 2A **Maximize RCS Cooldown** Maximize RCS heat removal via the steam generators. REFER TO RCS Heat Removal success path in use.	

* Continuously Applicable or Non-Sequential
# Hold Point Step

* 2B **Depressurize RCS {law4locaic2}**

IF high pressurizer pressure is preventing [adequate RCS injection flow],
THEN depressurize the RCS by **ANY** of the following:

a. Controlling RCS Heat Removal. REFER TO HR Success Path in use.

b. Operating the [PORVs or Pressurizer vent]. REFER TO RCS Pressure Control Success Path in use.

* 2C **Maximize Containment Cooling**

Ensure all available normal and emergency Containment Cooling units are in operation. REFER TO Containment Temperature and Pressure Control success path in use.

* 2D **Refill RWT or lineup an Alternate Injection Source bypassing the RWT.**

IF RAS is present,
THEN perform **ANY** of the following:

a. Ensure that the RWT is being refilled from **ANY** available source.

b. Ensure that **ANY** available source is being lined up for injection to the RCS.

* Continuously Applicable or Non-Sequential
\# Hold Point Step

2E **Attempt to reestablish SI pump suction from Containment Sump**

WHEN ALL of the following SI pump restart conditions have been established:

- **All** ECCS pumps aligned to the sump are stopped
- Management [TSC] concurrence
- Verify alignment for pump selected for restart
- [Vent selected pump]

THEN attempt to reestablish SI flow to the RCS from the containment sump.

a) Throttle injection valve(s).

b) Verify minimum recirculation valve to RWT is closed.

c) Start pump.

d) Monitor pump performance.

e) Control SI flow as necessary to ensure RVLMS is maintained greater than or equal to [the bottom of hot leg].

d.1 **IF** a lost of pump suction is indicated by **ANY** of the following:

- [Lower or unstable SI flow]
- [Lower or unstable discharge pressure]
- [Lower or unstable suction pressure]
- [Lower or unstable motor current]
- [Increased pump noise]

THEN stop the pump.

* Continuously Applicable or Non-Sequential
\# Hold Point Step

2F **Attempt to Discharge SITs**

IF there is inventory in the SITs,
THEN discharge SIT inventory as needed to replenish RCS inventory

a. Ensure pressurizer pressure to less than SIT pressure by **ANY** of the following means:

   1) Operate the TBVs or ADVs. REFER TO RCS Heat Removal success path in use. (Preferred)

   2) Operate the PORVs or pressurizer vent(s). REFER TO RCS Pressure Control Success Path in use.

b. Ensure selected SIT outlet isolation valve is open.

c. Verify RVLMS rises as SIT level lowers.

d. **WHEN** RVLMS indicates reactor vessel level greater than or equal to the [bottom of the hot leg],
THEN close the SIT outlet isolation valve.

e. Repeat SIT injection procedure as needed to control RCS inventory to the [bottom of the hot leg]

f. **WHEN** the SIT reaches [minimum indicated level],
THEN isolate or depressurize the SIT.

2G **Inject Refilled RWT to RCS**

IF RAS is present,
AND ALL of the following conditions exist:

- Containment sump recirculation capability is lost
- Usable inventory is available in RWT
- RWT boron concentration verified to be acceptable for current plant conditions
- Pressurizer pressure is less than selected injection pump shutoff head

THEN inject to the RCS as necessary to control reactor vessel level greater than or equal to the [bottom of the hot leg].

a. Ensure ECCS pump suction from Containment Sump is isolated.

b. Align suction for selected pump to RWT
   - HPSI pump
   - LPSI pump
   - Charging pump

c. Align pump discharge to RCS.
   - Hot or Cold Leg Injection
   - Normal or Alternate charging path

d. Operate pump as needed.

e. Monitor pump performance.

f. Control flow as necessary to ensure RVLMS is maintained greater than or equal to bottom of hot leg.

2H **Inject Alternate Source to RCS**

IF RAS is present,
AND ALL of the following conditions exist:

- Containment sump recirculation capability is lost
- A suitable alternate source is available
  - Normal RCS make up
  - Reprocessed reactor coolant
  - Spent Fuel Storage Pool
  - Adjacent unit RWT
  - Other
- Boron concentration of makeup water verified to be acceptable for current plant conditions
- Pressurizer pressure is less than selected injection pump shutoff head

THEN inject to the RCS as necessary to control reactor vessel level greater than or equal to the [bottom of the hot leg].

a. Ensure ECCS pump suction from Containment Sump is isolated.

b. Align pump suction to [alternate RCS makeup source].

c. Align pump discharge to RCS.

d. Operate pump as needed.

e. Monitor pump performance.

f. Control flow as necessary to ensure RVLMS is maintained greater than or equal to bottom of hot leg.

2l **Establish minimum SDC Entry Requirements and initiate SDC**

WHEN ALL of the following SDC entry conditions are established:

- [Representative] CET Temperature [less than superheat],
- Pressurizer pressure is less than [SDC entry pressure]
- RCS Th is less than [SDC entry temperature]
- Reactor Vessel level is greater than [center line of the hot leg],

THEN establish SDC. GO TO SDC operating instructions.

* 3. **Support restoration of Success Paths {frgicca}**

Take steps to restore function to a success path:

a. Restore the vital auxiliaries necessary to operate components or systems in the success path.

b. Manual operate alternate components as necessary to implement a success path.

* 4. **Evaluate further actions {frgicca}**

Evaluate further actions based on the urgency of other jeopardized safety functions.

* Continuously Applicable or Non-Sequential
# Hold Point Step

SUPPLEMENTARY INFORMATION: IC-CA

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (Reference 24). Hot and cold leg RTDs may be influenced by cold SIS injection and should be checked against each other.
2. Voids and void fraction in the reactor vessel head region may result in temporary unstable RVLMS readings. Allow time for fluid conditions in the RV head region to stabilize following changes such as initiating and altering injection flow rate to increase the reliability of readings.
3. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (Reference 34).
4. The overall objective of reinitiating reactor coolant system (RCS) injection is to regain RCS inventory control, to prevent loss of or regain core heat removal. With RCS inventory control lost and while attempting to restore it, it is very important to maintain RCS heat removal via the steam generators to support single or two-phase natural circulation.
5. [If possible, vent the suction side of the selected injection pump, if radiological conditions permit].
6. Ideally, RCS injection flow will maintain water level above the core and preclude excessive core temperatures. Initiating injection flow to an overheated core will cause rapid steam production and an RCS pressure spike, which may cause creep rupture failure of the RCS (including steam generator tubes). Creep rupture failure is caused by excessive metal temperature combined with excessive pressure. Injection flow should be reintroduced gradually to minimize the RCS pressure spike.
7. If core damage occurs, hydrogen may be generated as a result of the zirconium-water reaction. Accumulation of hydrogen in the steam generator tubes may reduce or eliminate natural circulation. For a LOCA inside containment, the hydrogen gas concentrations in containment may increase.
8. The solubility limit of boric acid should be considered to avoid boron precipitation in the core. Safety injection flow in excess of the core boil-off flow rate (core flushing flow) prevents boron precipitation in the core, if the inventory has been restored to a level where water is flowing out of the reactor vessel. If possible, use a simultaneous hot leg/cold leg injection strategy.

* Continuously Applicable or Non-Sequential
\# Hold Point Step

9. Cool ECCS water may cause thermal shock to fuel pins and result in more fuel damage. It is possible that a slower rate of injection may be better.

10. The accumulation of water in containment basement may:
    - Flood and thereby reduce or eliminate containment heat removal equipment.
    - Flood and thereby reduce or eliminate containment venting capability.
    - Submerge equipment and/or instrumentation desired to mitigate or monitor the event.

11. Higher level of flooding in the containment may render needed instrumentation inoperable.

12. [Charging from the concentrated boron source should not continue past the point where boron precipitation may result, unless required for reactivity control. The specific volumes (and concentration) vs. number of charging pumps should be specified in the procedure if this concern is applicable. If boron precipitation is a concern, charging pump suction should be shifted to a lower concentration source prior to injecting a quantity of boron that may start to precipitate out in the core region].

Page Intentionally left blank

* Continuously Applicable or Non-Sequential
\# Hold Point Step

RCS Inventory Control Bases

The purpose of maintaining RCS Inventory Control is to provide a medium for the removal of decay heat. To do this, RCS inventory is maintained between the minimum volume required to keep the core covered with an effective coolant medium and the maximum level desirable for operational purposes (i.e. to prevent water solid operations with its attendant pressure control problems).

Many plant conditions may result in a loss of inventory control. A break in the primary system piping, a stuck open relief valve, or a failure in the system used for normal fluid addition to the RCS are some examples of possible causes of low inventory. A high inventory situation may result from excessive fluid addition from the CVCS or SIS, RCS fluid expansion due to an uncontrolled heat addition, or an apparently high inventory condition may result from RCS voiding.

The methods available for RCS inventory control also affect RCS pressure control. For example, a high pressure situation may result from excessive RCS inventory. On the other hand, a high RCS pressure may hinder the achievement of RCS inventory control since the SIS pumps (for most plants) are centrifugal pumps with relatively low shutoff heads.

To achieve control of RCS inventory, the following methods are available:

IC-1: RCS Inventory Control via CVCS

IC-2: RCS Inventory Control via SIS

Continuing Actions for RCS Inventory Control

The bases for the recovery actions required for implementing each of the methods listed above are detailed as follows:

IC-1: RCS Inventory Control via CVCS

The preferred method of RCS Inventory Control is by automatic or manual operation of charging and letdown (CVCS). The goal is to provide sufficient pressurizer inventory to maintain the core covered with an adequate cooling medium and to prevent water solid plant conditions.

RCS Inventory Control Bases

Step Number 1 Protect RCP Seals

Intent

This step is applicable only if off-site power has been lost. The intent is to direct timely execution of actions needed to protect RCP seals from damage and consequently avoid excessive loss of inventory through the seals.

Method

Because RCP seal design is very plant specific, all the recommended actions in the generic guideline have been bracketed.

Each plant should review their design bases documentation to determine the risks associated with loss of RCP seal cooling and any assumptions regarding RCP seal integrity with loss of cooling. In general, restoration of RCP seal cooling is performed to minimize the possibility of seal degradation and subsequent seal replacement, and is not required to ensure plant safety.

Sequence

This step is related to ensuring RCS inventory control. Thus, RCP seal protection should be addressed early in the success path in order to take timely corrective action in an attempt to prevent seal damage.

Plant Parameters

None

RCS Inventory Control Bases

Step Number 2 IC-1, Minimize RCS Leakage

Intent

This step is applicable if a Station Blackout has occurred. The intent is to minimize loss of RCS inventory and prevent core uncovery, since there is no RCS make up capability during a SBO. Ensuring a minimal RCS leak rate reduces the rate of depressurization attributed to RCS leakage.

Method

Minimal RCS leakage can be met by ensuring:

a. Letdown isolation valves closed,

[b. RCP controlled bleedoff line isolation valve closed,]

c. RCS sample line(s) isolation valves closed,

Actions to protect RCP seals after they have been deenergized, during coastdown and thereafter are plant specific. Each plant should consult their RCP technical manual or pump vendor to determine the appropriate procedure to protect the seals following station blackout.

Charging line isolation valves may not need to be closed if it is known that charging line check valves are functioning as designed.

Sequence

This step is part of the initial mitigating actions associated with conserving RCS inventory. Therefore, it should be placed near the beginning of the success path.

Plant Parameters

None

RCS Inventory Control Bases

Step Number 3 IC-1, Restore Letdown

Intent

The intent of this step is to restore letdown so that it is available to support a cooldown, if necessary.

Method

Letdown is needed to support inventory/pressure control, especially when the RCS is water-solid. Therefore, if needed or desired, it should be restored as soon as possible. To do so, may require SIAS & CIAS to be blocked and reset. Plant specific administrative procedures must be followed when blocking and resetting these signals. However, if it can not be restored at the time or it may take considerable time to get letdown back, then the operator may restore letdown anytime conditions permit and when assistance is available.

If letdown is isolated and all of the following conditions exist, then the operator should attempt to restore letdown:

1) HPSI stop/throttle criteria are met, RCS inventory must be conserved. Any deliberate action to remove inventory from the RCS is not allowed if control of RCS inventory has not been achieved.
2) If it is needed or desired as deemed by [operations supervisor]. The operator should not attempt to restore letdown if the LOCA has been isolated and placing letdown in service will result in an uncontrolled loss of RCS inventory.

If letdown is not be needed for inventory control (i.e. facilitate maintain pressurizer level), it may be desired for other evolution's such as RCS chemistry control. If there is no current need or desire for letdown, then it does not have to be restored at this point.

RCS activity may be higher than normal due to the event in progress. Restoring letdown could create unacceptable radiological consequences in adjacent areas outside containment that may complicate access to the affected areas.

Sequence

This step is sequenced after the major mitigation steps.

Plant Parameters

None

RCS Inventory Control Bases

Step Number 4 IC-1, Maintain pressurizer level

Intent

The intent of this step is to ensure that the Inventory Control Safety Function is being adequately addressed.

Method

The charging pumps and letdown are used to maintain pressurizer level within the [transient maneuvering band]. Typically, charging must be placed in service prior to establishing letdown.

It may be necessary to exceed the upper pressurizer level if the operator is attempting to restore RCS subcooling as indicated in the safety injection termination criteria since pressurizer heaters may be unavailable and water solid operation may be necessary to restore subcooling.

Sequence

This step is the first major action in the sequence for the CVCS success path for maintaining the Inventory Control safety function.

Plant Parameters

Pressurizer level within the expected post-trip band

The upper engineering limit is based on engineering judgment to: 1) avoid water-solid conditions, 2) provide sufficient steam space to ensure pressure control using sprays, and 3) bound the highest pressurizer levels observed in best estimate analysis. The lower engineering limit is nominally [2%]. The lower operational limit, nominally [35"] corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The upper operational limit, nominally [245"] corresponds to the highest level judged to provide sufficient steam space to ensure pressure control using Pressurizer sprays without immediately bringing the plant to a water-solid condition. In the EPGs, the RCS is not considered water-solid if there is evidence of a steam void anywhere in the RCS, i.e. in the pressurizer, the reactor vessel head, or in the steam generator tubes. Pressurizer level between [35" to 245"] defines an acceptable transient control band following a reactor trip. Ultimately, level should be restored to the normal control band. Level in the transient band is indicative of RCS inventory control via a saturated bubble in the Pressurizer. It provides the operator with information to support the continued operability of the Pressurizer.

RCS Inventory Control Bases

Step Number 5 IC-1, Ensure Adequate Suction Sources for charging pumps

Intent

The intent of this step is to ensure adequate suction source of borated water for the charging pumps.

Method

Available suction sources for the charging pumps include the volume control tank (VCT), [boric acid storage tanks,] RWT, and spent fuel pool. The volume of borated water needed for controlling RCS inventory depend on the total amount needed for makeup, the time frame over which it must be introduced and the boron concentration of the makeup source. The VCT is the primary source of RCS makeup. If necessary for cases where RCS inventory losses are being incurred (e.g. a LOCA), then the [boric acid storage tanks,] RWT and spent fuel may be used as backup sources. If the RWT is used, then level should be maintained above the RAS setpoint.

Sequence

This step is a reminder to the operator to ensure adequate suction sources to the charging pumps.

Plant Parameters

None

Step Number 6 IC-1, Refer to void elimination instructions

Intent

The intent of this step is to direct the operator to steps mitigating RCS voiding if it exists.

Method

A high pressurizer level indication may be the result of RCS voiding. If this is the case, the actions concerning letdown may either have minimal effect on indicated pressurizer level or result in an even higher indicated pressurizer level. (The void expands upon pressure decrease with a resulting distribution of RCS fluid into the pressurizer.) The presence of such an RCS void may be the result of inadequate RCS/Core Heat Removal or the presence of non-condensable gases. If a high pressurizer level appears to be caused by excessive RCS voiding, then the RCS and Core Heat Removal success path in use should be referred to in order to eliminate the voiding. [The RVLMS indication may provide confirmation of this voiding, if voiding is present in the reactor vessel.]

Sequence

This step is last in the sequence after immediate actions to restore and maintain RCS inventory have been addressed.

Plant Parameters

None

Step Number 7 IC-1, Determine Status of Acceptance Criteria

Intent

The intent of this step is to verify that the acceptance criteria for the success path is satisfied.

Method

After implementing the above actions, Inventory Control is satisfied if pressurizer level is being maintained greater than [minimum level for inventory control], the RCS is at least [minimum RCS subcooling] subcooled, and RVLMS indicates level greater than [top of the hot leg nozzles]. In some cases, it may be necessary to fill the pressurizer solid in order to achieve adequate subcooling. Water solid operation of the plant is addressed in the Pressure Control success paths.

If the above criterion is not satisfied, then success path IC-1 is not adequate. The operator should go to another appropriate IC success path for further guidance to restore/maintain RCS Inventory Control.

If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

Sequence

This step is last in the sequence after all actions to restore and maintain RCS inventory have been addressed.

Plant Parameters

Pressurizer level greater than the minimum level for inventory control

The lower engineering limit corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The lower operational limit, nominally [35"], is approximately ([10%]) of a typical Combustion Engineering Pressurizer's range, and was chosen as the lower limit to account for some instrument and process fluid uncertainties. The lower limit is based on the lowest indication, approximately [2%] that with confidence reflects an actual Pressurizer level. Instrument uncertainties, assumed to be $\pm$ 8%, were conservatively applied to the engineering limit, yielding the lower operational limit of [10%].

(continue)

RCS Inventory Control Bases

(continued)

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that, 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

RCS Inventory Control Bases

IC-2: RCS Inventory Control via SIS

If automatic (or manual) operation of charging pumps and letdown is not satisfying the acceptance criteria of IC-1, then additional makeup fluid is available via the SIS.

RCS Inventory Control Bases

Step Number 1 IC-2, Ensure SIAS Actuation

Intent

The intent of this step is to ensure that the HPSI pumps are running and lined up to inject borated water into the RCS, regardless of Pressurizer pressure.

Method

The operator is instructed to ensure SIAS is actuated. If a SIAS has not actuated automatically, then the operator should manually actuate SIAS. Initiating SIAS is the preferred method to ensure that the HPSI pumps start and are lined up correctly. The exact method of SIAS actuation and ensuring HPSI is lined up to inject into the RCS should be determined on a plant specific basis and should be flexible enough to cover all situations where makeup capacity, in addition to that available via the charging pumps is required to restore and/or maintain inventory control.

Sequence

The step is the first major mitigative action taken by the operator in this success path.

Plant Parameters

None

RCS Inventory Control Bases

Step Number 2 IC-2, Optimize SI

Intent

The intent of this step is to ensure that SI flow is within the limits of the design basis SI flow. That is, SI flow should be in accordance with the SI delivery curves (Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure) for the given RCS pressure and the number of running SI pumps. Typical SI system design provides two redundant trains of SI, but only one train operation is necessary to meet the intent of the this step. Therefore, it may be optimum for RCS inventory recovery purposes to have two SI trains in operation delivering flow in accordance with the two pump curve, but one train in operation (one SI pump running with flow in accordance with the one pump curve) is acceptable.

Method

After a SIAS the Safety Injection (SI) system flow rate to the RCS is a function of pressurizer pressure. This flow can be predicted using standard fluid flow calculations. The SI flow delivery curves are the results of these fluid flow calculations and can be used by the operator to determine if the SI system is performing as designed and delivering the expected flow to the RCS. Therefore, unless SI flow is deliberately throttled, SI delivery flow should always be greater than or equal to the pump curve. Therefore, SI flow within the one pump curve while two SI pumps are operating is not considered an acceptable configuration, and the problem should be investigated to determine the cause of the deviation and appropriate actions taken to restore SI flow within the limits of the curve. Deviations from the SI delivery curves may be due to valve misalignments, SI pump problems, etc.

It must be noted, however, that the safety injection flow can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and stop or throttle SI flow when SI stop and throttle criteria are met.

[Start idle charging pumps], is a plant specific RCS inventory restoration action that may be implemented depending on the design basis and the normal equipment response to a SI actuation.

(continue)

(continued)

If SI flow is not within the SI flow curve then the operator is directed to perform any of the following to restore SI flow:

- Ensure electrical power to SI pumps and valves. This step ensures that pumps and valves which actuate on a SIAS have not tripped on overload and the electrical bus which supplies the loads is still available.
- Ensure correct SI valve lineup have been established. The operator should observe control board indications and ensure that a flowpath exists from the RWST to the RCS.
- Ensure auxiliary systems are in operation which are vital to the proper operation of the SI pumps. The operator ensures the necessary systems are in service to support the SI pumps.
- The operator is directed to start additional HPSI pumps as needed to ensure SI flow is within the [SI flow delivery curves]. The operator ensures that the pumps that are not running have electrical power, are lineup properly and that auxiliary systems are available to the pumps. Additional HPSI pumps provide additional water to satisfy RCS inventory control sooner.

Sequence

This step is located after instructions to ensure SIAS is actuated.

Plant Parameters

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

RCS Inventory Control Bases

Step Number 3 IC-2, Depressurize RCS

Intent

The intent of this step is to allow depressurization of the RCS to increase SI flow if high RCS pressure is causing RCS inventory or inventory trends to threaten adequate core cooling. RCS pressure above the shutoff head of the SI pumps will prevent SI injection to the RCS. Charging pumps should still be operating and be capable of providing sufficient boric acid flow to ensure adequate reactivity control. If necessary, a cooldown and depressurization should be performed by referring to the pressure and heat removal success paths in use. These success paths will provide guidance for RCS depressurization, while also providing guidance for maintaining adequate RCS subcooling and core cooling.

Method

a. The operator is directed to lower RCS pressure by increasing the rate of RCS heat removal by means of the HR success path in Use.

b. If available, main or auxiliary pressurizer sprays may be used to depressurize the RCS.

c. If HPSI throttle/stop criteria are met, charging pumps may be stopped as necessary to aid in depressurization. Charging pumps are operated to provide inventory throughout the cooldown as well as to provide auxiliary spray as needed. Letdown should not be required during a cooldown, but may be used to aid in inventory control, and thus RCS depressurization provided HPSI throttle/stop criteria are satisfied.

d. The [PORVs or Pressurizer vent valves] may be used to lower RCS pressure in the event that no other means has been successful in lowering RCS pressure sufficiently to permit HPSI injection.

Sequence

Continuously applicable

Plant Parameters

Adequate SI flow

Adequate SI flow is a plant specific and event specific value. It is based on the decay heat generation rate at the particular time in the event.

Step Number 3A Early Containment Spray Termination Criteria

Intent

In the course of the validation for interim change 5.3 (Scenario 2), the team discovered that the operator needed to encounter instructions to terminate a spray pump sooner when in the FRG. During the scenario, when the FRG was entered for a multiple event, CTPC was determined to be not in jeopardy or challenged, therefore a lower priority than IC and HR. In order to receive a benefit from CS termination in delaying the time to RAS, it must be happen earlier in the event. Therefore, the V&V team decided that CTPC-3 step 2 should also be located following IC-2 step 3. .

Therefore, the intent of early CS termination is to secure unneeded containment spray pumps as early as possible after it has been confirmed that they have performed their safety function (Reference 48). The overall objective is to:

- Reduce the demand on the RWT,
- Delay the time to the start of containment recirculation during small breaks,
- Reduce the flow rate to the sump when containment recirculation begins,
- Reduce the pressure differential across the sump screens if there is a build up of debris.

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action if it is determined to be risk beneficial with respect to containment sump blockage.]

A large break LOCA will reach peak containment pressure and temperature within five minutes. As the break size decreases the time to reach peak conditions will increase but the magnitude of the peaks will decrease. This makes it easier for the active heat removal systems to accomplish their safety functions. During a large break LOCA, securing the spray pumps has only a small effect on the time to RAS actuation. Smaller breaks commensurately increase this time interval. Verifying that containment temperature and pressure have peaked and are decreasing ensures that enough time has elapsed for containment spray to have accomplished its safety function prior to securing spray pump(s).

Proper operation of safety injection ensures that no core damage has occurred. If core damage has not occurred, there is no source term, so that containment spray is not required to meet the dose source term assumptions. Under these conditions, securing containment spray will not affect the analysis of record dose calculation. However, the requirement for containment spray for Iodine removal is a plant specific criterion. (continue)

(continued)

Securing the containment spray pumps leaves the containment fan coolers (CFCs) as the only active containment heat removal system. A loss of offsite power has the potential to reduce this containment heat removal capability by half. The CFC effectiveness defines how much time is available to restart the idle spray pump in the event that the operating pump fails. For the Reference CE Plant, time is infinite because soon after blowdown 2 of 4 CFCs can continue to reduce containment pressure and temperature after switching to containment recirculation. Analysis shows that the CFCs will maintain containment pressure and temperature control. Failure of half the CFCs does not challenge the containment pressure and temperature safety functions. Plant specific implementation of this step should include loss of one train of CFCs while containment spray pumps are secured. The results should demonstrate there is adequate time to start an idle spray pump and maintain the pressure and temperature below the current peak values in the AOR.

Method

a. Specify the criteria for early termination of containment spray.

- Both (all required) containment spray trains are operating as per design. That is, all required pumps started and associated discharge valves opens on the appropriate ESFAS signal(s). Both trains are delivering design flow rate,
- Containment pressure has peaked and is now less than [containment design pressure] and lowering,
- The required combination of one containment spray train and containment emergency fan coolers is in operation. 'Required' is defined as having sufficient capacity to provide 100% of containment design cooling,
- Safety Injection has actuated and flow is within the delivery curves. Verifying proper operation of safety injection confirms that no core damage has occurred. Therefore, containment spray would not be required to meet the dose source term assumptions, i.e. iodine removal,
- Containment spray is not required to maintain containment temperature less than the [EEQ requirement]. The maximum containment temperature limit associated with Equipment Environmental Qualification (EEQ) is a plant specific requirement,
- Then:

  1) Secure one containment spray train at a time until the minimum required combination of containment spray trains and containment emergency fan coolers is in operation.

  2) If containment pressure can not be controlled and maintained below containment design pressure, restart the idle train(s) as necessary.

(continue)

(continued)

a. Predetermine the optimal strategy for securing pumps. Select the preferred CS train (A or B) and the preferred HPSI train (A or B) to be secured first when the termination criteria are satisfied. Consider such factors as: pump power supplies, suction valve and piping configuration and sump design (split vs. common). An optimal configuration would include one CS pump and one HPSI pump with the same power supply, with a common suction line and common sump penetration or sump section. In this way the reliability of the standby pumps is enhanced.

Sequence

This instruction should be located early in the procedure after verification that containment spray has actuated per design.

Plant Parameters

Containment pressure is less than [containment design pressure]

The engineering limit is based on the containment design pressure. This limit is consistent with the FSAR design criteria and the limiting pressure assumed in the accident analysis for high energy line releases inside containment.

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

RCS Inventory Control Bases

Step Number 4 IC-2, Protect RCP Seals

Intent

This step is applicable only if off-site power has been lost. The intent is to direct timely execution of actions needed to protect RCP seals from damage and consequently avoid excessive loss of inventory through the seals.

Method

Because RCP seal design is very plant specific, all the recommended actions in the generic guideline have been bracketed.

Each plant should review their design bases documentation to determine the risks associated with loss of RCP seal cooling and any assumptions regarding RCP seal integrity with loss of cooling. In general, restoration of RCP seal cooling is performed to minimize the possibility of seal degradation and subsequent seal replacement, and is not required to ensure plant safety.

Sequence

This step is related to ensuring RCS inventory control. Thus, RCP seal protection should be addressed early in the success path in order to take timely corrective action in an attempt to prevent seal damage.

Plant Parameters

None

RCS Inventory Control Bases

Step Number 5 IC-2, Minimize RCS Leakage

Intent

This step is applicable if a Station Blackout has occurred. The intent is to minimize loss of RCS inventory and prevent core uncovery, since there is no RCS make up capability during a SBO. Ensuring a minimal RCS leak rate reduces the rate of depressurization attributed to RCS leakage.

Method

Minimal RCS leakage can be met by ensuring:

a. Letdown isolation valves closed,

[b. RCP controlled bleedoff line isolation valve closed,]

c. RCS sample line(s) isolation valves closed.

Actions to protect RCP seals after they have been deenergized, during coastdown and thereafter are plant specific. Each plant should consult their RCP technical manual or pump vendor to determine the appropriate procedure to protect the seals following station blackout.

Charging line isolation valves may not need to be closed if it is known that charging line check valves are functioning as designed.

Sequence

This step is part of the initial mitigating actions associated with conserving RCS inventory. Therefore, it should be placed near the beginning of the success path.

Plant Parameters

None

Step Number 6 IC-2, HPSI Pump Throttle Criteria

Intent

The intent of this step is to establish the conditions that must be met before HPSI flow can be reduced following a SIAS actuation.

Method

After SIAS actuation, two full trains of SI must remain in operation at full flow, until all HPSI throttle criteria are met. For most LOCAs, the HPSI pumps will run continuously for a long period of time while RCS inventory, pressure, and heat removal control are being regained. In some cases, control of these three safety functions is not regained during the accident (i.e. large break LOCA) and the HPSI pumps run for the duration of the event recovery. Throttling of HPSI is expected when the SIAS was spurious, the leak rate can be accommodated by HPSI and charging when RCS pressure lowers, or after the leak is isolated.

HPSI throttle criteria are as follows:

a. RCS subcooling is greater than the [minimum RCS subcooling] of the RCS P/T curve. T hot should be used to determine RCS subcooling if RCPs are operating. Representative CET temperature should be used if natural circulation is in progress. Because of the location of the CETs inside the ICI tubes, the CETs are exposed to a mixture of core exit fluid and core bypass fluid during forced circulation. Since the core bypass fluid is cooler than the core exit temperature, it is common that CET temperature reads somewhat less than the loop T hot RTD. When natural circulation is in progress the CETs provide the best indication of fluid conditions adjacent to the core. The CETs do not rely on loop flow (as do the RTDs) for detecting fluid conditions adjacent to the core. With no flow in the loops, the loop RTDs may not provide adequate indication of core fluid conditions.

   Establishing the [minimum required subcooling] ensures that the fluid surrounding the core is subcooled, and provides sufficient margin for reestablishing HPSI flow if the minimum value can not be maintained. Voids (e.g. saturated conditions) may exist in some parts of the RCS (e.g. reactor vessel head). In themselves, this is not a major problem, provided that the voids do not interfere with core heat removal.

b. Pressurizer level is greater than the [minimum level for inventory control] and not lowering. A pressurizer level greater than the [minimum level for inventory control] and not lowering, in conjunction with criterion (a), is an indication that RCS inventory control is established.

(continue)

(continued)

c. At least one steam generator is available for RCS heat removal. A steam generator is considered available for RCS heat removal if: 1) level is being maintained or restored to the [normal control band], 2) capable of being supplied with feedwater, and 3) is capable of being steamed. Feedflow may be provided by main or auxiliary feedwater. Steaming capability includes controlled steaming by: 1) turbine bypass valves, 2) atmospheric dump valves, 3) main steam safety valves.

   The steam generator must be available to remove heat because the HPSI will no longer be adequate to remove decay heat from the core. Now the RCS must perform that function and there must be a means of removing heat from the RCS.

d. Reactor vessel level is greater than the [top of the hot leg nozzles] using RVLMS. This provides an extra margin of core coverage, taken in conjunction with the above criterion, and serves as an additional indication that adequate RCS inventory control has been established].

e. Reactivity Control is satisfied by boration flowrate greater than or equal to [the capacity of one charging pump] OR reactor power less than [maximum expected reactor power 15 minutes after shutdown] and stable or lowering. Therefore, it is acceptable to throttle HPSI to less than [the capacity of one charging pump] if reactor power is less than [maximum expected reactor power 15 minutes after shutdown] and stable or lowering.

The operator should realize that when HPSI is throttled, the core and RCS are going to heat up until the steam generator heat removal (RCS heat removal) can be increased by the operator. Depending upon how long the adjustment takes, the RCS fluid could expand appreciably, thereby further complicating the event recovery.

If all of the HPSI throttle criteria are met, then the operator may either throttle the HPSI injection valves or stop the HPSI pumps as necessary, provided the previously stated criteria remain met.

Sequence

This step is sequenced commensurate with the expected condition of the Inventory Control and Pressure Control Safety Functions. For example, in the LOCA ORG the step is sequenced early in the section associated with actions to be taken after the LOCA is isolated. In SGTR it is positioned after the steps which address isolating the affected steam generator and controlling the level which are of a higher priority for this event.

(continue)

(continued)

Plant Parameters

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Pressurizer level greater than the minimum level for inventory control

The lower engineering limit corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The lower operational limit, nominally [35"], is approximately ([10%]) of a typical Combustion Engineering Pressurizer's range, and was chosen as the lower limit to account for some instrument and process fluid uncertainties. The lower limit is based on the lowest indication, approximately [2%] that with confidence reflects an actual Pressurizer level. Instrument uncertainties, assumed to be ± 8%, were conservatively applied to the engineering limit, yielding the lower operational limit of [10%].

Steam Generator level within the normal control band

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that: 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

RCS Inventory Control Bases

Step Number 7 IC-2, HPSI Pump Restart Criteria

Intent

The intent of this step is to ensure that all available trains of HPSI are restored to operation if any of the HPSI throttle criteria can not be met.

Method

After the HPSI throttle/stop criteria are met and HPSI is throttled or the HPSI pumps are stopped, the operator must monitor RCS inventory and pressure control. If any of the throttle/stop criteria cannot be maintained, the operator must raise HPSI flow and/or start HPSI pumps as necessary to regain the safety functions and once again meet the HPSI throttle/.stop criteria. It should be noted that this approach differs from the one that used to require full SI flow to be re-established. Industry operating experience has shown that blindly re-establishing full SI flow is unnecessary and can further complicate event recovery. Therefore, that method of re-establishing HPSI flow is no longer used.

Sequence

This step is sequenced immediately after the HPSI throttle criteria.

Plant Parameters

None

RCS Inventory Control Bases

Step Number 8 IC-2, LPSI Pump Stop Criteria

Intent

The intent of this step is to prevent damaging the LPSI pumps as a result of extended operation without adequate flow through the pump.

Method

If the RCS pressure is greater than the shutoff head, the pumps will not deliver any flow to the RCS. Therefore, they should be secured. In order to minimize the time of operation at shutoff head, they should be stopped if the pressurizer pressure rises too greater than [LPSI pump shutoff head] and is controlled. The pump is secured first, followed by closing the injection valves. This sequence is intended to minimize the time of operation with no flow. The LPSI injection valves are closed to prevent unintentionally cross-connecting the HPSI system to the LPSI system in the event of a leaking check valve in a LPSI pump discharge line.

Sequence

This step is sequenced after the HPSI pump termination criteria. It is sequenced early, but after immediate actions are taken to respond to establishing inventory control

Plant Parameters

Pressurizer pressure greater than the LPSI pump shutoff head

The engineering limit is the shutoff head of the LPSI pump, nominally [200 psia]

RCS Inventory Control Bases

Step Number 9 IC-2, LPSI Pump Restart Criteria

Intent

The intent of this step is to ensure that two complete trains of LPSI are restored to operation if any LPSI stop criteria can not be met.

Method

Once the LPSI pumps have been stopped and the injection valves have been closed, if the LPSI stop criteria cannot be maintained, the LPSI injection valves must be opened and the LPSI pumps must be restarted to ensure that adequate inventory and pressure control are maintained. The intent is to have one LPSI pump operating in each train with both cold leg injection valves fully open (not throttled). Once inventory control has been regained, and the LPSI stop criteria met, then LPSI pumps may be once again stopped.

This does not apply to the situation where pressurizer pressure has purposefully been reduced to less than [LPSI pump shutoff head] in a controlled manner to get the plant to SDC conditions. This does not apply when pressurizer pressure is less than [LPSI pump shutoff head] and the LPSI pumps were secured in response to RAS initiation.

Sequence

This step is sequenced immediately after the LPSI Stop criteria.

Plant Parameters

None

Step Number 9A Line up for RWT Refill or Alternate RCS Injection

Intent

The intent of this step is to initiate early action to line up to refill the RWT or lineup alternate sources for RCS injection bypassing the RWT. This is a preemptive/precautionary move to take reasonable prerequisite actions that would better position the plant to initiate RWT refill after RAS or alternate RCS injection if sump recirculation capability should subsequently be lost (Reference 48).

Possible sources of borated water for RWT refill or alternate RCS injection include:

- Normal make up water via plant specific chemical addition system,
- Reprocessed reactor coolant via plant specific liquid waste processing and recovery system,
- Spent Fuel Pool,
- Adjacent unit RWT,
- Other plant specific sources

The specific prerequisites selected for inclusion in this instruction are plant specific. Detailed guidance should be preplanned and available in an appropriate plant procedure or guideline. Prerequisites may include such things as: reviewing preplanned guidance, activating necessary support from other organizations (Chemistry, Maintenance, Health Physics, and Security etc.), sampling, removing flanges or installing other mechanical modifications, staging temporary pumps and hoses, staging and mixing solutions of borated water, flushing lines, starting a valve line-up, etc.

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action in their EOPs if it is determined to be risk beneficial with respect to containment sump blockage.]

Method

1. Initiate actions to make up to the RWT or,
2. Initiate actions to lineup to inject directly to the RCS bypassing the RWT.

Sequence

This is a floating step. For concerns associated with sump blockage, starting RWT refill as early as possible after RAS produces the greatest benefit. Therefore, refill prerequisites and line up should be started as soon as circumstances allow and resources are available because they may take considerable time. During a large break LOCA RAS could occur within 20 to 30 minutes.

Plant Parameters

RCS Inventory Control Bases

None

RCS Inventory Control Bases

Step Number 10 for SI — IC-2, Ensure Adequate Suction Sources pumps

Intent

The intent of this step is to verify that RWT water is exiting from the RCS rupture and ending up in the containment sump. This is necessary to ensure an adequate source of water when RAS initiates.

Method

If the LOCA is located inside containment, a lowering trend of RWT level should correspond to an rising trend of containment sump level. If a lowering trend in RWT level cannot be correlated to an rising containment sump level, then the LOCA is probably outside of containment.

The contingency actions direct the operator to verify that the LOCA is outside containment, initiate CIAS, initiate actions to start normal makeup and notify [plant management].

A LOCA outside of containment may result in insufficient water in the containment sump to support HPSI pump operation following a RAS. The operator should initiate actions to makeup to the RWST via the normal means. However, this method of makeup may be much slower that the drain down to the RCS. Therefore, depending on the size of the break, initiating normal makeup may prolong the time to RAS, provide additional time to isolate the leak and more time to [align an alternate source of makeup as directed by the Technical Support Center]. This event is outside the design bases of the plant.

If possible, for LOCAs outside containment, RWST level should be maintained above the [RAS setpoint] by replenishment from available sources. This will avert an undesirable RAS, which would align the HPSI pumps to a dry containment sump and cause air binding of the pumps.

Sequence

This step is located after the SIS pumps have been started, to remind the operator to continuously watch [RWST] levels, to ensure proper activation of RAS.

(continue)

(continued)

Plant Parameters

Refueling Water Storage Tank level less than the RAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for RAS, [nominally 10%]. The intent of the application is to prompt the operator to verify that RAS occurred automatically or to manually initiate RAS if it did not. The upper allowable value for this trip is set low enough to ensure RAS does not initiate before sufficient water is transferred to the containment sump. Premature recirculation could damage or disable the recirculation system if recirculation begins before the sump has enough water to prevent air entrainment in the suction. The lower allowable value is high enough to transfer suction to the containment sump prior to emptying the RWT and to prevent air entrainment during the transfer. Switchover from RWT to the Containment sump must occur before the RWT empties to prevent damage to the ECCS pumps and a loss of core cooling capability. For similar reasons, switchover must not occur before there is sufficient water in the Containment sump to support pump suction.

RCS Inventory Control Bases

Step Number 11 IC-2, RAS Initiation Criteria

Intent

The intent of this step is to ensure that RAS is initiated when required and that the associated equipment and systems function as designed.

Method

For breaks located inside containment, if the refueling water tank level lowers to [RAS setpoint], then the operator should perform the following:

a. The operator firsts verifies that RAS has automatically initiated. If it did not, then the operator should manually initiate RAS. Recirculation is actuated either automatically or manually in order to maintain a continuous flow of safety injection fluid to the RCS (required for inventory control) and a continuous flow of containment spray water (required for containment temperature and pressure control).

b. The operator then verifies that the LPSI pumps stop, since (by design) they are not required for RAS. If they do not stop, the operator should secure them.

c. The operator then verifies that the ESF pump suction valves form the containment sump are open. This will provide a suction flowpath for the operating ESF pumps. If the valves do not open automatically, then the operator should open them.

d. After verifying (a) through (e), the operator should close the RWT outlet valves one at a time. In addition, for events where high containment pressure is present, the check valves in the RWT outlet line may be forced shut and the RWT fluid will remain unavailable while the containment is pressurized.

e. The operator then ensures that the HPSI pump minimum recirculation flow valves are closed to prevent contaminated containment sump water from returning to the RWT.

f. All charging pumps are [disabled] to prevent low suction pressure trip while charging pumps are taking suction on RWT post RAS. [disabled] in this context is the plant specific method to prevent use or auto-start of charging pumps after RAS. Generally, the term “pull-to-lock” conveys the intent, but plant specific terms should be used.

[g. The auto-start function for all idle CS pumps and associated discharge valve should be disabled when RAS is initiated. The [CSAS] signal may have been reset and aligned for auto actuation prior to RAS. Post RAS, automatic actuation should be disabled. The purpose of this action is to prevent an unintended start of CS pumps that were intentionally secured earlier in the procedure. As a result of switching to containment sump recirculation, containment pressure may temporarily spike before settling out at a new equilibrium value. For plants with a relatively low CS actuation setpoint, the increase in containment pressure may be sufficient to re-actuate CS and start the idle pumps.

(continue)

(continued)

This is undesirable because it goes against strategies to minimize flow through the sump screens after RAS and avoid equipment operations that would increase the potential for debris transport and accumulation on the sump screens.]

Sequence

This step is sequenced after the step to monitor the RWT level and is fairly late in the steps. Reaching the RAS setpoint should take some time and therefore this step should not have to be early in the sequence.

Plant Parameters

Refueling Water Storage Tank level less than the RAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for RAS, [nominally 10%]. The intent of the application is to prompt the operator to verify that RAS occurred automatically or to manually initiate RAS if it did not. The upper allowable value for this trip is set low enough to ensure RAS does not initiate before sufficient water is transferred to the containment sump. Premature recirculation could damage or disable the recirculation system if recirculation begins before the sump has enough water to prevent air entrainment in the suction. The lower allowable value is high enough to transfer suction to the containment sump prior to emptying the RWT and to prevent air entrainment during the transfer. Switchover from RWT to the Containment sump must occur before the RWT empties to prevent damage to the ECCS pumps and a loss of core cooling capability. For similar reasons, switchover must not occur before there is sufficient water in the Containment sump to support pump suction.

RCS Inventory Control Bases

Step Number 12 IC-2, HPSI Pump Minimum Flow Criteria

Intent

The intent is to ensure that after RAS has actuated, sufficient flow is maintained through each high pressure safety pump such that damage to the pump does not occur (since the HPSI mini-flow recirc valves are closed after RAS).

After the switch to recirculation, the HPSI pump flows are monitored in order to ensure that HPSI pump minimum flow requirements per pump) for pump protection are met. One HPSI pump should be left operating at all times, unless the termination criteria are met. In addition, pumps may be restarted as necessary to meet other procedural requirements as long as the minimum flow criteria are met.

Method

The operator checks HPSI flow greater than the [minimum required HPSI pump flow] to be assured that HPSI pump minimum flow requirements are met. The exact method used to accomplish this is plant specific.

A check may also be made that HPSI pumps are not in a runout condition at this time. Pump discharge pressure and pump amps are used for this indication.

The primary concern is hydraulic instability and damage to pump components including the pump seals as the result of heat buildup in low flow conditions. As the heating effects can be cumulative and are dependent on temperature, pressure and flow conditions, an exact time to failure is not possible. However, generally manufacturers will specify minimum flow rates for various lengths of time at which pump damage is not anticipated.

Another consideration is the accuracy of the instrument used to determine the total flow as well as individual pump flow. The minimum flow based on the accuracy of the instrumentation may be higher than required to actually preclude pump damage.

Sequence

This step is sequenced after the step for verifying recirculation actuation. It ensures that sufficient flow is maintained through the HPSI pumps after the recirculation minimum flow line is isolated. Pump damage is not expected to be imminent with flow less than the minimum required. That is, as noted above, damage is dependent on several variables in particular the time at the flow condition. Except in extremely low flow conditions and excluding air binding of a pump it can be assumed that low flow for up to two hours can be accommodated. These are general statements and specific manufacturer recommendations should be adhered to.

(continue)

(continued)

Plant Parameters

Minimum required HPSI pump flowrate

The engineering limit is based on the minimum required flowrate through a HPSI pump that will avoid pump damage during continuous minimum flow operation, nominally [30 gpm]. The intent of the operational limit is to ensure that the HPSI pump is secured when the flowrate through the pump decreases to less than the minimum required for continuous minimum flow operation. This will ensure continued operability and availability of the HPSI pumps by avoiding over heating and subsequent pump damage.

Step Number 12A Post RAS HPSI Stop Criteria

Intent

The intent of this step is to permit securing one HPSI pump following RAS if two HPSI trains are not needed for core heat removal. This action reduces the total ECCS flow through the containment sump screens in order to reduce debris buildup on the screens. It also establishes a protected train for use at a later time if needed. This instruction is applicable post RAS only. It does not replace or alter the standard HPSI stop/throttle criterion which is available before and after RAS.

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action in their EOPs if it is determined to be risk beneficial with respect to containment sump blockage.] (Reference 48)

Method

a. Verify both HPSI trains are in operation. It is assumed that they are operating normally and delivering design flow rate to the core as determined by the [SI flow delivery curves]. With both trains in service at this time after the trip, there may be more safety injection flow than is needed to cool the core. Therefore, it is likely that one HPSI pump may be secured. The adequacy of core heat removal is made by assessing core conditions, i.e. representative CET Temperature less than [superheat], and reactor vessel level greater than [bottom of the hot leg]. To ensure that there will be sufficient time for the operator to recognize and respond to a failure of the remaining operating pump, an additional criteria based on the time from shutdown is also included. The time requirement is based on the time for successful fifteen minute operator response which is a typical time needed to complete of a round of safety function status checks.

b. If these conditions are met, then one HPSI pump may be secured. The other pump is then monitored to ensure continued normal operation. If at any time, any of the termination criteria can not be maintained, the standby pump must be restarted or flow increased as necessary to ensure adequate core cooling is maintained.

c. Predetermine the optimal strategy for securing pumps. Select the preferred CS train (A or B) and the preferred HPSI train (A or B) to be secured first when the termination criteria are satisfied. Consider such factors as: pump power supplies, suction valve and piping configuration and sump design (split vs. common). An optimal configuration would include one CS pump and one HPSI pump with the same power supply, with a common suction line and common sump penetration or sump section. In this way the reliability of the standby pumps is enhanced.

(continue)

(continued)

Alternate Methods

Post-RAS, some plants require subcooled injection to the suction of the HPSI pumps to maintain sufficient NPSH and prevent cavitation. By design, the subcooled injection is provided by the containment spray pumps since containment spray is cooled via CCW in the spray/SDC HTX. The cumulative effect of running one HPSI pump and one containment spray pump post-RAS may increase the total flow through the containment sump screens.

For plants requiring containment spray flow injection to the HPSI pumps, the need for subcooled flow may be reduced if HPSI pump discharge flow is also reduced proportionately. This will reduce the overall flow through the sump screens. Therefore, some plants may find it more beneficial to throttle both HPSI pumps post-RAS versus securing one HPSI. This is an acceptable alternate method of reducing flow through containment sump screens if plant staff has determined an overall beneficial effect. However, if this method is use, consider the following:

1. One HPSI pump at design flow (not throttled) is within the design bases and flow loss out the break is considered in the safety analyses.
2. If HPSI is throttled, core conditions must be monitored closely since there is no way to determine the proportion of flow actually reaching the core.
3. If diesel failure occurs and the subsequent loss of one HPSI pump, operators must promptly adjust throttling flow to ensure sufficient core cooling with the remaining running HPSI pump.

Sequence

This step is sequenced after verifying that HPSI pump flow is greater than the minimum required to protect the pump. It is a continuously applicable step that may be used at any time that the relative criteria are satisfied.

Plant Parameters

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and to corroborate core covered or core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower indicating limit, RVLMS level indication, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to cover the core, support adequate core cooling, and prevent core damage.

(continue)

(continued)

Reactor Vessel level greater than the top of active fuel region

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the active fuel. However, the lowest sensor in the Reactor Vessel Level Monitoring System (RVLMS) is typically located just above the top of the fuel alignment plate. Nominal operating value is the lowest-reading sensor in the RVLMS.

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

Supplemental Information from an engineering evaluation performed on this strategy (Reference 48)

Advantages

In order for the operator to secure one train of HPSI after initiating sump recirculation it is assumed that two trains of HPSI are in operation at the time of RAS and running normally; in addition, other specific criteria are met. During large break LOCA, all of the standard HPSI stop/throttle criteria may not be met. Yet, it may still be preferable to stop one HPSI pump after RAS, if the plant-specific risk of containment sump blockage is significant.

Since most plants only require one HPSI pump to meet licensing requirements, securing all but one HPSI pump after RAS still provides adequate core cooling consistent with the analytical bases. In addition, the normal HPSI Stop/Throttle criteria are still available to the operator prior to and after RAS.

Securing one HPSI pump reduces the total flow through the sump screens and thereby reduces the rate of debris transport to the screen surface and reduces the risk of blockage. The amount and size of debris collected at the containment sump screens is a function of screen size, the flow volume through the screens and the overall inflow to the containment sump. Greater volumetric flow is more likely to “sweep” debris to the containment sump screens and thereby increase the risk of blockage. The flow contribution of one HPSI pump is relatively small (less than 1/10) compared to containment spray pump. However, any flow reduction should reduce the risk of blockage.

PWR sump screens were typically designed assuming relatively small structural loads from the differential pressure associated with 50% debris blockage. Consequently, PWR sump screens may not be capable of accommodating the substantial structural loadings that may occur due to debris beds that cover the entire screen surface.

(continue)

(continued)

Inadequate structural reinforcement of a sump screen may result in its deformation, damage, or failure, which could allow large quantities of debris to be ingested into the HPSI and Containment Spray System piping, pumps, and other components, potentially leading to clogging and failure. Reducing both the risk and rate of sump blockage lowers the risk of containment sump screen failure and potential failure of operating HPSI and Containment Spray pumps.

Securing one HPSI pump post RAS provides additional assurance that the secured pump will not be damaged due to debris ingestion or loss of NPSH, thereby preserving one operable HPSI pump for later use.

Some plants have separate sumps for each ECCS train. In this case securing flow from one train will preserve the other sump for use in the event that the in-service sump screens become blocked. In addition, operation of the single screen might reduce the amount of free debris available to block the other screen. Therefore, operating a single sump may extend recirculation capability, preserving the second sump screen by sacrificially clogging the first.

Disadvantages

Stopping one (1) HPSI pump during recirculation mode may slightly increase the required NPSH for the remaining running HPSI pump due to the increase in flow through the running pump. During two pump operation all HPSI flow must pass through common loop headers into the cold leg. When one HPSI pump is stopped, the reduction in overall flow also reduces the line-loss to the cold leg and thus flow will increase slightly for the remaining running HPSI pump.

This increase in flow will result in a slight increase in required NPSH. This should not present a problem since the required NPSH for one HPSI pump operation is already accounted for in system design.

Typical plant licensing bases show adequate core cooling with one HPSI pump after recirculation actuation. However, since deliberate manual securing of one HPSI pump is not considered a “failure,” licensees may be required to show acceptable consequences with failure of the running HPSI pump after manually stopping one of two HPSI pumps. This would mean an interruption of HPSI flow until the operator could restart the previously secured HPSI pump. Since current licensing analysis does not account for an interruption in HPSI flow due to single failure, plant specific 10 CFR 50.59 evaluation may be required to determine the acceptability of securing one HPSI pump after recirculation actuation. Best estimate analyses have been performed to determine the time after trip when the decay heat level is low enough, such that, failure of “the one” running high pressure injection pump will result in approximately 15 minutes of reaction time before core temperature begins to rise.

(continue)

(continued)

Fifteen minutes was selected so that loss of the one remaining high pressure injection pump will allow one Safety Function Status Check interval for the operator to recognize the loss of injection flow and take corrective action to restore core cooling. Best estimate analyses show that at 40 minutes after trip there is approximately 15 minutes of operator reaction time before core temperatures begin to rise. Details of this analysis are contained in Reference 48, Appendix B. Since 40 minutes is an approximate value, each plant should complete a similar plant specific best estimate analysis.

By the time that the operator is expected to reach this step (up to 1 hour post-event), the injection flow required for decay heat removal may only be 200 – 300 gpm. This will make it difficult to balance the required flow between the four injection points (50 – 75 gpm each), because SI cold leg injection flow instrument uncertainties for a harsh environment may exceed this amount. This reality supports the strategy of stopping one pump, as opposed to the strategy of throttling flow to match decay heat.

Step Number 12B Refill Refueling Water Storage Tank (RWT)

Intent

The intent of this step is to initiate action to start refilling the RWT as soon as possible after RAS. The possible sources of borated water available for RWT refill include:

- Normal make up water via plant specific chemical addition system,
- Reprocessed reactor coolant via plant specific liquid waste processing and recovery system,
- Spent Fuel Pool,
- Adjacent unit RWT,
- Other plant specific sources

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action in their EOPs if it is determined to be risk beneficial with respect to containment sump blockage.]

Method

Initiate plant specific actions to refill the RWT.

Sequence

This is a floating step. For concerns associated with sump blockage, starting RWT refill as early as possible after RAS produces the greatest benefit. Therefore, the refill prerequisites and line up should be started as soon as circumstances allow and resources are available because it may take considerable time.

Plant Parameters

None

Step Number 12C Monitor for loss of ECCS pump suction

Intent

This instruction is applicable when ECCS pumps are operating in the sump recirculation mode (Reference 48). The overall objectives are to assist the operator in recognizing the onset of sump blockage, take immediate action to reduce recirculation flowrate, protect the operating HPSI pump and then transition to the FRG for contingency actions. It is assumed that the operator has previously secured unneeded CS pumps taking suction from the containment sump. It is expected that typically one CS and one HPSI pump will be operating taking a suction from the containment sump post RAS. The goal of the overall sump blockage strategy (LOCA and FRG) is to:

1. Monitor key parameters associated with containment sump blockage,
2. Identify symptoms indicative of degraded ECCS pump performance,
3. Implement a preemptive strategy to minimize the risk of a loss of core cooling
4. Provide compensatory actions to respond to a single pump failure,
5. Provide compensatory actions to restore core cooling in the event of loss of ECCS sump as a viable suction source.

Parameters that may be available and useful in monitoring for sump blockage:

1. *Containment wide range level indication
2. *Cold leg HPSI injection flowrate
3. *CS pump flowrate
4. *HPSI pump discharge pressure
5. *CS pump discharge pressure
6. HPSI and CS pump motor current
7. *[HPSI, LPSI and CS pump suction pressure]
8. *Containment narrow range pressure
9. [other plant specific indications]

*To the greatest extent possible, uses existing alarms, SSPDS and the plant computer to trend key parameters and alert operators to deviations from the nominal post RAS base line. From a human performance standpoint, it is not realistic to expect the operator to monitor these indications closely over the period of several hours without aids such as trending or alarms. They need some automated tool to give them a “poke” when conditions start to deviate from the norm. An example of an existing alarm at some plants that may be useful is the SDC pump discharge pressure alarm. It will come in as suction pressure decreases. When the pump is secured this sensor indicates pump suction pressure, which is suction pressure to the operating HPSI pump. The potential useful alarms will differ from plant to plant.

(continue)

(continued)

Expected trends and possible anomalies

Normal Trend:

Once in service, a baseline 'normal' trend for each pump should be established. Assuming no changes in system configuration, expect all parameters to be similarly affected by changes in containment pressure and sump water temperature. Containment water level should remain relatively constant after the RWT is transferred to containment. Unexpected increase in sump level may indicate in-leakage from component cooling water or essential service water systems. Lowering sump level may indicate an ECCS leakage outside containment, or pooling inside containment due to blocked chokepoints along the return path to the containment sump.

Degradation of single pump:

Individual pump mechanical degradation would be indicated by unexpected reduction or erratic behavior in pump flowrate, discharge pressure and motor current. Concurrently, other pumps operating on the same suction source would continue to trend as expected.

Blockage of sump screens:

The containment sump screens are designed to filter out debris and provide adequate suction flow to the ECCS pumps. Debris buildup on sump screens will impair suction flow return to the ECCS pumps. Typical containment sump screens are designed for 50% debris blockage and still deliver design rated flow. Debris blockage in excess of design (50% screen area) will adversely affect ECCS pump performance and may result in loss of NPSH, severe cavitation, and potential pump failure. All ECCS pumps taking suction directly from a common sump will be affected. (If ECCS pumps are connected in series, the pump taking suction directly on the containment sump will be affected before the downstream pump.) Minor Head loss (3 to 5%) should have minimal affect on pump performance. Moderate Head loss (10 to 20%) may be accompanied by noticeable reductions in flow and discharge pressure. A large Head loss (25% and more) will result in significant flow reduction, unstable pump operation and eventually cavitation will occur. Cavitation will be result in increased pump noise.

Failure of sump screens:

If the sump screens experience a large buildup of debris, a high differential pressure may result in screen failure. If the screens fail, the pumps will ingest debris. Blockage of small internal passages and mechanical binding may occur. The pump will behave erratically, performance will decline and it will ultimately fail.

(continue)

(continued)

Multi-stage, high pressure injection pumps are more susceptible to damage from debris ingestion than low pressure single stage pumps. Ingested debris may also cause downstream valves to fail due to blockage between the valve disc and seat.

Method

a. Monitor of all available indications for signs of a loss of ECCS pump suction, i.e. sump blockage, as indicated by any of the following (listed in order of likely occurrence):
   a) [Unstable or lower than expected HPSI or CS flow]
   b) [Unstable or lower than expected HPSI or CS pump discharge pressure]
   c) [Lower than expected HPSI or CS pump suction pressure, low suction pressure alarm]
   d) [Unstable or lower than expected HPSI or CS pump motor current]
   e) [Increased HPSI or CS pump noise]
   f) [other plant specific indications]
b. If there are indications of a reduction in NPSH or pump performance, the operator should review parameter trends and attempt to diagnose what is happening. For example: an individual pump in distress, a valve or system component failure or sump screen blockage. Accurate diagnosis of these occurrences under accident conditions is difficult and will require the operator to rely heavily on knowledge, experience and training. None of the available indications will provide a 100% conclusive diagnoses. Nevertheless, time is of the essence. If the operator is fairly certain that a loss of suction is taking place, he must act quickly to avert equipment damage and avoid inadequate core cooling.
c. Stop all Containment Spray pumps still in operation. The purpose of this action is to reduce the demand on the sump to a minimum and protect the remaining HPSI pump and buy some time to implement the FRG. Core heat removal takes precedence over the containment safety functions.
d. The operator should then notify plant management of the loss of sump suction and impending loss of recirculation capability. Once blockage starts, it is unlikely that it will improve on its own. The buildup will continue until the screens are totally blocked or the screens fail.
e. The operator should monitor the remaining HPSI pump performance closely. If pump performance does not improve, throttle HPSI flow to the to the [minimum required HPSI pump flowrate] for pump protection. If pump performance still does not improve, stop the pump. If the pump is operating satisfactory at minimum flow, gradually increase flow to achieve the maximum available and continue to monitor.

(continue)

(continued)

Additional Guidance on Compensatory Actions

Actions to avert ECCS pump damage:

As stated earlier, the best overall strategy to reduce the risk of sump screen blockage, loss of all ECCS pump capability and loss of core cooling, is to stop unneeded HPSI and CS pumps as soon as possible and place them in standby. To the extent possible, this should have been done prior to getting to this step. System alignment should not be changed, so that the possibility of realignment failures is avoided. This strategy reduces the demand on the containment sump and establishes reliable backup capability. If this strategy is used, the post RAS lineup would then consist of one operating HPSI pump aligned to inject to the RCS, and possibly one CS pump operating in recirculation mode to remove heat from the containment sump water. Note that CS and the SDC heat exchanger may not be needed for long term cooling. Without spray recirculating and cooling the sump, water in the sump will reach saturated conditions and create steam. The energy in the steam is then removed from the containment atmosphere by the CFCs and transferred to CCW. Thus decay heat may be removed without spray and heat exchangers.

Some plants may also align the CS pump discharge to provide suction to the HPSI pump. Piggyback operation increases the reliability of HPSI pumps by having only the most robust pumps aligned directly to the containment sump.

Actions to restore ECCS flow in the event of ECCS pump failure:

With the preemptive strategy discussed above in use, if an individual ECCS pump fails or is diagnosed to be seriously degraded due to reasons other than sump blockage, the pump should be stopped and the standby pump placed in service after performing the necessary verifications to avoid a possible common cause failure.

Actions to mitigate increasing screen blockage:

If there are indications of increasing sump screen blockage, consider reducing the flow demand through the sump screens to as little as possible consistent with adequate core cooling. For example, consider intermittent operation of ECCS pumps based on reactor vessel level (core covered), containment conditions, and sump water temperature. Permit bulk temperature to rise to [just below the maximum]. Also, consider going to a piggy back alignment (if possible) in order to insulate the HPSI pump from damage due to possible Head loss. Throttle HPSI flow or intermittently operate the HPSI pump as needed to maintain core heat removal, until an alternate RCS injection source is available.

Sequence

This step is a continuously applicable step and is located directly after RAS initiation.

(continue)

(continued)

Plant Parameters

Minimum required HPSI pump flowrate

The engineering limit is based on the minimum required flowrate through a HPSI pump that will avoid pump damage during continuous minimum flow operation, nominally [30 gpm]. The intent of the operational limit is to ensure that the HPSI pump is secured when the flowrate through the pump decreases to less than the minimum required for continuous minimum flow operation. This will ensure continued operability and availability of the HPSI pumps by avoiding over heating and subsequent pump damage.

Actions to maintain or restore core cooling if the containment sump is blocked (Addressed in detail by FRG IC-2 Continuing actions):

Containment: Ensure all available normal and emergency containment cooling units are in operation to maximize containment heat removal and support indirect cooling of the RCS and reactor core. Without spray and SDC heat exchangers, water in the sump will reach saturated conditions and create steam. Steam energy is removed by the CFCs and transferred to CCW. Thus decay heat is removed without spray and heat exchangers.

Steam Generators: Take maximum advantage of steam generators as a heat sink. RCS heat removal can be accomplished via single phase heat transfer to the steam generators or two phase reflux cooling. Ensure adequate steam generator level and control steam flow to maintain steam generator temperature lower than the RCS, i.e., ensure steam generator is heat sink, not heat source. Continue rapid cooldown and depressurize the RCS using the secondary system to reduce break flow (RCS mass loss), and thereby reduce the need for ECCS makeup flow.

Shutdown Cooling: If RCS conditions permit, consider placing the SDC system in service as follows. The reactor vessel level must be stable and equal or greater than [mid-level on the hot leg] to ensure adequate pump suction. It is not necessary that pressurizer level be above the heaters. The RCS will likely be saturated, so care must be taken to initiate flow slowly and minimize pump cavitation.

Borated Water alternate Source: Commence RCS injection of borated water from an alternate source (non-RWT). Since the RWT may still be empty in the early stages of a sump blockage event, bypassing the RWT using an existing plant specific source may be the preferred success path. Success of refilling and using an alternate source requires that a HPSI, LPSI or charging pump be available. The suction sources, pumps and necessary alignments are plant specific.

RCS Inventory Control Bases

Step Number 13 IC-2, Determine Status of Acceptance Criteria

Intent

The intent of this step is to verify that the acceptance criteria for the success path is satisfied.

Method

After implementing the above actions of Success Path IC-2, Inventory Control is satisfied if:

- **IF** RAS has **NOT** occurred,
  THEN ALL available charging pumps are operating.
- **IF** RAS has **NOT** occurred,
  AND LPSI termination criteria are **NOT** met,
  THEN LPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.
- **IF** HPSI termination criteria are **NOT** met,
  THEN HPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.
- RVLMS level is greater than [top of the active fuel region]

If the above criterion is not satisfied, then success path IC-2 is not adequate. The operator should go to Continuing Actions for RCS Inventory Control.

If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

Sequence

This step is last in the sequence after all actions to restore and maintain RCS inventory have been addressed.

Plant Parameters

Reactor Vessel level greater than the top of active fuel region

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the active fuel. However, the lowest sensor in the Reactor Vessel Level Monitoring system~~Heated Junction Thermocouple System~~ (RVLMS~~HJTCS~~) is typically located just above the top of the fuel alignment plate. Nominal operating value is the lowest level sensor in the RVLMS~~HJTCS~~.

Continuing Actions for Inventory Control

The EPGs typically do not address specific beyond design basis events. The safety function based functional structure of the EPGs provides the best overall approach to respond to and mitigate the consequences of all events. Implementation of many of the following strategies requires close coordination with the TSC and concurrent implementation of the Severe Accident Management Guidelines (SAMGs). Refer to reference 48 and plant specific SAMGs for additional guidance.

Step Number 1 CA, Consideration of Other Safety Functions

Intent

If RCS Inventory Control is still in jeopardy, then the operator must continue to attempt to establish RCS Inventory control while attending to other safety functions in jeopardy.

Method

Actions to establish inventory control should be taken in parallel with pursuing other safety functions in jeopardy.

Sequence

This step is first in the sequence of continuing actions to restore and maintain RCS inventory.

Plant Parameters

None

Step Number 2 CA, Evaluate RCS Leakage

Intent

The intent of this step is to continue efforts to isolate potential sources of RCS leakage which can be rapidly and remotely isolated, to minimize RCS inventory losses.

Method

The following guidance is provided to isolate the leak:

a. Letdown is isolated to isolate a break and to preclude loss of RCS inventory to the CVCS. The operator should first close letdown containment isolation valves from the Control Room. If necessary, the operator may direct that letdown be isolated locally

b. RCS sampling should be terminated and all sampling lines should be isolated. If necessary, this isolation should be performed manually. Isolating RCS sample lines minimizes RCS inventory losses and minimizes the possibility of inadvertent personnel exposure, if there is a break in the sample system.

c. RCS to CCW leakage should be detected by the CCW high radiation alarm or abnormal trend. A rise in CCW surge tank level, indicated by high level alarms or abnormal trend, may also be an indication of reactor coolant to CCW in-leakage. A higher CCW heat load, possibly caused by high containment temperatures will also cause surge tank level to rise to the point where an abnormally high level rise may possibly be discerned. If RCS to CCW leakage is evident, then an attempt at locating and isolating the leak should be made.

d. RCP controlled bleedoff line isolation valve(s) should be isolated.

If there are other plant specific systems which could isolate the LOCA, then they should be listed.

Sequence

Continuously applicable.

Plant Parameters:

None

Step Number 2A CA, Maximize RCS Cooldown

Intent

The intent of this step is to ensure that deliberate action is taken by the operator to maximize remove stored energy from the SGs and consequently the RCS. In the event of sump blockage (i.e. a beyond design bases event) and Inventory Control in jeopardy and Core Heat Removal challenged, the TS cooldown limits do not apply. Thermal stresses in the reactor vessel are a minor concern for the extreme conditions associated with this situation.

Take maximum advantage of steam generators as a heat sink. RCS heat removal can be accomplished via single phase heat transfer to the steam generators or two phase reflux cooling. Ensure adequate steam generator level and control steam flow to maintain steam generator temperature lower than the RCS, i.e., ensure steam generator is heat sink, not heat source. Continue rapid cooldown and depressurize the RCS using the secondary system to reduce break flow (RCS mass loss), and thereby reduce the need for ECCS makeup flow. In addition, RCS depressurization may facilitate SIT injection if they have not yet discharged to the RCS.

SG heat removal is always beneficial to overall event mitigation strategy. It will support RCS depressurization to SDC entry conditions, especially in the case of a small break LOCA. In the case of a large break LOCA this action will help re-couple the RCS to the steam generators and promote reflux boiling (two-phase natural circulation) Lowering RCS pressure will also limit the associated break flow (loss of RCS inventory) by reducing the stored energy in the plant.

During a large break LOCA, break flow cools the core. Steam Generators are decoupled from the rest of the RCS and not the primary means of core heat removal. ECCS in-flow down the vessel wall and flow out the break is the dominant cooling mechanism. The operator has little control over reactor vessel cooldown rate because of uncontrolled cooldown and the impact of SI flow on indicated Tcold. The operator may be prompted to stop steaming the steam generators because of large uncoltrolled cooldown. However, it is still important to remove stored energy from the SGs for the reasons described above. Recall that in a LBLOCA the SGs are uncoupled from the RCS. During a small or medium size LOCA, SG heat removal is also important to lower Pressurizer pressure to ensure that the HPSI pumps are able to inject into the RCS. If a smaller break size holds Pressurizer pressure above HPSI shutoff head, it is important to maintain RCS heat removal via the steam generators, and to maintain forced circulation, if possible, using the RCP trip two / leave two strategy.

A conflict may arise for the operator in implementing the SG cooldown strategy. The initial uncontrolled cooldown of the reactor vessel is beyond his control. The influence of cool SI flow on cold leg RTDs is beyond his control. Compliance with TS RCS cooldown rates is not possible until the system stabilizes. SG cooldown can be controlled by the operator. PTS is not a concern as long as the RCS is not allowed to rapidly repressurize.

Continue)

(continued)

Reactor vessel wall delta-temperature stresses will dissipate with time. Then a controlled cooldown within the TS limits can be initiated. A 'controlled' cooldown implies that the operator is in control of the cooldown, i.e., that the cooldown is within the designed reset capabilities of MSIS and SIAS, or that the operator has the ability to stop or maintain a given pressure and temperature band.

A plant cooldown will change the reactivity conditions in the reactor core. Therefore, whenever a cooldown is performed the crew must consider the effects of the cooldown on reactivity control and take appropriate actions to maintain the [reactor shutdown]. This may include borating and sampling the RCS, both, prior to and during the cooldown. This step assumes that emergency boration will be in progress due to SIAS and therefore no direction is given to commence boration.

Method

Refer to the RCS Heat Removal success path in use. Two methods are provided for accomplishing this task; the turbine bypass valves, and the atmospheric dump valves. If the main condenser is available, the turbine bypass valves are the preferred method. Use of the turbine bypass valves conserves secondary inventory and provides for greater control over possible releases from the steam generators to the atmosphere. However, if systems are not available to support this method, or for some other reason it is not desired, then the Atmospheric dump valves may be used.

Sequence

Continuously applicable.

Plant Parameters

None

Step Number 2B CA, Depressurize RCS

Intent

The intent of this step is to ensure that all possible is being done to lower RCS pressure to support getting on Shutdown Cooling. In addition, rapid cooldown and depressurize the RCS using the secondary system helps to reduce break flow (RCS mass loss), and thereby reduce the need for ECCS makeup flow. RCS depressurization may also facilitate SIT injection if they have not yet discharged to the RCS.

Depressurization should be performed IAW the pressure and heat removal success paths in use. In this situation, cooling down at the maximum achievable rate is permissible, considering the alternatives. Consequently the ASME Section XI Appendix G cooldown limits (controlled cooldown TS limits) may be exceeded. However, it is unlikely that this action would exceed the Appendix E limits (uncontrolled cooldown). The P/T limits are not derived from Design Basis Accident (DBA) Analyses. They are prescribed during normal operation to avoid encountering pressure, temperature, and temperature rate of change conditions that might cause undetected flaws to propagate and cause nonductile failure of the reactor coolant pressure boundary (RCPB), an unanalyzed condition. The FSAR establishes the methodology for determining the P/T limits. Since the P/T limits are not derived from any DBA, there are no acceptance limits related to the P/T limits. Rather, the P/T limits are acceptance limits themselves since they preclude operation in an unanalyzed condition.

Take maximum advantage of steam generators as a heat sink. RCS heat removal can be accomplished via single phase heat transfer to the steam generators or two phase reflux cooling. Ensure adequate steam generator level and control steam flow to maintain steam generator temperature lower than the RCS, i.e., ensure steam generator is heat sink, not heat source.

Method

a. Lower RCS pressure by increasing the rate of RCS heat removal via the steam generators. Refer to the HR success path in Use.

b. The [PORVs or Pressurizer vent valves] may be used to lower RCS pressure in the event that no other means has been successful. Refer to the PC success path in Use.

Sequence

This action is continuously applicable.

Plant Parameters

None

Step Number 2C CA, Maximize Containment Cooling

Intent

The intent of this step is to ensure that all available containment fan coolers (CFCs) and ventilation systems are aligned to provide the maximum amount of heat removal and air recirculation. This will support indirect cooling of the RCS, containment sump inventory and ultimately the reactor core in the absence of SI and sump recirculation. The optimal configuration is plant specific. Refer to the Containment Temperature and Pressure Control success path in use.

Without the availability of containment sprays and the SDC heat exchangers to cool water in the containment sump, the sump water and the RCS will reach saturated conditions and create steam. The latent heat of vaporization can be removed by the CFCs and transferred to the CCW system and the ultimate heat sink. Thus core decay heat can be removed as long as there is some inventory in the reactor vessel. Therefore, it is very important to replenish RV inventory to any degree possible and any way possible. Restoration of inventory control is addressed in another CA.

Method

Ensure all available normal containment air recirculation systems are operating. The operator should check that all normal containment air recirculation fans are lined up for normal operation.

Ensure all available containment cooling fans are operating in the emergency mode. Emergency operation is defined by plant specific system design. The following items should be considered when developing the plant specific version of this instruction:

a. Ensure cooling water flow through cooling coils. The operator should ensure that component cooling water is lined up to the containment normal cooling coils by control board valve line up verification and flow instrument checks.

b. Ensure availability of heat sink. The operator should verify that service water is supplying in service component cooling water heat exchangers.

c. Ensure fans operating in emergency mode. The operator should verify that containment cooling fans are operating in the emergency mode by checking control switch position and flow indication.

Sequence

This action is continuously applicable.

Plant Parameters

None

Step Number 2D CA, Refill RWT or Line up for Alternate RCS Injection

Intent

The intent of this step is to ensure that actions are being taken to refill the RWT or lineup an alternate source for RCS injection (bypassing the RWT). The best option is plant specific. This action may already be in progress from previous instructions. However, once sump recirculation capability is actually lost, alternate injection from any source becomes a much higher priority. (Reference 48). Without any means of adding inventory to the reactor vessel, core uncovery is eminent. The time to uncovery and the onset of fuel damage will depend on decay heat level and boil off rate.

Possible sources of borated water for RWT refill or alternate RCS injection include:

- Normal make up water via plant specific chemical addition system,
- Reprocessed reactor coolant via plant specific liquid waste processing and recovery system,
- Spent Fuel Pool,
- Adjacent unit RWT,
- Other plant specific sources

The specific prerequisites selected for inclusion in this instruction are plant specific. Detailed guidance should be preplanned and available in an appropriate plant procedure or guideline. Prerequisites may include such things as: reviewing preplanned alternate injection guidance, activating necessary support from other organizations (Chemistry, Maintenance, Health Physics, and Security etc.), sampling, removing flanges or installing other mechanical modifications, staging temporary pumps and hoses, staging and mixing solutions of borated water, flushing lines, starting a valve line-up, etc.

Method

a. Initiate actions to make up to the RWT or,
b. Initiate actions to lineup to inject directly to the RCS bypassing the RWT.

Concentrated boric acid solution in the BASTs may be a good first choice. To avoid boric acid precipitation issues in the reactor vessel, consider diluting the BASTs by batching straight DI water. Ensure proper mixing prior to injecting to the RCS.

Sequence

This is a floating step. For concerns associated with sump blockage, starting RWT refill as early as possible after RAS produces the greatest benefit. Therefore, refill prerequisites and line up should be started as soon as circumstances allow and resources are available because they may take considerable time. During a large break LOCA RAS could occur within 20 to 30 minutes.

(continue)

(continued)

Plant Parameters

None

Step Number 2E CA, Attempt to intermittently refill reactor vessel using HPSI pump taking suction from Containment Sump

Intent

The intent of this step is to try to refill the reactor vessel (makeup for boil off) with a HPSI pump taking a suction from a partially blocked containment sump. Westinghouse best-estimate analyses indicate that, with no injection following recirculation actuation, the inventory boils off at decay heat levels. The amount of inventory available above the top of the active fuel depends on the location of the break and, to a lesser extent, the size of the break. In the most limiting case, there will be approximately 10 minutes to core uncovery and another 10 minutes until core overheating begins.

Intermittent refill from a partially blocked sump is an important interim action to be taken while preparing to inject from a refilled RWT or other viable source. The idea is to try to add enough water to at least make up for boil off. The assumption is that the screens may not be 100% blocked and it may be possible to get some flow through them on an intermittent bases. However, once the screens start to block, they will never unblock on their own.

With this procedure, there is a high risk that the HPSI pump will be damaged, but the risk is acceptable considering the high risk of core damage if a reliable means of inventory control is not reestablished before all the water around the active fuel boils off.

Method

a. The intent of the restart conditions are to increase the likelihood of success in transferring some water to the RCS and to ensure that the TSC is involved in all decisions to inject into a potentially damaged core. Ideally, limited intermittent RCS injection will maintain water level above the core for a period of time and preclude excessive core temperatures. However, if core uncovery occurs, initiating injection to an overheated core will cause rapid steam production and possible RCS pressure spike, which may cause creep rupture failure of the RCS (including steam generator tubes). Creep rupture failure is caused by excessive metal temperature combined with excessive pressure. Therefore, injection flow should be reintroduced gradually to minimize the potential for RCS pressure spike (TSC guidance required). In addition, try to inject only what is needed to keep the core covered, don't waste water.

(continue)

(continued)

b. The intent of verifying all ECCS pumps are stopped is to allow time for screen differential pressure to drop to zero. Doing so will allow as much material buildup on the screens as possible to fail off before attempting to restart a pump. It is not practical to further quantify how much time is needed to allow this to occur. The benefit of this action is plant specific. It depends on the type and quantity of specific materials found in containment that may become dislodged find their way to the sump. Some material will easily settle out, others will stay suspended. In either case, a few minutes to allow for potential settling to take place will probably achieve the maximum possible benefit (TSC guidance required).

c. The decision of the order in which the HPSI pumps will be used is event and plant specific. Consider pump condition and alignment considerations. Save the best pumps for last.

d. Depending on the extent if any of core damage at this point in the event, the HPSI pumps may be inaccessible due to high radiation. Verify suction alignment for selected pump (remotely). If the selected pump previously loss suction, it is possible that it may be air bound. If deemed necessary and the area is accessible from a radiological perspective, attempt to vent the pump if possible.

e. Prior to starting the pump, ensure that the SI Injection valve(s) are throttled for minimum flow for pump protection. Cold or hot leg injection may be used. Verify that the minimum recirculation line to the RWT is isolated.

f. Note initial reactor vessel level (RVLMS) and representative CET temperature. Trend these parameters using the plant computer during the injection process. If initial RVLMS indicates reactor vessel level is less than the [top of the active fuel region] and representative CET temperature is superheat, then initiate flow slowly. Expect rapid steam production and a possible pressure spike. Cladding damage and a change in radiological conditions in containment are possible (Refer to TSC for additional guidance).

g. Start the pump while observing SI flow, discharge pressure, -and pump amperage. Monitor RVLMS and CET temperatures and observe if reactor vessel water level increases. Note that changes in the void fraction of the mixture in the reactor vessel head region may result in temporary unstable RVLMS readings. Allow time (a few minutes) for fluid conditions in the RV head region to stabilize to improve the reliability of the RVLMS reading. Secure the pump if suction can not be established or if suction is lost.

h. Run the pump only long enough to achieve a maximum level at the bottom of the hot leg. Then, secure the pump to avoid spilling inventory out the break. Note, refill to greater than the [middle of the hot leg] if attempting to establish initial conditions for SDC system operation.

(continue)

(continued)

i. Monitor RVLMS and CET temperature. Repeat the refill process as necessary prior to uncovering the top of the active fuel. If SDC system is in operation, refill as necessary to ensure level remains close to the center line of the hot leg.

Sequence

This is a contentiously applicable. This is one of the first things to be attempted to keep the core covered as an alternate injection source is being lined up.

Plant Parameters

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

Reactor Vessel level greater than the top of active fuel region

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the active fuel. However, the lowest sensor in the Reactor Vessel Level Monitoring System (RVLMS) is typically located just above the top of the fuel alignment plate. Nominal operating value is the lowest-reading sensor in the RVLMS.

RVLMS at center line of the hot leg

The engineering limit is based on the water level in the hot leg needed to support SDC pump NPSH requirements.

Step Number 2F CA, Attempt a Controlled Discharge of the SITs.

Intent

This contingency action may be useful in the event of a loss of containment sump recirculation capability due to sump blockage. The intent of the step is to utilize inventory remaining in the SITs to keep the active fuel covered until an alternate RCS injection source can be lined up, or to maintain RCS level above the center line of the hot leg to support SDC system operation. This option is attractive because it utilizes a design source of borated water and no injection pump is required. However, the available inventory is very limited; but it may buy some time. The best strategy may be to release one tank at a time in a controlled manner.

Method

a. In the event of a small or medium size LOCA, the SITs may not completely discharge. If inventory is available in the SITs, the operator should attempt to utilize it to restore inventory control to the extent possible.

b. Consider isolating all SITs, and then unisolating them one at a time as needed.

c. Ensure that RCS pressure is less than SIT pressure. The preferred way to lower RCS pressure, if necessary, is by increasing RCS heat removal via the steam generators. However, pressure may also be lowered by operation of the PORVs or the pressurizer vent(s). Refer to the RSC Heat Removal or Pressure Control Success Paths in use.

d. The inventory in the SITs may be useful in supporting SDC entry conditions to maintain RCS level above the centerline of the hot leg.

e. Initiate the transfer by lowering RCS pressure and then opening the SIT isolation valve. Verify RVLMS rises and SIT level drops. Cycle the isolation valve as needed to maintain RVLMS near the center of the hot leg.

f. When SIT inventory is depleted, close the isolation valve and vent it.

Sequence

This is a floating step.

Plant Parameters

None

Step Number 2G CA, Inject Refilled RWT to RCS

Intent

The intent of reinitiating RCS injection from a refilled RWT is to regain a more reliable means of RCS inventory control for the near term. Make up sources are limited. With RCS inventory control lost and while attempting to restore it, it is very important to maintain RCS heat removal via the steam generators to support single or two-phase natural circulation (i.e., core heat removal) and to maintain containment cooling.

Westinghouse best-estimate analyses indicate that, with no injection following recirculation actuation, the inventory boils off at decay heat levels. The amount of inventory available above the top of the active fuel depends on the location of the break and, to a lesser extent, the size of the break. In the most limiting case, there will be approximately 10 minutes to core uncovery and another 10 minutes until core overheating begins.

The transfer of greater than one RWT volume to containment is outside the design bases of the plant, and may exceed the containment flooding limit with the potential for submergence of equipment and instrumentation inside containment that may be required for the recovery. Therefore, attempt to inject only what is necessary to maintain the core covered (reactor vessel filled to bottom or middle of the hot leg). These issues must be evaluated on a plant specific bases.

Method

A refilled RWT could be injected into the RCS by any available charging pump via the normal charging line (or alternate charging line), a HPSI pump, or a LPSI pump using the cold/hot leg injection lines.

a. In the event that containment sump blockage is preventing normal ECCS pump recirculation operation, once the RWT have been refilled to a usable level, it should be made available for injection to the RCS as needed. The RWT should be adequately mixed and sampled prior to injection, if possible. Core cooling takes precedence if there is not enough time to perform a chemistry verification by sampling.

b. If previous attempts to restore or maintain minimal RCS inventory control have been unsuccessful, inject additional water to the RCS from the RWT to cover the active fuel and maintain the RCS level at least at the bottom of the hot leg.

(continue)

(continued)

c. Ensure that RCS pressure is less than the shutoff head of the selected injection pump. Ensure suction from the containment sump is isolated. Align pump suction to RWT. Align the pump discharge to RCS.

d. Prior to starting the pump, ensure that the SI Injection valve(s) are throttled for minimum flow for pump protection. Select a discharge path. Either normal or alternate changing line, cold or hot leg injection may be used. Verify that the minimum recirculation line to the RWT is isolated to limit the transfer of contaminated water back to the RWT. .

e. Note initial containment sump level, containment pressure, reactor vessel level (RVLMS) and representative CET temperature. Trend these parameters using the plant computer during the injection process. If initial RVLMS indicates reactor vessel level is less than the [top of the active fuel region] and representative CET temperature is superheat, then initiate flow slowly. Expect rapid steam production and a possible pressure spike. Cladding damage and a change in radiological conditions in containment are possible (Refer to TSC for additional guidance).

f. Start the pump while observing discharge flow, discharge pressure, and pump amperage (if available). Monitor RVLMS and CET temperatures and observe that reactor vessel water level increases. Note that changes in the void fraction of the mixture in the reactor vessel head region may result in temporary unstable RVLMS readings. Allow time (a few minutes) for fluid conditions in the RV head region to stabilize to improve the reliability of the RVLMS reading. Secure the pump if suction can not be established or if suction is lost.

g. Inject only long enough to achieve a maximum level at the bottom of the hot leg. Then, secure the pump to avoid spilling inventory out the break. Note, refill to greater than the [middle of the hot leg] if attempting to establish initial conditions for SDC system operation.

h. Monitor, containment sump level, containment pressure, RVLMS and CET temperature. Repeat the refill process as necessary prior to uncovering the top of the active fuel. If SDC system is in operation, refill as necessary to ensure level remains close to the center line of the hot leg.

Sequence

This is a contentiously applicable. This is one of the last things to be attempted to keep the core covered or support SDC system operation.

(continue)

(continued)

Plant Parameters

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

Reactor Vessel level greater than the top of active fuel region

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the active fuel. However, the lowest sensor in the Reactor Vessel Level Monitoring System (RVLMS) is typically located just above the top of the fuel alignment plate. Nominal operating value is the lowest-reading sensor in the RVLMS.

RVLMS at center line of the hot leg

The engineering limit is based on the water level in the hot leg needed to support SDC pump NPSH requirements.

Step Number 2H CA, Inject to the RCS from an Alternate Source, bypassing the RWT

Intent

The intent of reinitiating RCS injection from an alternate source is to regain a more reliable means of RCS inventory control for the near term. Make up sources are limited. With RCS inventory control lost and while attempting to restore it, it is very important to maintain RCS heat removal via the steam generators to support single or two-phase natural circulation (i.e., core heat removal) and to maintain containment cooling.

Westinghouse best-estimate analyses indicate that, with no injection following recirculation actuation, the inventory boils off at decay heat levels. The amount of inventory available above the top of the active fuel depends on the location of the break and, to a lesser extent, the size of the break. In the most limiting case, there will be approximately 10 minutes to core uncovery and another 10 minutes until core overheating begins.

The transfer of greater than one RWT volume to containment is outside the design bases of the plant, and may exceed the containment flooding limit with the potential for submergence of equipment and instrumentation inside containment that may be required for the recovery. Therefore, attempt to inject only what is necessary to maintain the core covered (reactor vessel filled to bottom or middle of the hot leg). These issues must be evaluated on a plant specific bases.

Method

An alternate source could be injected into the RCS using any appropriate pump depending on the source via the normal charging line (or alternate charging line) or the cold/hot leg injection lines. Details are plant specific.

a. In the event that containment sump blockage is preventing normal ECCS pump recirculation operation, once an alternate source has been lined up, it should be made available for injection to the RCS as needed. The alternate source should be adequately mixed and sampled prior to injection, if possible. Core cooling takes precedence if there is not enough time to perform a chemistry verification by sampling.

   Concentrated boric acid solution in the BASTs may be a good first choice. To avoid boric acid precipitation issues in the reactor vessel, consider diluting the BASTs by batching straight DI water. Ensure proper mixing prior to injecting to the RCS.

b. If previous attempts to restore or maintain minimal RCS inventory control have been unsuccessful, inject additional water to the RCS from an alternate source to cover the active fuel and maintain the RCS level at least at the bottom of the hot leg.

(continue)

(continued)

c. Ensure that RCS pressure is less than the shutoff head of the selected injection pump. Ensure suction from the containment sump is isolated. Align pump suction to the source.

d. Prior to starting the pump, ensure that the injection valve(s) are throttled for minimum flow for pump protection. Select a discharge path. Either normal or alternate changing line, cold or hot leg injection may be used. Verify that the minimum recirculation line to the RWT is isolated to limit the transfer of contaminated water back to the RWT. .

e. Note initial containment sump level, containment pressure, reactor vessel level (RVLMS) and representative CET temperature. Trend these parameters using the plant computer during the injection process. If initial RVLMS indicates reactor vessel level is less than the [top of the active fuel region] and representative CET temperature is superheat, then initiate flow slowly. Expect rapid steam production and a possible pressure spike. Cladding damage and a change in radiological conditions in containment are possible (Refer to TSC for additional guidance).

f. Start the pump while observing discharge flow, discharge pressure, and pump amperage (if available). Monitor RVLMS and CET temperatures and observe that reactor vessel water level increases. Note that changes in the void fraction of the mixture in the reactor vessel head region may result in temporary unstable RVLMS readings. Allow time (a few minutes) for fluid conditions in the RV head region to stabilize to improve the reliability of the RVLMS reading. Secure the pump if suction can not be established or if suction is lost.

g. Inject only long enough to achieve a maximum level at the bottom of the hot leg. Then, secure the pump to avoid spilling inventory out the break. Note, refill to greater than the [middle of the hot leg] if attempting to establish initial conditions for SDC system operation.

h. Monitor, containment sump level, containment pressure, RVLMS and CET temperature. Repeat the refill process as necessary prior to uncovering the top of the active fuel. If SDC system is in operation, refill as necessary to ensure level remains close to the center line of the hot leg.

Sequence

This is a contentiously applicable. This is one of the last things to be attempted to keep the core covered or support SDC system operation.

(continue)

(continued)

Plant Parameters

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

Reactor Vessel level greater than the top of active fuel region

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the active fuel. However, the lowest sensor in the Reactor Vessel Level Monitoring System (RVLMS) is typically located just above the top of the fuel alignment plate. Nominal operating value is the lowest-reading sensor in the RVLMS.

RVLMS at center line of the hot leg

The engineering limit is based on the water level in the hot leg needed to support SDC pump NPSH requirements.

Step Number 2I CA, Establish minimum SDC Entry Conditions and Initiate SDC

Intent

The intent of this step is to attempt to go on shutdown cooling as soon as conditions permit. This option is attractive (especially for small breaks) because it does not require a large volume of RCS makeup and it eliminates the need for injection flow out the break to cool the reactor. All that is needed is sufficient make up to replace boil off and maintain RCS level equal to or greater than the center of the hot leg.

However, there are several issues that must be considered prior to attempting it. For example: 1) the ability to maintain RCS level equal to or greater that the center line of the hot leg needs to be established, 2) if RCS is at saturated conditions, pump cavitation may make it difficult to maintain suction, 3) system alignment to support SDC may make it necessary to enter high radiation areas (potential for failed fuel), 4) the SDC alignment will impact the availability of one CS flow path and one HPSI flowpath, 5) once into it, it may be very difficult to back out because of local high radiation areas. Therefore, implementation of this option deserves careful consideration before launching into it.

Method

The following minimum conditions should be met prior to establishing SDC. It is desirable that all of the entry conditions are stable or trending to further within the entry conditions. However this situation with no way to recirculate and inject the containment sump water, it may be necessary to attempt it even if conditions are not ideal.

a. The minimum RCS inventory for successful SDC pump operation is at the centerline of the hot leg. If the operator is successful in getting SDC in service, he may still require intermittent RCS makeup from some source to maintain the required level. Some options to consider are:
   - Intermittent HPSI pump operation on the containment sump
   - Periodic injection from a refilled RWT.
   - Periodic injection for an alternate source.
   - Controlled periodic release of available SIT inventory

b. RCS pressure should be at or below the [SDC entry pressure] to protect the integrity of shutdown cooling piping, which is not rated for the higher pressures which could exist in the RCS.

c. RCS hot leg temperature should be at or below the [SDC entry temperature]. It may be saturated. This may lead to flashing in the pump suction, erratic pump discharge pressure and flowrate. SDC pumps are typically robust and can withstand a significant amount of cavitation (plant specific). The risk of pump damage may be acceptable based on the options available the risk of core damage.

(continue)

(continued)

a. Before the shutdown cooling system is operated, the RCS activity levels must be considered since the RCS fluid will now be circulated outside of the containment building. If high activity is present. Such circulation has the potential for release to the environment. If the potential for significant releases exists, it may be more desirable to continue using the established method of cooling the plant. In addition, access to equipment where the coolant will be circulated must also be considered. Access may be dose prohibitive due to failed fuel.

Sequence

Continuously applicable.

Plant Parameters

Pressurizer pressure less than the Shutdown Cooling entry pressure

The upper engineering limit is based on the shutdown cooling system design pressure. The shutdown cooling system may be placed in operation when the RCS has been depressurized to the point that the shutdown cooling system will not be exposed to pressures greater than its design pressure. The operational limit, nominally [300 psia] (including the instrument uncertainties) should be less than the setpoint of the permissive interlock which prevents opening of the shutdown cooling suction line isolation valves.

RCS hot leg temperature less than the Shutdown Cooling entry temperature]

The upper engineering limit is based on the design temperature of the shutdown cooling system components, nominally [300]°F. The shutdown cooling system may be placed in operation when hot leg temperature is less than [300]°F.

RCS Inventory Control Bases

Step Number 3 CA, Support Restoration of Success Paths~~Continuing Actions~~

Intent

The intent of this step is to provide a list of actions for the operators to consider in deciding how and whether to continue to pursue the Inventory Control safety function.

Method

If RCS Inventory Control is still in jeopardy, then the operator must continue to attempt to establish RCS Inventory control while attending to other safety functions in jeopardy. In determining what actions to take and when they should be taken other safety functions in jeopardy must be considered and priorities determined based on the overall status of the plant. The following actions are considered.

Ensuring a minimal RCS leak rate reduces the rate of depressurization attributed to RCS leakage.

The evaluation of the urgency of RCS Inventory Control should be based on rate of change of inventory and potential for damage to the RCS, the urgency of other safety functions in jeopardy, and the feasibility of restoring equipment to restore success paths. Clearly, if inventory trends are threatening core uncovery, the operator must take all possible steps to restore inventory. This may involve the manipulation of other safety functions. (e.g. RCS pressure reduction to lower RCS pressure below the shutoff head of the SIS pumps).

Plant Parameters

None

RCS Inventory Control Bases

Step Number 4 CA, ~~Continuing Actions~~Evaluate Further Actions

Intent

The intent of this step is to direct the operator to evaluate further actions based on the urgency of the other jeopardized safety functions.

Method

Not specified.

Plant Parameters

None

SAFETY FUNCTION: **RCS and Core Heat Removal**
SUCCESS PATH: **Via SG with SIS NOT in operation; HR-1**
RESOURCE TREE: **Tree E**

INSTRUCTIONS	CONTINGENCY ACTIONS
1. **Maintain Shutdown Margin during the cooldown {law27locahr1}** **IF** Station Blackout has occurred **AND** at least one vital [4.16kV] AC bus has **NOT** been energized, **THEN** take actions to maintain RCS subcooling: a. Perform a plant cooldown, as necessary to maintain RCS subcooling based on [representative] CET temperature.	a.1 Ensure **BOTH** of the following conditions exist: • At least one steam generator has level maintained or restored to [normal control band]. • [Representative] CET temperature in [**NOT** superheated].
b. Verify that the reactor will [remain shutdown] for 50°F less than indicated Tc and boron concentration at time of event initiation, at 50°F intervals.	b.1 **IF** projected shutdown margin indicates that the reactor will **NOT** [remain shutdown], **THEN** stop the cooldown.
2. **Controlled cooldown {law2locahr1}** **IF** at least one vital [4.16kV] AC bus is energized, **THEN:**	
a. Cooldown using the Turbine Bypass Valves.	a.1 Cooldown using the Atmospheric Dump Valves.
b. Borate the RCS to maintain [adequate shutdown margin]	

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS		CONTINGENCY ACTIONS
* 3. **Verify Single Phase Natural Circulation {pk21loophr1}** **IF** NO RCPs are operating, **THEN** verify natural circulation flow in at least one loop by **ALL** of the following: • Loop delta T less than [normal full power delta T] • Hot and cold leg temperature constant or lowering • RCS subcooling greater than or equal to [minimum RCS subcooling] based on [representative] CET temperature • [NO abnormal difference] between T hot RTDs and [representative] CET temperature	3.1	Ensure proper control of steam generator feeding and steaming.
* 4. Bypass automatic MSIS and SIAS Initiation {law12sgtrhr1} As cooldown and depressurization proceed, lower or bypass automatic initiation setpoints: a. **IF** MSIS is **NOT** present, **THEN** lower or bypass the automatic initiation setpoint for MSIS. b. **IF** SIAS is **NOT** present, **THEN** lower or bypass the automatic initiation setpoint for SIAS.		

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 5. **Protect Main Condenser {jc14loophr1}**

IF offsite power has been lost,
THEN isolate steam to the main condenser:

[a. Ensure MSIVs are closed.]

[b. Ensure steam generator blowdown is isolated.]

* 6. **Determine if SGTR has occurred {law5sgtrhr1}**

IF a SGTR has occurred as indicated by **ANY** of the following:

- Steam Generator activities
- Main steam piping radiation levels
- Steam Generator level change when **NOT** feeding
- Steam Generator blowdown activities
- One Steam Generator level rising faster than the other with feed and steaming rates being essentially the same for both
- Feed flow mismatch between Steam Generators
- Steam flow vs. feed flow mismatch in a Steam Generator prior to the trip

THEN determine the most affected steam generator.

* Step Performed Continuously or Non-sequential Step
# Hold Point Step

INSTRUCTIONS		CONTINGENCY ACTIONS
7. **SGTR Bypass {hr1}** **IF** there are NO indications of a steam generator tube rupture, **THEN** GO TO Step 19.		
* 8. **Cooldown RCS to T-hot Less Than [SG safety valve lift prevent temperature] {law 20sgtrhr1}** Cooldown the RCS to T hot less than [MSSV lift prevent temperature] minus 15°F using the Turbine Bypass Valves.	8 .1	Cooldown the RCS to T hot less than [MSSV valve lift prevent temperature] minus 15°F using the Atmospheric Dump Valves.
* 9. **Lower and Control RCS Pressure {pk46sgtrhr1}** Depressurize the RCS:		
a. Maintain pressurizer pressure within **ALL** of the following criteria: • Less than [lowest MSSV setpoint] • [Approximately equal] to the isolated steam generator pressure • [Post Accident PT curves] • [RCP NPSH limits]	a.1	[**IF** pressurizer pressure can **NOT** be lowered and maintained within all of the specified criteria, **THEN** operate the [PORVs or pressurizer vent valves]. REFER TO Pressure Control Success Path PC-2.
b. Operate main or auxiliary pressurizer spray.		
c. **IF** HPSI throttle criteria are met, **THEN**: 1) Control charging and letdown flow. 2) Throttle HPSI flow as necessary.		

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 10. **Isolation of the SG Most Affected by SGTR {law11sgtrhr1}**

IF RCS hot leg temperature is less than [MSSV lift prevent temperature] minus 15°F,
THEN isolate the most affected steam generator:

a. [Raise the setpoint for the associated ADV to the upper end of [the expected post-trip control band] or isolate the ADV for the affected steam generator].

b. Close the associated MSIV.

c. Close the MSIV bypass valve.

d. Close the associated main feedwater isolation valve.

e. Isolate blowdown from the associated steam generator.

f. Close MS line drains located upstream of the associated MSIVs.

g. Verify SG safety valves are closed.

h. [Close the auxiliary feedwater isolation valve(s) including the steam driven pump steam supply valve associated with the steam generator being isolated].

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 11. **Maintain isolated SG pressure less than MSSV lift pressure {law32sgtrhr1}** Maintain the most affected SG pressure less than the upper end of [expected post-trip band] by **ANY** of the following: • Manual operation of the associated ADV • Local operation of the associated ADV	
* 12. **Verify Isolation of Most Affected Steam Generator with SGTR {law19sgtrhr1}** Verify the most affected steam generator is isolated by considering **ALL** of the following: • Steam generator activities • Steam plant radiation levels • Steam generator levels • Steam generator pressures • RCS cold leg temperatures	12.1 **IF** the wrong steam generator was isolated, **THEN** Restore feeding and steaming capability to the isolated steam generator. 12.2 **WHEN** RCS heat removal has been re-established on the least affected steam generator **THEN** Isolate the most affected steam generator.
* 13. **Sample for Boron Periodically {law37sgtrhr1}** **IF** pressurizer pressure is less than SG pressure, **THEN** sample RCS for boron concentration [on a fixed interval].	
* 14. **Disable RCP Restart {law38sgtrhr1}** **IF** all RCPs have been stopped, **THEN** disable both RCPs in the affected loop to prevent inadvertent start.	

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 15. **Maintain isolated SG Level {sgtrhr1}**

Maintain the isolated steam generator level less than [top of the indicated range] by **ANY** of the following methods:

- Lowering pressurizer pressure to below isolated steam generator pressure.
- Blowing down the isolated steam generator to the condenser.
- Steaming the isolated steam generator to the condenser.
- Steaming the isolated steam generator to atmosphere.

* 16. **Sample condensate and other systems for activity {sgtrhr1}**

Sample the Condensate System and other connecting systems, including Turbine Building sumps, for activity.

* 17. **Monitor radiation monitors {sgtrhr1}**

Monitor the Turbine and Auxiliary Building ventilation radiation monitors and any other applicable radiation monitors.

* Step Performed Continuously or Non-sequential Step
# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 18. **Cool and Depressurize Isolated SG {law3sgtrhr1}**

As the cooldown proceeds, cool and depressurize the isolated steam generator as necessary by **ANY** of the following methods in the order listed:

- **IF** at least one RCP is operating, **THEN**, draining the isolated steam generator via backflow to [top of the tube bundle] and refill to [top of the indicated range].
- [**IF** at least one RCP is operating, **THEN**, draining the isolated steam generator via backflow to expose the upper portion of the SG tubes and controlling level with feedwater.]
- Steaming the isolated steam generator to the Main Condenser using the TBVs.
- Blowing down to [the appropriate system] and feeding the isolated steam generator.
- Cooling the affected steam generator by losses to ambient.
- Steaming the isolated steam generator to the atmosphere using the ADVs.

* Step Performed Continuously or Non-sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 19. **Determine if ESDE has occurred {pk2esdehr1}** **IF** an ESDE has occurred as indicated by **ANY** of the following: • High steam flow from SG • Dropping SG pressure • Dropping SG level • Dropping RCS cold leg temperature • Dropping pressurizer pressure • Dropping pressurizer level **THEN** determine the most affected steam generator.	
20. **ESDE Bypass {hr1}** **IF** there are NO indications of an Excess Steam Demand Event **THEN** GO TO Step 24.	

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 21. **Isolate Most Affected SG with ESDE {pk6esdehr1}** Isolate the most affected steam generator: a. [Raise the setpoint for the associated ADV to the upper end of [the expected post-trip control band] or isolate the ADV for the affected steam generator]. b. Close the associated MSIV. c. Close the MSIV bypass valve. d. Close the associated main feedwater isolation valve. e. Isolate blowdown from the associated steam generator. f. Close MS line drains located upstream of the associated MSIVs. g. Verify SG safety valves are closed. h. [Close the auxiliary feedwater isolation valve(s) including the steam driven pump steam supply valve associated with the steam generator being isolated].	
* 22. **Verify isolation of Most Affected SG with ESDE {pk18esdehr1}** Verify the most affected SG is isolated by observing **ALL** of the following: • SG pressures • RCS cold leg temperatures • SG levels	22.1 **IF** the wrong steam generator was isolated, **THEN** Restore feeding and steaming capability to the isolated steam generator. 22.2 **WHEN** RCS heat removal has been re-established on the least affected steam generator **THEN** Isolate the most affected steam generator.

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 23. **Stabilize RCS Temperature Control Following ESDE {pk16esde}**

Stabilize RCS temperature within [Post Accident PT limits]. REFER TO Figure 13-8, Typical Post Accident Pressure-Temperature limits.

a. Steam the least affected steam generator using the atmospheric dump valves.

b. Control feedwater flow to the least affected steam generator.

c. Stabilize RCS temperature within [Post Accident PT limits].

d. Record time, temperature and pressure when control was regained.

{e. **IF** [Post Accident PT limits] were exceeded,
AND no RCPs are running,
THEN soak for [at least 2 hours].}

* Step Performed Continuously or Non-sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 24. **Determine if LOAF has occurred {hr1}**

Determine if a LOAF has occurred as indicated by **ANY** of the following:

- Lowering steam generator water level, low level alarm, Reactor Trip on low water level
- Rising steam generator pressure before the reactor trip, followed by a lowering and stabilizing trend
- Rising pressurizer level and pressure before the reactor trip, followed by a lowering and stabilizing trend
- [Auxiliary Feedwater Actuation Signal (AFAS)] generated on low steam generator water level
- Low main feedwater pump flow, suction pressure, main feedwater pump trip alarm

25. **LOAF Bypass {hr1}**

IF there are NO indications of Loss of All Feedwater Event
THEN GO TO Step 32.

* 26. **Stop RCPs {loafhr1}**

Stop all RCPs.

* Step Performed Continuously or Non-sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 27. **Conserve steam generator inventory {loafhr1}** Conserve steam generator inventory: a. Isolate Steam generator blowdown. b. Isolate Secondary sampling.	
* 28. **Restore Steam Generator Inventory {loafhr1}** Replenish inventory in at least one steam generator by restoring **ANY** of the following: • Auxiliary Feedwater flow • Main Feedwater flow	28.1 **IF** high pressure feedwater sources can not be restored, **THEN:** a. Depressurize the Steam Generator(s). b. Establish an alternate, low pressure feedwater source to at least one steam generator.

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 29. **Guidelines to Prevent Feed Ring Damage During FW Restoration {pk5loafhr1}** **WHEN** feedwater is restored, **THEN** control water level in the affected SG(s): a. **IF** indicated SG level is [below the feedring], **THEN** limit feedwater flow rate to the affected steam generator to less than [maximum feedflow that will **NOT** cause water hammer]. b. **WHEN ANY** of the following conditions exist: • Rise in SG level • Feed Flow has been supplied for [5 minutes] • SG water level is above the feedring **THEN** control feedwater flow rate as necessary to restore and maintain level within [normal control band.]	
* 30. **Ensure TBS is controlling RCS temperature {law21loafhr1}** Verify that turbine bypass system is controlling [RCS Tave or Tc] less than [maximum expected post-trip temperature]	30.1 Ensure [RCS Tave or Tc] is being controlled less than [maximum expected post-trip temperature] by operation of **ANY** of the following: • ADVs • MSSVs

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS		CONTINGENCY ACTIONS
* 31. **Verify Adequate RCS Heat Removal with At Least One SG {pk17loafhr1}**		
Verify adequate RCS heat removal with at least one SG by observing **BOTH** of the following conditions exist: • At least one SG has level greater than [SG level for initiating OTC] • RCS Tc is stable or lowering	31.1	**IF** wide range SG level in both SGs is less than [SG level for initiating OTC], **OR** Tc rises uncontrollably 5°F or greater, **THEN** establish heat removal via once-through-cooling. GO TO RCS and Core Heat Removal Success Path HR-3.
* 32. **Ensure Adequate Condensate Inventory {law6esdehr1}**		
Ensure the condensate inventory is greater than the minimum required. REFER TO Figure 13.14, Typical Feedwater capacity vs. Time Remaining Until Shutdown Cooling and Figure 13.15, Typical Feedwater Required for Removal of Sensible Heat.		
* 33. **Maintain SG Level in Normal Control Band {law22esdehr1}**		
Ensure the least affected steam generator has level being maintained or restored to [normal control band].		

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 34. **RCP Restart Criteria {pk10sgtrhr1}**

IF RCP restart is desirable,
THEN ensure RCP restart criteria are met:

a. Verify single phase natural circulation has been established for the preceding [20 minutes] in the loop selected for RCP restart.

b. **IF** a SGTR is indicated,
THEN sample RCS for boron concentration.

c. Verify RCS pressure and temperature are within [Post Accident PT curves] limits for RCP operation. REFER TO Figure 13.8, Post Accident PT Curves.

d. Verify the duration of [CCW] interruption to RCPs is within limits for RCP restart. REFER TO RCP technical manual.

e. Verify RCP seal pressures and temperatures are within limits for RCP restart. REFER TO RCP technical manual.

f. Verify RCP auxiliaries are operating properly to support RCP operation.

g. [Verify the RCS conditions are within the RCP start limits of plant technical specifications].

h. Ensure at least one steam generator is maintaining RCS heat removal with level in [normal control band]

i. Ensure pressurizer level is within [RCP restart level band].

j. Ensure electrical power is available to the RCPs.

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 35. **RCP Start {pk11sgtrhr1}**	
IF RCP restart is desired, **AND** RCP restart criteria are satisfied, **THEN**:	
a. Maintain pressurizer level within [RCP restart level band]:	
1) Operate available charging pumps as needed to control pressurizer level.	
2) **IF** RCS pressure is less than [HPSI pump shutoff head] **THEN** operate HPSI pumps as needed to control pressurizer level.	
b. Select RCPs to be started, **THEN** perform **BOTH** of the following:	
1) Start **ONE** RCP in the unaffected loop.	
2) Enable and start **ONE** RCP in the affected loop.	
c. Verify RCS pressure and temperature are within [Post Accident PT curves] limits for RCP operation. REFER TO Figure 13.8, Post Accident PT Curves.	c.1 **IF** RCP NPSH is **NOT** within limits, REFER TO Figure 13.8, Post Accident PT Curves, **THEN** stop the RCPs.
d. Operate charging and HPSI pumps until HPSI throttle criteria are met.	
* 36. **SIT Isolation and Venting {law17sgtrhr1}**	
WHEN Pressurizer pressure is less than [SIT isolation pressure] and controlled, **THEN** isolate or depressurize the SITs as necessary to prevent SIT injection.	

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 37. **LTOP Initiation Criteria {jc5sgtrhr1}**

WHEN **[LTOP enabling criteria] are met,**
THEN **initiate low temperature over-pressurization protection.**

* 38. **Void Elimination {jc13loafhr1}**
IF the RCS fails to depressurize
AND voiding is suspected,
THEN take steps to mitigate voiding:

a. Ensure minimum letdown, or letdown is isolated.

b. Stop depressurizing the RCS.

c. Take steps to eliminate the void:

1) Raise and lower the RCS pressure within the [Post Accident PT limits] with **ANY** of the following:

- Pressurizer heaters and spray
- HPSI and charging pumps

2) Operate the reactor vessel head vents as necessary.

3) Monitor Pressurizer level and Reactor Vessel level for RCS inventory trends.

38.1 **IF** depressurization to the SDC entry conditions is **NOT** possible,
AND voiding is suspected in the steam generator tubes,
THEN take steps to eliminate the voiding:

a) Steam the suspected steam generator using **ONE** of the following methods:

- Turbine Bypass System
- Atmospheric Dump Valves

b) Feed and bleed the suspect steam generator using feedwater and SG blowdown to maintain level within [normal control band].

c) Monitor Pressurizer level and Reactor Vessel level for RCS inventory trends.

* 39. **Reset Safety Systems {law36loafhr1}**

IF ANY safety signals have initiated
AND are no longer needed,
THEN reset the appropriate signals.

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 40. **Verification of Acceptance Criteria {hr1}**	
Verify HR-1(RCS and Core Heat Removal via SG with SIS **NOT** in operation) is satisfied by **ALL** of the following: • At least one SG level is within [normal control band] or being restored by feedwater. • **IF** RCPs are operating, **THEN** Loop delta T is less than [maximum expected shutdown delta-T with forced circulation] and **NOT** rising. • **IF** RCPs are **NOT** operating, **THEN** Loop delta T is less than [normal full power delta-T] and **NOT** rising. • RCS subcooling is greater than or equal to [minimum RCS subcooling] based on [representative] CET temperature • RVLMS indicates greater than [top of the hot leg nozzles].	40.1 **IF** the Heat Removal safety function is still in jeopardy, **THEN** GO TO the next appropriate Heat Removal success path.

* Step Performed Continuously or Non-sequential Step
\# Hold Point Step

SUPPLEMENTARY INFORMATION: HR-1

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Verification of temperature responses to a plant change cannot be accomplished until approximately 5 to 15 minutes following the action due to increased loop cycle times during natural circulation (Reference 11).

2. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel (Reference 8), unless Post-Accident Pressure/Temperature Limits are maintained, REFER TO: Figure 13.8, Post Accident PT Curves.

3. If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 13.8, Post Accident PT Curves, then maintaining of adequate core cooling will be given the higher priority. Maintaining [minimum RCS subcooling] has precedence over PTS considerations.

4. If cooling down by natural circulation with an isolated steam generator, and an inverted delta T (i.e. Tc higher Th) may be observed in the idle loop. This is due to a small amount of reverse heat transfer in the isolated steam generator and will have no affect on natural circulation flow in the operating steam generator loop (Reference 11).

5. All available indications should be used to aid in the evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (Refer. 24).

6. Water solid operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless [minimum RCS subcooling] cannot be maintained in the RCS Figure 13.8, Post Accident PT Curves. If the RCS is solid, closely monitor any makeup or drainage and any system heatup or cooldown to avoid any unfavorable pressure excursions.

7. When a void exists in the reactor vessel, and RCPs are not operating, the RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the RVLMS (Reference 15).

The indicated level also differs from different RVLMS designs under these conditions. Information concerning reactor vessel liquid inventory trending may still be discerned. However, operators are cautioned not to rely solely on the RVLMS indication when RCPs are operating.

8. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes the heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost (Reference 14).

9. If there is a conflict between isolating a steam generator (e.g., due to indications of steam generator tube leakage or excessive steam demand) and maintaining adequate heat removal via at least one SG, then maintain RCS heat removal via the least affected steam generator has precedence. At least one steam generator should always be available for heat removal, if at all possible. [Isolation of both SGs and going to OTC is a last resort option.]

10. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (Reference 34).

11. The operator should not add feedwater to a dry steam generator if another steam generator still contains water. Re-establish feedwater only to the steam generator that is not dry. If both steam generators become dry, then refill only one steam generator to reinitiate core cooling.

12. In a LOAF event, the operator should strive to conserve SG inventory by steaming only as necessary to control RCS temperature.

SAFETY FUNCTION: **RCS and Core Heat Removal**
SUCCESS PATH: **via SG with SIS in operation, HR-2**
RESOURCE TREE: **Tree E**

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. **Ensure SIAS Actuation {pk20pc3hr2}** Ensure SIAS is actuated.	
* 2. **Optimize SI {pk8pc3hr2}** Optimize SI: a. Ensure SI pumps have started. b. Verify SI flow within the [SI flow delivery curves]. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.	b.1 Take steps to restore SI flow: 1) Ensure electrical power to SI pumps and valves. 2) Ensure correct SI valve lineup. 3) Ensure operation of necessary auxiliary systems. 4) Start additional SI pumps as needed until SI flow is within [SI flow delivery curves].
[c. Start idle charging pumps]	

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 3. **Depressurize RCS {law4locahr2}**	
IF high pressurizer pressure is preventing [adequate SI flow], **THEN** depressurize the RCS:	
a. Control RCS heat removal.	
b. Control pressurizer heaters and main or auxiliary pressurizer spray.	
c. **IF** HPSI throttle criteria are met, **THEN:**	
1) Control charging and letdown.	
2) Throttle HPSI flow as necessary.	
d. Operate the [PORVs or Pressurizer vent].	
4. **Maintain Shutdown Margin during the cooldown {law27locahr1}**	
IF Station Blackout has occurred **AND** at least one vital [4.16kV] AC bus has **NOT** been energized, **THEN** take actions to maintain RCS subcooling:	
a. Perform a plant cooldown, as necessary to maintain RCS subcooling based on [representative] CET temperature.	a.1 Ensure **BOTH** of the following conditions exist: • At least one steam generator has level maintained or restored to [normal control band]. • [Representative] CET temperature in [**NOT** superheated].
b. Verify that the reactor will [remain shutdown] for 50°F less than indicated Tc and boron concentration at time of event initiation, at 50°F intervals.	b.1 **IF** projected shutdown margin indicates that the reactor will **NOT** [remain shutdown], **THEN** stop the cooldown.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS	CONTINGENCY ACTIONS
5. **Controlled cooldown {law2locahr1}** **IF** at least one vital [4.16kV] AC bus is energized, **THEN:**	
a. Cooldown using the Turbine Bypass Valves.	a.1 Cooldown using the Atmospheric Dump Valves.
b. Borate the RCS to maintain [adequate shutdown margin].	
* 6. **Verify Single Phase Natural Circulation {pk21loophr2}** **IF** NO RCPs are operating, **THEN** verify natural circulation flow in at least one loop by **ALL** of the following: • Loop delta T less than [normal full power delta T] • Hot and cold leg temperature constant or lowering • RCS subcooling greater than or equal to [minimum RCS subcooling] based on [representative] CET temperature • [NO abnormal difference] between Thot RTDs and [representative] CET temperature	6.1 Ensure proper control of steam generator feeding and steaming.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 7. **Ensure Heat Removal Under Two Phase Natural Circulation {pk3locahr2}**

IF NO RCPs are operating,
AND single phase natural circulation can **NOT** be maintained,
THEN ensure **ALL** of the following conditions exist:

- All available charging pumps are operating
- SI flow is within [SI flow delivery curves]. REFER TO Figure 13.13, SI Flow Delivery Curves
- At least one steam generator is available for RCS heat removal with level being maintained or restored to [normal control band].
- [Representative] CET temperature is [**NOT** superheated]

8. **Bypass automatic MSIS and SIAS Initiation {law12sgtrhr2}**

As cooldown and depressurization proceed, lower or bypass automatic initiation setpoints:

a. **IF** MSIS is **NOT** present,
THEN lower or bypass the automatic initiation setpoint for MSIS.

* Step Performed Continuously or Non-Sequential Step
# Hold Point step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 9. **Protect Main Condenser {jc14loophr2}**

IF offsite power has been lost,
THEN isolate steam to the Main Condenser:

[a. Ensure MSIVs are closed.]

[b. Ensure steam generator blowdown is isolated.]

* 10. **Determine if SGTR has occured {law5sgtrhr2}**

IF a SGTR has occurred as indicated by **ANY** of the following:

- Steam Generator activities
- Main steam piping radiation levels
- Steam Generator level change when **NOT** feeding
- Steam Generator blowdown activities
- One Steam Generator level rising faster than the other with feed and steaming rates being essentially the same for both
- Feed flow mismatch between Steam Generators
- Steam flow vs. feed flow mismatch in a Steam Generator prior to the trip

THEN determine the most affected steam generator.

* Step Performed Continuously or Non-Sequential Step
# Hold Point step

INSTRUCTIONS	CONTINGENCY ACTIONS
11. **SGTR Bypass {hr2}** **IF** there are NO indications of a steam generator tube rupture, **THEN** GO TO Step 24.	
* 12. **Cooldown RCS to T-hot Less Than [SG safety valve lift prevent temperature] {law 20sgtrhr2}** Cooldown the RCS to T hot less than [MSSV lift prevent temperature] minus 15°F using the Turbine Bypass Valves.	12.1 Cooldown the RCS to T hot less than [MSSV valve lift prevent temperature] minus 15°F using the Atmospheric Dump Valves.
* 13. **Lower and Control RCS Pressure {pk46sgtrhr2}** Depressurize the RCS: a. Maintain pressurizer pressure within **ALL** of the following criteria: • Less than [lowest MSSV setpoint] • [Approximately equal] to the isolated steam generator pressure • [Post Accident PT curves] • [RCP NPSH limits] b. Operate main or auxiliary pressurizer spray. c. **IF** HPSI throttle criteria are met, **THEN**: 1) Control charging and letdown flow. 2) Throttle HPSI flow as necessary.	a.1 [**IF** pressurizer pressure can **NOT** be lowered and maintained within all of the specified criteria, **THEN** operate the [PORVs or pressurizer vent valves]. REFER TO Pressure Control Success Path PC-2.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 14. **Isolation of the SG Most Affected by SGTR {law11sgtrhr2}**

WHEN RCS hot leg temperature is less than [MSSV lift prevent temperature] minus 15°F,
THEN isolate the most affected steam generator:

a. [Raise the setpoint for the associated ADV to upper end of [expected post-trip band] or isolate the ADV for the affected steam generator].

b. Close the associated MSIV.

c. Close the MSIV bypass valve.

d. Close the associated main feedwater isolation valve.

e. Isolate blowdown for the affected SG.

f. Close MS line drains located upstream of the associated MSIVs.

g. Verify SG safety valves are closed.

h. [Close the auxiliary feedwater isolation valve(s) including the steam driven pump steam supply valve associated with the steam generator being isolated].

* Step Performed Continuously or Non-Sequential Step
# Hold Point step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 15. **Maintain isolated SG pressure less than MSSV lift pressure {law32sgtrhr2}** Maintain the most affected SG pressure less than upper end of [expected post-trip band] by **ANY** of the following: • Manual operation of the associated ADV • Local operation of the associated ADV	
* 16. **Verify Isolation of Most Affected Steam Generator with SGTR {law19sgtrhr2}** Verify the most affected steam generator is isolated by considering **ALL** of the following: • Steam generator activities • Steam plant radiation levels • Steam generator levels • Steam generator pressures • RCS cold leg temperatures	16.1 **IF** the wrong steam generator was isolated, **THEN** Restore feeding and steaming capability to the isolated steam generator. 16.2 **WHEN** RCS heat removal has been re-established on the least affected steam generator **THEN** Isolate the most affected steam generator.
* 17. **Sample for Boron Periodically {law37sgtrhr2}** **IF** pressurizer pressure is less than SG pressure, **THEN** sample RCS for boron concentration [on a fixed interval].	
* 18. **Disable RCP Restart {law38sgtrhr2}** **IF** all RCPs have been stopped, **THEN** disable both RCPs in the affected loop to prevent inadvertent start.	

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 19. **Maintain isolated SG Level {sgtrhr2}**

Maintain the isolated steam generator level less than [top of the indicated range] by **ANY** of the following methods:

- Lowering pressurizer pressure to below isolated steam generator pressure.
- Blowing down the isolated steam generator to the condenser.
- Steaming the isolated steam generator to the condenser.
- Steaming the isolated steam generator to atmosphere.

* 20. **Sample condensate and other systems for activity {sgtrhr2}**

Sample the Condensate System and other connecting systems, including Turbine Building sumps, for activity.

* 21. **Monitor radiation monitors {sgtrhr2}**

Monitor the Turbine and Auxiliary Building ventilation radiation monitors and any other applicable radiation monitors.

* Step Performed Continuously or Non-Sequential Step
# Hold Point step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 22. **Cool and Depressurize Isolated SG {law3sgtrhr2}**

As the cooldown proceeds, cool and depressurize the isolated steam generator as necessary by **ANY** of the following methods in the order listed:

- **IF** at least one RCP is operating, **THEN** draining the isolated steam generator via backflow to [top of the tube bundle] and refilling to [top of the indicated range].
- **IF** at least one RCP is operating, **THEN** draining the isolated steam generator via backflow to expose the upper portion of the SG tubes and controlling level with feedwater.]
- Steaming the isolated steam generator to the Main Condenser using the TBVs.
- Blowing down the isolated steam generator to the Main Condenser and feeding the isolated steam generator.
- Cooling the affected steam generator by losses to ambient.
- Steaming the isolated steam generator to the atmosphere using the ADVs.

* Step Performed Continuously or Non-Sequential Step
# Hold Point step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 23. **Determine if ESDE has occured {pk2esdehr2}**

IF an ESDE has occurred as indicated by **ANY** of the following:

- High steam flow from SG
- Dropping SG pressure
- Dropping SG level
- Dropping RCS cold leg temperature
- Dropping pressurizer pressure
- Dropping pressurizer level

THEN determine the most affected steam generator.

24. **ESDE bypass {hr2}**

IF there are NO indications of an Excess Steam Demand Event
THEN GO TO Step 29.

* Step Performed Continuously or Non-Sequential Step
# Hold Point step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 25. **Isolate Most Affected SG with ESDE {pk6esdehr2}**

Isolate the most affected steam generator:

a. [Raise the setpoint for the associated ADV to the upper end of [the expected post-trip control band] or isolate the ADV for the affected steam generator].

b. Close the associated MSIV.

c. Close the MSIV bypass valve.

d. Close the associated main feedwater isolation valve.

e. Isolate blowdown from the associated steam generator.

f. Close MS line drains located upstream of the associated MSIVs.

g. Verify SG safety valves are closed.

h. [Close the auxiliary feedwater isolation valve(s) including the steam driven pump steam supply valve associated with the steam generator being isolated].

* Step Performed Continuously or Non-Sequential Step
# Hold Point step

INSTRUCTIONS

* 26. **Verify isolation of Most Affected SG with ESDE {pk18esdehr2}**

Verify the most affected SG is isolated by observing **ALL** of the following:

- SG pressures
- SG levels
- RCS cold leg temperatures

* 27. **Stabilize RCS Temperature Control Following ESDE {pk16esde}**

Stabilize RCS temperature within [Post Accident PT limits]. REFER TO Figure 13-8, Typical Post Accident Pressure-Temperature limits.

a. Steam the least affected steam generator using the atmospheric dump valves.

b. Control feedwater flow to the least affected steam generator.

c. Stabilize RCS temperature within [Post Accident PT limits].

d. Record time, temperature and pressure when control was regained.

{e. **IF** [Post Accident PT limits] were exceeded,
AND no RCPs are running,
THEN soak for [at least 2 hours].}

CONTINGENCY ACTIONS

26.1 **IF** the wrong steam generator was isolated,
THEN Restore feeding and steaming capability to the isolated steam generator.

26.2 When RCS heat removal has been re-established on the least affected steam generator
THEN Isolate the most affected steam generator.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 28. **Determine if LOAF has occurred {hr2}**

Determine if a LOAF has occurred as indicated by **ANY** of the following:

- Lowering steam generator water level, low level alarm, Reactor Trip on low water level
- Rising steam generator pressure before the reactor trip, followed by a lowering and stabilizing trend
- Rising pressurizer level and pressure before the reactor trip, followed by a lowering and stabilizing trend
- Auxiliary feedwater actuation signal (AFAS) generated on low steam generator water level
- Low main feedwater pump flow, suction pressure, main feedwater pump trip alarm

29. **LOAF bypass {hr2}**

IF there are NO indications of a Loss of All Feedwater Event
THEN GO TO Step 37.

* 30. **Stop RCPs {loafhr2}**

Stop all RCPs.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 31. **Conserve steam generator inventory {loafhr2}** Conserve steam generator inventory: a. Isolate Steam generator blowdown. b. Isolate Secondary sampling.	
* 32. **Restore Steam Generator Inventory {loafhr2}** Replenish inventory in at least one steam generator by restoring **ANY** of the following: • Auxiliary Feedwater flow • Main Feedwater flow	32.1 **IF** high pressure feedwater sources can not be restored, **THEN:** a. Depressurize the Steam Generator(s). b. Establish an alternate, low pressure feedwater source to at least one steam generator.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 33. **Guidelines to Prevent Feed Ring Damage During FW Restoration {pk5loafhr2}** **WHEN** feedwater is restored, **THEN** control water level in the affected SG(s): a. **IF** indicated SG level is [below the feedring], **THEN** limit feedwater flow rate to the affected steam generator to less than [maximum feedflow that will **NOT** cause water hammer]. b. **WHEN ANY** of the following conditions exist: • Rise in SG level • Feed Flow has been supplied for [5 minutes] • SG water level is above the feedring **THEN** control feedwater flow rate as necessary to restore and maintain level within [normal control band.]	
* 34. **Ensure TBS is controlling RCS temperature {law21loafhr2}** Verify that turbine bypass system is controlling [RCS Tave or Tc] less than [maximum expected post-trip temperature]	34.1 Ensure [RCS Tave or Tc] is being controlled less than [maximum expected post-trip temperature] by operation of **ANY** of the following: • ADVs • MSSVs

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 35. **Verify Adequate RCS Heat Removal with At Least One SG {pk17loafhr2}**	
Verify adequate RCS heat removal with at least one SG by observing **BOTH** of the following conditions exist: • At least one SG has level greater than [SG level for initiating OTC] • RCS Tc is stable or lowering	35.1 **IF** wide range SG level in both SGs is less than [SG level for initiating OTC], **OR** Tc rises uncontrollably 5°F or greater, **THEN** establish heat removal via once-through-cooling and GO TO RCS and Core Heat Removal Success Path HR-3.
* 36. **Ensure Adequate Condensate Inventory {law6esdehr2}**	
Ensure the condensate inventory is greater than the minimum required. REFER TO Figure 13.14, Typical Feedwater capacity vs. Time Remaining Until Shutdown Cooling and Figure 13.15, Typical Feedwater Required for Removal of Sensible Heat.	
* 37. **Maintain SG Level in Normal Control Band {law22esdehr2}**	
Ensure the least affected steam generator has level being maintained or restored to within [normal control band].	

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 38. **RCP Restart Criteria {pk10sgtrhr2}**

IF RCP restart is desirable,
THEN ensure RCP restart criteria are met:

a. Verify single phase natural circulation has been established for the preceding [20 minutes] in the loop selected for RCP restart.

b. **IF** a SGTR is indicated,
THEN sample RCS for boron concentration.

c. Verify RCS pressure and temperature are within [Post Accident PT curves] limits for RCP operation. REFER TO Figure 13.8, Post Accident PT Curves.

d. Verify the duration of [CCW] interruption to RCPs is within limits for RCP restart. REFER TO RCP technical manual.

e. Verify RCP seal pressures and temperatures are within limits for RCP restart. REFER TO RCP technical manual.

f. Verify RCP auxiliaries are operating properly to support RCP operation.

g. [Verify the RCS conditions are within the RCP start limits of plant technical specifications].

h. Ensure at least one steam generator is maintaining RCS heat removal with level in [normal control band]

i. Ensure pressurizer level is within [RCP restart level band].

j. Ensure electrical power is available to the RCPs.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 39. **RCP Start {pk11sgtrhr2}**	
IF RCP restart is desired, **AND** RCP restart criteria are satisfied, **THEN**:	
a. Maintain pressurizer level within [RCP restart level band]:	
1) Operate available charging pumps as needed to control pressurizer level.	
2) **IF** RCS pressure is less than [HPSI pump shutoff head] **THEN** operate HPSI pumps as needed to control pressurizer level.	
b. Select RCPs to be started, **THEN** perform **BOTH** of the following:	
1) Start **ONE** RCP in the unaffected loop.	
2) Enable and start **ONE** RCP in the affected loop.	
c. Verify RCS pressure and temperature are within [Post Accident PT curves] limits for RCP operation. REFER TO Figure 13.8, Post Accident PT Curves.	c.1 **IF** RCP NPSH is **NOT** within limits, REFER TO Figure 13.8, Post Accident PT Curves, **THEN** stop the RCPs.
d. Operate charging and HPSI pumps until HPSI throttle criteria are met.	
* 40. **SIT Isolation and Venting {law17sgtrhr2}**	
WHEN Pressurizer Pressure is less than [SIT isolation pressure] and controlled, **THEN** isolate or depressurize the SITs as necessary to prevent SIT injection.	

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 41. **LTOP Initiation Criteria {jc5sgtrhr2}**

WHEN [LTOP enabling criteria] are met,
THEN initiate low temperature over-pressurization protection.

* 42. **Void Elimination {jc13loca}**

IF the RCS fails to depressurize
AND voiding is suspected,
THEN take steps to mitigate voiding:

a. Ensure minimum letdown, or letdown is isolated.

b. Stop depressurizing the RCS.

c. Take steps to eliminate the void:

1) Raise and lower the RCS pressure within the [Post Accident PT limits] with **ANY** of the following:

- Pressurizer heaters and spray
- HPSI and charging pumps

2) Operate the reactor vessel head vents as necessary.

3) Monitor Pressurizer level and Reactor Vessel level for RCS inventory trends.

42.1 **IF** depressurization to the SDC entry conditions is **NOT** possible,
AND voiding is suspected in the steam generator tubes,
THEN take steps to eliminate the voiding:

a) Steam the suspected steam generator using **ONE** of the following methods:

- Turbine Bypass System
- Atmospheric Dump Valves

b) Feed and bleed the suspect steam generator using feedwater and SG blowdown to maintain level within [normal control band].

c) Monitor Pressurizer level and Reactor Vessel level for RCS inventory trends.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS

* 43. **Ensure Adequate Suction for SI Pumps {jc12locahr2}**

Confirm LOCA is inside containment:

a. Verify containment sump level is rising as the RWT level drops.

* 44. **RAS Initiation Criteria {law26locahr2}**

IF the break is inside containment,
AND RWT level is less than [RAS setpoint],
THEN ensure proper Recirculation Actuation:

a. Ensure that RAS is initiated.

b. Ensure that both LPSI pumps are stopped.

c. Ensure that ESF pump suction has shifted to the containment sump.

d. Ensure that RWT outlet valve(s) to the SIS are closed.

e. Ensure that HPSI minimum recirculation flow valves are closed.

f. [**IF** charging pump suction is aligned to the RWT,
THEN disable all charging pumps.]

[g. Ensure that the auto-start function for all idle CS pumps is disabled.]

CONTINGENCY ACTIONS

43.1 [Confirm LOCA is outside containment].

43.2 [Initiate actions to makeup to the RWT].

43.3 Verify CIAS.

43.4 Notify [plant management].

* Step Performed Continuously or Non-Sequential Step
# Hold Point step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 45. **HPSI Pump Minimum Flow Criteria {law8locahr2}**

IF RAS is present,
THEN verify that HPSI flow is greater than [minimum required HPSI pump flowrate].

45.1 Stop one HPSI pump at a time until the [minimum required HPSI pump flowrate] is met.

45A **Post RAS HPSI stop criteria**

IF RAS is present,
AND ALL of the following conditions exist,

- **BOTH** HPSI trains are in operation
- HPSI flow rate is within the [SI flow delivery curves], REFER TO Figure 13.13. SI Flow Delivery Curves
- [Representative] CET Temperature [less than superheat]
- Reactor Vessel level is greater than [bottom of the hot leg]
- Time from reactor shutdown is greater than [time for successful 15 minute operator response]

THEN stop one HPSI pump at a time until only one pump is in operation.

a) Stop one HPSI pump.

b) Verify SI flowrate greater than [SI flow delivery curves], REFER TO Figure 13.13. SI Flow Delivery Curves.

c) Verify [Representative] CET Temperature less than [superheat].

d) Verify Reactor Vessel level greater than [top of active fuel].

45A.1 **IF ANY** of the HPSI Stop criteria can **NOT** be maintained,
THEN:

a. Start HPSI pumps as necessary.

b. Raise HPSI flow as necessary.

* Step Performed Continuously or Non-Sequential Step
# Hold Point step

INSTRUCTIONS

CONTINGENCY ACTIONS

46. **Hot and Cold Leg Injection {jc3locahr2}**

IF elapsed time from the start of the LOCA is between [2 and 4 hours]
AND ANY of the following conditions exist:

- RCS subcooling is less than [minimum RCS subcooling] based on [representative] CET temperature
- Pressurizer level is less than [minimum for inventory control]
- Reactor vessel level is less than [top of the hot leg nozzles]

THEN establish simultaneous hot and cold leg injection.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 47. **Verification of Acceptance Criteria {hr2}**

Verify HR-2 (RCS and Core Heat Removal via SG with SIS in operation) is satisfied by **ALL** of the following:

a. At least one SG level is within [normal control band] or being restored by feedwater.

b. [Representative] CET temperature is [less than superheated].

c. **IF** RAS has **NOT** occurred,
AND HPSI throttle criteria are **NOT** met,
THEN all available charging pumps are operating.

d. **IF** RAS has **NOT** occurred,
AND LPSI termination criteria are **NOT** met,
THEN LPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.

e. **IF** HPSI throttle criteria are **NOT** met,
THEN HPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.

47.1 **IF** the Heat Removal safety function is still in jeopardy,
THEN GO TO the next appropriate Heat Removal success path.

* Step Performed Continuously or Non-Sequential Step
\# Hold Point step

SUPPLEMENTARY INFORMATION: HR-2:

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place system in "manual unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (Reference 34).
2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (Reference 24). Hot and cold leg RTDs may be influenced by the cold SIS injection and should be checked against each other.
3. Water solid operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless [minimum RCS subcooling] cannot be maintained in the RCS. If the RCS is water solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable pressure excursions.
4. The operator should be cautioned against prematurely initiating an RAS. The operator should check containment sump level to ensure adequate suction for the SIS before switching to recirculation. This manual action should not be taken unless an automatic RAS is required.
5. When a void exists in the reactor vessel, and RCPs are not operating, the RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the RVLMS (Reference 15). The indicated level also differs from different RVLMS designs under these conditions. Information concerning reactor vessel liquid inventory trending can still be discerned. However, operators are cautioned not to rely solely on the RVLMS indication when RCPs are operating.
6. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes the heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost (Reference 14).
7. During recirculation, at least one HPSI pump should be operating at all times unless HPSI throttle criteria are met.
8. If there is a conflict between isolating a steam generator (e.g. due to indications of steam generator tube leakage or excessive steam demand) and maintaining adequate heat removal via at least one SG, then maintain RCS heat removal <u>via the least affected steam generator</u> has precedence. At least one steam generator should always be available for heat removal, if at all possible. [Isolation of both SGs and going to OTC is a last resort option.]

9. In a LOAF event, the operator should strive to conserve SG inventory by steaming only as necessary to control RCS temperature.

SAFETY FUNCTION: **RCS and Core Heat Removal**
SUCCESS PATH: **via [Once-Through-Cooling], HR-3**
RESOURCE TREE: **Tree E**

INSTRUCTIONS

* 1. **OTC Initiation {law25loafhr3}**

[**IF** wide range SG level in both SGs is less than [SG level for initiating OTC],
OR Tc rises uncontrollably 5°F or greater,
THEN establish heat removal via once-through-cooling:

[a. De-energize all pressurizer heaters.]

[b. **IF** Main condenser is available,
THEN Ensure all Turbine Bypass Valves are open.]

[c. Ensure all Atmospheric Dump Valves are open.]

d. Ensure all RCPs are stopped.

e. Ensure SIAS is actuated.

f. Ensure HPSI pumps have started.

g. Ensure that all cold leg injection valves are open.

h. [Ensure that all available charging pumps have started].

i. Ensure both PORV block valves are open.

j. **WHEN** HPSI pumps have started,
THEN open both PORVs.

CONTINGENCY ACTIONS

f.1 **IF** all HPSI pumps are **NOT** operating,
THEN:

a. Ensure both PORVs are closed.

b. GO TO Continuing Actions for Heat Removal.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

1.A SG Isolation following OTC initiation
WHEN wide range SG level is less than [lowest reliable indicated level],
THEN:
a. Close TBVs and ADVs.
b. Close MSIVs.
c. Close MSIV bypass valves.
d. Isolate SG blowdown.
e. Close MS line drains located upstream of MSIVs.
f. Verify SG Safety Valves are closed

1.B Maintain SG Pressure less than MSSV Setpoint

IF SG pressure approaches [MSSV Setpoint],
THEN Operate the TBVs/ADVs as necessary to maintain SG pressure near the [upper end of the expected post-trip band].

* 2. **Bypass automatic MSIS Initiation {law12locahr3}**

IF MSIS is **NOT** present,
THEN lower or bypass automatic MSIS initiation.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 3. **Optimize SI {pc3hr3}** Optimize SI: a. Ensure SI pumps have started. b. Verify SI flow within [SI flow delivery curves]. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.	b.1 Take steps to restore SI flow: 1) Ensure electrical power to SI pumps and valves. 2) Ensure correct SI valve lineup. 3) Ensure operation of necessary auxiliary systems. 4) Start additional SI pumps as needed until SI flow is within [SI flow delivery curves].
[c. Start idle charging pumps.]	
* 4. **Close TBVs and ADVs {pkhr34}** **[WHEN** feedwater is to be restored to steam generator(s), **THEN** close Turbine Bypass Valves and Atmospheric Dump Valves.]	
5. **Restore Steam Generator Inventory {loaf}** Replenish inventory in at least one steam generator by restoring **ANY** of the following: • Auxiliary Feedwater flow • Main Feedwater flow	5.1 **IF** high pressure feedwater sources can not be restored, **THEN:** a. Depressurize the Steam Generator(s). b. Establish an alternate, low pressure feedwater source to at least one steam generator.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 6. **Guidelines to Prevent Feed Ring Damage During FW Restoration {pk5loafhr3}**

WHEN feedwater is restored,
THEN control water level in the affected SG(s):

a. **IF** indicated SG level is [below the feedring],
THEN limit feedwater flow rate to the affected steam generator to less than [maximum feedflow that will **NOT** cause water hammer].

b. **WHEN ANY** of the following conditions exist:

- Rise in SG level
- Feed Flow has been supplied for [5 minutes]
- SG water level is above the feedring

THEN control feedwater flow rate as necessary to restore and maintain level within [normal control band.]

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS

CONTINGENCY ACTIONS

* 7. **HPSI Throttle Criteria {law10locahr3}**

IF HPSI pumps are operating and **ALL** of the following conditions are satisfied:

- RCS subcooling is greater than or equal to [minimum RCS subcooling]
- Pressurizer level is greater than [minimum level for inventory control] and **NOT** lowering
- At least one steam generator is available for RCS heat removal with level being maintained or restored to [normal control band].
- Reactor vessel level is greater than the [top of the hot leg nozzles]
- Reactivity control safety function is satisfied as defined in the acceptance criteria

THEN throttle HPSI flow or stop one HPSI pump at a time.

* 8. **HPSI Pump Restart Criteria {law9locahr3}**

IF ANY of the HPSI throttle criteria can **NOT** be maintained,
THEN:

a. Raise HPSI flow.

b. Start HPSI pumps as necessary.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 9. **LPSI Pump Stop Criteria {law13locahr3}**

IF pressurizer pressure is greater than [LPSI pump shutoff head] and controlled, **THEN**:

a. Stop the LPSI pumps.

b. Close the LPSI injection valves.

* 10. **LPSI Pump Restart Criteria {law33locahr3}**

IF pressurizer pressure lowers to less than [LPSI pump shutoff head]
AND BOTH of the following conditions are satisfied:

- LPSI pumps have been stopped,
- RAS has **NOT** occured

THEN:

a. Start LPSI pumps as necessary.

b. Open the LPSI injection valves.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 11. **OTC Termination {pkhr3}** [**IF** Once-Through-Cooling termination is desired, **AND ALL** of the following criteria are satisfied: • At least one SG has level greater than [SG level for terminating O-T-C], with feed and steam flow capability • CET temperature is less than [saturation temperature corresponding to PSVs/PORVs lift pressure] and **NOT** rising • RVLMS indicates greater than [top of the hot leg nozzles] • PORVs are not required to be open for Success Path PC-2, PORVs **THEN** close both PORVs.	11.1 Verify pressurizer pressure is less than [expected PORV closure pressure] and close PORV block valve(s)].
* 12. Confirm LOCA is inside containment: a. Verify containment sump level is rising as the RWT level drops.	12.1 [Confirm LOCA is outside containment]. 12.2 [Initiate actions to makeup to the RWT]. 12.3 Verify CIAS. 12.4 Notify [plant management].

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 13. **RAS Initiation Criteria {law26locahr3}**	
IF the break is inside containment, **AND** RWT level is less than [RAS setpoint], **THEN** ensure proper recirculation actuation:	
a. Ensure that RAS is initiated.	
b. Ensure that both LPSI pumps are stopped.	
c. Ensure that ESF pump suction has shifted to the containment sump.	
d. Ensure that RWT outlet valve(s) to the SIS are closed.	
e. Ensure that HPSI minimum recirculation flow valves are closed.	
[f. **IF** charging pump suction is aligned to the RWT, **THEN** disable all charging pumps.]	
[g. Ensure that the auto-start function for all idle CS pumps is disabled.]	
* 14. **HPSI Pump Minimum Flow Criteria {law 8locahr3}**	
IF RAS is present, **THEN** verify that HPSI flow is greater than [minimum required HPSI pump flowrate]	13.1 **IF** [minimum required HPSI pump flowrate] is **NOT** met, **THEN** stop one HPSI pump at a time until [minimum required HPSI pump flowrate] is met.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

14A **Post RAS HPSI stop criteria**

IF RAS is present,
AND ALL of the following conditions exist,

- **BOTH** HPSI trains are in operation
- HPSI flow rate is within the [SI flow delivery curves], REFER TO Figure 13.13. SI Flow Delivery Curves
- [Representative] CET Temperature [less than superheat]
- Reactor Vessel level is greater than [bottom of the hot leg]
- Time from reactor shutdown is greater than [time for successful 15 minute operator response]

THEN stop one HPSI pump at a time until only one pump is in operation.

e) Stop one HPSI pump.

f) Verify SI flowrate greater than [SI flow delivery curves], REFER TO Figure 13.13. SI Flow Delivery Curves.

g) Verify [Representative] CET Temperature less than [superheat].

h) Verify Reactor Vessel level greater than [top of active fuel].

CONTINGENCY ACTIONS

14A.1 **IF ANY** of the HPSI Stop criteria can **NOT** be maintained,
THEN:

c. Start HPSI pumps as necessary.

d. Raise HPSI flow as necessary.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point Step

INSTRUCTIONS

* 15. **Verification of Acceptance Criteria {hr3}**

Verify HR-3 (RCS and Core Heat Removal via [Once-Through-Cooling]) is satisfied by **ALL** of the following:

- [Representative] CET temperatures [less than superheated].
- **IF** RAS has **NOT** occurred, **AND** HPSI throttle criteria are **NOT** met, **THEN** all available charging pumps are operating.
- **IF** RAS has **NOT** occurred, **AND** LPSI termination criteria are **NOT** met, **THEN** LPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.
- **IF** HPSI throttle criteria are **NOT** met, **THEN** HPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.
- Pressurizer pressure is less than [SBLOCA plateau pressure] or dropping.

CONTINGENCY ACTIONS

14.1 **IF** the Heat Removal safety function is still in jeopardy, **THEN** GO TO Continuing Actions for Heat Removal.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

SUPPLEMENTARY INFORMATION: HR-3

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual' must be checked frequently to ensure proper operation (Reference 34).
2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (Reference 24). Hot and cold leg RTDs may be influenced by the cold SIS injection and should be checked against each other.
3. Water solid operation of the pressurizer should be avoided unless [minimum RCS subcooling] cannot be maintained, REFER TO: Figure 13.8, Post Accident PT Curves. The RCS may be taken water-solid to restore RCS subcooling. If the RCS is solid, closely monitor any makeup or draining, and any system heatup or cooldown, to avoid any unfavorable rapid pressure excursions.
4. The operator should be cautioned against prematurely initiating an RAS. The operator should check containment sump level to ensure adequate suction for the SIS before switching to recirculation. This manual action should not be taken unless an automatic RAS is required.
5. During recirculation, at least one HPSI pump should be operating at all times unless HPSI throttle criteria are met.
6. If pressurizer pressure is less than the PSV reset value and greater than the SIAS setpoint, and the operator suspects that a PSV is not fully closed, then pressurizer pressure may be intentionally lowered in an attempt to reset the PSV. When doing so, pressurizer pressure should be maintained greater than the SIAS setpoint and the minimum required subcooling shall be maintained.

CONTINUING ACTIONS FOR RCS AND CORE HEAT REMOVAL

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. **Continue efforts to restore safety functions {hrca}** **IF** the Heat Removal is still in jeopardy, **THEN** pursue Heat Removal and other jeopardized safety functions simultaneously.	
* 2. **Additional means of HR via SG {hrca}** **IF** safety injection flow to the RCS is adequate, **THEN** take steps to transfer additional heat through the steam generators: a. Restore the vital auxiliaries necessary to feed at least one steam generator. b. Feed steam generators from **ANY** of the following water supplies: • Condensate • Demineralized Water • Domestic Water • Fire Service • [Raw Water] c. Steam the steam generator through **ANY** of the following paths: • Turbine Bypass valves • Atmospheric Dump valves • Steam Driven Feedwater pump • MSIV bypass and MS trap bypasses	

3. **Additional means of HR via SG – SI not-adequate {hrca}**
   IF safety injection flow to the RCS is **NOT** adequate,
   THEN implement **ANY** of the following as necessary to restore a Heat Removal success path:
   - Restoring vital auxiliaries necessary to regain needed components or subsystems.
   - **IF** remote valve operation fails, **THEN** operating failed valves locally.
   - Steaming and feeding steam generators from alternate sources.
   - Depressurizing or cooling the RCS to raise or establish safety injection flow.

* 4. **Maintain Two-phase Natural Circulation {hrca}**

   IF BOTH of the following conditions exist:
   - AC power is **NOT** available
   - RCS subcooling can **NOT** be maintained

   THEN take steps to maintain two-phase natural circulation:
   a. Control steam generator feeding and steaming.
   b. Maintain [representative] CET temperature [less than superheated]

Last Page Bookmark Follows this Hidden Text

RCS and Core Heat Removal Bases

Bases for RCS and Core Heat Removal

The purpose of the RCS and Core Heat Removal safety function is to remove the decay heat generated in the core and transfer it to the RCS fluid, where it can be transferred to the secondary system or to some other heat sink.

The following methods are available to control RCS and Core Heat Removal, and to continually provide a heat sink for decay heat removal:

HR-1: RCS and Core Heat Removal via SG with SIS NOT in operation

HR-2: RCS and Core Heat Removal via SG with SIS in operation

HR-3: RCS and Core Heat Removal via [Once-Through-Cooling]

The bases for the operator actions required to implement the above success paths are detailed as follows:

HR-1: RCS and Core Heat Removal via SG with SIS NOT in operation

Reactor coolant pump forced circulation is the preferred method for RCS heat removal. The reactor coolant absorbs the core heat and transfers this heat to the steam generators providing for the RCS and Core Heat Removal safety function. This requires that at least one steam generator be available to act as a heat sink. The heat is transferred to the secondary system fluid supplied by the main or auxiliary feedwater systems.

HR-1 Step Number 1. Maintain Subcooling and Shutdown Margin during Station Blackout

Intent

This step is intended to maintain subcooling and the reactor shutdown if a Station Blackout is in progress and no vital AC power is available.

The operator is instructed to cooldown as necessary to maintain RCS subcooling based on CET temperature. If [minimum RCS subcooling] can not be maintained, than the operator should ensure that at least one steam generator is available for RCS heat removal with level being restored to the [normal control band] and CET temperature not superheated.

To verify that the reactor [remains Shutdown] as the plant cools down, the operator is instructed to estimate the resultant Shutdown Margin based on a change in RCS temperature. If the projected shutdown margin indicates that the reactor will not [remain shutdown], then he should take actions to reduce and stop the cooldown to prevent a return to power based on a change in RCS temperature. This strategy is used when there is no available means to borate the RCS.

The purpose of this strategy is to use the data from the projected shutdown margin calculation and plant specific curves (described in the Implementation Section) to determine, ahead of time, when to stop the cooldown to prevent loss of the reactivity control safety function.

Method

If station Blackout has occurred, the operator should cooldown as necessary to maintain the [allowable range of subcooling during SBO] by maintaining or restoring steam generator level to within the [normal operating band] using auxiliary feedwater and by controlled steaming via the ADVs. The direction for steam generator level control and RCS temperature control is provide later in this procedure and are continuously applicable.

The purpose of this strategy is to preserve the ability to maintain single phase natural circulation for as long as possible by minimizing RCS leakage. For plants with minimal RCS leakage it may be possible to maintain hot standby conditions for [3 to 4] hours. During this time period, subcooling will slowly decrease due to pressurizer level lowering from RCS leakage. In order to maintain minimum subcooling a deliberate cooldown is performed as necessary to maintain subcooling within the [allowable range of subcooling during SBO], based on [representative] CET temperature.

(continue)

(continued)

The RCS may be cooled by maintaining at least one steam generator available as a heat sink using the turbine driven auxiliary feedwater pump to maintain steam generator level while steaming via the atmospheric dump valves. If a RCS cooldown is initiated with minimal pressurizer inventory, RCS subcooling will not be maintained. Also, a high RCS leak rate combined with a cooldown will rapidly depressurize the RCS resulting in a loss of subcooling. In the event of loss of subcooling, adequate core cooling can be maintained via two-phase natural circulation as described in HR-2 (RCS and Core heat Removal Via SG with SIS not in Operation).

If the plant is outside the condition limits of the LCO, the operator is required to continue efforts to comply with the technical specification action statement and restore the conditions of the LCO as conditions permit. However, there may be competing factors that collectively warrant cooling down the RCS to the greatest extent possible while maintaining a margin to criticality of 1% delta K/K or greater.

When choosing this reactivity control strategy, the utility makes a deliberate decision to operate outside the Shutdown Margin LCO. This means that the plant may no longer be protected for a MSLB, CEA bank withdrawal, CEA ejection, inadvertent RCP start or inadvertent boron dilution. The decision to lessen the required margin to criticality is justified by the fact that the specifics of the event and the need to cooldown may take precedence over the need to maintain the TS Shutdown Margin LCO.

An example of when this may apply is during a Station Blackout (SB), when there is no ability to borate to the RCS. The MSLB analysis assumes boron will be injected during the MSLB event. Maintaining the Shutdown Margin LCO during a SB no longer maintains the plant within the assumptions of the MSLB analysis. Cooling and depressurizing the plant will minimize loss of inventory while maintaining the RCS subcooled. Many multiple casualty events are beyond the design bases and attempting to maintain an LCO under these conditions may not provide the best strategy to mitigate multiple events. Under such conditions maintaining the reactor Keff .99 or less will maintain the reactor shutdown as defined in the Technical Specification of Operational Modes.

Each plant should determine the best indications to be used by the operator to implement this strategy. A plant specific table and curves, similar to the that located in the implementation section of CEN-152 under “Reactivity Control Strategy” could be developed. The curves would show the minimum temperature that the operator could cooldown to and not exceed the engineering limit and still maintain the [reactor shutdown], assuming all rods in, one rod stuck out, or one or two charging pumps operating.

(continue)

(continued)

The insertion of all the CEAs will provide more than the required shutdown margin for all C-E plants. When there is no available means to borate the RCS, such as during a station blackout, RCS temperature control is then the only available method of controlling reactivity changes. Performing a projected shutdown margin calculation at 50°F intervals with actual plant conditions (i.e. indicated Tc, boron concentration at event initiation, actual rod worth, etc.) identifies whether the next 50°F cooldown has the potential to challenge reactivity control. 50°F has been selected to provide the operators with sufficient lead time to stop the cooldown in advance of any problem. For conservatism, each calculated shutdown margin should be based on 50°F less than indicated Tc and use the boron concentration at time of event initiation. Therefore, the shutdown margin calculation for an indicated Tc of 450°F should use 400°F as input (assumed value) to the calculation.

Sequence

This step is sequenced prior to taking actions to initiate a deliberate RCS cooldown.

Plant Parameters

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Steam Generator level within the normal control range

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate.

(continue)

(continued)

For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

Reactor shutdown

The intent of the engineering limit is to ensure that the reactor is maintained subcritical during accident conditions when there is no available means to borate the RCS, such as during a station blackout. The engineering limit is based on the reactivity condition (Keff) used in the technical specification definition of Hot Standby, Hot Shutdown and Cold Shutdown (Modes 3, 4 and 5). The engineering limit is Keff less than 0.99.

Allowable range of subcooling during SBO

The lower engineering limit is based on avoiding superheated conditions (e.g. subcooling less than 0°F) in the reactor coolant system. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit on subcooling currently contained in the CE Emergency Procedure Guidelines is nominally [20°F]. The numerical value of this limit is based on engineering judgment.

HR-1 Step Number 2. Commence a Cooldown

Intent

A fundamental strategy of the EPGs is that when entering the Functional Recover Procedure, a controlled cooldown should be commenced immediately. This action is conservative in that it will reduce the pressure and temperature of the plant when the exact nature of the event is not know. In the case of a LOCA, SGTR, or ESDE this limits the associated break flow by reducing the stored energy in the plant.

A plant cooldown will change the reactivity conditions in the reactor core. Therefore, whenever a cooldown is performed the crew must consider the effects of the cooldown on reactivity control and take appropriate actions to maintain [adequate shutdown margin]. This may include borating and sampling the RCS, both, prior to and during the cooldown.

Method

Two methods are provided for accomplishing this task; the turbine bypass valves and the atmospheric dump valves. If the main condenser is available, the turbine bypass valves is the preferred method. Use of the turbine bypass valves conserves secondary inventory and provides for greater control over possible releases from the steam generators to the atmosphere. However, if systems are not available to support this method, or for some other reason is not desired, then the Atmospheric dump valves may be used.

During a prolonged station blackout, the natural circulation process can take different forms. The two principal modes are single phase natural circulation and a more complex two phase natural circulation. The simplest mode is single phase liquid connective cooling. Single phase natural circulation is the preferred mode and is self-regulating when RCS subcooling and heat removal are controlled properly.

Two phase natural circulation is more complex and can take several forms. Two phase natural circulation depends on the amount of decay heat, the amount of inventory and pressure control degradation, the RCS leak rate, and the status of the SIS and the steam generators. Two Phase NC is addresses in HR-2.

(continue)

(continued)

Sequence

For events in which reducing the energy in the RCS is of high priority, this action would be placed early in the sequence of events. Reducing the energy in the RCS helps minimize the loss of inventory associated with a break in the primary or secondary system. However, the replenishment of RCS inventory is normally of higher importance therefore this would normally follow such steps.

Plant Parameters

Adequate shutdown margin

The intent of the engineering limit is to be in compliance with plant specific technical specification shutdown margin requirements based on moderator temperature.

HR-1 Step Number 3. Verify Single Phase Natural Circulation

Intent

The intent of this step is to verify natural circulation flow is established and is supporting RCS heat removal. After RCPs are tripped, natural circulation RCS flow should develop within 5-15 minutes (longer if the plant tripped from a low power level). Natural circulation flow will continue as long as RCS pressure and inventory control are maintained, and at least one steam generator is available for RCS heat removal.

Method

Natural circulation flow is determined by a combination of factors. The factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. These density differences occur when primary to secondary heat removal through the steam generator tubes is utilized. Figure [10-10] illustrates that a reactor vessel upper head void and natural circulation flow can occur at the same time.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

1. Loop delta T less than [normal full power delta T]. This ensures by plant design that the Power/Flow ratio remains less than 1.0. A Power/flow ratio of less than 1.0 ensures that heat can be removed from the RCS during the establishment of natural circulation. Initially, T hot may increase causing the loop delta - to rise, but once natural circulation is established the loop delta T will drop.

   During the initial development of the natural circulation acceptance criteria there was no maximum delta-T criterion. Operators would observe T hot rising fairly rapidly and would interpret this as being a failure of natural circulation to develop. They would increase the steam generator feeding and steaming rate in an attempt to establish natural circulation. Unfortunately, this would only exacerbate the problem because T hot would have to increase more to cause enough of a density difference to start full-flow natural circulation. Therefore, it was determined that when both steam generators were available, if the operator did nothing but ensure normal steaming and feeding, the core delta-T never exceeded the full-power delta-T. In addition, with both steam generators available, it was determined that if the full-power delta-T was exceeded, natural circulation flow would be inadequate. Therefore, it was decided that full-power delta-T should be added as a maximum limit for the plant to stay within for adequate single phase natural circulation.

(continue)

(continued)

It should be noted, however, that at the start of natural circulation or even during a natural circulation cooldown, If an asymmetric steam generator plant cooldown is initiated, the full-power delta-T value may be briefly exceeded. This is acceptable as long as the least affected steam generator remains operable. Eventually the delta-T will fall below the full-power delta-T limit and this acceptance criterion will be passed.

2. Hot and cold leg temperature constant or dropping. This is direct feedback to the operator as to how RCS heat removal is progressing. Initially T hot will increase but as natural circulation is established T hot turn and both T hot and T cold will be decrease until the point at which they become constant.

3. RCS is greater than or equal to the [minimum RCS subcooling] based on CET temperature. Adequate subcooling ensures that an adequate amount of fluid in its desired status is available to remove decay heat. During natural circulation CET subcooling should be used to determine if adequate subcooling exist. The CETs do not rely on loop flow (as do the RTDs) for detecting fluid conditions adjacent to the core any would therefore be the most accurate indication of core temperature.

4. No abnormal difference between T hot RTDs and CET temperature. Hot leg RTD temperatures should be consistent with the [representative CETs]. The intent is to observe that *same temperature* fluid is moving from the core to the hot leg. Therefore, adequate natural circulation flow is indicated by the [representative CET] temperature being approximately equal to the hot leg RTD temperatures. An abnormal difference between Th and [representative CET] could be any difference greater than [10°F], and would indicate possible blockage in the RCS loop or uncoupling on the core and the loops.

If the RCS does not indicate natural circulation is in progress, operators should ensure that the systems and safety functions needed to support natural circulation are available and functioning properly. Specifically, the operator should ensure that RCS heat removal is available via a SG, and that heat removal is being controlled by steam generator feeding and steaming.

<u>Sequence</u>

Used whenever the need to ensure proper natural circulation flow occurs.

(continue)

(continued)

Plant Parameters

RCS Loop delta T less than normal full power delta T

The engineering limit is based on the normal full power delta T. The intent of the engineering limit is to provide a value that enables the operators to assess the status of single phase liquid natural circulation flow in at least one RCS loop. Under single phase natural circulation flow, the operating loop delta-T should be less than the normal full power delta-T. A loop delta-T less than the full power delta-T ensures that the [power/flow] ratio is within the nominal thermal hydraulic parameters for the RCS (i.e. the power to flow ratio is less than that for full power operation).

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

No abnormal difference between Thot RTDs and representative CET temperature

The engineering limit is based on engineering judgment. The operational value is nominally [+/-10 °F]. The intent of the engineering limit is to provide an approximate operational value that can be used, in conjunction with other indications, to assess the status of single phase liquid natural circulation flow in at least one RCS loop. Under single phase natural circulation flow, core exit thermocouple temperatures should be consistent with the operating loop hot leg temperature. Approximate agreement between hot leg temperature and CET is corroborative evidence that there is fluid communication (flow) between the core and at least one hot leg.

HR-1 Step Number 4. Bypassing automatic MSIS and SIAS Initiation

Intent

The intent of this step is to ensure that MSIS and SIAS do not actuate unnecessarily and complicate the event.

Method

During a controlled cooldown and depressurization, automatic operation of MSIS and SIAS is not wanted when it is not needed. Therefore, SIAS (low PZR Pressure) and MSIS (low SG Pressure) must be [blocked, bypassed, or lowered], if they have not actuated automatically, as the cooldown proceeds to ensure that automatic actuation does not occur unnecessarily. The preferred method for RCS cooldown is using the turbine bypass system, but an unnecessary MSIS would interrupt this flowpath and force the operator to either reset the MSIS or use the ADVs. An unnecessary SIAS would start both emergency diesel generators, [start emergency containment cooling], isolate letdown and commence emergency boration.

"CONTROLLED COOLDOWN: The operator is in control of the cooldown, i.e, the cooldown is within the designed reset capabilities of MSIS and SIAS, or the operator has the ability to stop or maintain a given pressure and temperature band."

Sequence

This step is sequenced after the directions to commence a cooldown.

Plant Parameters

None

HR-1 Step Number 5. Protect the Main Condenser

Intent

The intent of this step is to prevent overpressurizing the Main Condenser in the absence of condenser cooling water.

Method

The operator closes the MSIVs to isolate the major main steam supply to the condenser and steam generator blowdown. Note that up-stream main steam traps and MSIV bypass valves may also be isolated on a plant specific bases as time permits. The substeps are bracketed to permit each plant to do what ever is necessary to prevent overpressurizing the main condenser.

Sequence

This step is located just prior to the RCS heat removal steps of the procedure. It may be located earlier, if necessary, on a plant specific bases.

Plant Parameters

None

HR-1 Step Number 6. Determine if a SGTR has occurred

Intent

The intent of this step is to determine if a SGTR has occurred and which seam generator is most affected by the tube rupture

Method

Several different indications are listed for the operator to consider when making this determination. The operator should evaluate all available indications to determine with a high degree of certainty, the most affected steam generator. It is important to evaluate trends both prior to and after the trip, taking into consideration known pre-existing leakage prior to the trip.

The following indications should be evaluated. The operator is not limited to using only these indications.

1. Steam generator activities should be compared to the activities existing prior to the trip, as well as after the trip.
2. Main steam line activity as observed by the steam line radiation monitors. It is important to note that this indication will not provide accurate information after the MSIVs are closed.
3. Steam generator blowdown activities should be compared to the activities existing prior to the trip, as well as after the trip.
4. If steam generator level continues to increase when feed to the generator is isolated and RCS temperature and pressure are not changing significantly,
5. If level is rising in one steam generator faster than in the other steam generator with similar feed rates and steaming rates in both steam generators.
6. If with no manual action, there is a feed flow mismatch between the steam generators.
7. If by evaluating the pre-trip trends for feed flow, a mismatch is observed.

There might be ESD/SGTR combinations. Therefore the operator should refer to the applicable portions of this success path to aid in identifying an ESD, if it is suspected that a dual event is in progress.

(continue)

(continued)

Sequence

This step is sequenced early in the guideline to aid in isolating the steam generator as early as possible, thereby containing the activity in the secondary side of the steam generator and minimizing contamination of the secondary plant and subsequent releases to the environment.

Plant Parameters

None

HR-1 Step Number 7. SGTR Bypass Step

Intent

The intent of this step is to direct the operators to bypass steps dealing with SGTR if no indications of steam generator tube leakage exist (e.g. condenser air ejector radiation alarm, blowdown radiation alarm, high activity in a steam generator liquid sample, etc.). The operator should perform steps 8 through 18 if a SGTR is evident.

Method

N/A

Sequence

N/A

Plant Parameters

None

HR-1 Step Number 8. Cooldown RCS to T-hot Less Than [MMSV lift prevent temperature minus [15]°F]

Intent

The intent of this step is to ensure that the temperature of the RCS is lowered to less than the [SG safety valve lift prevent temperature] minus [15°F] prior to isolating the affected steam generator to prevent lifting the main steam safety valves (MSSVs) on the affected steam generator after isolation.

Method

This step is most easily accomplished when RCPs are operating and when one or more steam generators are providing cooling. If all RCPs have been tripped and natural circulation is the heat removal process, then it is necessary to cooldown both steam generator to provide uniform RCS cooling.

Under natural circulation flow conditions, T hot will rise approximately [15°F] as the core differential temperature rises as a result of the change from two loop to one loop heat removal. The temperature in the isolated SG will be essentially equivalent to Th since it is no longer being used as a heat sink. The MSSVs open at [1000 psia] which corresponds to a saturation temperature of [545°F]. Allowing a margin below the corresponding saturation temperature and accounting for the rise in Th that will result in a plant specific value for isolating the affected SG. For forced flow conditions, the increase in Th is negligible ([1°F]). Thus, the value selected to cover natural circulation conditions will cover forced circulation conditions. If RCS hot leg temperature is not less than the desired value then the RCS should be cooled down to this value.

Natural circulation cooldown of the RCS is not effective for cooling the RV head region. If natural circulation cooling provides the reduction of Th to [less than Saturation temperature corresponding to lowest MSSV setpoint], heat transfer to the steam generator from the RCS loops will not cause lifting the secondary safety valves. However, the energy stored in the RV head region and pressurizer has to be dealt with to bring RCS pressure close to steam generator pressure to minimize leakage into the steam generator and to preclude steam generator safety valve opening due to filling the steam generator with high RCS pressure. Controlling RCS pressure with the pressurizer and with an uncooled RV head region is addressed in a later actions.

(continue)

(continued)

This action may be performed by feeding the steam generators with feedwater and dumping steam to the condenser via manual control of the turbine bypass valves. If the condenser or turbine bypass system is not available, then the atmospheric dump valves may be used. However, it is less desirable to use the atmospheric dump valves to cooldown the RCS because of the un-monitored release of activity to the environment. Operation of the ADVs is more desirable than operation of the MSSVs for two reasons. First, the MSSVs may stick open or leak by. MSSVs can not be isolated, and the ADVs can. Secondly, the ADVs provide a more controlled release than do the MSSVs.

Sequence

This step is necessary before the steam generator most affected by the tube rupture has been identified and isolated.

Plant Parameters

Hot leg temperature less than MSSV lift prevent temperature

The bases for the engineering limit is the lift setpoint of the lowest lifting MSSV. The lowest lifting Main Steam Safety Valve (MSSV) setpoint for the reference plant is [1000] psia, with a tolerance of [± 1% (10 psi)]. Therefore, this safety valve may open at a steam generator pressure of [990] psia. The saturation temperature at [990] psia is approximately [540]°F. In order to prevent the steam generator pressure from exceeding the MSSV setpoint, the temperature in the steam generator must remain less than [540]°F. Assuming the hot leg temperature is equal to the steam generator saturation temperature, the hot leg temperature must also remain below [540]°F. The resultant heatup that is expected to take place due to transferring from two steam generators of cooling to one steam generator of cooling must also be accounted for. Following steam generator isolation, the hot leg temperature in both loops is expected to rise due to the increased heat removal load on the unisolated steam generator. Best estimate analyses have shown this rise may be as much as [15]°F. To ensure that the MSSVs do not open following this temperature rise, the hot leg temperature prior to isolation must be reduced by this amount. Therefore, hot leg temperature prior to steam generator isolation which will ensure the MSSVs do not open after the subsequent increase in hot leg temperature after isolation, is [540°F-15] or [525]°F.

HR-1 Step Number 9. Lower and Control RCS Pressure

Intent

The intent of this step is to minimize the transfer of inventory from and to the RCS, and to prevent lifting the steam generator safety valves.

The general goals associated with RCS pressure control are: providing subcooling to support the core heat removal process, avoiding overpressure situations for PTS and RT NDT considerations, minimizing the pressure differential between the steam generator and the RCS to minimize the leakage, and controlling RCS pressure so that it is below the main steam safety valve (MSSV) setpoints. This step addresses steam generator to RCS pressure differential and RCS depressurization to below the MSSV setpoint.

Method

Pressurizer pressure is reduced by:

1. Operation of Pressurizer sprays and heaters.
2. Control charging pumps, letdown and HPSI pumps, if HPSI Stop/Throttle criteria are met.
3. As a last resort, operate the [PORVs or pressurizer vents] using the associated Pressure Control Success Path (PC-2).

Maintaining the RCS pressure within the PT limits and approximately equal to the isolated steam generator pressure [±50 psi] and below the [lowest MSSV lift setpoint] will minimize the loss of primary fluid to the secondary side and the possibility of overfilling the isolated SG. This action will minimize the potential for release of radiation to the environment by minimizing RCS to steam generator leakage.

Maintaining RCS pressure approximately equal to or less than the affected SG pressure allows for the backflow of secondary water into the RCS which provides several operational benefits. These benefits include:

1. SG level will be maintained within the indicating range,
2. The chance of filling the main steam piping with water is greatly reduced,
3. Minimal use of the blowdown system should be required for SG level control,
4. The isolated SG depressurization would be easier (without steaming) because there would be less steam compression and a smaller layer of water between the SG tubes and the steam,

(continue)

(continued)

5. Less makeup water is required for the RCS cooldown.

Boron dilution of the RCS would occur due to unborated secondary water flowing through the tube rupture into the RCS. However, under most circumstances, this dilution will not threaten the maintenance of [adequate shutdown margin].

A important point in the strategy for the SGTR event is to maintain or restore forced circulation if possible. However, maintaining adequate NPSH for RCP operation may cause the operator to hold RCS pressure above secondary pressure until the RCS is cooled down beyond the SG isolation temperature. The requirement to maintain NPSH takes precedence over the strategy of equalizing primary pressure and secondary pressure.

During the forced circulation cooldown process the isolated steam generator may cool faster in the lower regions (see Figure 6-10). The cooling of the isolated SG steam space will significantly lag in the cooldown and cause the fluid in the lower regions to be subcooled. If the tube rupture is located in this subcooled region, as it is most likely to be, then the primary fluid can be at the same pressure as the secondary fluid and still be subcooled. However the continued depressurization of the primary during the cooldown will now be limited by the ability to depressurize the isolated SG.

During natural circulation cooldown conditions the isolated steam generator will not cool unless there is a transfer of mass in the isolated SG. This complicates RCS pressure control during the cooldown. It is desirable to cool the RCS such that the tube bundle region of the affected SG remains subcooled. Voiding in the tube bundle region can be expected and may result in the region becoming a pressurizing source for the RCS. Maintaining the presence of subcooled liquid in affected loop will be a complicated process under natural circulation conditions. Forced circulation conditions are much more desirable and if possible should be maintained or restored. During natural circulation conditions the cooldown and depressurization of the RCS will be limited to the operator's ability to control the conditions of the isolated steam generator.

Sequence

This step is sequenced after the most affected steam generator, after the step for verifying that the most affected steam generator has been isolated, and after the step for the methods of controlling RCS pressure.

(continue)

(continued)

Plant Parameters

Steam Generator pressure less than the lowest MSSV lift setpoint

The bases for the engineering limit is the lift setpoint of the lowest MSSV, minus lift tolerance. The intent of the application is prevent lifting an MSSV which then sticks open, resulting in an uncontrolled release to the environment, because the operator can do nothing to stop it. The operational limit, [950 psia] was derived by taking the lowest MSSV setting [1000 psia.], subtracting the lift tolerance, typically ±1% (), [± 10 psi], and additional operational margin [40 psi].

Pressurizer pressure approximately equal to SG pressure

The engineering limits provide an operational band, nominally [± 50 psi] that minimizes backflow, while permitting some back flow to control SG level or to aid in cooldown of the affected SG. Maintaining the RCS pressure approximately equal (± 50 psi) to the isolated steam generator pressure will accomplish two goals: 1) minimize the loss of primary fluid to the secondary side and the possibility of overfilling the isolated steam generator; 2) minimize the amount of unborated water flowing into the RCS from the steam generator which could reduce the RCS boron concentration.

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

HR-1 Step Number 10. Isolation of the SG Most Affected by SGTR

Intent

The intent of this step is to isolate the SG most affected by the tube rupture from the environment and the rest of the secondary system.

Method

Prior to affected SG isolation, RCS temperature (T hot) should be lowered to less than the [MSSV lift prevent temperature] minus 15°F. This action is necessary to prevent inadvertently opening a MSSV after the steam generator is isolation. Steam generator isolation is intended to re-establish the containment isolation safety function breached by the SGTR. If pressure in the isolated steam generator approaches the [lift pressure for the lowest MSSV], the operator should ensure that the ADV opens first. ADV operation is desirable from the perspective of positive operator control. This is accomplished by raising the automatic ADV lift setpoint to the upper end of the [post-trip control band], or manually opening the ADV prior to SG pressure reaching the [lift pressure for the lowest MSSV]. To minimize the un-monitored release of radioactivity, use of the atmospheric steam dump valves on the affected steam generator should be minimized. If both steam generators have tube ruptures, then the operators must determine which generator is most affected and isolate that generator.

The most affected steam generator is isolated as follows:

a. [The atmospheric steam dump valve (ADV) setpoint is raised to a value below the [upper end of the expected post-trip band] (not all plant have this capability) or the ADV for the affected steam generator is isolated]

b. The associated main steam isolation valve is closed.

c. The associated main steam isolation valve bypass valves is verified closed, or closed.

d. The main feedwater isolation valves are closed.

e. The associated steam generator blowdown is isolated.

f. MS line drains located upstream of the associated MSIVs are isolated from the main condenser.

(continue)

(continued)

g. The associated steam generator safety valves are verified closed.

h. [The auxiliary feedwater isolation valves are closed, including the steam driven pump steam supply valve associated with the steam generator being isolated].

This completes steam generator isolation. The instructions are intended to contain the contaminated secondary fluid within the affected steam generator. Steam generator isolation does not address the control of secondary system contamination which occurred prior to isolation. Secondary plant contamination is address in another instruction.

Sequence

This step is sequenced after the step for identifying the most affected steam generator.

Plant Parameters

Hot leg temperature less than MSSV lift prevent temperature

The bases for the engineering limit is the lift setpoint of the lowest lifting MSSV. The lowest lifting Main Steam Safety Valve (MSSV) setpoint for the reference plant is [1000] psia, with a tolerance of [± 1% (10 psi)]. Therefore, this safety valve may open at a steam generator pressure of [990] psia. The saturation temperature at [990] psia is approximately [540]°F. In order to prevent the steam generator pressure from exceeding the MSSV setpoint, the temperature in the steam generator must remain less than [540]°F. Assuming the hot leg temperature is equal to the steam generator saturation temperature, the hot leg temperature must also remain below [540]°F. The resultant heatup that is expected to take place due to transferring from two steam generators of cooling to one steam generator of cooling must also be accounted for. Following steam generator isolation, the hot leg temperature in both loops is expected to rise due to the increased heat removal load on the unisolated steam generator. Best estimate analyses have shown this rise may be as much as [15]°F. To ensure that the MSSVs do not open following this temperature rise, the hot leg temperature prior to isolation must be reduced by this amount. Therefore, hot leg temperature prior to steam generator isolation which will ensure the MSSVs do not open after the subsequent increase in hot leg temperature after isolation, is [540°F-15] or [525]°F.

(continue)

(continued)

Steam Generator pressure less than the lowest MSSV lift setpoint

The bases for the engineering limit is the lift setpoint of the lowest MSSV, minus lift tolerance. The intent of the application is prevent lifting an MSSV which then sticks open, resulting in an uncontrolled release to the environment, because the operator can do nothing to stop it. The operational limit, [950 psia] was derived by taking the lowest MSSV setting [1000 psia.], subtracting the lift tolerance, typically ±1% (), [± 10 psi], and additional operational margin [40 psi].

Steam Generator pressure within the expected post-trip control band. The engineering limits are based on a 10°F post-trip RCS temperature control band of nominally [525 - 535°F] which was established based on engineering judgment (including, but not centered on the no-load temperature) to arrive at the SG pressure control band. The resulting nominal SG pressure band is [850 - 920 psia], with a nominal TBV setpoint of 885 psia. The intent of this application is to assist the operator in detecting a malfunction of the TBVs, MSSVs or steam bypass control system (SBCS) as soon as possible.

HR-1 Step Number 11. Maintain isolated SG pressure less than MSSV lift pressure

Intent

The intent of this step is to ensure that high pressure in the isolated steam generator does not cause a safety valve to lift causing an uncontrolled release.

Method

The affected SG pressure is maintained less than the upper end of the [normal control band] by manual operation or local operation of the associated ADV. This action is taken to mitigate a high pressure in the isolated SG.

Should the pressure in an isolated steam generator approach the lift setpoint for the associated MSSVs, it is desirable from the perspective of positive operator control that the ADV open first. This is accomplished by manually opening the ADV, or locally opening the ADV. To minimize the un-monitored release of radioactivity, use of the atmospheric steam dump valves on the affected steam generator should be minimized.

The MSIV bypass valve might also be used to steam to the condenser. However, the effectiveness of the bypass valve is limited based on its size. It is, however, more desirable to steam the affected steam generator to the condenser if necessary than to steam directly to the environment. By steaming to the condenser some of the activity will be retained in the condenser versus to the environment (health and safety of the public) and this will provide a monitored release path via the off gas monitor.

Sequence

This step is sequenced immediately after the isolation of the affected steam generator to ensure that actions are taken to prevent lifting a safety valve after the generator has been isolated.

Plant Parameters

Steam Generator pressure within the expected post-trip control band

The engineering limits are based on a 10°F post-trip RCS temperature control band of nominally [525 - 535°F] which was established based on engineering judgment (including, but not centered on the no-load temperature) to arrive at the SG pressure control band. The resulting nominal SG pressure band is [850 - 920 psia], with a nominal TBV setpoint of 885 psia. The intent of this application is to assist the operator in detecting a malfunction of the TBVs, MSSVs or steam bypass control system (SBCS) as soon as possible.

HR-1 Step Number 12. Verify Isolation of Most Affected Steam Generator with SGTR

Intent

The intent of this step is to verify that the steam generator that is most affected by the tube rupture has been isolated. Since both steam generators may have tube leaks, the steam generator with the most severe symptoms should be isolated.

Method

Once the most affected steam generator is isolated, the operator should verify that the correct steam generator was isolated. The operator should observe trends of steam generator activities, steam plant radiation levels, and steam generator levels to make this determination. If the wrong steam generator has been isolated then the operator should restore feed and steam capability on the isolated steam generator and isolate the most affected steam generator

Because there could be combinations of ESDs & SGTRs in this section, the verification of isolation includes verifications for ESD by checking steam generator pressures and RCS cold leg temperatures.

If the wrong steam generator was isolated then the operator should first restore feed and steaming capability to the isolated steam generator. When heat removal has been established via the least affected steam generator, then the most affected steam generator is isolated.

Sequence

This step is sequenced after the step to isolate the most affected steam generator. It provides a prompt review of the action just accomplished to confirm that the correct steam generator was isolated.

Plant Parameters

None

HR-1 Step Number 13. Sample Boron Periodically

Intent

The intent of this step is to periodically monitor boron concentration to ensure that shutdown margin is maintained.

Method

When pressurizer pressure is less than SG pressure at the rupture site, dilution of the RCS by the secondary may occur depending on the original boron concentration of the RCS. Therefore, periodic sampling of the RCS for boron is necessary to ensure adequate SDM is maintained. A fixed sampling interval of 30 minutes is recommended but not mandatory. The sampling frequency is plant specific.

Sequence

This step is sequenced after the step for cooldown and after the step for controlling RCS pressure with respect to the isolated steam generator pressure.

Plant Parameters

None

HR-1 Step Number 14. Disable RCP Restart

Intent

The intent of this step is to prevent starting a RCP in the loop with the isolated steam generator and rapidly adding positive reactivity as the result of a slug of reduced boron concentration water passing to the reactor.

Method

When RCP operation is lost, the RCPs in the affected loop should be disabled (e.g. tag out, remove control fuses, or rack out breakers). This action is necessary to minimize the possibility of operator error in starting the wrong RCP following natural circulation cooldown. During a natural circulation cooldown, a slug of water with reduced boron concentration may collect in the affected loop, due to S/G Backflow. If under these circumstances, an affected loop RCP is then started, a positive reactivity addition may occur. Therefore, this step directs the operator to disable both RCPs in the affected loop to prevent this from happening.

Sequence

This step is sequenced after the step for isolating the affected steam generator and before the steps for restarting reactor coolant pumps.

Plant Parameters

None

HR-1 Step Number 15. Maintain Isolated Steam Generator Level

Intent

The intent of this step is to prevent overfilling of the isolated steam generator, resulting in a loss of steam generator level indication and possible transfer of water to the MS lines. It is preferred to maintain SG level less than the top of the indicating range. Level indication is very useful when performing various SG recovery strategies. For, example, backflowing to assist in cooling and depressurizing the isolated SG. Level indication is the best tool available to know which way the water is flowing through the break. Without level indication, the operator will be hampered when trying to determine how much backflow is occurring and if there is a boron dilution concern.

Method

The potential exists for flow of reactor coolant via the tube rupture into the isolated steam generator and filling the steam generator steam space and the main steam piping to the MSIV. This action could result in the inadvertent opening of the MSSVs and presents an undesirable spread of contamination.

If the isolated SG level is rising due to RCS in-leakage, let it continue to rise to greater than the top of the tubes, then maintain it less than [the top of the indicated range]. If it is initially less than[the top of the tubes], do not deliberately feed it to raise level too greater than [the top of the tubes]. The intent of this step is to maintain the isolated SG level to prevent over filling and keep the tubes covered.

Reducing RCS pressure below the isolated steam generator pressure (i.e. backflow to the RCS) can lower steam generator level. Draining to the [radiation waste system or other appropriate system] can also be done to reduce level and minimize the spread of contamination. If the generator draining is not feasible or is insufficient, then steaming the generator to the condenser will also reduce level and minimize radioactivity release. As a last resort, the SG may be steamed to the atmosphere. Before doing so, the off-site dose coordinator should assess the radioactive releases to the environment.

Backflow to the RCS can reduce the boron concentration of the RCS. This is a concern if RCPs are not running. The circumstance in which RCP operation has been lost, due to a loss of offsite power or other reasons, has been analyzed in Reference (44), Task 780. That task analyzed the effects of back flow of SG water while in natural circulation (NC) and the effects of restarting an RCP after a period of NC operations. As part of the conclusions in Reference (2), it was considered highly desirable to minimize any SG back flow while in NC operation.

(continue)

(continued)

The sole exception to this was to allow back flow as a means of preventing the SG water level from exceeding the high end of the indicating range.

Sequence

This step is sequenced after the major mitigation steps.

Plant Parameters

Steam Generator level less than top of the indicated range

Engineering Limit is the upper end of the indicated range (NR), nominally 85%. The upper limit maintains level in the indicated range to limit the possibility of filling the affected steam generator to the point that the main steam header is also filled.

HR-1 Step Number 16. Sample condensate and other systems for activity

Intent

The intent of this step is to identify if other plant systems have been radiologically contaminated as a result of the SGTR.

Method

The condensate and all other connecting systems, including the turbine building sumps, should be sampled for activity that may have been transferred from the affected steam generator(s). These samples aid in determining the extent of contamination throughout the plant systems.

Sequence

This step should be sequenced to provide timely notice to the crew to sample condensate and other systems for activity in order to take the appropriate isolation and containment actions.

Plant Parameters

None

HR-1 Step Number 17. Monitor radiation monitors

Intent

The intent of this step is to monitor the installed radiation monitors to detect any unexpected release of activity due to the SGTR.

Method

The [turbine and auxiliary] building ventilation system radiation monitors, and any other applicable radiation monitors, should be observed for increased activity that may have resulted from the SGTR event.

Sequence

This step should be sequenced to provide timely notice to the crew in order to meet the intent.

Plant Parameters

None

HR-1 Step Number 18. Cool and Depressurize Isolated SG

The intent of this step is to cool and depressurize the isolated steam generator to SDC entry conditions. While doing this, the operator should: 1) minimize radioactive releases to the environment, 2) minimize generation of contaminated water, and 3) minimize the spread of contamination.

Method

It is important to understand why the isolated SG needs to be cooled. Although the unaffected (or least affected) SG is being used to remove heat from the RCS, the isolated SG can hinder RCS depressurization during the cooldown because it will remain at a elevated temperature and pressure unless actions are taken to cool it down as the rest of the RCS is being cooled.

There are several methods available for cooling and depressurizing the isolated steam generator. The methods listed below are arranged in a preferred order, from the perspective of minimizing the radiological impact. The operator may choose to use any or all of the methods. The choice depends on the conditions existing at the time. The guidelines describe the "optimal" process for each method. It is recognized that decisions as to when to commence cooling the isolated SG will depend on how far you can cool the RCS prior to addressing the isolated SG.

For maximum effect, perform all feed and bleed evolutions after the RCS has been cooled to the maximum extent possible. Stay within the PT limits. If it is possible to make it all the way to SDC entry temperature before starting, all the better. Portions of the isolated SG will be cooled during the RCS cooldown, but not the upper steam space of the steam generator. Thus, RCS pressure will be held up at some point as determined by the saturation temperature of the steam space in the isolated steam generator. The cooler the water in the evaporator section before performing a feed and bleed evolution, the more effective the process will be at: 1) cooling the steam space, 2) limiting the number of times the evolution will have to be performed, and 3) reducing the volume of makeup water that will be required (i.e. minimizes generation of waste water).

a) Feed and backflow to the RCS

At least one RCP must be operating to use this method. This is necessary to prevent formation of an lower borated slug of water somewhere in the RCS, which may eventually be transported to the core. The feed rate may be limited by the backflow rate in order to prevent overfilling the SG. The rate of backflow is dependent on the size of the tube rupture and the differential pressure at the break site. Heat removal is enhanced if the SG water level is maintained above the moisture separator can-deck.

(continue)

(continued)

This will provide greater thermal circulation of water within the generator since a return path to the downcomer region is provided when level is above the shroud.

Prior to proceeding to drain the secondary of the steam generator to the RCS via backflow, the adequacy of shutdown margin must be verified and monitored throughout the draining evolution. Perform the back flow operation prior to commencing to feed the SG. Also, drain as close to the top of the tubes as possible to prevent leaving a thick layer of hot water on the surface in the riser section. Draining first and to a low level ensures that when the fill evolution begins, the water which eventually spills out of the separators will be as much subcooled as possible. Thus, it will have the greatest heat transfer effect on the steam volume.

Fill the SG with the coldest possible source of makeup feedwater and continue to feed until water begins to spill out of the separators onto the can deck. The operator will know that this is occurring when SG pressure begins to decrease. Then stop the feedwater flow and allow the manometric effect to equalize level in the downcomer and riser regions. Do not overfill with feedwater because this will actually inhibit the heat transfer at the water surface.

Once the depressurization has stopped, if further depressurization is necessary, then allow the SG to soak for 10 to 15 minutes. This will remove as much heat as possible from the immersed SG walls and metal structure. Then drain (back flow) to expand the steam volume and expose it to cold SG metal surfaces. Continue draining until SG pressure is at the desired value or until SG level is at the top of the tubes. Commence another fill operation, if required. Note that approximately 13,500 gallons of feedwater are required per fill cycle, for the generic 2700 Mwt SG.

b) Exposing a portion of SG tubes

As an alternative to the "drain and fill" method to depressurize the ruptured SG, a portion of the SG tubes can be exposed to the steam space to directly condense steam. This method has been shown to be effective because of the large differential temperatures which are possible and the large surface area which can be exposed for a few inches of water level change. To optimize this method of depressurizing the SG the following factors should be considered:

a. Cool the RCS to the lowest possible temperature (SDC entry conditions) prior to the tube uncovery evolution.
b. When draining the SG (back flow) to the RCS, use the minimum d/p necessary to achieve acceptable flow rates. This statement applies mostly when the SG level is very close to uncovering tubes.

(continue)

(continued)

c. Maximize RCS flow to the ruptured SG during the tube uncovery operation. Run at least one RCP in the ruptured loop.

d. Uncover the minimum area of the tubes necessary to achieve an acceptable depressurization rate. This will allow the operator to have the greatest control when SG pressures approach the desired values. Only a few inches of uncovered tubes should be required.

The advantages to this method of depressurizing the SG are speed and the use of little or no makeup feedwater to the ruptured SG. In addition, level indicating systems are well within range for this evolution; thus, the caveats of the "drain and fill" method are not impediments in this procedure. Because of all the advantages and relative lack of disadvantages, this method may be the optimum procedure for lowering SG pressure.

c) Steaming to the main condenser

Short duration steaming of the isolated steam generator will rapidly depressurize the steam generator. Two methods of steaming are available. Less steaming will be required if the evaporator region has been cooled by the operation of the RCPs.

The advantage of steaming to the main condenser is that the radioactive releases to the environment will be filtered and monitored. However, it will continue to contaminate the secondary system. During the cooldown, the operator should maintain level in the indicated range and above the tubes. Maintaining the tubes covered is desirable to minimize the transfer of radionuclides from the primary to the secondary side of the SG through pre-existing cracks as well as the ruptured tube(s).

d) Feed and blowdown to the main condenser

This a slow method which transfers feedwater through the downcomer region and out the blowdown line. Heat is transferred to the feedwater across the SG shroud from the tube bundle region. The feed rate that can be maintained will determine the effectiveness of this method. The disadvantages of using feedwater and the blowdown system include; 1) Additional contamination of the secondary system, 2) Generation of additional contaminated water in the secondary system, 3) Additional loading of condensate polisher resins, 4) Increased probability of un-monitored airborne releases from existing secondary leaks, 5) Relatively slow cooldown rate.

For plants with surface blowdown taps, using the surface blowdown with auxiliary feedwater results in more efficient heat removal from the steam generator.

(continue)

(continued)

e) Ambient cooling of the affected SG

Simply allowing ambient cooling to cool the RCS and the SG can be used to lower SG temperature and pressure (i.e. neither the turbine bypass valves nor the atmospheric dump valves are used). The time required to cooldown by this method will vary widely from one plant to another depending on the type of insulation on the steam generators and other factors. It has been estimated that the time required may be in the range of 30 to 300 hours. If steam generator level control can be maintained during this period, this may be the optimum method since no radiological releases occur after the steam generator is isolated. Ambient cooling may be accelerated by existing small steam leaks (such as leakage past the MSIVs). Even the low "normal" leakage coupled with ambient cooling may be sufficient to cool and depressurize the isolated steam generator.

During the cooldown, the operator should maintain level in the indicated range and above the tubes. Maintaining the tubes covered is desirable to minimize the transfer of radionuclides from the primary to the secondary side of the SG through pre-existing cracks.

If SG level can be maintained in the indicated range and if time permits, this method may be the optimum method to use to cool down since radiological releases are minimized after the affected steam generator is isolated. However, for most cases, the time required makes this method the least desirable.

f) Steaming to the atmosphere

Steaming using the ADVs will result in radiological release to the environment. For this reason it is preferable that it only be used for short periods of time, on a limited basis, and as a last resort.

Sequence

This step is sequenced after the immediate actions for response to a SGTR. It is sequenced before steps that will monitor the consequences of the cooldown method selected (e.g. sample condensate for activity, monitor turbine building ventilation radiation monitors).

Plant Parameters

Steam Generator level less than top of the indicated range

Engineering Limit is the upper end of the indicated range (NR), nominally 85%. The upper limit maintains level in the indicated range to limit the possibility of filling the affected steam generator to the point that the main steam header is also filled.

HR-1 Step Number 19. Determine if ESD has occurred and the most Affected SG with ESDE

Intent

The intent of the step is to determine if an ESDE has occurred. And, if an ESDE is indicated, determine which SG is most affected. It is important to identify the most affected SG to ensure that the correct SG will be isolated and to prevent further use of the faulted SG.

Method

The following parameters usually characterize an ESDE:

a. Rising steam flow from the steam generators.

b. Dropping steam generator pressure and water level (initially, there may be level swell).

c. Dropping RCS average temperature causing a drop in pressurizer pressure and water level.

d. Reactor trip caused by [thermal margin or CPC], high core power, low steam generator water level, low pressurizer pressure, low steam generator pressure, or high containment pressure depending on the size and location of the break.

e. SIAS may be generated from low pressurizer pressure or high containment pressure (if ESDE within the containment).

f. A [CIAS, CSAS and MSIS] may be generated on high containment pressure (if ESDE within the containment).

g. Possible rise in containment pressure, temperature, humidity, and/or containment sump level.

h. Possible rise in containment hydrogen concentration due to corrosion of zinc and aluminum by the containment spray system.

The most affected steam generator is determined by comparing both SG pressures, cold leg temperatures and steam generator levels. The parameters associated with the affected SG will be dropping. If there is a break in each steam generator, then the goal of this step is to determine which break is the largest, i.e. contributing most to the cooldown.

(continue)

(continued)

The break contributing most to the cooldown should be isolated and if possible, the smaller one should remain un-isolated to maintain the availability at least one steam generator for RCS heat removal. During the blowdown phase and before MSIS isolation it is difficult to determine which SG is most affected since both SGs are supplying the break flow.

If the ESDE is downstream of the MSIVs, both steam generators' pressures and loop temperatures should be nearly the same values and then raise following MSIV closure i.e. break isolation.

If the ESDE is unisolable — a break upstream of MSIVs — the differences between the affected and unaffected steam generators will be more pronounced because the affected SG will continue to blowdown after the MSIVs are shut. At that point, the steam generator with the lower loop Tc, and lower steam pressure is the affected steam generator. Due to the unpredictable performance of the affected steam generator level indication during ESDE it should only be used as supportive indication, and not relied on as the sole indicator of the most affected SG. Note that due to the harsh containment environment conditions, all instrumentation inside containment will be affected by the event, including the steam generator level indication on the least affected steam generator.

If RCPs are running during the blowdown of an unisolable ESDE, loop temperatures may not reflect a clear distinction between the affected and unaffected SG due to mixing. If less than the normal four pump complement of RCPs are running, the distinction between loop temperatures may be even more obscure.

Sequence

The most affected SG should be determined prior to SG isolation to prevent inadvertent isolation of the wrong SG.

Plant Parameters

None

HR-1 Step Number 20. If no ESDE then GO TO Step

Intent

If no indications of ESDE exist, then the operator is directed to skip ESDE steps and move on in the procedure for further guidance. If a ESDE is evident then the operator must perform steps 21 through 24.

Method

N/A

Sequence

N/A

Plant Parameters

None

HR-1 Step Number 21 Isolate Most Affected SG with ESDE

Intent

The intent of this step is to isolate the most affected SG during a ESDE.

The most affected steam generator should be isolated to stop the uncontrolled plant cooldown and to stabilize the plant. If the break is unisolable, the affected SG needs to be isolated from the rest of the plant to mitigate the affects of the cooldown.

If both steam generators are found to be affected, then isolate the most affected steam generator (worse ESDE), if it can be determined, and attempt to maintain RCS heat removal capability via one steam generator. This action is designed to mitigate the uncontrolled cooldown and ready the plant for event recovery.

Method

This step accomplishes the intent by closing all valves that connect the affected SG to other systems or the environs and thus should completely isolate the affected SG from further leakage. Ensuring closure and isolation of the affected SG should include local manual closure of any valves that cannot be closed from the control room.

Sequence

This step should be used during ESDE shortly after the most affected SG is identified.

Plant Parameters

None

HR-1 Step Number 22 Verify Isolation of Most Affected SG with ESDE

Intent

The intent of this step is to perform a check that the correct steam generator has been isolated. If the wrong steam generator was isolated, then the operator is instructed to restore feeding and steaming capability on the isolated steam generator, and isolate the most affected steam generator.

Method

Once the steam generator has been isolated, isolation of the correct (most affected) steam generator should be verified by checking steam generator pressures, RCS cold leg temperatures, and steam generator levels. Operator training should address how to recognize both, the most affected SG during an ESDE, and the follow up indications that the most affected SG has been isolated.

If the wrong steam generator has been isolated, then restore feeding and steaming capability on the isolated steam generator, and isolate the most affected steam generator.

Sequence

This step should be placed shortly after any attempt is made to isolate the affected SG as a check that the correct SG was isolated.

Plant Parameters

None

HR-1 Step Number 23 Stabilize RCS Temperature Control Following ESDE

Intent

The main objective following an overcooling event is to minimize the stresses on the reactor vessel, return RCS temperature to within the [Post Accident PT limits] (ASME Section XI Appendix G limits of Tech Specs) and establish stable RCS presssure and temperature until a cooldown to SDC entry conditions can be started. In general, a controlled cooldown should be started as soon as possible.

Method

RCS temperature control is achieved by steaming the least affected SG using the atmospheric dump valves as necessary, and by ensuring adequate SG inventory for heat removal.

A heat removal method via the least affected SG should be established before SG dry out occurs, if possible. Operator training should address the PTS concerns regarding an ESDE and the factors or mitigating trends that tend to lessen PTS concerns. These include:

1. limiting RCS repressurization as much as possible while maintaining minimum RCS subcooling requirements,

2. restoring and maintaining control of RCS temperature within the limits of the Appendix G post accident PT limits.

In case the atmospheric dump valves are not available, SG safeties on the unaffected SG will serve as a heat removal method. Steaming via the SG safeties is not the preferred method because it results in RCS pressure increasing as SG temperature/pressure rise to the SG safety valve lift setpoint. Therefore, every effort should be made to regain use of the atmospheric dump valves to eliminate the possibility of RCS repressurization.

RCS temperature will rise after the affected steam generator dries out unless a means of RCS heat removal is established. The associated rise in RCS temperature may result in a water-solid condition due to the additional inventory added from safety injection and charging during the blowdown phase of the event. The post dryout heatup and repressurization also presents a PTS threat.

In order to mitigate RCS heatup, a controllable heat removal method should be established before the dryout condition occurs. The intent is to regain RCS temperature control and stabilize Tc, thus preventing uncontrolled RCS heatup and repressurization.

(continue)

(continued)

Feedwater temperature and flow rate can have a significant affect on RCS temperatures. Therefore, the affect of feedwater should be taken into account when attempting to stabilize RCS temperatures. A rapid refill of the unaffected steam generator with cold feedwater may:

1. Further the cooldown, or
2. Provide a substantial RCS heat sink and thus mitigate the RCS heatup.

The method of establishing RCS temperature control during an Excess Steam Demand will be plant and event specific, based on plant design, decay heat, break location and the size of the steam leak. The following provides some methods of establishing RCS temperature control:

1. A break downstream of the MSIVs can be controlled by closing the MSIVs and using the atmospheric dump valves to control RCS temperature.

2. A blowdown may result in the unaffected steam generator being isolated at a temperature much higher than the minimum RCS temperature. This may result in a significant delay between the time the RCS begins to heatup and the time when the unaffected steam generator becomes an effective heat sink.

Establishing RCS temperature control following a excess steam demand may require selecting an optimal time to begin steaming the least affected steam generator. The following are examples of methods that can be used to establish an optimal time to steam the unaffected steam generator:

- As the CET temperatures begin to rise, start steaming the least affected steam generator.

- Establish a level in the most affected steam generator at which to begin steaming the least affected steam generator.

- Begin steaming the least affected steam generator to maintain the saturation temperature corresponding to steam generator pressure between [25 and 50°F] above the most affected loop's hot leg temperature.

The method selected to control the RCS temperature should not raise the RCS cooldown or present an unrestricted path from the containment atmosphere.

(continue)

(continued)

Once RCS temperature and pressure control is regained, record the time, temperature and pressure. This information will be needed later in the procedure when evaluating adequate soak time prior to initiating a controlled cooldown. [Typically, PTS is more of a concern on natural circulation than with the RCPs operating. However, this is plant specific. Therefore, the requirement to initiate a soak usually only applies if RCPs are NOT operating.]

Sequence

This step should follow identification and isolation of the affected SG.

Plant Parameters

within Post-Accident PT limits

Engineering limits are derived from plant specific PT limits. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). ASME Section XI, Appendix G, requires the establishment of PT limits for material fracture toughness requirements of the RCPB materials.

HR-1 Step Number 24 Determine if LOAF has occurred

Intent

The intent of this step is to determine if a loss of all feedwater event has occurred.

Method

A Loss of All Feedwater results from a loss of both main feedwater and auxiliary feedwater to both steam generators. Some possible causes for a Loss of All Feedwater include:

a. Loss of all main and auxiliary feedwater pumps.
b. Malfunction of the feedwater control system which closes the main feedwater control valves.
c. Inadvertent isolation, or blockage, of the feedwater flow path.
d. Malfunction of the condensate system.
e. Feedwater line break (loss of feedwater resulting from a feedwater line break which is not isolable from the steam generator is covered under Excess Steam Demand Event).

A Loss of All Feedwater is characterized by specific parameters that may be indicated in the control room. Some of these indications are:

a. Lowering steam generator water level. The existence of this condition may be indicated by an alarm in the control room.
b. Rising steam generator pressure before a reactor trip, followed by a lowering and stabilizing trend.
c. Rising pressurizer level and pressure before a reactor trip, followed by a lowering and stabilizing trend.
d. Reactor trip generated on low steam generator water level.
e. Auxiliary feedwater actuation signal (AFAS) generated on low steam generator water level.
f. Turbine/generator trip.
g. Low main feedwater pump flow/suction pressure, resulting in a main feedwater pump trip alarm. (The main feedwater pump flow may possibly be high if there is a feedwater line break.)
h. Containment pressure may rise if a feedwater line breaks inside containment. In addition, possible rise in containment pressure, temperature, humidity, or containment sump level.
i. A feedwater line break outside containment may be indicated by noise.

(continue)

(continued)

j. Possible equipment operational irregularities, such as a loss of feedwater control indication, a failure of the feedwater flow control valves, or a closure of a main feedwater system isolation valve.

k. Possible steam flow vs. feedwater flow mismatch noted.

Sequence

This step should follow instructions that address ESDE

Plant Parameters

None

HR-1 Step Number 25 If no LOAF then GO TO Step

Intent

If no indications of LOAF exist, then the operator is directed to skip LOAF steps and move on in the procedure for further guidance. If a LOAF is evident, then the operator must perform steps 26 to 32.

Method

N/A

Sequence

N/A

Plant Parameters

None

HR-1 Step Number 26 Stop RCPs

Intent

The intent of this step is to cease adding heat to the RCS.

Method

A Loss of All Feedwater results in a reduction of the ability of the steam generators to remove heat from the RCS. Since natural circulation heat removal is adequate to remove the decay heat generated in the core, the RCPs are stopped to eliminate their heat input to the RCS.

Sequence

This step is the first major mitigating action taken in a LOAF event.

Plant Parameters

None

HR-1 Step Number 27 Conserve Steam Generator Inventory

Intent

The intent of this step is to conserve as much inventory in the steam generators as possible.

Method

Until feedwater is restored, any remaining steam generator water inventory must be reserved for maintaining control of RCS temperature. Non-essential drains must therefore be secured to maximize the amount of inventory available for steaming. Releasing inventory as steam removes more heat than releasing it a liquid. This step directs that steam generator blowdown and sampling discharges be isolated since the liquid released does not make maximum use of the heat removal potential of remaining steam generator inventory.

Sequence

This action is taken immediately after all RCPs are secured.

Plant Parameters

None

HR-1 Step Number 28 Restore Steam Generator Inventory

Intent

The intent of this step is to continue the efforts to restore feedwater to at least one steam generator. This step is a continuation of operations which were begun in the Standard Post Trip Actions (SPTAs). The operator should focus his efforts on restoration of an auxiliary feedwater supply first.

Method

These efforts may include restoring electrical power, operating valves, starting pumps, or restoring necessary auxiliary systems for feedwater system operation.

In most cases, one or both main feedwater pumps will have been supplying feedwater to the steam generators prior to the reactor trip. Since feedwater has been lost, it is likely that a problem with main feedwater initiated the event.

Efforts to restore feedwater flow focus first on the systems and methods that are the least complex and most likely to be operational. Even if a main feedwater pump is available, it may take some time to place it in service. Auxiliary feedwater is a less complex system, and if one or more electric-driven pumps are available, they represent the quickest and simplest way to restore feedwater flow.

If unable to start either electric-driven auxiliary feedwater pump, the operator should attempt to start the steam driven auxiliary feedwater pump. The steam driven auxiliary feed pump does not rely on electrical power being available. It is considered reliable and is relatively simple to place in service quickly. Operators should also be trained to operate the pump locally and to reset the overspeed trip, should it be needed.

If unable to start any auxiliary feedwater pumps, an attempt is made to start a main feedwater pump. In the absence of auxiliary feedwater, main feedwater is the only remaining potential feedwater source that does not require an abnormal plant alignment. This is because it is expected that main feedwater will be in operation at the start of the event, and that restoring one of the pumps to service can be performed without additional plant alignments.

[If main or auxiliary feedwater cannot be restored to at least one steam generator, then all low pressure plant specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Using such sources will require that the plant be cooled down and depressurized to permit their use. That is, the pressure in the steam generators must be low enough such that the source can provide sufficient flow to the generator. Steam generator pressure is dependent upon saturation temperature in the SG which is directly related to RCS temperature.

(continue)

(continued)

Depressurization is done at the maximum controllable rate, in order to regain flow as quickly as possible. If depressurization is not performed in a timely manner, SG level may become low enough to require the use of once-through-cooling before SG pressure can be lowered enough to restore feed flow. If pressure is reduced to the limiting valve and no flow is observed, some other difficulty exists that is preventing flow, and further reduction of SG pressure would be counterproductive.

Examples of alternate low-pressure sources of feedwater are fire pumps, condensate pumps, portable pumps, etc. When developing plant procedures, alternate low-pressure sources of feedwater should be identified and their use should be indicated in the procedures. Guidelines on steam generator depressurization should be developed for those cases when the operator is relying on low pressure sources of feedwater as a backup feedwater supply. Figure 8-8 provides an example of the type of information that must be developed on a plant specific basis. The figure provides a typical steam generator dump area required to remove heat from the steam generator for various times after shutdown. The required heat removal, compared to the available heat removal capacity (e.g. atmospheric dump valves), provides the technical basis for which guidance may be developed on steam generator depressurization to permit use of alternate low-pressure sources of feedwater.

Sequence

This action is taken immediately after actions to conserve steam generator inventory.

Plant Parameters

None

HR-1 Step Number 29 Guidelines to Prevent Feedring Damage During FW Restoration

Intent

The intent of this step is to provide guidance for the restoration of feedwater to the steam generator for those plants susceptible to feed ring damage. Damage to the feedring can be caused by water hammer during restoration of feedwater when SG water level is below the feedring. This latter portion of the step applies to those plants susceptible to feedring damage.

Method

If the ability to provide feedwater is restored and steam generator level is below the feedring, the operator should limit feed water flow to less than [flow that could cause water hammer] for [5 minutes].

There is no analytical correlation between feedwater flow rate and the conditions necessary to prevent feedring failure. A flow rate of [150 gpm] has been traditionally accepted as a limit by industry and the NRC for water hammer protection.

When feedwater to a steam generator has been restored for greater than [five minutes] and level is above the feedring, then feed as necessary to restore and maintain level within the [normal control band].

Sequence

This step should follow the point in the procedure when the ability to feed the affected SG is restored. Since feedwater may be restored at any time, it is a continuously applicable step.

Plant Parameters

Steam Generator level below the feedring

The engineering limit is based on traditionally accepted industry and NRC guidance for the prevention of water hammer damage to feed rings. With steam generator level at the bottom of the feedring, following an interruption of feedwater flow, water hammer and the resultant structural damage to the feed ring will be avoided when feedflow is restored. Operator training should stress slow restoration of feedflow to the steam generator. If the ability to accurately monitor feedflow rate to a voided SG feedring is compromised, then, the only other corroborative methods that address the intent of the bases is to rely on operator skill and judgment to very slowly re-establish feed to the voided SG feedring.

(continue)

(continued)

Feedwater flowrate less than the maximum flowrate that will not cause water hammer

The maximum MFW/AFW flowrate to a drained steam generator feed ring that can be demonstrated will not cause water-hammer damage to the feed ring of piping leading to the feed ring, nominally [150 gpm]. This limit is only applicable to plants that are equipped with feed rings which are susceptible to damage due to water-hammer. The engineering limit is based on preventing feed ring damage due to re-establishing feedwater to a voided feed ring too quickly.

Feedflow has been supplied for [5 minutes]

Five minutes is a very conservative estimate of the time required to fill a drained feed ring. Five minutes is an approximation, arrived at by assuming that the capacity of a typical feed ring to be 350 gals. 2 X 350 = 700 gals. Therefore, 700 gals of water would be required to fill a feed ring twice. At a fill rate of 150 gpm, it would take approximately 5 minutes to deliver 750 gals of water, which is more than twice the capacity of the feed ring (700 gals).

Steam Generator level within the normal control band

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

HR-1 Step Number 30 Ensure that the Turbine Bypass System (TBS) is Controlling RCS temperature

Intent

The intent of this step is to establish and maintain a controlled RCS heat removal process via one or both steam generators.

Method

This step ensures that [RCS Tave or T cold] is stabilized and controlled by the turbine bypass system at or less than the [maximum expected post-trip temperature]. This temperature corresponds to steam generator pressure in the upper end of the turbine bypass valve control band.

If condenser vacuum is lost, the turbine bypass system is not available, or if the MSIVs have closed, then the atmospheric dump valves must be used to control RCS temperature. This action is performed to maintain steam generator pressure below the secondary safety valve setpoints, preventing them from opening, and to allow a controlled RCS heat removal process using the steam generators.

The Main Steam Safety Valves are an acceptable last resort means of RCS heat removal.

Sequence

This step is located in the RCS heat removal portion of the procedure and is continuously applicable.

Plant Parameters

RCS average temperature or T cold less than the maximum expected post-trip temperature

The engineering limit is based on the normal control band for TBVs\ SBCS. This associated operational limit, nominally [535°F] is intended to queue the operator to take corrective action to recover a means of controlled RCS heat removal prior to opening the ADVs or reaching a MSSV lift setpoint. Greater than [535°F] was chosen as an operational limit for this application because it will facilitate early recognition of a decrease in RCS heat removal following a reactor trip. It is assumed that if Tave increases to greater than [535°F], the normal control systems are malfunctioning and should be investigated and corrected. This operational limit corresponds to the upper end of the SBCS control band [850 to 920 psia].

HR-1 Step Number 31 Verify Adequate RCS Heat Removal with At Least One SG

Intent

The intent of this step is to verify that previous efforts to restore feedwater to at least one SG been successful, and that adequate RCS heat removal via a SG exists. If adequate heat removal is not available, then once-through-cooling (OTC) should be initiated, the LOAF ORG should be exited and the Functional Recovery Guideline implemented in its entirety. This means that the FRG is implemented as it normally would be using the FRG Entry Procedure and not by simply going straight to HR3. The contingency provides the direction for these actions. The intent of the contingency action is to identify inadequate SG heat removal and provide guidance for the transition to Once-Through-Cooling. This contingency applies only to plant with PORVs.

In the event of a total loss of all feed water, if once-through-cooling (OTC) is not initiated before both SGs are lost as a heatsink, core uncovery and possible core damage will occur. The loss of SG heatsink will result in reactor coolant system (RCS) temperature and pressure increasing rapidly. RCS expansion into the pressurizer will result in RCS pressure opening the PORVs. Following a period of subcooled depressurization, two phase repressurization occurs resulting in the primary safety valves (PSVs) lifting and RCS pressure remaining above high pressure safety injection (HPSI) pump shutoff head. The duration of the subsequent two phase depressurization phase of the event depends on decay heat generation rate at the time feedwater was lost. However, RCS inventory will continue to be lost through the PSVs or the PORVs, with no means to replenish it and core uncovery will occur before HPSI injection is reestablished.

Method

At least one SG with [SG level for initiating OTC] ensures that the in use SG has sufficient inventory for RCS heat removal. When inventory is below the [SG level for initiating OTC], the SGs start to become ineffective as a heat sink, and an alternate heat removal mode must be established. A transitional level is provided to allow the establishment of this alternate mode prior to reaching the point where the SGs are no longer an effective heat sink.

Checking SG level above this minimum level ensures that adequate inventory exists to permit using one or both SGs as a heat sink. Checking for stable or lowering RCS temperature is indication that heat is being removed form the RCS, while allowing for momentary correctable reductions in RCS heat removal.

If a feedwater source was successfully established in earlier steps, this step monitors the effectiveness of the SGs as a heat sink as inventory is restored. If feedwater was not reestablished before reaching this step, conditions can be monitored using these criteria, until the point is reached where O-T-C must be established.

(continue)

(continued)

Since O-T-C is the method of last resort for core cooling, inventory in excess of the minimum required allows some extra time to recover a feedwater source while continuing use of SGs as a heat sink

If both SG levels are less than [SG level for initiating OTC] or if RCS Tc raises uncontrollably [approximately 5°F or greater], then the operator is instructed to initiate O-T-C, implement the Functional Recovery Guideline and go to Core Heat Removal success path HR-3.

The actions of the contingency are designed to accomplish four main objectives, 1) depressurize the RCS, 2) ensure a supply of borated water to the RCS, 3) ensure that an adequate vent path from the RCS is open, 4) implement the FRG in its entirety.

To avoid core damage, it is very important that, once the decision has been made to initiate OTC, implementing that decision becomes the top priority. Efforts to restore feedflow become secondary. Effective OTC relies on moving large quantities of relatively cool borated water through the core to remove heat. To establish flow through the RCS, the operator most first do everything possible to lower RCS pressure. This is accomplished by ensuring all RCPs are secured, and venting the secondary side of both steam generators by using the TBVs and ADVs. The operator is then instructed to ensure SIAS is actuated and ensure that two full trains of SI are injecting water into the RCS. All available charging pumps should also be aligned to inject into the RCS. Charging flow is very important in the early phase of OTC initiation to ensure a supply of water to the RCS when RCS pressure may be greater than the HPSI pump shutoff head. The PORVs are then opened to complete the line up be providing a flow path from the RCS.

Once OTC has been lined up in this step, then the operator should exit this guideline and implement the FRG, proceeding to RCS and Core Heat Removal Success Path HR-3.

<u>Sequence</u>

This step is necessary to verify RCS heat removal capability by at least one SG. It should be used prior to switching RCS heat removal from an alternate method of heat removal to SG heat removal. Or, when SG heat removal capability is being monitored closely because of a potential compromise in its effectiveness (ex. loss of feed).

(continue)

(continued)

Plant Parameters

Steam Generator level for initiating O-T-C

The engineering limit is the point at which the steam generator starts to become ineffective as a heat sink, nominally [15%] WR level. The intent of this limit is to ensure that action is taken to line up Once-Through-Cooling (OTC), after a loss of all feedwater event, while some margin still exists to the point where the steam generator starts to become ineffective as a heat sink. This margin is necessary to ensure that OTC will be initiated prior to a complete loss of SG heat removal, and ultimately prevent core uncovery. An effective SG heatsink is defined as a SG having enough secondary inventory with steaming capability such that core decay heat can be removed without uncontrolled RCS temperature increase.

HR-1 Step Number 32 Ensure Adequate Condensate Inventory

Intent

The intent of this step is to ensure that there is sufficient condensate inventory available to maintain hot standby within technical specification allowable time limitations, cooling down to SDC entry conditions, and making the transition to forced cooldown using the SDC system.

Method

The available condensate inventory should be continually monitored, and replenished from available sources as necessary to provide a source for a secondary heat sink. Examples of alternate sources of condensate are non-seismic tanks, fire mains, lake water supplies, portable tanks, etc. Alternate sources of feedwater may be identified and cited in the procedure as considered necessary. The amount of condensate required to either maintain the plant at hot standby conditions or during a cooldown may be determined from plant specific figures.

The step refers to two figures which can be used to determine the amount of condensate required based on the existing temperature and the time after shutdown. The existing temperature provides for determining the inventory required based on the sensible heat that must be removed. The time after shutdown provides a basis for determining the inventory required based on the decay heat remaining in the plant assuming that the event occurred from a stable full power configuration. Each of the figures should assume a nominal leakage from the systems based on plant experience.

Additional allowances should be included to accommodate the time required to actually transition to forced cooling by the SDC system.

Sequence

This step is sequenced early enough in the guideline to ensure sufficient time for actions which may be necessary to replenish the inventory from normal or alternate sources.

Plant Parameters

Condensate Storage Tank inventory adequate to support cooldown

The engineering limit is the minimum quantity of available feedwater needed to remove sensible and decay heat to cool down to Shutdown Cooling entry conditions within an assumed period of time. The intent of condensate inventory information, whether it is presented in graphical, nomograph, or other forms, is to enable the operating staff to determine whether sufficient inventory exists for the planned actions. It should give the operator information in a timely manner such that, if a cooldown is required, enough condensate will be available to accomplish the task. In the event that enough condensate does not exist for a cooldown to shutdown cooling entry conditions, the operator(s) can plan accordingly to maximize the time to establish alternate sources of condensate.

HR-1 Step Number 33 Maintain SG Level in Normal Band

Intent

The intent is to ensure an adequate RCS heat sink is available via a SG since some LOCAs with small break flow still require a SG heat sink. The instruction states that at least one SG level should be restore to and maintained within the [normal control band] with main or auxiliary feedwater. This level provides adequate heat removal capability under forced flow and natural circulation conditions. The reason the step specifies level being restored by 'main or auxiliary feedwater" is because sometimes level can rise due to a heatup of the steam generator or due to steam generator swell. This step requires the operator to verify that main or auxiliary feedwater is flowing to the steam generator(s) to restore level and that the level rise is not from another heatup or swell.

In general, it is desirable to restore SG level to the normal band. During a LOCA it is assumed that the operator will not encounter problems restoring SG level. But during large break LOCA conditions and certain size small break LOCAs, immediate and aggressive recovery of SG level to the [normal control band] may exacerbate an already rapid cooldown rate due to SI flow into the RCS. Therefore, the operator should be aware of the potential for overcooling due to excessive feed to the steam generators. Due to the low probability of the large break LOCA occurring and considering the generic EPG strategy that does not require the operator to distinguish between break sizes, feeding up the steam generators under these conditions is a worth risk. Therefore, the operator is directed to feed up steam generators even if a large break LOCA or a large small break LOCA has occurred and the cooldown rate is being exacerbated. However, the operator should limit the feedwater flowrate under these conditions to just what is necessary to refill the steam generators.

Method

At least one steam generator level is restored to and maintained in the [normal control band] using main or auxiliary feedwater.

Sequence

This step is sequenced early in the procedure. It is important to the RCS Heat removal safety functions

(continue)

(continued)

Plant Parameters

Steam Generator level within the normal control band

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

HR-1 Step Number 34 RCP Restart Criteria

Intent

The intent of this step is to ensure the RCS and the RCP(s) selected for restart are in the proper condition to support RCP restart and operation. This step is only applicable if RCP restart is desired.

In general, forced circulation is normally the preferred mode of core cooling because it provides more responsive control of RCS temperature and pressure. But the need for forced circulation operation must be weighed against any potential risks of RCP operation. Once RCPs have been stopped, restarting of RCPs should be considered a major plant evolution and given considerable thought before restart is attempted. In addition to the RCP restart criteria given in the instruction the following items should be considered when deciding whether RCP restart is desirable: 1) the effectiveness of RCS heat removal using natural circulation, and 2) the need for main pressurizer spray capability.

Method

Sample RCS for boron concentration. If there is doubt regarding the existence of a slug of water with reduced boron concentration in the RCS, then RCS boron concentration should be sampled prior to starting RCPs to ensure the boron concentration and distribution is sufficient to prevent loss of SDM after RCP restart. During a SGTR there is a possibility that a slug of water with reduced boron concentration may accumulate in the affected loop. Therefore, RCS boron concentration in the affected loop should be considered (determined if possible) prior to starting the RCP in that loop if there is doubt about the existence and/or size of a slug of water with reduced boron concentration in that loop.

Verify RCS pressure and temperature are within the [Post Accident PT curve] limits for RCP operation, REFER TO Figure 13.8. This substep is a check to see that RCS pressure and temperature conditions will support RCP restart. The [Post Accident PT curve] should include RCP operation curves that ensure RCP NPSH and reactor core subcooling requirements are within their limits. Minimum RCS subcooling should be based on [representative CET] temperature.

In addition, to checking the RCS [Post Accident PT curve], the operators should be aware that the pressurizer water and steam space may not have reached equilibrium saturation conditions if there was a large level change (rise) a short time ago. This may result in the pressurizer being much less able to mitigate the pressure effects of a significant outsurge.

(continue)

(continued)

Verify the duration of [CCW] interruption to RCPs is within limits for RCP restart, REFER TO [RCP technical manual]. This substep prompts the operator to check that any cooling interruption to RCPs is within limits that allow for RCP restart. Each plant should establish guidelines for RCP restart after cooling interruption. The guidelines should be based on RCP vendor information and other appropriate sources.

Verify RCP seal pressures and temperatures are within limits for RCP restart, REFER TO [RCP technical manual]. This substep prompts the operator to check that RCP seal conditions are within limits that allow for RCP restart. Each plant should have guidelines for limiting RCP seal conditions based on RCP vendor information and other appropriate sources.

Verify the following RCP auxiliaries are operating properly to support RCP operation: oil lift system, bearing and motor cooling systems. This substep is an additional reminder to specifically check that the RCP oil lift system, and bearing and motor cooling systems are operating properly. There should be no bearing and motor cooling systems high temperature alarms on the selected RCPs.

[Verify RCS conditions are within the RCP start limits of plant technical specifications]. Plant technical specification typically provide LCO requirements regarding RCP restart and: RCS and steam generator delta T, pressurizer pressure, and pressurizer level. These limits and their bases should be reviewed for applicability prior to RCP restart.

Ensure at least one steam generator is maintaining RCS heat removal with [minimum level for 1/3 tube coverage]. The intent of this substep is to ensure that an effective heat sink is available prior to starting RCPs. One-third tube coverage is considered adequate to remove decay heat either via natural circulation or forced flow conditions.

Use of SG safeties is generally considered an acceptable method for RCS heat removal, although not a preferred method because of the loss of RCS temperature control and the inability to cooldown. Therefore, starting RCPs while on the SG safeties should only be done after a through review of the likely affects of RCP restart, and a determination that these affects are manageable within the context of current plant status. The intent here is to maximize the reasonable options available to the operator and allow RCP restart and operation while on SG safeties.

There are some predictable affects of transitioning from natural circulation to forced flow while on the SG safeties. From best estimate analysis it's assumed that post trip RCS heat removal via SG safeties is likely to be a cyclical evolution where the SG safety valve opens periodically removing heat and then shuts. The period of the cycling (the time between safety valve lifts) is determined by heat removal requirements. While heat removal from the RCS is through the SG safeties, RCS Tc will seek a temperature just slightly higher than the corresponding saturation temperature for the lowest SG safety valve lift pressure.

(continue)

(continued)

Therefore, under natural circulation, with a much wider delta T than forced flow, there will be a higher overall effective RCS temperature than under forced flow conditions. During the initial moments after starting a RCP, Tave will drop as the core delta T collapses with the subsequent change in pressurizer level. The additional heat input from the RCPs may raise the cycle rate of the SG safeties (lift, blowdown and close), but should not appreciably change the RCS temperature at which the SG safety lifts. These affects should be considered before starting an RCP while on the SG safety valves.

A pressurizer level [within the RCP restart level band] provides a minimum level to help mitigate the effects of RCS void collapse during RCP restart. And, a maximum level to keep a pressurizer steam space available for slight raise in RCS temperatures. Plant technical specifications typically address this topic and should be consulted when determining the plant specific RCP restart level band.

Ensure electrical power is available to the RCPs. This substep directs the operator to evaluate the availability and reliability of RCP power supplies, and to ensure their readiness to support RCP restart.

[RCP technical manual] is used generically to mean plant specific RCP technical information.

Sequence

This step should be placed just before actual RCP restart.

Plant Parameters

Pressurizer pressure within RCP NPSH limits

The engineering Limit is based on the reactor coolant pump suction pressure that meets or exceeds the minimum NPSH and pump seal pressure requirements. The engineering limit is intended on preserving RCP operability. Operation of the RCPs must be constrained to ensure that adequate net positive suction head (NPSH) is available to preclude pump cavitation and damage. The RCP seals also require a minimum suction pressure for reliable long-lived service. These pump suction pressure requirements are established by the pump vendor.

Steam Generator level within the normal control band

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

(continue)

(continued)

Pressurizer level in the restart level control band

Establishing pressurizer level within the required restart level band provides a minimum level, nominally [200"] to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. The upper engineering limit is based on TS RCP restart requirements which will ensure that there is still sufficient steam space to ensure pressure control using Pressurizer sprays, and preclude a large pressure surge in the RCS following restart. The lower engineering limit is based on keeping the pressurizer heaters covered to preserve normal means of RCS pressure control following RCP restart. The pressurizer heaters maintain RCS pressure to keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow.

HR-1 Step Number 35 RCP Start

Intent

The intent of this step is to take final actions in preparation for RCP restart, start the selected RCPs, and monitor plant response and RCP operation after RCP start.

Method

A pressurizer level [within the RCP restart level band] provides a minimum level to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. Plant technical specifications typically address this topic and should be consulted when determining the plant specific RCP restart level band.

The charging system is operated as necessary to maintain pressurizer level. If RCS pressure is less than the [HPSI shut off Head], then the HPSI pumps may be used to control pressurizer level

Starting one RCP in opposite loops provides forced circulation through the core, better cooling of the RV head region, the capability for the use of normal pressurizer spray, condenses RCS steam voids, and removes non-condensable gases from the SG tubes. Further, starting a RCP in each loop simplifies RCS temperature control and facilitates a plant cooldown. RCP operation should be limited to one reactor coolant pump in each loop to minimize heat input to the RCS (Reference 22). When restarting RCPs, it is preferable to first start an RCP in the loop with the unaffected steam generator. This will avoid the confusion which could occur from a temporary reversal of Th and Tc indications in the operating loop and promotes mixing of inventory from the isolated loop.

Plant technical specification typically provide LCO requirements regarding RCP restart and: RCS and steam generator delta T, pressurizer pressure, and pressurizer level. These limits and their bases should be reviewed for applicability prior to RCP restart.

Verify RCS pressure and temperature are within the [Post Accident PT curve] limits for RCP operation, REFER TO Figure 13.8. This substep is a check to see that RCS pressure and temperature conditions are responding favorably to RCP restart and will support continued operation of RCPs. The [Post Accident PT curve] should include RCP operation curves that ensure RCP NPSH and reactor core subcooling requirements are within their limits. Minimum RCS subcooling should be based on [representative CET] temperature. If RCP NPSH requirements can not be maintained, then the affected RCPs must be secured.

In addition to the conditions stated above, plant specific RCP operating limits should be verified immediately after restart as well as closely monitoring RCP operation while they are in operation.

(continue)

(continued)

Operating charging and HPSI pumps until HPSI throttle criteria are met ensures that pressurizer heaters remain covered in the event of RCS void collapse after RCP restart.

If steam voids are present in the RCS during RCP restart, pressurizer level and pressure may lower due to steam void condensation. Depending on the void volume, there is a potential to drain the pressurizer. The operator should be mindful of this affect and immediately commence restoring pressurizer level using charging and HPSI pumps if void collapse is suspected. This issue should be addressed in operator training.

Sequence

This step should immediately follow the RCP restart criteria step.

Plant Parameters

Pressurizer level in the restart level control band

Establishing pressurizer level within the required restart level band provides a minimum level, nominally [200"] to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. The upper engineering limit is based on TS RCP restart requirements which will ensure that there is still sufficient steam space to ensure pressure control using Pressurizer sprays, and preclude a large pressure surge in the RCS following restart. The lower engineering limit is based on keeping the pressurizer heaters covered to preserve normal means of RCS pressure control following RCP restart. The pressurizer heaters maintain RCS pressure to keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow.

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

(continue)

(continued)

Pressurizer pressure less than HPSI shut-off head

The engineering limit is based on the shutoff head of the HPSI pumps, nominally [1300] psia. This application is used in two different ways in the EPGs. The first appears in the Functional Recovery Guideline, Heat Removal safety function, success path HR-3 (Once-Through-Cooling). Observing HPSI pump flow is positive indication that OTC is established.

Pressurizer pressure within RCP NPSH limits

The engineering Limit is based on the reactor coolant pump suction pressure that meets or exceeds the minimum NPSH and pump seal pressure requirements. The engineering limit is intended on preserving RCP operability. Operation of the RCPs must be constrained to ensure that adequate net positive suction head (NPSH) is available to preclude pump cavitation and damage. The RCP seals also require a minimum suction pressure for reliable long-lived service. These pump suction pressure requirements are established by the pump vendor.

HR-1 Step Number 36 SIT Isolation and Venting Criteria

Intent

The intent of this step is to prevent unnecessary injection of the Safety Injection Tank (SIT) water volume and possible injection of the SIT cover gas during a cooldown. Do not isolate SITs until it is confirmed that RCS pressure is under control and no LOCA event requiring SIT injection is in progress. If injected into the RCS, nitrogen gas could cause the steam generator tubes to become gas bound, thereby reducing their effectiveness as a heat sink.

Method

When pressurizer pressure reaches [SIT isolation pressure] the SITs should be isolated by closing their discharge valves and depressurized to prevent an undesired injection of water or the nitrogen cover gas into the RCS as RCS pressure is reduced during a cooldown.

Sequence

This step is sequenced after instructions to cooldown/depressurize the RCS. Ensure that no LOCA event is in progress prior to SIT isolation by verifying RCS inventory and pressure are under control. As there is no urgency to perform this step until the SIT pressure is approached. Even then, it will take some time for the entire SIT volume to be injected and N2 injection to be a real possibility.

Plant Parameters

Pressurizer pressure less then the SIT isolation pressure

The engineering Limit is based on the maximum Safety Injection Tank (SIT) pressure, nominally [250 psia]. The SITs are isolated and vented to prevent SIT discharge of water or nitrogen gas into the RCS during a plant cooldown/depressurization. For plants with high pressure SITs, this may be necessary to allow the plant to be brought to shutdown cooling system entry conditions.

HR-1 Step Number 37 LTOP Initiation Criteria

Intent

The intent of this step is to ensure Low Temperature Overpressure Protection is initiated when required.

Low Temperature overpressurization protection (LTOP) is instituted at a temperature of [LTOP enabling criteria] to protect against subjecting the RCS pressure boundary to high pressure at low temperature, which could lead to brittle fracture.

Method

When [LTOP enabling criteria] are met, the operator initiates low temperature overpressurization protection.

Sequence

This step is to be located late in the procedure, after the plant has been cooled to the LTOP enabling criteria.

Plant Parameters

RCS temperature less than the LTOP enabling criteria

The engineering limit is based on the LTOP enabling temperature found in technical specifications, nominally [285°F]. This operational limit is intended to ensure that low temperature overpressurization protection (LTOP) is lined up at the required cold leg temperature to protect against subjecting the RCS pressure boundary to low temperature brittle fracture.

HR-1 Step Number 38 Void Elimination

Intent

The intent of this step is to eliminate voids in the RCS that may prevent lowering RCS pressure to SDC entry conditions.

Method

The operator should continuously monitor for the presence of voids in the reactor coolant system. If voiding is suspected, then the operator should proceed as follows:

a. The operator is directed to minimize letdown. If voiding is occurring, the continued net loss of inventory from the RCS will only make the situation worst. Letdown may be throttled to a minimum flow value, provided charging is maintaining a net gain in RCS inventory, or it secured completely while performing the void elimination procedure. Throttling versus securing may be preferred if a plant is concerned about thermal shocking letdown components such as the heat exchangers.

b. The operator is directed to stop attempting to depressurize the RCS. Depressurization activities will only make the situation worst by enlarging the void.

c. There are two primary methods which have been demonstrated successful for eliminating voiding in the RCS. They are: 1) cycling RCS pressure and 2) operating the reactor vessel vent valves. The operator should monitor pressurizer level and reactor vessel level trends to determine the effectiveness of the void elimination procedure.

If indications of RCS voiding continue, and voiding is suspected to exist in the steam generator tubes, then the actions can be used to cool the steam generator and eliminate the voiding. This determination can be made by observing if saturated temperature in the steam generator is greater than RCS temperature. The suspected steam generator can then be cooled by performing any combination of the following: 1) steam to the condenser using the TBVs or to the atmosphere with the ADVs, 2) feed to add cool water and restore level.

Monitor pressurizer level and RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

Continue void elimination procedures until either the voiding is eliminated or the attempts have proved unsuccessful.

(continue)

(continued)

Sequence

This step should be located soon after commencing plant cooldown.

Plant Parameters

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

HR-1 Step Number 39 Reset Safety Systems

Intent

The intent of this step is to secure or restore safety systems that have actuated because they were needed, but are no longer needed.

Method

The operator is directed to restore safety systems to normal standby status using plant specific procedures. It is best to place the plant in as normal a configuration as possible prior to exiting the procedure. This is especially important if the operator will be exiting to a normal operating procedure which would not expect ESFAS signals to be present.

Sequence

This step is located at this position within the LOCA procedure because it is least important in carrying out the LOCA strategy and all other LOCA instructions have been taken.

Plant Parameters

None

HR-1 Step Number 40 Determine status of Acceptance Criteria

Intent

After implementing the above actions, Heat Removal is satisfied if the following conditions exits:

- At least one SG level is within [normal control range], OR being restored by feedwater,
- IF RCPs are operating, THEN Loop delta T less than [maximum expected delta-T shutdown with forced circulation] and NOT rising,
- IF RCPs are NOT operating, THEN Loop delta T less than [normal full power delta-T] and NOT rising,
- RCS subcooling equal to or greater than the [minimum RCS subcooling] based on [representative] CET temperature,
- RVLMS indicates greater than [top of the hot leg nozzles].

Method

If the above criterion is not satisfied, then success path HR-1 is not adequate. The operator should go to another appropriate HR success path for further guidance to restore/maintain Heat Removal. Resource Assessment Trees (Section 5) may be useful in determining the appropriate success path.

If the acceptance criterion for success path HR-1 is satisfied, then success path HR-1 is successfully controlling RCS and Core Heat Removal. Heat Removal is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the Long Term Actions (Section 14)

Sequence

This is the last step in the sequence of steps for a given success path.

Plant Parameters

Steam Generator level within the normal control range

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

(continue)

(continued)

RCS Loop delta T less than normal full power delta T

The engineering limit is based on the normal full power delta T. The intent of the engineering limit is to provide a value that enables the operators to assess the status of single phase liquid natural circulation flow in at least one RCS loop. Under single phase natural circulation flow, the operating loop delta-T should be less than the normal full power delta-T. A loop delta-T less than the full power delta-T ensures that the [power/flow] ratio is within the nominal thermal hydraulic parameters for the RCS (i.e. the power to flow ratio is less than that for full power operation).

RCS Loop delta T less than the maximum expected with forced circulation while shutdown

The engineering limit is based on best estimate analysis of the maximum delta-T expected with minimum forced circulation (only 1 RCP operating) and maximum decay heat, nominally [10°F]. Post-trip core heat removal with forced flow is dependent on circulating subcooled fluid through the core to remove decay heat. The intent of the operational limit is to provide a "nominal" value that can be used corroboratively with SG delta-P verify that at least one RCP is successfully circulating fluid through the core/RCS (i.e. no sheared shaft) for core heat removal.

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that, 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

HR-2: RCS and Core Heat Removal via SG with SIS in operation

In some instances, RCS and Core Heat Removal may be satisfied by a combination of steam generator heat removal and heat removal by venting energy out of an RCS opening such as a break or a stuck open [PORV].

HR-2 Step Number 1 Ensure SIAS Actuation

Intent

The intent of this step is to ensure that the HPSI pumps are running and lined up to inject borated water into the RCS, regardless of Pressurizer pressure.

Method

The operator is instructed to ensure SIAS is actuated. If a SIAS has not actuated automatically, then the operator should manually actuate SIAS. Initiating SIAS is the preferred method to ensure that the HPSI pumps start and are lined up correctly. The exact method of SIAS actuation and ensuring HPSI is lined up to inject into the RCS should be determined on a plant specific basis and should be flexible enough to cover all situations where makeup capacity, in addition to that available via the charging pumps is required to restore and/or maintain inventory control.

Sequence

The step is the first major mitigative action taken by the operator in this success path.

Plant Parameters

None

HR-2 **Step Number 2 Optimize SI**

Intent

The intent of this step is to ensure that SI flow is within the limits of the design basis SI flow. That is, SI flow should be in accordance with the SI delivery curves (Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure) for the given RCS pressure and the number of running SI pumps. Typical SI system design provides two redundant trains of SI, but only one train operation is necessary to meet the intent of the this step. Therefore, it may be optimum for RCS inventory recovery purposes to have two SI trains in operation delivering flow in accordance with the two pump curve, but one train in operation (one SI pump running with flow in accordance with the one pump curve) is acceptable.

Method

After a SIAS the Safety Injection (SI) system flow rate to the RCS is a function of pressurizer pressure. This flow can be predicted using standard fluid flow calculations. The SI flow delivery curves are the results of these fluid flow calculations and can be used by the operator to determine if the SI system is performing as designed and delivering the expected flow to the RCS. Therefore, unless SI flow is deliberately throttled, SI delivery flow should always be greater than or equal to the pump curve. Therefore, SI flow within the one pump curve while two SI pumps are operating is not considered an acceptable configuration, and the problem should be investigated to determine the cause of the deviation and appropriate actions taken to restore SI flow within the limits of the curve. Deviations from the SI delivery curves may be due to valve misalignments, SI pump problems, etc.

It must be noted, however, that the safety injection flow can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and stop or throttle SI flow when SI stop and throttle criteria are met.

[Start idle charging pumps], is a plant specific RCS inventory restoration action that may be implemented depending on the design basis and the normal equipment response to a SI actuation.

(continue)

(continued)

If SI flow is not within the SI flow curve then the operator is directed to perform any of the following to restore SI flow:

- Ensure electrical power to SI pumps and valves. This step ensures that pumps and valves which actuate on a SIAS have not tripped on overload and the electrical bus which supplies the loads is still available.
- Ensure correct SI valve lineup have been established. The operator should observe control board indications and ensure that a flowpath exists from the RWST to the RCS.
- Ensure auxiliary systems are in operation which are vital to the proper operation of the SI pumps. The operator ensures the necessary systems are inservice to support the SI pumps.
- The operator is directed to start additional HPSI pumps as needed to ensure SI flow is within the [SI flow delivery curves]. The operator ensures that the pumps that are not running have electrical power, are lineup properly and auxiliary systems are available. Additional HPSI pumps provide additional water to satisfy RCS inventory control sooner.

Sequence

This step should be located shortly after any event sequence where a SIAS is likely.

Plant Parameters

Safety Injection flow [within the SI delivery curves]

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

HR-2 Step Number 3 Depressurize RCS

Intent

The intent of this step is to allow depressurization of the RCS to increase SI flow if high RCS pressure is causing RCS inventory or inventory trends to threaten adequate core cooling.

RCS pressure above the shutoff head of the SI pumps will prevent SI injection to the RCS. Charging pumps should still be operating and be capable of providing sufficient boric acid flow to ensure adequate reactivity control. If necessary, a cooldown and depressurization should be performed by referring to the pressure and heat removal success paths in use. These success paths will provide guidance for RCS depressurization, while also providing guidance for maintaining adequate RCS subcooling and core cooling.

Method

Sequence

Continuously applicable

Method

a. The operator is directed to lower RCS pressure by increasing the rate of RCS heat removal by means of the HR success path in Use.

b. If available, main or auxiliary pressurizer sprays may be used to depressurize the RCS.

c. If HPSI throttle/stop criteria are met, charging pumps may be stopped as necessary to aid in depressurization. Charging pumps are operated to provide inventory throughout the cooldown as well as to provide auxiliary spray as needed. Letdown should not be required during a cooldown, but may be used to aid in inventory control, and thus RCS depressurization provided HPSI throttle/stop criteria are satisfied.

d. The [PORVs or Pressurizer vent valves] may be used to lower RCS pressure in the event that no other means has been successful in lowering RCS pressure sufficiently to permit HPSI injection.

Plant Parameters

Adequate SI flow
Adequate SI flow is a plant specific and event specific value. It is based on the decay heat generation rate at the particular time in the event.

HR-2 Step Number 4 Maintain Subcooling and Shutdown Margin during Station Blackout

Intent

This step is intended to maintain subcooling the reactor shutdown if a Station Blackout is in progress and no vital AC power is available.

The operator is instructed to cooldown as necessary to maintain RCS subcooling based on CET temperature. If [minimum RCS subcooling] can not be maintained, than the operator should ensure that at least one steam generator is available for RCS heat removal with level being restored to the [normal control band] and CET temperature not superheated.

To verify that the reactor [remains Shutdown] as the plant cools down, the operator is instructed to estimate the resultant Shutdown Margin based on a change in RCS temperature. If the projected shutdown margin indicates that the reactor will not [remain shutdown], then he should take actions to reduce and stop the cooldown to prevent a return to power based on a change in RCS temperature. This strategy is used when there is no available means to borate the RCS.

The purpose of this strategy is to use the data from the projected shutdown margin calculation and plant specific curves (described in the Implementation Section) to determine, ahead of time, when to stop the cooldown to prevent loss of the reactivity control safety function.

Method

If station Blackout has occurred, the operator should cooldown as necessary to maintain the [allowable range of subcooling during SBO] by maintaining or restoring steam generator level to within the [normal operating band] using auxiliary feedwater and by controlled steaming via the ADVs. The direction for steam generator level control and RCS temperature control is provide later in this procedure and are continuously applicable.

The purpose of this strategy is to preserve the ability to maintain single phase natural circulation for as long as possible by minimizing RCS leakage. For plants with minimal RCS leakage it may be possible to maintain hot standby conditions for [3 to 4] hours. During this time period, subcooling will slowly decrease due to pressurizer level lowering from RCS leakage. In order to maintain minimum subcooling a deliberate cooldown is performed as necessary to maintain subcooling within the [allowable range of subcooling during SBO], based on [representative] CET temperature.

(continue)

(continued)

The RCS may be cooled by maintaining at least one steam generator available as a heat sink using the turbine driven auxiliary feedwater pump to maintain steam generator level while steaming via the atmospheric dump valves. If a RCS cooldown is initiated with minimal pressurizer inventory, RCS subcooling will not be maintained. Also, a high RCS leak rate combined with a cooldown will rapidly depressurize the RCS resulting in a loss of subcooling. In the event of loss of subcooling, adequate core cooling can be maintained via two-phase natural circulation as described in HR-2 (RCS and Core heat Removal via SG with SIS not in Operation).

If the plant is outside the condition limits of the LCO, the operator is required to continue efforts to comply with the technical specification action statement and restore the conditions of the LCO as conditions permit. However, there may be competing factors that collectively warrant cooling down the RCS to the greatest extent possible while maintaining a margin to criticality of 1% delta K/K or greater.

When choosing this reactivity control strategy, the utility makes a deliberate decision to operate outside the Shutdown Margin LCO. This means that the plant may no longer be protected for a MSLB, CEA bank withdrawal, CEA ejection, inadvertent RCP start or inadvertent boron dilution. The decision to lessen the required margin to criticality is justified by the fact that the specifics of the event and the need to cooldown may take precedence over the need to maintain the TS Shutdown Margin LCO.

An example of when this may apply is during a Station Blackout (SB), when there is no ability to borate to the RCS. The MSLB analysis assumes boron will be injected during the MSLB event. Maintaining the Shutdown Margin LCO during a SB no longer maintains the plant within the assumptions of the MSLB analysis. Cooling and depressurizing the plant will minimize loss of inventory while maintaining the RCS subcooled. Many multiple casualty events are beyond the design bases and attempting to maintain an LCO under these conditions may not provide the best strategy to mitigate multiple events. Under such conditions maintaining the reactor Keff .99 or less will maintain the reactor shutdown as defined in the Technical Specification of Operational Modes.

Each plant should determine the best indications to be used by the operator to implement this strategy. A plant specific table and curves, similar to the that located in the implementation section of CEN-152 under “Reactivity Control Strategy” could be developed. The curves would show the minimum temperature that the operator could cooldown to and not exceed the engineering limit and still maintain the [reactor shutdown], assuming all rods in, one rod stuck out, or one or two charging pumps operating.

(continue)

(continued)

The insertion of all the CEAs will provide more than the required shutdown margin for all C-E plants. When there is no available means to borate the RCS, such as during a station blackout, RCS temperature control is then the only available method of controlling reactivity changes. Performing a projected shutdown margin calculation at 50°F intervals with actual plant conditions (i.e. indicated Tc, boron concentration at event initiation, actual rod worth, etc.) identifies whether the next 50°F cooldown has the potential to challenge reactivity control. 50°F has been selected to provide the operators with sufficient lead time to stop the cooldown in advance of any problem. For conservatism, each calculated shutdown margin should be based on 50°F less than indicated Tc and use the boron concentration at time of event initiation. Therefore, the shutdown margin calculation for an indicated Tc of 450°F should use 400°F as input (assumed value) to the calculation.

Sequence

This step is sequenced prior to taking actions to initiate a deliberate RCS cooldown.

Plant Parameters

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Steam Generator level within the normal control range

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate.

(continue)

(continued)

For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

Reactor shutdown

The intent of the engineering limit is to ensure that the reactor is maintained subcritical during accident conditions when there is no available means to borate the RCS, such as during a station blackout. The engineering limit is based on the reactivity condition (Keff) used in the technical specification definition of Hot Standby, Hot Shutdown, and Cold Shutdown (Modes 3, 4 and 5). The engineering limit is Keff less than 0.99.

Allowable range of subcooling during SBO

The lower engineering limit is based on avoiding superheated conditions (e.g. subcooling less than 0°F) in the reactor coolant system. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit on subcooling currently contained in the CE Emergency Procedure Guidelines is nominally [20°F]. The numerical value of this limit is based on engineering judgment.

HR-2 Step Number 5 Commence a Cooldown

Intent

A fundamental strategy of the EPGs is that when entering the Functional Recover Procedure, a ~~controlled~~ cooldown should be commenced immediately. This action is conservative in that it will reduce the pressure and temperature of the plant when the exact nature of the event is not know. In the case of a LOCA, SGTR, or ESDE this limits the associated break flow by reducing the stored energy in the plant.

In the event of a LOCA, this step also ensures that deliberate action is taken by the operator to remove stored energy from the SGs. As long as the operator has the ability to feed and steam the SG, then SG heat removal is always beneficial to the overall event mitigation strategy. It will support RCS depressurization to SDC entry conditions, especially in the case of a small break LOCA. In the case of a large break LOCA this action will help re-couple the RCS to the steam generators and promote reflux boiling (two-phase natural circulation).

During a large break LOCA, break flow cools the core. Steam Generators are decoupled from the rest of the RCS and not the primary means of core heat removal. ECCS in-flow down the vessel wall and flow out the break is the dominant cooling mechanism. The operator has little control over reactor vessel cooldown rate because of uncontrolled cooldown and the impact of SI flow on indicated Tcold. The operator may be prompted to stop steaming the steam generators because of large uncontrolled cooldown. However, it is still important to remove stored energy from the SGs for the reasons described above. Recall that in a LBLOCA the SGs are uncoupled from the RCS. During a small or medium size LOCA, SG heat removal is also important to lower Pressurizer pressure to ensure that the HPSI pumps are able to inject into the RCS. If a smaller break size holds Pressurizer pressure above HPSI shutoff head, it is important to maintain RCS heat removal via the steam generators, and to maintain forced circulation, if possible, using the RCP trip two / leave two strategy.

A conflict may arise for the operator in implementing the SG cooldown strategy in a LOCA. The initial uncontrolled cooldown of the reactor vessel is beyond his control. The influence of cool SI flow on cold leg RTDs is also beyond his control. Compliance with TS cooldown rates is not possible until the system stabilizes. SG cooldown can be controlled by the operator. PTS is not a concern as long as the RCS is not allowed to rapidly repressurize. Reactor vessel wall delta-temperature stresses will dissipate with time. Then a controlled cooldown within the TS limits can be initiated. A 'controlled' cooldown implies that the operator is in control of the cooldown, i.e., that the cooldown is within the designed reset capabilities of MSIS and SIAS, or that the operator has the ability to stop or maintain a given pressure and temperature band.

(continue)

(continued)

A plant cooldown will change the reactivity conditions in the reactor core. Therefore, whenever a cooldown is performed the crew must consider the effects of the cooldown on reactivity control and take appropriate actions to maintain [adequate shutdown margin]. This may include borating and sampling the RCS, both, prior to and during the cooldown.

Method

Two methods are provided for accomplishing this task; the turbine bypass valves and the atmospheric dump valves. If the main condenser is available, the turbine bypass valves is the preferred method. Use of the turbine bypass valves conserves secondary inventory and provides for greater control over possible releases from the steam generators to the atmosphere. However, if systems are not available to support this method, or for some other reason is not desired, then the Atmospheric dump valves may be used.

During a prolonged station blackout, the natural circulation process can take different forms. The two principal modes are single phase natural circulation and a more complex two phase natural circulation. The simplest mode is single phase liquid connective cooling. Single phase natural circulation is the preferred mode and is self-regulating when RCS subcooling and heat removal are controlled properly.

Two phase natural circulation is more complex and can take several forms. Two phase natural circulation depends on the amount of decay heat, the amount of inventory and pressure control degradation, the RCS leak rate, and the status of the SIS and the steam generators.

Sequence

For events in which reducing the energy in the RCS is of high priority, this action would be placed early in the sequence of events. Reducing the energy in the RCS helps minimize the loss of inventory associated with a break in the primary or secondary system. However, the replenishment of RCS inventory is normally of higher importance therefore this would normally follow such steps.

Plant Parameters

Adequate shutdown margin

The intent of the engineering limit is to be in compliance with plant specific technical specification shutdown margin requirements based on moderator temperature.

HR-2 Step Number 6 Verify Single Phase Natural Circulation

Intent

The intent of this step is to verify natural circulation flow is established and is supporting RCS heat removal. After RCPs are tripped, natural circulation RCS flow should develop within 5-15 minutes (longer if the plant tripped from a low power level). Natural circulation flow will continue as long as RCS pressure and inventory control are maintained, and at least one steam generator is available for RCS heat removal.

Method

Natural circulation flow is determined by a combination of factors. The factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. These density differences occur when primary to secondary heat removal through the steam generator tubes is utilized. Figure [10-10] illustrates that a reactor vessel upper head void and natural circulation flow can occur at the same time.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

1. Loop delta T less than [normal full power delta T]. This ensures by plant design that the Power/Flow ratio remains less than 1.0. A Power/flow ratio of less than 1.0 ensures that heat can be removed from the RCS during the establishment of natural circulation. Initially, T hot may increase causing the lop delta to rise, but once natural circulation is established the loop delta T will drop.

   During the initial development of the natural circulation acceptance criteria there was no maximum delta-T criterion. Operators would observe T hot rising fairly rapidly and would interpret this as being a failure of natural circulation to develop. They would increase the steam generator feeding and steaming rate in an attempt to establish natural circulation. Unfortunately, this would only exacerbate the problem because T hot would have to increase more to cause enough of a density difference to start full-flow natural circulation. Therefore, it was determined that when both steam generators were available, if the operator did nothing but ensure normal steaming and feeding, the core delta-T never exceeded the full-power delta-T. In addition, with both steam generators available, it was determined that if the full-power delta-T was exceeded, natural circulation flow would be inadequate. Therefore, it was decided that full-power delta-T should be added as a maximum limit for the plant to stay within for adequate single phase natural circulation.

   (continue)

(continued)

It should be noted, however, that at the start of natural circulation or even during a natural circulation cooldown. If an asymmetric steam generator plant cooldown is initiated, the full-power delta-T value may be briefly exceeded. This is acceptable as long as the least affected steam generator remains operable. Eventually the delta-T will fall below the full-power delta-T limit and this acceptance criterion will be passed.

2. Hot and cold leg temperature constant or dropping. This is direct feedback to the operator as to how RCS heat removal is progressing. Initially T hot will increase but as natural circulation is established T hot turn and both T hot and T cold will be decrease until the point at which they become constant.

3. RCS is greater than or equal to the [minimum RCS subcooling] based on CET temperature. Adequate subcooling ensures that an adequate amount of fluid in its desired status is available to remove decay heat. During natural circulation CET subcooling should be used to determine if adequate subcooling exist. The CETs do not rely on loop flow (as do the RTDs) for detecting fluid conditions adjacent to the core any would therefore be the most accurate indication of core temperature.

4. No abnormal difference between T hot RTDs and CET temperature. Hot leg RTD temperatures should be consistent with the [representative CETs]. The intent is to observe that *same temperature* fluid is moving from the core to the hot leg. Therefore, adequate natural circulation flow is indicated by the [representative CET] temperature being approximately equal to the hot leg RTD temperatures. An abnormal difference between Th and [representative CET] could be any difference greater than [10°F], and would indicate possible blockage in the RCS loop or uncoupling on the core and the loops.

If the RCS does not indicate natural circulation is in progress, operators should ensure that the systems and safety functions needed to support natural circulation are available and functioning properly. Specifically, the operator should ensure that RCS heat removal is available via a SG, and that heat removal is being controlled by steam generator feeding and steaming.

<u>Sequence</u>

This step is usually put after the evaluation of restarting RCPs, after the initial event mitigation steps are initiated. Or, may be used whenever the need to ensure proper natural circulation flow occurs.

(continue)

(continued)

Plant Parameters

RCS Loop delta T less than normal full power delta T

The engineering limit is based on the normal full power delta T. The intent of the engineering limit is to provide a value that enables the operators to assess the status of single phase liquid natural circulation flow in at least one RCS loop. Under single phase natural circulation flow, the operating loop delta-T should be less than the normal full power delta-T. A loop delta-T less than the full power delta-T ensures that the [power/flow] ratio is within the nominal thermal hydraulic parameters for the RCS (i.e. the power to flow ratio is less than that for full power operation).

RCS subcooling is greater than the [minimum RCS subcooling]

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

No abnormal difference between Thot RTDs and representative CET temperature

The engineering limit is based on engineering judgment. The operational value is nominally [+/- 10°F]. The intent of the engineering limit is to provide an approximate operational value that can be used, in conjunction with other indications, to assess the status of single phase liquid natural circulation flow in at least one RCS loop. Under single phase natural circulation flow, core exit thermocouple temperatures should be consistent with the operating loop hot leg temperature. Approximate agreement between hot leg temperature and CET is corroborative evidence that there is fluid communication (flow) between the core and at least one hot leg.

HR-2 Step Number 7 Ensure Heat Removal under Two Phase Natural Circulation

Intent

The intent of this step is to monitor the effectiveness of core heat removal during two phase natural circulation cooling. Under two phase natural circulation the operational imperatives are to: 1) use every available means to fill the RCS and restore single phase (liquid) natural circulation; 2) to ensure an effective heat sink is available to the RCS; and 3) monitor core exit temperatures to determine the effectiveness of core heat removal.

During a LOCA, the natural circulation process can take different forms. These forms include single-phase natural circulation and a more complex two phase natural circulation. The simplest form of natural circulation is a single phase liquid convective cooling. Single phase natural circulation is the most probable mode when RCS inventory control and pressure control maintain the RCS hot leg completely flooded and subcooled. Single phase natural circulation cooling removes core decay heat using the same flow path as forced circulation cooling. The motive force for single phase natural circulation is the liquid density difference between the warmer column of water from the core to the SG (Th), and the cooler column from the SG back to the reactor vessel.

Two phase natural circulation is more complex and can take several forms. The characteristics of two phase natural circulation depend on the amount of decay heat, the amount of inventory, pressure control degradation, RCS leak rate, the status of Safety Injection and the operability of the steam generators.

One form of two phase natural circulation is known as reflux. The reflux process occurs with a partially voided hot leg: where steam leaves the core region, travels to the steam generator U-tubes, condenses, and the condensate flows back to the core via the hot leg where the cycle begins again. Another form of two phase natural circulation is similar to reflux, except the steam from the core goes over the top of the steam generator U-tube bend and is condensed on the cold leg side. In this mode the condensate flows back to the core via the cold leg. A combination of the two processes is also possible.

Method

RCS loop delta-T and loop temperature trend information can be used along with other corroborating parameters to confirm the effectiveness of single phase (liquid) natural circulation.

(continue)

(continued)

Because the two phase natural circulation processes is more complex, loop delta-T is not an indicator of effective natural circulation cooling. Therefore, in cases where two phase natural circulation cooling is the principal core heat removal process, other parameters and plant conditions must be used.

The following methods and bases meet the intent of this step:

Charging pumps operating and SI flow [within the SI delivery curves], ensure that a deliberate effort is being made to replenish RCS inventory. SI flow alone is acceptable to satisfy the intent of the step if no charging pumps are available and SI flow is in accordance with the SI flow delivery curve of Figure 13.13.

At least one steam generator is maintaining RCS heat removal with [minimum level for 1/3 tube coverage], ensures that an effective heat sink is available to the RCS. This includes heat removal via SG safety valves if necessary.

One-third tube area coverage is the minimum level, a higher level is preferred (100% tubes covered) during reflux boiling.

[Representative CET temperature is NOT superheated], ensures superheated conditions do not exist in the core region. Representative CET not superheated is the best available indication that the core is covered and that core heat removal is effective (Reference 9). If the core is uncovered, the CET would rise rapidly into the superheated region.

Sequence

This step is placed last in a series of steps regarding RCS flow and core cooling status. Since two phase natural circulation is one of the more complex, and least preferred, methods of core cooling, the steps preceding this step deal with RCP operation, RCP restart and single phase (liquid) natural circulation. If the previous steps flow conditions do not apply, then guidance is provided for two phase natural circulation.

Plant Parameters

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

(continue)

(continued)

Steam Generator level within the normal control band

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

HR-2 Step Number 8 Bypass automatic MSIS

Intent

The intent of this step is to ensure that MSIS does not actuate unnecessarily and complicate the event.

Method

During a controlled cooldown and depressurization, automatic operation of MSIS is not wanted when it is not needed. Therefore, MSIS (low SG Pressure) must be [blocked, bypassed, or lowered], if it has not actuated automatically, as the cooldown proceeds to ensure that automatic actuation does not occur unnecessarily. The preferred method for RCS cooldown is using the turbine bypass system, but an unnecessary MSIS would interrupt this flowpath and force the operator to either reset the MSIS or use the ADVs.

"CONTROLLED COOLDOWN: The operator is in control of the cooldown, i.e, the cooldown is within the designed reset capabilities of MSIS and SIAS, or the operator has the ability to stop or maintain a given pressure and temperature band."

Sequence

This step is sequenced after the directions to commence a cooldown.

Plant Parameters

None

HR-2 Step Number 9 Protect the Main Condenser

Intent

The intent of this step is to prevent overpressurizing the Main Condenser in the absence of condenser cooling water.

Method

The operator closes the MSIVs to isolate the major main steam supply to the condenser and steam generator blowdown. Note that up-stream main steam traps and MSIV bypass valves may also be isolated on a plant specific bases as time permits. The substeps are bracketed to permit each plant to do what ever is necessary to prevent overpressurizing the main condenser.

Sequence

This step is located just prior to the RCS heat removal steps of the procedure. It may be located earlier, if necessary, on a plant specific bases.

Plant Parameters

None

HR-2 Step Number 10 Determine which SG has the tube rupture

Intent

The intent of this step is to determine which seam generator is most affected by a tube rupture

Method

Several different indications are listed for the operator to consider when making this determination. The operator should evaluate all available indications to determine with a high degree of certainty, the most affected steam generator. It is important to evaluate trends both prior to and after the trip, taking into consideration known pre-existing leakage prior to the trip.

The following indications should be evaluated. The operator is not limited to using only these indications.

1. Steam generator activities should be compared to the activities existing prior to the trip, as well as after the trip.
2. Main steam line activity as observed by the steam line radiation monitors. It is important to note that this indication will not provide accurate information after the MSIV s are closed.
3. Steam generator blowdown activities should be compared to the activities existing prior to the trip, as well as after the trip.
4. If steam generator level continues to increase when feed to the generator is isolated and RCS temperature and pressure are not changing significantly,
5. If level is rising in one steam generator faster than in the other steam generator with similar feed rates and steaming rates in both steam generators.
6. If with no manual action, there is a feed flow mismatch between the steam generators.
7. If by evaluating the pre-trip trends for feed flow, a mismatch is observed.

There might be ESD/SGTR combinations. Therefore the operator should refer to the applicable portions of this success path to aid in identifying an ESD, if it is suspected that a dual event is in progress.

(continue)

(continued)

Sequence

This step is sequenced early in the guideline to aid in isolating the steam generator as early as possible, thereby containing the activity in the secondary side of the steam generator and minimizing contamination of the secondary plant and subsequent releases to the environment.

Plant Parameters

None

HR-2 Step Number 11 SGTR Bypass Step

Intent

The intent of this step is to direct the operators to bypass steps dealing with SGTR if no indications of steam generator tube leakage exist (e.g. condenser air ejector radiation alarm, blowdown radiation alarm, high activity in a steam generator liquid sample, etc.).

Method

N/A

Sequence

N/A

Plant Parameters

None

HR-2 Step Number 12 Cooldown RCS to T-hot Less Than [SG safety valve lift prevent temperature minus [15]°F]

Intent

The intent of this step is to ensure that the temperature of the RCS is lowered to less than the [SG safety valve lift prevent temperature] minus [15°F] prior to isolating the affected steam generator to prevent lifting the main steam safety valves (MSSVs) on the affected steam generator after isolation.

Method

This step is most easily accomplished when RCPs are operating and when one or more steam generators are providing cooling. If all RCPs have been tripped and natural circulation is the heat removal process, then it is necessary to cooldown both steam generator to provide uniform RCS cooling.

Under natural circulation flow conditions, T hot will rise approximately [15°F] as the core differential temperature rises as a result of the change from two loop to one loop heat removal. The temperature in the isolated SG will be essentially equivalent to Th since it is no longer being used as a heat sink. The MSSVs open at [1000 psia] which corresponds to a saturation temperature of [545°F]. Allowing a margin below the corresponding saturation temperature and accounting for the rise in Th that will result in a plant specific value for isolating the affected SG. For forced flow conditions, the increase in Th is negligible ([1°F]). Thus, the value selected to cover natural circulation conditions will cover forced circulation conditions. If RCS hot leg temperature is not less than the desired value then the RCS should be cooled down to this value.

Natural circulation cooldown of the RCS is not effective for cooling the RV head region. If natural circulation cooling provides the reduction of Th to [less than Saturation temperature corresponding to lowest MSSV setpoint], heat transfer to the steam generator from the RCS loops will not cause lifting the secondary safety valves. However, the energy stored in the RV head region and pressurizer has to be dealt with to bring RCS pressure close to steam generator pressure to minimize leakage into the steam generator and to preclude steam generator safety valve opening due to filling the steam generator with high RCS pressure. Controlling RCS pressure with the pressurizer and with an uncooled RV head region is addressed in a later actions.

(continue)

(continued)

This action may be performed by feeding the steam generators with feedwater and dumping steam to the condenser via manual control of the turbine bypass valves. If the condenser or turbine bypass system is not available, then the atmospheric dump valves may be used. However, it is less desirable to use the atmospheric dump valves to cooldown the RCS because of the un-monitored release of activity to the environment. Operation of the ADVs is more desirable than operation of the MSSVs for two reasons. First, the MSSVs may stick open or leak by. MSSVs can not be isolated, and the ADVs can. Secondly, the ADVs provide a more controlled release than do the MSSVs.

Sequence

This step is necessary before the steam generator most affected by the tube rupture has been identified and isolated.

Plant Parameters

Hot leg temperature less than MSSV lift prevent temperature

The bases for the engineering limit is the lift setpoint of the lowest lifting MSSV. The lowest lifting Main Steam Safety Valve (MSSV) setpoint for the reference plant is [1000] psia, with a tolerance of [± 1% (10 psi)]. Therefore, this safety valve may open at a steam generator pressure of [990] psia. The saturation temperature at [990] psia is approximately [540]°F. In order to prevent the steam generator pressure from exceeding the MSSV setpoint, the temperature in the steam generator must remain less than [540]°F. Assuming the hot leg temperature is equal to the steam generator saturation temperature, the hot leg temperature must also remain below [540]°F. The resultant heatup that is expected to take place due to transferring from two steam generators of cooling to one steam generator of cooling must also be accounted for. Following steam generator isolation, the hot leg temperature in both loops is expected to rise due to the increased heat removal load on the unisolated steam generator. Best estimate analyses have shown this rise may be as much as [15]°F. To ensure that the MSSVs do not open following this temperature rise, the hot leg temperature prior to isolation must be reduced by this amount. Therefore, hot leg temperature prior to steam generator isolation which will ensure the MSSVs do not open after the subsequent increase in hot leg temperature after isolation, is [540°F-15] or [525]°F.

HR-2 Step Number 13 Lower and Control RCS Pressure

Intent

The intent of this step is to minimize the transfer of inventory from and to the RCS, and to prevent lifting the steam generator safety valves.

The general goals associated with RCS pressure control are: providing subcooling to support the core heat removal process, avoiding overpressure situations for PTS and RT NDT considerations, minimizing the pressure differential between the steam generator and the RCS to minimize the leakage, and controlling RCS pressure so that it is below the main steam safety valve (MSSV) setpoints. This step addresses steam generator to RCS pressure differential and RCS depressurization to below the MSSV setpoint.

Method

Pressurizer pressure is reduced by:

1. Operation of Pressurizer sprays and heaters.
2. Control charging pumps, letdown and HPSI pumps, If HPSI Stop/Throttle criteria are met.
3. As a last resort, go to the FRG and operate the [PORVs or pressurizer vents] using the associated Pressure Control Success Path.

Maintaining the RCS pressure within the PT limits and approximately equal to the isolated steam generator pressure [±50 psi] and below the [lowest MSSV lift setpoint] will minimize the loss of primary fluid to the secondary side and the possibility of overfilling the isolated SG. This action will minimize the potential for release of radiation to the environment by minimizing RCS to steam generator leakage.

Maintaining RCS pressure approximately equal to or less than the affected SG pressure allows for the backflow of secondary water into the RCS that provides several operational benefits. These benefits include:

1. SG level will be maintained within the indicating range,
2. The chance of filling the main steam piping with water is greatly reduced,
3. Minimal use of the blowdown system should be required for SG level control,
4. The isolated SG depressurization would be easier (without steaming) because there would be less steam compression and a smaller layer of water between the SG tubes and the steam,

(continue)

(continued)

5. Less makeup water is required for the RCS cooldown.

Boron dilution of the RCS would occur due to unborated secondary water flowing through the tube rupture into the RCS. However, under most circumstances, this dilution will not threaten the maintenance of [adequate shutdown margin].

A important point in the strategy for the SGTR event is to maintain or restore forced circulation if possible. However, maintaining adequate NPSH for RCP operation may cause the operator to hold RCS pressure above secondary pressure until the RCS is cooled down beyond the SG isolation temperature. The requirement to maintain NPSH takes precedence over the strategy of equalizing primary pressure and secondary pressure.

During the forced circulation cooldown process the isolated steam generator may cool faster in the lower regions (see Figure 6-10). The cooling of the isolated SG steam space will significantly lag in the cooldown and cause the fluid in the lower regions to be subcooled. If the tube rupture is located in this subcooled region, as it is most likely to be, then the primary fluid can be at the same pressure as the secondary fluid and still be subcooled. However the continued depressurization of the primary during the cooldown will now be limited by the ability to depressurize the isolated SG.

During natural circulation cooldown conditions the isolated steam generator will not cool unless there is a transfer of mass in the isolated SG. This complicates RCS pressure control during the cooldown. It is desirable to cool the RCS such that the tube bundle region of the affected SG remains subcooled. Voiding in the tube bundle region can be expected and may result in the region becoming a pressurizing source for the RCS. Maintaining the presence of subcooled liquid in affected loop will be a complicated process under natural circulation conditions. Forced circulation conditions are much more desirable and if possible should be maintained or restored. During natural circulation conditions the cooldown and depressurization of the RCS will be limited to the operator's ability to control the conditions of the isolated steam generator.

Sequence

This step is sequenced after the isolation of the most affected steam generator, after the step for verifying that the most affected steam generator has been isolated, and after the step for the methods of controlling RCS pressure.

(continue)

(continued)

Plant Parameters

Steam Generator pressure less than the lowest MSSV lift setpoint

The bases for the engineering limit is the lift setpoint of the lowest MSSV, minus lift tolerance. The intent of the application is prevent lifting an MSSV which then sticks open, resulting in an uncontrolled release to the environment, because the operator can do nothing to stop it. The operational limit, [950 psia] was derived by taking the lowest MSSV setting [1000 psia.], subtracting the lift tolerance, typically ±1% (), [± 10 psi], and additional operational margin [40 psi].

HR-2 Step Number 14 Isolation of the SG Most Affected by SGTR

Intent

The intent of this step is to isolate the SG most affected by the tube rupture from the environment and the rest of the secondary system.

Method

Prior to affected SG isolation, RCS temperature (T hot) should be lowered to less than the [MSSV lift prevent temperature] minus 15°F. This action is necessary to prevent inadvertently opening a MSSV after the steam generator is isolation. Steam generator isolation is intended to re-establish the containment isolation safety function breached by the SGTR. If pressure in the isolated steam generator approaches the [lift pressure for the lowest MSSV], the operator should ensure that the ADV opens first. ADV operation is desirable from the perspective of positive operator control. This is accomplished by raising the automatic ADV lift setpoint to the upper end of the [post-trip control band], or manually opening the ADV prior to SG pressure reaching the [lift pressure for the lowest MSSV]. To minimize the un-monitored release of radioactivity, use of the atmospheric steam dump valves on the affected steam generator should be minimized. If both steam generators have tube ruptures, then the operators must determine which generator is most affected and isolate that generator.

The most affected steam generator is isolated as follows:

a. [The atmospheric steam dump valve (ADV) setpoint is raised to a value below the [upper end of the expected post-trip band] (not all plant have this capability) or the ADV for the affected steam generator is isolated]

b. The main steam isolation valves is closed.

c. The main steam isolation valve bypass valves is verified closed, or closed.

d. The main feedwater isolation valve is closed.

e. Steam generator blowdown is isolated.

f. MS line drains located upstream of the MSIVs are isolated from the main condenser.

g. The affected steam generator safety valves are verified closed.

(continue)

(continued)

h. [The auxiliary feedwater isolation valves are closed, including the steam driven pump steam supply valve associated with the steam generator being isolated].

This completes steam generator isolation. The instructions are intended to contain the contaminated secondary fluid within the affected steam generator. Steam generator isolation does not address the control of secondary system contamination, which occurred prior to isolation. Secondary plant contamination is address in another instruction.

Sequence

This step is sequenced after the step for identifying the most affected steam generator.

Plant Parameters

Hot leg temperature less than MSSV lift prevent temperature

The bases for the engineering limit is the lift setpoint of the lowest lifting MSSV. The lowest lifting Main Steam Safety Valve (MSSV) setpoint for the reference plant is [1000] psia, with a tolerance of [± 1% (10 psi)]. Therefore, this safety valve may open at a steam generator pressure of [990] psia. The saturation temperature at [990] psia is approximately [540]°F. In order to prevent the steam generator pressure from exceeding the MSSV setpoint, the temperature in the steam generator must remain less than [540]°F. Assuming the hot leg temperature is equal to the steam generator saturation temperature, the hot leg temperature must also remain below [540]°F. The resultant heatup that is expected to take place due to transferring from two steam generators of cooling to one steam generator of cooling must also be accounted for. Following steam generator isolation, the hot leg temperature in both loops is expected to rise due to the increased heat removal load on the unisolated steam generator. Best estimate analyses have shown this rise may be as much as [15]°F. To ensure that the MSSVs do not open following this temperature rise, the hot leg temperature prior to isolation must be reduced by this amount. Therefore, hot leg temperature prior to steam generator isolation which will ensure the MSSVs do not open after the subsequent increase in hot leg temperature after isolation, is [540°F-15] or [525]°F.

Steam Generator pressure less than the lowest MSSV lift setpoint

The bases for the engineering limit is the lift setpoint of the lowest MSSV, minus lift tolerance. The intent of the application is prevent lifting an MSSV which then sticks open, resulting in an uncontrolled release to the environment, because the operator can do nothing to stop it. The operational limit, [950 psia] was derived by taking the lowest MSSV setting [1000 psia.], subtracting the lift tolerance, typically ±1% (), [± 10 psi], and additional operational margin [40 psi].

(continue)

(continued)

Steam Generator pressure within the expected post-trip control band

The engineering limits are based on a 10°F post-trip RCS temperature control band of nominally [525 - 535°F] which was established based on engineering judgment (including, but not centered on the no-load temperature) to arrive at the SG pressure control band. The resulting nominal SG pressure band is [850 - 920 psia], with a nominal TBV setpoint of 885 psia.. The intent of this application is to assist the operator in detecting a malfunction of the TBVs, MSSVs or steam bypass control system (SBCS) as soon as possible.

HR-2 Step Number 15 Maintain isolated SG pressure less than MSSV lift pressure

Intent

The intent of this step is to ensure that high pressure in the isolated steam generator does not cause a safety valve to lift causing an uncontrolled release.

Method

The affected SG pressure is maintained less than or equal to [upper end of normal control band] by manual operation or local operation of the associated ADV. This action is taken to mitigate a high pressure in the isolated SG.

Should the pressure in an isolated steam generator approach the lift setpoint for the associated MSSVs, it is desirable from the perspective of positive operator control that the ADV open first. This is accomplished by manually opening the ADV, or locally opening the ADV. To minimize the un-monitored release of radioactivity, use of the atmospheric steam dump valves on the affected steam generator should be minimized.

The MSIV bypass valve might also be used to steam to the condenser. However, the effectiveness of the bypass valve is limited based on its size. It is, however, more desirable to steam the affected steam generator to the condenser if necessary than to steam directly to the environment. By steaming to the condenser some of the activity will be retained in the condenser versus to the environment (health and safety of the public) and this will provide a monitored release path via the off gas monitor.

Sequence

This step is sequenced immediately after the isolation of the affected steam generator to ensure that actions are taken to prevent lifting a safety valve after the generator has been isolated.

Plant Parameters

Steam Generator pressure within the [expected post-trip control band]

The engineering limits are based on a 10°F post-trip RCS temperature control band of nominally [525 - 535°F] which was established based on engineering judgment (including, but not centered on the no-load temperature) to arrive at the SG pressure control band.

(continue)

(continued)

The resulting nominal SG pressure band is [850 - 920 psia], with a nominal TBV setpoint of 885 psia. The intent of this application is to assist the operator in detecting a malfunction of the TBVs, MSSVs or steam bypass control system (SBCS) as soon as possible.

HR-2 Step Number 16 Verify Isolation of Most Affected Steam Generator with SGTR

Intent

The intent of this step is to verify that the steam generator that is most affected by the tube rupture has been isolated. Since both steam generators may have tube leaks, the steam generator with the most severe symptoms should be isolated.

Method

Once the most affected steam generator is isolated, the operator should verify that the correct steam generator was isolated. The operator should observe trends of steam generator activities, steam plant radiation levels, and steam generator levels to make this determination. If the wrong steam generator has been isolated then the operator should restore feed and steam capability on the isolated steam generator and isolate the most affected steam generator

Because there could be combinations of ESDs & SGTRs in this section, the verification of isolation includes verifications for ESD by checking steam generator pressures and RCS cold leg temperatures.

Sequence

This step is sequenced after the step to isolate the most affected steam generator. It provides a prompt review of the action just accomplished to confirm that the correct steam generator was isolated.

Plant Parameters

None

HR-2 Step Number 17 Sample Boron Periodically

Intent

The intent of this step is to periodically monitor boron concentration to ensure that shutdown margin is maintained.

Method

When pressurizer pressure is less than SG pressure at the rupture site, dilution of the RCS by the secondary may occur depending on the original boron concentration of the RCS. Therefore, periodic sampling of the RCS for boron is necessary to ensure adequate SDM is maintained. A fixed sampling interval of 30 minutes is recommended but not mandatory. The sampling frequency is plant specific.

Sequence

This step is sequenced after the step for cooldown and after the step for controlling RCS pressure with respect to the isolated steam generator pressure.

Plant Parameters

None

HR-2 Step Number 18 Disable RCP Restart

Intent

The intent of this step is to prevent starting a RCP in the loop with the isolated steam generator and rapidly adding positive reactivity as the result of a slug of reduced boron concentration water passing to the reactor.

Method

When RCP operation is lost, the RCPs in the affected loop should be disabled (e.g. tag out, remove control fuses, or rack out breakers). This action is necessary to minimize the possibility of operator error in starting the wrong RCP following natural circulation cooldown. During a natural circulation cooldown, a slug of water with reduced boron concentration may collect in the affected loop, due to S/G Backflow. If under these circumstances, an affected loop RCP is then started, a positive reactivity addition may occur. Therefore, this step directs the operator to disable both RCPs in the affected loop to prevent this from happening.

Sequence

This step is sequenced after the step for isolating the affected steam generator and before the steps for restarting reactor coolant pumps.

Plant Parameters

None

HR-2 Step Number 19 Maintain Isolated Steam Generator Level

Intent

The intent of this step is to prevent overfilling of the isolated steam generator, resulting in a loss of steam generator level indication and possible transfer of water to the MS lines. It is preferred to maintain SG level less than the top of the indicating range. Level indication is very useful when performing various SG recovery strategies. For, example, backflowing to assist in cooling and depressurizing the isolated SG. Level indication is the best tool available to know which way the water is flowing through the break. Without level indication, the operator will be hampered when trying to determine how much backflow is occurring and if there is a boron dilution concern.

Method

The potential exists for flow of reactor coolant via the tube rupture into the isolated steam generator and filling the steam generator steam space and the main steam piping to the MSIV. This action could result in the inadvertent opening of the MSSVs and presents an undesirable spread of contamination.

If the isolated SG level is rising due to RCS in-leakage, let it continue to rise to greater than the top of the tubes, then maintain it less than [the top of the indicated range]. If it is initially less than[the top of the tubes], do not deliberately feed it to raise level too greater than [the top of the tubes]. The intent of this step is to maintain the isolated SG level to prevent over filling and keep the tubes covered.

Reducing RCS pressure below the isolated steam generator pressure (i.e. backflow to the RCS) can lower steam generator level. Draining to the [radiation waste system or other appropriate system] can also be done to reduce level and minimize the spread of contamination. If the generator draining is not feasible or is insufficient, then steaming the generator to the condenser will also reduce level and minimize radioactivity release. As a last resort, the SG may be steamed to the atmosphere. Before doing so, the off-site dose coordinator should assess the radioactive releases to the environment.

Backflow to the RCS can reduce the boron concentration of the RCS. This is a concern if RCPs are not running. The circumstance in which RCP operation has been lost, due to a loss of offsite power or other reasons, has been analyzed in Reference (44), Task 780. That task analyzed the effects of back flow of SG water while in natural circulation (NC) and the effects of restarting an RCP after a period of NC operations. As part of the conclusions in Reference (2), it was considered highly desirable to minimize any SG back flow while in NC operation. The sole exception to this was to allow back flow as a means of preventing the SG water level from exceeding the high end of the indicating range.

(continue)

(continued)

Sequence

This step is sequenced after the major mitigation steps.

Plant Parameters

Steam Generator level less than top of the indicated range

Engineering Limit is the upper end of the indicated range (NR), nominally 85%. The upper limit maintains level in the indicated range to limit the possibility of filling the affected steam generator to the point that the main steam header is also filled.

HR-2 Step Number 20 Sample condensate and other systems for activity

Intent

The intent of this step is to identify if other plant systems have been radiologically contaminated as a result of the SGTR.

Method

The condensate and all other connecting systems, including the turbine building sumps, should be sampled for activity that may have been transferred from the affected steam generator(s). These samples aid in determining the extent of contamination throughout the plant systems.

Sequence

This step should be sequenced to provide timely notice to the crew to sample condensate and other systems for activity in order to take the appropriate isolation and containment actions.

Plant Parameters

None

HR-2 Step Number 21 Monitor radiation monitors

Intent

The intent of this step is to monitor the installed radiation monitors to detect any unexpected release of activity due to the SGTR.

Method

The [turbine and auxiliary] building ventilation system radiation monitors, and any other applicable radiation monitors, should be observed for increased activity that may have resulted from the SGTR event.

Sequence

This step should be sequenced to provide timely notice to the crew in order to meet the intent.

Plant Parameters

None

HR-2 Step Number 22 HR-2 Cool and Depressurize Isolated SG

The intent of this step is to cool and depressurize the isolated steam generator to SDC entry conditions. While doing this, the operator should: 1) minimize radioactive releases to the environment, 2) minimize generation of contaminated water, and 3) minimize the spread of contamination

Method

It is important to understand why the isolated SG needs to be cooled. Although the unaffected (or least affected) SG is being used to remove heat from the RCS, the isolated SG can hinder RCS depressurization during the cooldown because it will remain at a elevated temperature and pressure unless actions are taken to cool it down as the rest of the RCS is being cooled.

There are several methods available for cooling and depressurizing the isolated steam generator. The methods listed below are arranged in a preferred order, from the perspective of minimizing the radiological impact. The operator may choose to use any or all of the methods. The choice depends on the conditions existing at the time. The guidelines describe the "optimal" process for each method. It is recognized that decisions as to when to commence cooling the isolated SG will depend on how far you can cool the RCS prior to addressing the isolated SG.

For maximum effect, perform all feed and bleed evolutions after the RCS has been cooled to the maximum extent possible. Stay within the PT limits. If it is possible to make it all the way to SDC entry temperature before starting, all the better. Portions of the isolated SG will be cooled during the RCS cooldown, but not the upper steam space of the steam generator. Thus, RCS pressure will be held up at some point as determined by the saturation temperature of the steam space in the isolated steam generator. The cooler the water in the evaporator section before performing a feed and bleed evolution, the more effective the process will be at: 1) cooling the steam space, 2) limiting the number of times the evolution will have to be performed, and 3) reducing the volume of makeup water that will be required (i.e. minimizes generation of waste water).

a) and b) Feed and backflow to the RCS

At least one RCP must be operating to use this method. This is necessary to prevent formation of an lower borated slug of water somewhere in the RCS, which may eventually be transported to the core. The feed rate may be limited by the backflow rate in order to prevent overfilling the SG. The rate of backflow is dependent on the size of the tube rupture and the differential pressure at the break site. Heat removal is enhanced if the SG water level is maintained above the moisture separator can-deck.

(continue)

(continued)

This will provide greater thermal circulation of water within the generator since a return path to the downcomer region is provided when level is above the shroud.

Prior to proceeding to drain the secondary of the steam generator to the RCS via backflow, the adequacy of shutdown margin must be verified and monitored throughout the draining evolution. Perform the back flow operation prior to commencing to feed the SG. Also, drain as close to the top of the tubes as possible to prevent leaving a thick layer of hot water on the surface in the riser section. Draining first and to a low level ensures that when the fill evolution begins, the water which eventually spills out of the separators will be as much subcooled as possible. Thus, it will have the greatest heat transfer effect on the steam volume.

Fill the SG with the coldest possible source of makeup feedwater and continue to feed until water begins to spill out of the separators onto the can deck. The operator will know that this is occurring when SG pressure begins to decrease. Then stop the feedwater flow and allow the manometric effect to equalize level in the downcomer and riser regions. Do not overfill with feedwater because this will actually inhibit the heat transfer at the water surface.

Once the depressurization has stopped, if further depressurization is necessary, then allow the SG to soak for 10 to 15 minutes. This will remove as much heat as possible from the immersed SG walls and metal structure. Then drain (back flow) to expand the steam volume and expose it to cold SG metal surfaces. Continue draining until SG pressure is at the desired value or until SG level is at the top of the tubes. Commence another fill operation, if required. Note that approximately 13,500 gallons of feedwater are required per fill cycle, for the generic 2700 Mwt SG.

c) Exposing a portion of SG tubes

As an alternative to the "drain and fill" method to depressurize the ruptured SG, a portion of the SG tubes can be exposed to the steam space to directly condense steam. This method has been shown to be effective because of the large differential temperatures, which are possible, and the large surface area that can be exposed for a few inches of water level change. To optimize this method of depressurizing the SG the following factors should be considered:

a. Cool the RCS to the lowest possible temperature (SDC entry conditions) prior to the tube uncovery evolution.
b. When draining the SG (back flow) to the RCS, use the minimum d/p necessary to achieve acceptable flow rates. This statement applies mostly when the SG level is very close to uncovering tubes.
c. Maximize RCS flow to the ruptured SG during the tube uncovery operation. Run at least one RCP in the ruptured loop.

(continue)

(continued)

d. Uncover the minimum area of the tubes necessary to achieve an acceptable depressurization rate. This will allow the operator to have the greatest control when SG pressures approach the desired values. Only a few inches of uncovered tubes should be required.

The advantages to this method of depressurizing the SG are speed and the use of little or no makeup feedwater to the ruptured SG. In addition, level indicating systems are well within range for this evolution; thus, the caveats of the "drain and fill" method are not impediments in this procedure. Because of all the advantages and relative lack of disadvantages, this method may be the optimum procedure for lowering SG pressure.

d) Steaming to the main condenser

Short duration steaming of the isolated steam generator will rapidly depressurize the steam generator. Two methods of steaming are available. Less steaming will be required if the evaporator region has been cooled by the operation of the RCPs.

The advantage of steaming to the main condenser is that the radioactive releases to the environment will be filtered and monitored. However, it will continue to contaminate the secondary system. During the cooldown, the operator should maintain level in the indicated range and above the tubes. Maintaining the tubes covered is desirable to minimize the transfer of radionuclides from the primary to the secondary side of the SG through pre-existing cracks as well as the ruptured tube(s).

e) Feed and blowdown to the main condenser

This a slow method which transfers feedwater through the downcomer region and out the blowdown line. Heat is transferred to the feedwater across the SG shroud from the tube bundle region. The feed rate that can be maintained will determine the effectiveness of this method. The disadvantages of using feedwater and the blowdown system include; 1) Additional contamination of the secondary system, 2) Generation of additional contaminated water in the secondary system, 3) Additional loading of condensate polisher resins, 4) Increased probability of un-monitored airborne releases from existing secondary leaks, 5) Relatively slow cooldown rate.

For plants with surface blowdown taps, using the surface blowdown with auxiliary feedwater results in more efficient heat removal from the steam generator.

f) Ambient cooling of the affected SG

Simply allowing ambient cooling to cool the RCS and the SG can be used to lower SG temperature and pressure (i.e. neither the turbine bypass valves nor the atmospheric dump valves are used).

(continue)

(continued)

The time required to cooldown by this method will vary widely from one plant to another depending on the type of insulation on the steam generators and other factors. It has been estimated that the time required may be in the range of 30 to 300 hours. If steam generator level control can be maintained during this period, this may be the optimum method since no radiological releases occur after the steam generator is isolated. Ambient cooling may be accelerated by existing small steam leaks (such as leakage past the MSIVs). Even the low "normal" leakage coupled with ambient cooling may be sufficient to cool and depressurize the isolated steam generator.

During the cooldown, the operator should maintain level in the indicated range and above the tubes. Maintaining the tubes covered is desirable to minimize the transfer of radionuclides from the primary to the secondary side of the SG through pre-existing cracks.

If SG level can be maintained in the indicated range and if time permits, this method may be the optimum method to use to cool down since radiological releases are minimized after the affected steam generator is isolated. However, for most cases, the time required makes this method the least desirable.

g) Steaming to the atmosphere

Steaming using the ADVs will result in radiological release to the environment. For this reason it is preferable that it only be used for short periods of time, on a limited basis, and as a last resort.

Sequence

This step is sequenced after the immediate actions for response to a SGTR. It is sequenced before steps that will monitor the consequences of the cooldown method selected (e.g. sample condensate for activity, monitor turbine building ventilation radiation monitors).

Plant Parameters

Steam Generator level less than top of the indicated range

Engineering Limit is the upper end of the indicated range (NR), nominally 85%. The upper limit maintains level in the indicated range to limit the possibility of filling the affected steam generator to the point that the main steam header is also filled.

HR-2 Step Number 23 Determine if ESD has occurred and the most Affected SG with ESDE

Intent

The intent of the step is to determine if an ESDE has occurred. And, if an ESDE is indicated, determine which SG is most affected. It is important to identify the most affected SG to ensure that the correct SG will be isolated and to prevent further use of the faulted SG.

Method

The following parameters usually characterize an ESDE:

a. Rising steam flow from the steam generators.

b. Dropping steam generator pressure and water level (initially, there may be level swell).

c. Dropping RCS average temperature causing a drop in pressurizer pressure and water level.

d. Reactor trip caused by [thermal margin or CPC], high core power, low steam generator water level, low pressurizer pressure, low steam generator pressure, or high containment pressure depending on the size and location of the break.

e. SIAS may be generated from low pressurizer pressure or high containment pressure (if ESDE within the containment).

f. A [CIAS, CSAS and MSIS] may be generated on high containment pressure (if ESDE within the containment).

g. Possible rise in containment pressure, temperature, humidity, and/or containment sump level.

h. Possible rise in containment hydrogen concentration due to corrosion of zinc and aluminum by the containment spray system.

The most affected steam generator is determined by comparing both SG pressures, cold leg temperatures and steam generator levels. The parameters associated with the affected SG will be dropping. If there is a break in each steam generator, then the goal of this step is to determine which break is the largest, i.e. contributing most to the cooldown.

(continue)

(continued)

The break contributing most to the cooldown should be isolated and if possible, the smaller one should remain un-isolated to maintain the availability at least one steam generator for RCS heat removal. During the blowdown phase and before MSIS isolation it is difficult to determine which SG is most affected since both SGs are supplying the break flow. If the ESDE is downstream of the MSIVs, both steam generators' pressures and loop temperatures should be nearly the same values and then raise following MSIV closure i.e. break isolation.

If the ESDE is unisolable — a break upstream of MSIVs — the differences between the affected and unaffected steam generators will be more pronounced because the affected SG will continue to blowdown after the MSIVs are shut. At that point, the steam generator with the lower loop Tc, and lower steam pressure is the affected steam generator. Due to the unpredictable performance of the affected steam generator level indication during ESDE it should only be used as supportive indication, and not relied on as the sole indicator of the most affected SG. Note that due to the harsh containment environment conditions, all instrumentation inside containment will be affected by the event, including the steam generator level indication on the least affected steam generator.

If RCPs are running during the blowdown of an unisolable ESDE, loop temperatures may not reflect a clear distinction between the affected and unaffected SG due to mixing. If less than the normal four pump complement of RCPs are running, the distinction between loop temperatures may be even more obscure.

Sequence

The most affected SG should be determined prior to SG isolation to prevent inadvertent isolation of the wrong SG.

Plant Parameters

None

HR-2 Step Number 24 HR-2 If no ESDE then GO TO Step

Intent

If no indications of ESDE exist, then the operator is directed to skip ESDE steps and move on in the procedure for further guidance.

Method

N/A

Sequence

N/A

Plant Parameters

None

HR-2 Step Number 25 Isolate Most Affected SG with ESDE

Intent

The intent of this step is to isolate the most affected SG during a ESDE.

The most affected steam generator should be isolated to stop the uncontrolled plant cooldown and to stabilize the plant. If the break is unisolable, the affected SG needs to be isolated from the rest of the plant to mitigate the affects of the cooldown.

If both steam generators are found to be affected, then isolate the most affected steam generator (worse ESDE), if it can be determined, and attempt to maintain RCS heat removal capability via one steam generator. This action is designed to mitigate the uncontrolled cooldown and ready the plant for event recovery.

Method

This step accomplishes the intent by closing all valves that connect the affected SG to other systems or the environs and thus should completely isolate the affected SG from further leakage. Ensuring closure and isolation of the affected SG should include local manual closure of any valves that cannot be closed from the control room.

Sequence

This step should be used during ESDE shortly after the most affected SG is identified.

Plant Parameters

None

HR-2 Step Number 26 Verify Isolation of Most Affected SG with ESDE

Intent

The intent of this step is to perform a check that the correct steam generator has been isolated. If the wrong steam generator was isolated, then the operator is instructed to restore feeding and steaming capability on the isolated steam generator, and isolate the most affected steam generator.

Method

Once the steam generator has been isolated, isolation of the correct (most affected) steam generator should be verified by checking steam generator pressures, RCS cold leg temperatures, and steam generator levels. Operator training should address how to recognize both, the most affected SG during an ESDE, and the follow up indications that the most affected SG has been isolated.

If the wrong steam generator has been isolated, then restore feeding and steaming capability on the isolated steam generator, and isolate the most affected steam generator.

Sequence

This step should be placed shortly after any attempt is made to isolate the affected SG as a check that the correct SG was isolated.

Plant Parameters

None

HR-2 Step Number 27 Stabilize RCS Temperature Control Following ESDE

Intent

The main objective following an overcooling event is to minimize the stresses on the reactor vessel, return RCS temperature to within the [Post Accident PT limits] (ASME Section XI Appendix G limits of Tech Specs) and establish stable RCS presssure and temperature until a cooldown to SDC entry conditions can be started. In general, a controlled cooldown should be started as soon as possible.

Method

RCS temperature control is achieved by steaming the least affected SG using the atmospheric dump valves as necessary, and by ensuring adequate SG inventory for heat removal.

A heat removal method via the least affected SG should be established before SG dry out occurs, if possible. Operator training should address the PTS concerns regarding an ESDE and the factors or mitigating trends that tend to lessen PTS concerns. These include:

3. limiting RCS repressurization as much as possible while maintaining minimum RCS subcooling requirements,

4. restoring and maintaining control of RCS temperature within the limits of the Appendix G post accident PT limits.

In case the atmospheric dump valves are not available, SG safeties on the unaffected SG will serve as a heat removal method. Steaming via the SG safeties is not the preferred method because it results in RCS pressure increasing as SG temperature/pressure rise to the SG safety valve lift setpoint. Therefore, every effort should be made to regain use of the atmospheric dump valves to eliminate the possibility of RCS repressurization.

RCS temperature will rise after the affected steam generator dries out unless a means of RCS heat removal is established. The associated rise in RCS temperature may result in a water-solid condition due to the additional inventory added from safety injection and charging during the blowdown phase of the event. The post dryout heatup and repressurization also presents a PTS threat.

In order to mitigate RCS heatup, a controllable heat removal method should be established before the dryout condition occurs. The intent is to regain RCS temperature control and stabilize Tc, thus preventing uncontrolled RCS heatup and repressurization.

(continue)

(continued)

Feedwater temperature and flow rate can have a significant affect on RCS temperatures. Therefore, the affect of feedwater should be taken into account when attempting to stabilize RCS temperatures. A rapid refill of the unaffected steam generator with cold feedwater may:

1. Further the cooldown, or
2. Provide a substantial RCS heat sink and thus mitigate the RCS heatup.

The method of establishing RCS temperature control during an Excess Steam Demand will be plant and event specific, based on plant design, decay heat, break location and the size of the steam leak. The following provides some methods of establishing RCS temperature control:

1. A break downstream of the MSIVs can be controlled by closing the MSIVs and using the atmospheric dump valves to control RCS temperature.

2. A blowdown may result in the unaffected steam generator being isolated at a temperature much higher than the minimum RCS temperature. This may result in a significant delay between the time the RCS begins to heatup and the time when the unaffected steam generator becomes an effective heat sink.

Establishing RCS temperature control following a excess steam demand may require selecting an optimal time to begin steaming the least affected steam generator. The following are examples of methods that can be used to establish an optimal time to steam the unaffected steam generator:

- As the CET temperatures begin to rise, start steaming the least affected steam generator.

- Establish a level in the most affected steam generator at which to begin steaming the least affected steam generator.

- Begin steaming the least affected steam generator to maintain the saturation temperature corresponding to steam generator pressure between [25 and 50°F] above the most affected loop's hot leg temperature.

The method selected to control the RCS temperature should not raise the RCS cooldown or present an unrestricted path from the containment atmosphere.

(continue)

(continued)

Once RCS temperature and pressure control is regained, record the time, temperature and pressure. This information will be needed later in the procedure when evaluating adequate soak time prior to initiating a controlled cooldown. [Typically, PTS is more of a concern on natural circulation than with the RCPs operating. However, this is plant specific. Therefore, the requirement to initiate a soak usually only applies if RCPs are NOT operating.]

Sequence

This step should follow identification and isolation of the affected SG.

Plant Parameters

within Post-Accident PT limits

Engineering limits are derived from plant specific PT limits. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). ASME Section XI, Appendix G, requires the establishment of PT limits for material fracture toughness requirements of the RCPB materials.

HR-2 Step Number 28 Determine if LOAF has occurred

Intent

The intent of this step is to determine if a loss of all feedwater event has occurred.

Method

A Loss of All Feedwater results from a loss of both main feedwater and auxiliary feedwater to both steam generators. Some possible causes for a Loss of All Feedwater include:

a. Loss of all main and auxiliary feedwater pumps.
b. Malfunction of the feedwater control system that closes the main feedwater control valves.
c. Inadvertent isolation, or blockage, of the feedwater flow path.
d. Malfunction of the condensate system.
e. Feedwater line break (loss of feedwater resulting from a feedwater line break which is not isolable from the steam generator is covered under Excess Steam Demand Event).

A Loss of All Feedwater is characterized by specific parameters that may be indicated in the control room. Some of these indications are:

a. Lowering steam generator water level. The existence of this condition may be indicated by an alarm in the control room.
b. Rising steam generator pressure before a reactor trip, followed by a lowering and stabilizing trend.
c. Rising pressurizer level and pressure before a reactor trip, followed by a lowering and stabilizing trend.
d. Reactor trip generated on low steam generator water level.
e. Auxiliary feedwater actuation signal (AFAS) generated on low steam generator water level.
f. Turbine/generator trip.
g. Low main feedwater pump flow/suction pressure, resulting in a main feedwater pump trip alarm. (The main feedwater pump flow may possibly be high if there is a feedwater line break.)

(continue)

(continued)

h. Containment pressure may rise if a feedwater line breaks inside containment. In addition, possible rise in containment pressure, temperature, humidity, or containment sump level.

i. A feedwater line break outside containment may be indicated by noise.

j. Possible equipment operational irregularities, such as a loss of feedwater control indication, a failure of the feedwater flow control valves, or a closure of a main feedwater system isolation valve.

k. Possible steam flow vs. feedwater flow mismatch noted.

Sequence

This step should follow instructions that address ESDE.

Plant Parameters

None

HR-2 Step Number 29 If no LOAF then GO TO Step

Intent

If no indications of LOAF exist, then the operator is directed to skip LOAF steps and move on in the procedure for further guidance.

Method

N/A

Sequence

N/A

Plant Parameters

None

HR-2 Step Number 30 Stop RCPs

Intent

The intent of this step is to cease adding heat to the RCS.

Method

A Loss of All Feedwater results in a reduction of the ability of the steam generators to remove heat from the RCS. Since natural circulation heat removal is adequate to remove the decay heat generated in the core, the RCPs are stopped to eliminate their heat input to the RCS.

Sequence

This step is the first major mitigating action taken in a LOAF event.

Plant Parameters

None

HR-2 Step Number 31 Conserve Steam Generator Inventory

Intent

The intent of this step is to conserve as much inventory in the steam generators as possible.

Method

Until feedwater is restored, any remaining steam generator water inventory must be reserved for maintaining control of RCS temperature. Non-essential drains must therefore be secured to maximize the amount of inventory available for steaming. Releasing inventory as steam removes more heat than releasing it a liquid. This step directs that steam generator blowdown and sampling discharges be isolated since the liquid released does not make maximum use of the heat removal potential of remaining steam generator inventory.

Sequence

This action is taken immediately after all RCPs are secured.

Plant Parameters

None

HR-2 Step Number 32 Restore Steam Generator Inventory

Intent

The intent of this step is to continue the efforts to restore feedwater to at least one steam generator. This step is a continuation of operations that were begun in the Standard Post Trip Actions (SPTAs).

Method

These efforts may include restoring electrical power, operating valves, starting pumps, or restoring necessary auxiliary systems for feedwater system operation.

In most cases, one or both main feedwater pumps will have been supplying feedwater to the steam generators prior to the reactor trip. Since feedwater has been lost, it is likely that a problem with main feedwater initiated the event.

Efforts to restore feedwater flow focus first on the systems and methods that are the least complex and most likely to be operational. Even if a main feedwater pump is available, it may take some time to place it in service. Auxiliary feedwater is a less complex system, and if one or more electric-driven pumps are available, they represent the quickest and simplest way to restore feedwater flow.

If unable to start either electric-driven auxiliary feedwater pump, the operator should attempt to start the steam driven auxiliary feedwater pump. The steam driven auxiliary feed pump does not rely on electrical power being available. It is considered reliable and is relatively simple to place in service quickly. Operators should also be trained to operate the pump locally and to reset the overspeed trip, should it be needed.

If unable to start any auxiliary feedwater pumps, an attempt is made to start a main feedwater pump. In the absence of auxiliary feedwater, main feedwater is the only remaining potential feedwater source that does not require an abnormal plant alignment. This is because it is expected that main feedwater will be in operation at the start of the event, and that restoring one of the pumps to service can be performed without additional plant alignments.

[If main or auxiliary feedwater cannot be restored to at least one steam generator, then all low pressure plant specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Using such sources will require that the plant be cooled down and depressurized to permit their use. That is, the pressure in the steam generators must be low enough such that the source can provide sufficient flow to the generator. Steam generator pressure is dependent upon saturation temperature in the SG which is directly related to RCS temperature.

(continue)

(continued)

Depressurization is done at the maximum controllable rate, in order to regain flow as quickly as possible. If depressurization is not performed in a timely manner, SG level may become low enough to require the use of once-through-cooling before SG pressure can be lowered enough to restore feed flow. If pressure is reduced to the limiting valve and no flow is observed, some other difficulty exists that is preventing flow, and further reduction of SG pressure would be counterproductive.

Examples of alternate low-pressure sources of feedwater are fire pumps, condensate pumps, portable pumps, etc. When developing plant procedures, alternate low-pressure sources of feedwater should be identified and their use should be indicated in the procedures. Guidelines on steam generator depressurization should be developed for those cases when the operator is relying on low pressure sources of feedwater as a backup feedwater supply. Figure 8-8 provides an example of the type of information that must be developed on a plant specific basis. The figure provides a typical steam generator dump area required to remove heat from the steam generator for various times after shutdown. The required heat removal, compared to the available heat removal capacity (e.g. atmospheric dump valves), provides the technical basis for which guidance may be developed on steam generator depressurization to permit use of alternate low-pressure sources of feedwater.]

Sequence

This action is taken immediately after actions to conserve steam generator inventory.

Plant Parameters

None

HR-2 Step Number 33 Guidelines to Prevent Feedring Damage During FW Restoration

Intent

The intent of this step is to provide guidance for the restoration of feedwater to the steam generator for those plants susceptible to feed ring damage. Damage to the feedring can be caused by water hammer during restoration of feedwater when SG water level is below the feedring. This latter portion of the step applies to those plants susceptible to feedring damage.

Method

If the ability to provide feedwater is restored and steam generator level is below the feedring, the operator should limit feed water flow to less than [flow that could cause water hammer] for [5 minutes].

There is no analytical correlation between feedwater flow rate and the conditions necessary to prevent feedring failure. A flow rate of [150 gpm] has been traditionally accepted as a limit by industry and the NRC for water hammer protection.

Sequence

This step should follow the point in the procedure when the ability to feed the affected SG is restored. Since feedwater may be restored at any time, it is a continuously applicable step.

Plant Parameters

Steam Generator level below the feedring

The engineering limit is based on traditionally accepted industry and NRC guidance for the prevention of water hammer damage to feed rings. With steam generator level at the bottom of the feedring, following an interruption of feedwater flow, water hammer and the resultant structural damage to the feed ring will be avoided when feedflow is restored. Operator training should stress slow restoration of feedflow to the steam generator. If the ability to accurately monitor feedflow rate to a voided SG feedring is compromised, then, the only other corroborative methods that address the intent of the bases is to rely on operator skill and judgment to very slowly re-establish feed to the voided SG feedring.

(continue)

(continued)

Feedwater flowrate less than the maximum flowrate that will not cause water hammer

The maximum MFW/AFW flowrate to a drained steam generator feed ring that can be demonstrated will not cause water-hammer damage to the feed ring of piping leading to the feed ring, nominally [150 gpm]. This limit is only applicable to plants that are equipped with feed rings which are susceptible to damage due to water-hammer. The engineering limit is based on preventing feed ring damage due to re-establishing feedwater to a voided feed ring too quickly.

Feedflow has been supplied for [5 minutes]

Five minutes is a very conservative estimate of the time required to fill a drained feed ring. Five minutes is an approximation, arrived at by assuming that the capacity of a typical feed ring to be 350 gals. 2 X 350 = 700 gals. Therefore, 700 gals of water would be required to fill a feed ring twice. At a fill rate of 150 gpm, it would take approximately 5 minutes to deliver 750 gals of water, which is more than twice the capacity of the feed ring (700 gals).

Steam Generator level within the normal control band

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

HR-2 Step Number 34 Ensure that the Turbine Bypass System (TBS) is Controlling RCS temperature

Intent

The intent of this step is to establish and maintain a controlled RCS heat removal process via one or both steam generators.

Method

This step ensures that [RCS Tave or T cold] is stabilized and controlled by the turbine bypass system at or less than the [maximum expected post-trip temperature]. This temperature corresponds to steam generator pressure in the upper end of the turbine bypass valve control band. If condenser vacuum is lost, the turbine bypass system is not available, or if the MSIVs have closed, then the atmospheric dump valves must be used to control RCS temperature. This action is performed to maintain steam generator pressure below the secondary safety valve setpoints, preventing them from opening, and to allow a controlled RCS heat removal process using the steam generators.

Sequence

This step is located in the RCS heat removal portion of the procedure and is continuously applicable.

Plant Parameters

RCS average temperature or T cold less than the maximum expected post-trip temperature

The engineering limit is based on the normal control band for TBVs/SBCS. This associated operational limit, nominally [535°F] is intended to queue the operator to take corrective action to recover a means of controlled RCS heat removal prior to opening the ADVs or reaching a MSSV lift setpoint. Greater than [535°F] was chosen as an operational limit for this application because it will facilitate early recognition of a decrease in RCS heat removal following a reactor trip. It is assumed that if Tave increases to greater than [535°F], the normal control systems are malfunctioning and should be investigated and corrected. This operational limit corresponds to the upper end of the SBCS control band [850 to 920 psia].

HR-2 Step Number 35 Verify Adequate RCS Heat Removal with At Least One SG

Intent

The intent of this step is to verify that previous efforts to restore feedwater to at least one SG been successful, and that adequate RCS heat removal via a SG exists. If adequate heat removal is not available, then once-through-cooling (OTC) should be initiated, the LOAF ORG should be exited and the Functional Recovery Guideline implemented in its entirety. This means that the FRG is implemented as it normally would be using the FRG Entry Procedure and not by simply going straight to HR3). The contingency provides the direction for these actions. The intent of the contingency action is to identify inadequate SG heat removal and provide guidance for the transition to Once-Through-Cooling. This contingency applies only to plant with PORVs.

In the event of a total loss of all feed water, if once-through-cooling (OTC) is not initiated before both SGs are lost as a heatsink, core uncovery and possible core damage will occur. The loss of SG heatsink will result in reactor coolant system (RCS) temperature and pressure increasing rapidly. RCS expansion into the pressurizer will result in RCS pressure opening the PORVs. Following a period of subcooled depressurization, two phase repressurization occurs resulting in the primary safety valves (PSVs) lifting and RCS pressure remaining above high pressure safety injection (HPSI) pump shutoff head. The duration of the subsequent two phase depressurization phase of the event depends on decay heat generation rate at the time feedwater was lost. However, RCS inventory will continue to be lost through the PSVs or the PORVs, with no means to replenish it and core uncovery will occur before HPSI injection is reestablished.

Method

At least one SG with [SG level for initiating OTC] ensures that the in use SG has sufficient inventory for RCS heat removal. When inventory is below the [SG level for initiating OTC], the SGs start to become ineffective as a heat sink, and an alternate heat removal mode must be established. A transitional level is provided to allow the establishment of this alternate mode prior to reaching the point where the SGs are no longer an effective heat sink.

Checking SG level above this minimum level ensures that adequate inventory exists to permit using one or both SGs as a heat sink. Checking for stable or lowering RCS temperature is indication that heat is being removed form the RCS, while allowing for momentary correctable reductions in RCS heat removal.

(continue)

(continued)

If a feedwater source was successfully established in earlier steps, this step monitors the effectiveness of the SGs as a heat sink as inventory is restored.

If feedwater was not reestablished before reaching this step, conditions can be monitored using these criteria, until the point is reached where O-T-C must be established. Since O-T-C is the method of last resort for core cooling, inventory in excess of the minimum required allows some extra time to recover a feedwater source while continuing use of SGs as a heat sink.

If both SG levels are less than [SG level for initiating OTC] or if RCS Tc raises uncontrollably [approximately 5°F or greater], then the operator is instructed to initiate O-T-C, implement the Functional Recovery Guideline and go to Core Heat Removal success path HR-3.

The actions of the contingency are designed to accomplish four main objectives, 1) depressurize the RCS, 2) ensure a supply of borated water to the RCS, 3) ensure that an adequate vent path from the RCS is open, 4) implement the FRG in its entirety.

To avoid core damage, it is very important that, once the decision has been made to initiate OTC, implementing that decision becomes the top priority. Efforts to restore feedflow become secondary. Effective OTC relies on moving large quantities of relatively cool borated water through the core to remove heat. To establish flow through the RCS, the operator most first do everything possible to lower RCS pressure. This is accomplished by ensuring all RCPs are secured, and venting the secondary side of both steam generators by using the TBVs and ADVs. The operator is then instructed to ensure SIAS is actuated and ensure that two full trains of SI are injecting water into the RCS. All available charging pumps should also be aligned to inject into the RCS. Charging flow is very important in the early phase of OTC initiation to ensure a supply of water to the RCS when RCS pressure may be greater than the HPSI pump shutoff head. The PORVs are then opened to complete the line up be providing a flow path from the RCS.

Once OTC has been lined up in this step, then the operator should exit this guideline and implement the FRG, proceeding to RCS and Core Heat Removal Success Path HR-3.

<u>Sequence</u>

This step is necessary to verify RCS heat removal capability by at least one SG. It should be used prior to switching RCS heat removal from an alternate method of heat removal to SG heat removal. Or, when SG heat removal capability is being monitored closely because of a potential compromise in its effectiveness (ex. loss of feed).

(continue)

(continued)

Plant Parameters

Steam Generator level for initiating O-T-C

The engineering limit is the point at which the steam generator starts to become ineffective as a heat sink, nominally [15%] WR level. The intent of this limit is to ensure that action is taken to line up Once-Through-Cooling (OTC), after a loss of all feedwater event, while some margin still exists to the point where the steam generator starts to become ineffective as a heat sink. This margin is necessary to ensure that OTC will be initiated prior to a complete loss of SG heat removal, and ultimately prevent core uncovery. An effective SG heatsink is defined as a SG having enough secondary inventory with steaming capability such that core decay heat can be removed without uncontrolled RCS temperature increase.

HR-2 Step Number 36 Ensure Adequate Condensate Inventory

Intent

The intent of this step is to ensure that there is sufficient condensate inventory available to maintain hot standby within technical specification allowable time limitations, cooling down to SDC entry conditions and making the transition to forced cooldown using the SDC system.

Method

The available condensate inventory should be continually monitored, and replenished from available sources as necessary to provide a source for a secondary heat sink. Examples of alternate sources of condensate are non-seismic tanks, fire mains, lake water supplies, portable tanks, etc. Alternate sources of feedwater may be identified and cited in the procedure as considered necessary. The amount of condensate required to either maintain the plant at hot standby conditions or during a cooldown may be determined from plant specific figures.

The step refers to two figures which can be used to determine the amount of condensate required based on the existing temperature and the time after shutdown. The existing temperature provides for determining the inventory required based on the sensible heat that must be removed. The time after shutdown provides a basis for determining the inventory required based on the decay heat remaining in the plant assuming that the event occurred from a stable full power configuration. Each of the figures should assume a nominal leakage from the systems based on plant experience.

Additional allowances should be included to accommodate the time required to actually transition to forced cooling by the SDC system.

(continue)

(continued)

Sequence

This step is sequenced early enough in the guideline to ensure sufficient time for actions which may be necessary to replenish the inventory from normal or alternate sources.

Plant Parameters

Condensate Storage Tank inventory adequate to support cooldown

The engineering limit is the minimum quantity of available feedwater needed to remove sensible and decay heat to cool down to Shutdown Cooling entry conditions within an assumed period of time. The intent of condensate inventory information, whether it is presented in graphical, nomograph, or other forms, is to enable the operating staff to determine whether sufficient inventory exists for the planned actions. It should give the operator information in a timely manner such that, if a cooldown is required, enough condensate will be available to accomplish the task. In the event that enough condensate does not exist for a cooldown to shutdown cooling entry conditions, the operator(s) can plan accordingly to maximize the time to establish alternate sources of condensate.

HR-2 Step Number 37 Maintain SG Level in Normal Band

Intent

The intent is to ensure an adequate RCS heat sink is available via a SG since some LOCAs with small break flow still require a SG heat sink. The instruction states that at least one SG level should be restore to and maintained within the [normal control band] with main or auxiliary feedwater. This level provides adequate heat removal capability under forced flow and natural circulation conditions. The reason the step specifies level being restored by 'main or auxiliary feedwater" is because sometimes level can rise due to a heatup of the steam generator or due to steam generator swell. This step requires the operator to verify that main or auxiliary feedwater is flowing to the steam generator(s) to restore level and that the level rise is not from another heatup or swell.

In general, it is desirable to restore SG level to the normal band. During a LOCA it is assumed that the operator will not encounter problems restoring SG level. But during large break LOCA conditions and certain size small break LOCAs, immediate and aggressive recovery of SG level to the [normal control band] may exacerbate an already rapid cooldown rate due to SI flow into the RCS. Therefore, the operator should be aware of the potential for overcooling due to excessive feed to the steam generators. Due to the low probability of the large break LOCA occurring and considering the generic EPG strategy that does not require the operator to distinguish between break sizes, feeding up the steam generators under these conditions is a worth risk. Therefore, the operator is directed to feed up steam generators even if a large break LOCA or a large small break LOCA has occurred and the cooldown rate is being exacerbated. However, the operator should limit the feedwater flowrate under these conditions to just what is necessary to refill the steam generators.

Method

At least one steam generator level is restored to and maintained in the [normal control band] using main or auxiliary feedwater.

Sequence

This step is sequenced early in the procedure. It is important to the RCS Heat removal safety functions.

Plant Parameters

Steam Generator level within the normal control band.

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

HR-2 Step Number 38 RCP Restart Criteria

Intent

The intent of this step is to ensure the RCS and the RCP(s) selected for restart are in the proper condition to support RCP restart and operation. This step is only applicable if RCP restart is desired.

In general, forced circulation is normally the preferred mode of core cooling because it provides more responsive control of RCS temperature and pressure. But the need for forced circulation operation must be weighed against any potential risks of RCP operation. Once RCPs have been stopped, restarting of RCPs should be considered a major plant evolution and given considerable thought before restart is attempted. In addition to the RCP restart criteria given in the instruction the following items should be considered when deciding whether RCP restart is desirable: 1) the effectiveness of RCS heat removal using natural circulation, and 2) the need for main pressurizer spray capability.

Method

Sample RCS for boron concentration. If there is doubt regarding the existence of a slug of water with reduced boron concentration in the RCS, then RCS boron concentration should be sampled prior to starting RCPs to ensure the boron concentration and distribution is sufficient to prevent loss of SDM after RCP restart. During a SGTR there is a possibility that a slug of water with reduced boron concentration may accumulate in the affected loop. Therefore, RCS boron concentration in the affected loop should be considered (determined if possible) prior to starting the RCP in that loop if there is doubt about the existence and/or size of a slug of water with reduced boron concentration in that loop.

Verify RCS pressure and temperature are within the [Post Accident PT curve] limits for RCP operation, REFER TO ~~Figure 1~~Figure 13.8. This substep is a check to see that RCS pressure and temperature conditions will support RCP restart. The [Post Accident PT curve] should include RCP operation curves that ensure RCP NPSH and reactor core subcooling requirements are within their limits. Minimum RCS subcooling should be based on [representative CET] temperature.

In addition, to checking the RCS [Post Accident PT curve], the operators should be aware that the pressurizer water and steam space may not have reached equilibrium saturation conditions if there was a large level change (rise) a short time ago. This may result in the pressurizer being much less able to mitigate the pressure effects of a significant outsurge.

(continue)

(continued)

Verify the duration of [CCW] interruption to RCPs is within limits for RCP restart, REFER TO [RCP technical manual]. This substep prompts the operator to check that any cooling interruption to RCPs is within limits that allow for RCP restart. Each plant should establish guidelines for RCP restart after cooling interruption. The guidelines should be based on RCP vendor information and other appropriate sources.

Verify RCP seal pressures and temperatures are within limits for RCP restart, REFER TO [RCP technical manual]. This substep prompts the operator to check that RCP seal conditions are within limits that allow for RCP restart. Each plant should have guidelines for limiting RCP seal conditions based on RCP vendor information and other appropriate sources.

Verify the following RCP auxiliaries are operating properly to support RCP operation: oil lift system, bearing and motor cooling systems. This substep is an additional reminder to specifically check that the RCP oil lift system, and bearing and motor cooling systems are operating properly. There should be no bearing and motor cooling systems high temperature alarms on the selected RCPs.

[Verify RCS conditions are within the RCP start limits of plant technical specifications]. Plant technical specification typically provide LCO requirements regarding RCP restart and: RCS and steam generator delta T, pressurizer pressure, and pressurizer level. These limits and their bases should be reviewed for applicability prior to RCP restart.

Ensure at least one steam generator is maintaining RCS heat removal with [minimum level for 1/3 tube coverage]. The intent of this substep is to ensure that an effective heat sink is available prior to starting RCPs. One-third tube coverage is considered adequate to remove decay heat either via natural circulation or forced flow conditions.

Use of SG safeties is generally considered an acceptable method for RCS heat removal, although not a preferred method because of the loss of RCS temperature control and the inability to cooldown. Therefore, starting RCPs while on the SG safeties should only be done after a through review of the likely affects of RCP restart, and a determination that these affects are manageable within the context of current plant status. The intent here is to maximize the reasonable options available to the operator and allow RCP restart and operation while on SG safeties.

There are some predictable affects of transitioning from natural circulation to forced flow while on the SG safeties. From best estimate analysis it's assumed that post trip RCS heat removal via SG safeties is likely to be a cyclical evolution where the SG safety valve opens periodically removing heat and then shuts. The period of the cycling (the time between safety valve lifts) is determined by heat removal requirements. While heat removal from the RCS is through the SG safeties, RCS Tc will seek a temperature just slightly higher than the corresponding saturation temperature for the lowest SG safety valve lift pressure.

(continue)

(continued)

Therefore, under natural circulation, with a much wider delta T than forced flow, there will be a higher overall effective RCS temperature than under forced flow conditions. During the initial moments after starting a RCP, Tave will drop as the core delta T collapses with the subsequent change in pressurizer level. The additional heat input from the RCPs may raise the cycle rate of the SG safeties (lift, blowdown and close), but should not appreciably change the RCS temperature at which the SG safety lifts. These affects should be considered before starting an RCP while on the SG safety valves.

A pressurizer level [within the RCP restart level band] provides a minimum level to help mitigate the effects of RCS void collapse during RCP restart. And, a maximum level to keep a pressurizer steam space available for slight raise in RCS temperatures. Plant technical specifications typically address this topic and should be consulted when determining the plant specific RCP restart level band.

Ensure electrical power is available to the RCPs. This substep directs the operator to evaluate the availability and reliability of RCP power supplies, and to ensure their readiness to support RCP restart.

[RCP technical manual] is used generically to mean plant specific RCP technical information.

Sequence

This step should be placed just before actual RCP restart.

Plant Parameters

Pressurizer pressure within RCP NPSH limits

The engineering Limit is based on the reactor coolant pump suction pressure that meets or exceeds the minimum NPSH and pump seal pressure requirements. The engineering limit is intended on preserving RCP operability. Operation of the RCPs must be constrained to ensure that adequate net positive suction head (NPSH) is available to preclude pump cavitation and damage. The RCP seals also require a minimum suction pressure for reliable long-lived service. These pump suction pressure requirements are established by the pump vendor.

Steam Generator level within the normal control band

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

(continue)

(continued)

Pressurizer level in the restart level control band

Establishing pressurizer level within the required restart level band provides a minimum level, nominally [200"] to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. The upper engineering limit is based on TS RCP restart requirements which will ensure that there is still sufficient steam space to ensure pressure control using Pressurizer sprays, and preclude a large pressure surge in the RCS following restart. The lower engineering limit is based on keeping the pressurizer heaters covered to preserve normal means of RCS pressure control following RCP restart. The pressurizer heaters maintain RCS pressure to keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow.

HR-2 Step Number 39 RCP Start

Intent

The intent of this step is to take final actions in preparation for RCP restart, start the selected RCPs, and monitor plant response and RCP operation after RCP start.

Method

A pressurizer level [within the RCP restart level band] provides a minimum level to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. Plant technical specifications typically address this topic and should be consulted when determining the plant specific RCP restart level band.

Starting one RCP in opposite loops provides forced circulation through the core, better cooling of the RV head region, the capability for the use of normal pressurizer spray, condenses RCS steam voids, and removes non-condensable gases from the SG tubes. Further, starting a RCP in each loop simplifies RCS temperature control and facilitates a plant cooldown. RCP operation should be limited to one reactor coolant pump in each loop to minimize heat input to the RCS (Reference 22). When restarting RCPs, it is preferable to first start an RCP in the loop with the unaffected steam generator. This will avoid the confusion which could occur from a temporary reversal of Th and Tc indications in the operating loop and promotes mixing of inventory from the isolated loop.

Plant technical specification typically provide LCO requirements regarding RCP restart and: RCS and steam generator delta T, pressurizer pressure, and pressurizer level. These limits and their bases should be reviewed for applicability prior to RCP restart.

Verify RCS pressure and temperature are within the [Post Accident PT curve] limits for RCP operation, REFER TO Figure 13.8. This substep is a check to see that RCS pressure and temperature conditions are responding favorably to RCP restart and will support continued operation of RCPs. The [Post Accident PT curve] should include RCP operation curves that ensure RCP NPSH and reactor core subcooling requirements are within their limits. Minimum RCS subcooling should be based on [representative CET] temperature.

In addition to the conditions stated above, plant specific RCP operating limits should be verified immediately after restart as well as closely monitoring RCP operation while they are in operation.

(continue)

(continued)

Operating charging and HPSI pumps until HPSI throttle criteria are met ensures that pressurizer heaters remain covered in the event of RCS void collapse after RCP restart.

If steam voids are present in the RCS during RCP restart, pressurizer level and pressure may lower due to steam void condensation. Depending on the void volume, there is a potential to drain the pressurizer. The operator should be mindful of this affect and immediately commence restoring pressurizer level using charging and HPSI pumps if void collapse is suspected. This issue should be addressed in operator training.

Sequence

This step should immediately follow the RCP restart criteria step.

Plant Parameters

Pressurizer level in the restart level control band

Establishing pressurizer level within the required restart level band provides a minimum level, nominally [200"] to help mitigate the effects of RCS void collapse during RCP restart, and a maximum level to keep a pressurizer steam space available for RCS pressure control. The upper engineering limit is based on TS RCP restart requirements which will ensure that there is still sufficient steam space to ensure pressure control using Pressurizer sprays, and preclude a large pressure surge in the RCS following restart. The lower engineering limit is based on keeping the pressurizer heaters covered to preserve normal means of RCS pressure control following RCP restart. The pressurizer heaters maintain RCS pressure to keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow.

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

(continue)

(continued)

Pressurizer pressure less than HPSI shut-off head

The engineering limit is based on the shutoff head of the HPSI pumps, nominally [1300] psia. This application is used in two different ways in the EPGs. The first appears in the Functional Recovery Guideline, Heat Removal safety function, success path HR-3 (Once-Through-Cooling). Observing HPSI pump flow is positive indication that OTC is established.

Pressurizer pressure within RCP NPSH limits

The engineering Limit is based on the reactor coolant pump suction pressure that meets or exceeds the minimum NPSH and pump seal pressure requirements. The engineering limit is intended on preserving RCP operability. Operation of the RCPs must be constrained to ensure that adequate Net Positive Suction Head (NPSH) is available to preclude pump cavitation and damage. The RCP seals also require a minimum suction pressure for reliable long-lived service. These pump suction pressure requirements are established by the pump vendor.

HR-2 Step Number 40 SIT Isolation and Venting Criteria

Intent

The intent of this step is to prevent unnecessary injection of the Safety Injection Tank (SIT) water volume and possible injection of the SIT cover gas during a cooldown. Do not isolate SITs until it is confirmed that RCS pressure is under control and no LOCA event requiring SIT injection is in progress. If injected into the RCS, nitrogen gas could cause the steam generator tubes to become gas bound, thereby reducing their effectiveness as a heat sink.

Method

When pressurizer pressure reaches [SIT isolation pressure] the SITs should be isolated by closing their discharge valves and depressurized to prevent an undesired injection of water or the nitrogen cover gas into the RCS as RCS pressure is reduced during a cooldown.

Sequence

This step is sequenced after instructions to cooldown/depressurize the RCS. Ensure that no LOCA event is in progress prior to SIT isolation by verifying RCS inventory and pressure are under control. As there is no urgency to perform this step until the SIT pressure is approached. Even then, it will take some time for the entire SIT volume to be injected and N2 injection to be a real possibility.

Plant Parameters

Pressurizer pressure less then the SIT isolation pressure

The engineering Limit is based on the maximum Safety Injection Tank (SIT) pressure, nominally [250 psia]. The SITs are isolated and vented to prevent SIT discharge of water or nitrogen gas into the RCS during a plant cooldown/depressurization. For plants with high pressure SITs, this may be necessary to allow the plant to be brought to shutdown cooling system entry conditions.

HR-2 Step Number 41 LTOP Initiation Criteria

Intent

The intent of this step is to ensure Low Temperature Overpressure Protection is initiated when required.

Low Temperature overpressurization protection (LTOP) is instituted at a temperature of [LTOP enabling criteria] to protect against subjecting the RCS pressure boundary to high pressure at low temperature, which could lead to brittle fracture.

Method

When [LTOP enabling criteria] are met, the operator initiates low temperature overpressurization protection.

Sequence

This step is to be located late in the procedure, after the plant has been cooled to the LTOP enabling criteria.

Plant Parameters

RCS temperature less than the LTOP enabling criteria

The engineering limit is based on the LTOP enabling temperature found in technical specifications, nominally [285°F]. This operational limit is intended to ensure that low temperature overpressurization protection (LTOP) is lined up at the required cold leg temperature to protect against subjecting the RCS pressure boundary to low temperature brittle fracture.

HR-2 Step Number 42 HR-2 Void Elimination

Intent

The intent of this step is to eliminate voids in the RCS that may prevent lowering RCS pressure to SDC entry conditions.

Method

The operator should continuously monitor for the presence of voids in the reactor coolant system. If voiding is suspected, then the operator should proceed as follows:

a. The operator is directed to minimize letdown. If voiding is occurring, the continued net loss of inventory from the RCS will only make the situation worst. Letdown may be throttled to a minimum flow value, provided charging is maintaining a net gain in RCS inventory, or it secured completely while performing the void elimination procedure. Throttling versus securing may be preferred if a plant is concerned about thermal shocking letdown components such as the heat exchangers.

b. The operator is directed to stop attempting to depressurize the RCS. Depressurization activities will only make the situation worst by enlarging the void.

c. There are two primary methods which have been demonstrated successful for eliminating voiding in the RCS. They are: 1) cycling RCS pressure, and 2) operating the reactor vessel vent valves.

If indications of RCS voiding continue, and voiding is suspected to exist in the steam generator tubes, then the actions can be used to cool the steam generator and eliminate the voiding. This determination can be made by observing if saturated temperature in the steam generator is greater than RCS temperature. The suspected steam generator can then be cooled by performing any combination of the following: 1) steam to the condenser or to the atmosphere, 2) feed to add cool water and restore level.

Monitor pressurizer level and RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

Continue void elimination procedures until either the voiding is eliminated or the attempts have proved unsuccessful.

Sequence

This step should be located soon after commencing plant cooldown.

(continue)

(continued)

Plant Parameters

Pressurizer pressure within the post-accident PT curves

Engineering limits are derived from plant specific PT curves. The plant Technical Specifications establish operating limits that provide a margin to brittle failure of the reactor vessel and piping of the reactor coolant pressure boundary (RCPB). 10 CFR 50, Appendix G, requires the establishment of P/T limits for material fracture toughness requirements of the RCPB materials. It also requires an adequate margin to brittle failure during normal operation, anticipated operational occurrences, and system hydrostatic tests. It mandates the use of the ASME Code, Section III, Appendix G.

HR-2 Step Number 43 Verify LOCA not outside Containment

Intent

The intent of this step is to determine if the LOCA is outside of containment, and to provide the operator with direction regarding systems that should be considered when attempting to isolate a LOCA outside containment.

A L0CA outside of containment is a very low probability event. But if it does occur, and appropriate actions are not taken, the consequences can be severe due to the limited ability to make up to the RWST. The actions taken should control and limit the release of fission products to the environment.

Method

The operator is directed to check for indications of abnormal radiation levels and contamination outside containment. If a break occurs in a system connected to the RCS such as the CVCS, auxiliary building radiation levels and sump levels will increase. The spread of contamination outside of containment will be apparent by increases in airborne activity as well as area radiation levels in adjoining buildings.

The operator is directed to locate the leak (by observing the indication from the radiation monitors, sump level alarms and local indications of the leak). The operator should then use operating experience to isolate the leak in the best possible way. CIAS is initiated as an attempt to quickly isolate a leak in a process line connected to the RCS. The actions taken will limit the release of radionuclides to the environment and minimize the loss of RCS inventory.

The operator is directed to initiate actions to makeup to the RWT to attempt to maintain level greater than the RAS setpoint. If the leak is outside of containment, then the RCS inventory loss will not be collected in the containment emergency sump and will not be available as a suction source for SI flow following a RAS. Actions should therefore be taken to maintain RWST levels above the [RAS setpoint] to preclude a loss of RCS makeup.

If the LOCA is outside of containment, [Management] must be notified immediately to initiate actions to provide additional makeup to the RWT for alternate sources.

Sequence

This step is placed after attempts to isolate the LOCA are complete.

(continue)

(continued)

Plant Parameters

Refueling Water Storage Tank level less than the RAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for RAS, [nominally 10%]. The intent of the application is to prompt the operator to verify that RAS occurred automatically or to manually initiate RAS if it did not. The upper allowable value for this trip is set low enough to ensure RAS does not initiate before sufficient water is transferred to the containment sump. Premature recirculation could damage or disable the recirculation system if recirculation begins before the sump has enough water to prevent air entrainment in the suction. The lower allowable value is high enough to transfer suction to the containment sump prior to emptying the RWT and to prevent air entrainment during the transfer. Switchover from RWT to the Containment sump must occur before the RWT empties to prevent damage to the ECCS pumps and a loss of core cooling capability. For similar reasons, switchover must not occur before there is sufficient water in the Containment sump to support pump suction.

HR-2 Step Number 44 RAS Initiation Criteria

Intent

The intent of this step is to ensure that RAS is initiated when required and that the associated equipment and systems function as designed.

Method

For breaks located inside containment, if the refueling water tank level lowers to [RAS setpoint], then the operator should perform the following:

a. The operator firsts verifies that RAS has automatically initiated. If it did not, then the operator should manually initiate RAS. Recirculation is actuated either automatically or manually in order to maintain a continuous flow of safety injection fluid to the RCS (required for inventory control) and a continuous flow of containment spray water (required for containment temperature and pressure control).

b. The operator then verifies that the LPSI pumps stop, since (by design) they are not required for RAS. If they do not stop, the operator should secure them.

c. The operator then verifies that the ESF pump suction valves form the containment sump are open. This will provide a suction flowpath for the operating ESF pumps. If the valves do not open automatically, then the operator should open them.

d. After verifying (a) through (e), the operator should close the RWT outlet valves one at a time. In addition, for events where high containment pressure is present, the check valves in the RWT outlet line may be forced shut and the RWT fluid will remain unavailable while the containment is pressurized.

e. The operator then ensures that the HPSI pump minimum recirculation flow valves are closed to prevent contaminated containment sump water from returning to the RWT.

f. All charging pumps are [disabled] to prevent low suction pressure trip while charging pumps are taking suction on RWT post RAS. [disabled] in this context is the plant specific method to prevent use or auto-start of charging pumps after RAS. Generally, the term “pull-to-lock” conveys the intent, but plant specific terms should be used. [

(continue)

(continued)

g. [The auto-start function for all idle CS pumps and associated discharge valve should be disabled when RAS is initiated. The [CSAS] signal may have been reset and aligned for auto actuation prior to RAS. Post RAS, automatic actuation should be disabled. The purpose of this action is to prevent an unintended start of CS pumps that were intentionally secured earlier in the procedure. As a result of switching to containment sump recirculation, containment pressure may temporarily spike before settling out at a new equilibrium value. For plants with a relatively low CS actuation setpoint, the increase in containment pressure may be sufficient to re-actuate CS and start the idle pumps. This is undesirable because it goes against strategies to minimize flow through the sump screens after RAS and avoid equipment operations that would increase the potential for debris transport and accumulation on the sump screens.]

The verification of adequate containment sump level is accomplished in a prior step. A LOCA outside of containment will result in inadequate containment sump inventory to allow recirculation. The operator should exercise caution against prematurely initiating a RAS. A possible complication of a premature RAS is alignment of the ESF pumps to a dry sump and air binding of the pumps, leading to loose of both ESF trains.

Sequence

This step is sequenced after the step to monitor the RWT level and is fairly late in the steps. Reaching the RAS setpoint should take some time and therefore this step should not have to be early in the sequence.

Plant Parameters

Refueling Water Storage Tank level less than the RAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for RAS, [nominally 10%]. The intent of the application is to prompt the operator to verify that RAS occurred automatically or to manually initiate RAS if it did not. The upper allowable value for this trip is set low enough to ensure RAS does not initiate before sufficient water is transferred to the containment sump. Premature recirculation could damage or disable the recirculation system if recirculation begins before the sump has enough water to prevent air entrainment in the suction. The lower allowable value is high enough to transfer suction to the containment sump prior to emptying the RWT and to prevent air entrainment during the transfer. Switchover from RWT to the Containment sump must occur before the RWT empties to prevent damage to the ECCS pumps and a loss of core cooling capability. For similar reasons, switchover must not occur before there is sufficient water in the Containment sump to support pump suction.

HR-2 Step Number 45 HPSI Pump Minimum Flow Criteria

Intent

The intent is to ensure that after RAS has actuated, sufficient flow is maintained through each high pressure safety pump such that damage to the pump does not occur (since the HPSI mini-flow recirc valves are closed after RAS).

After the switch to recirculation, the HPSI pump flows are monitored in order to ensure that HPSI pump minimum flow requirements per pump) for pump protection are met. One HPSI pump should be left operating at all times, unless the termination criteria are met. In addition, pumps may be restarted as necessary to meet other procedural requirements as long as the minimum flow criteria are met.

Method

The operator checks HPSI flow greater than the [minimum required HPSI pump flow] to be assured that HPSI pump minimum flow requirements are met. The exact method used to accomplish this is plant specific.

A check may also be made that HPSI pumps are not in a runout condition at this time. Pump discharge pressure and pump amps are used for this indication.

The primary concern is hydraulic instability and damage to pump components including the pump seals as the result of heat buildup in low flow conditions. As the heating effects can be cumulative and are dependent on temperature, pressure and flow conditions, an exact time to failure is not possible. However, generally manufacturers will specify minimum flow rates for various lengths of time at which pump damage is not anticipated.

Another consideration is the accuracy of the instrument used to determine the total flow as well as individual pump flow. The minimum flow based on the accuracy of the instrumentation may be higher than required to actually preclude pump damage.

Sequence

This step is sequenced after the step for verifying recirculation actuation. It ensures that sufficient flow is maintained through the HPSI pumps after the recirculation minimum flow line is isolated. Pump damage is not expected to be imminent with flow less than the minimum required. That is, as noted above, damage is dependent on several variables in particular the time at the flow condition. Except in extremely low flow conditions and excluding air binding of a pump it can be assumed that low flow for up to two hours can be accommodated. These are general statements and specific manufacturer recommendations should be adhered to.

(continue)

(continued)

Plant Parameters

Minimum required HPSI pump flowrate

The engineering limit is based on the minimum required flowrate through a HPSI pump that will avoid pump damage during continuous minimum flow operation, nominally [30 gpm]. The intent of the operational limit is to ensure that the HPSI pump is secured when the flowrate through the pump decreases to less than the minimum required for continuous minimum flow operation. This will ensure continued operability and availability of the HPSI pumps by avoiding over heating and subsequent pump damage.

Step Number 45A Post RAS HPSI Stop Criteria

Intent

The intent of this step is to permit securing one HPSI pump following RAS if two HPSI trains are not needed for core heat removal. This action reduces the total ECCS flow through the containment sump screens in order to reduce debris buildup on the screens. It also establishes a protected train for use at a later time if needed. This instruction is applicable post RAS only. It does not replace or alter the standard HPSI stop/throttle criteria which is available before and after RAS..

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action in their EOPs if it is determined to be risk beneficial with respect to containment sump blockage.] (Reference 48)

Method

a. Verify both HPSI trains are in operation. It is assumed that they are operating normally and delivering design flow rate to the core as determined by the [SI flow delivery curves]. With both trains in service at this time after the trip, there may be more safety injection flow than is needed to cool the core. Therefore, it is likely that one HPSI pump may be secured. The adequacy of core heat removal is made by assessing core conditions, i.e. representative CET Temperature less than [superheat], and reactor vessel level greater than [bottom of the hot leg]. To ensure that there will be sufficient time for the operator to recognize and respond to a failure of the remaining operating pump, an additional criteria based on the time from shutdown is also included. The time requirement is based on the time for successful fifteen minute operator response which is a typical time needed to complete of a round of safety function status checks.

b. If these conditions are met, then one HPSI pump may be secured. The other pump is then monitored to ensure continued normal operation. If at any time, any of the termination criteria can not be maintained, the standby pump must be restarted or flow increased as necessary to ensure adequate core cooling is maintained.

c. Predetermine the optimal strategy for securing pumps. Select the preferred CS train (A or B) and the preferred HPSI train (A or B) to be secured first when the termination criteria are satisfied. Consider such factors as: pump power supplies, suction valve and piping configuration and sump design (split vs. common). An optimal configuration would include one CS pump and one HPSI pump with the same power supply, with a common suction line and common sump penetration or sump section. In this way the reliability of the standby pumps is enhanced.

(continue)

(continued)

Alternate Methods

Post-RAS, some plants require subcooled injection to the suction of the HPSI pumps to maintain sufficient NPSH and prevent cavitation. By design, the subcooled injection is provided by the containment spray pumps since containment spray is cooled via CCW in the spray/SDC HTX. The cumulative effect of running one HPSI pump and one containment spray pump post-RAS may increase the total flow through the containment sump screens.

For plants requiring containment spray flow injection to the HPSI pumps, the need for subcooled flow may be reduced if HPSI pump discharge flow is also reduced proportionately. This will reduce the overall flow through the sump screens. Therefore, some plants may find it more beneficial to throttle both HPSI pumps post-RAS versus securing one HPSI. This is an acceptable alternate method of reducing flow through containment sump screens if plant staff has determined an overall beneficial effect. However, if this method is use, consider the following:

1. One HPSI pump at design flow (not throttled) is within the design bases and flow loss out the break is considered in the safety analyses.
2. If HPSI is throttled, core conditions must be monitored closely since there is no way to determine the proportion of flow actually reaching the core.
3. If diesel failure occurs and the subsequent loss of one HPSI pump, operators must promptly adjust throttling flow to ensure sufficient core cooling with the remaining running HPSI pump.

Sequence

This step is sequenced after verifying that HPSI pump flow is greater than the minimum required to protect the pump. It is a continuously applicable step that may be used at any time that the relative criteria are satisfied.

Plant Parameters

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and to corroborate core covered or core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower indicating limit, RVLMS level indication, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to cover the core, support adequate core cooling, and prevent core damage.

(continue)

(continued)

Reactor Vessel level greater than the top of active fuel region

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the active fuel. However, the lowest sensor in the Reactor Vessel Level Monitroring System (RVLMS) is typically located just above the top of the fuel alignment plate. Nominal operating value is the lowest-reading sensor in the RVLMS.

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

Supplimental Information from an engineering evaluation performed on this strategy (Reference 48)

Advantages

In order for the operator to secure one train of HPSI after initiating sump recirculation it is assumed that two trains of HPSI are in operation at the time of RAS and running normally; in addition, other specific criteria are met. During large break LOCA, all of the standard HPSI stop/throttle criteria may not be met. Yet, it may still be preferable to stop one HPSI pump after RAS, if the plant-specific risk of containment sump blockage is significant. Since most plants only require one HPSI pump to meet licensing requirements, securing all but one HPSI pump after RAS still provides adequate core cooling consistent with the analytical bases. In addition, the normal HPSI Stop/Throttle criteria are still available to the operator prior to and after RAS.

Securing one HPSI pump reduces the total flow through the sump screens and thereby reduces the rate of debris transport to the screen surface and reduces the risk of blockage. The amount and size of debris collected at the containment sump screens is a function of screen size, the flow volume through the screens and the overall inflow to the containment sump. Greater volumetric flow is more likely to “sweep” debris to the containment sump screens and thereby increase the risk of blockage. The flow contribution of one HPSI pump is relatively small (less than 1/10) compared to containment spray pump. However, any flow reduction should reduce the risk of blockage.

PWR sump screens were typically designed assuming relatively small structural loads from the differential pressure associated with 50% debris blockage. Consequently, PWR sump screens may not be capable of accommodating the substantial structural loadings that may occur due to debris beds that cover the entire screen surface. Inadequate structural reinforcement of a sump screen may result in its deformation, damage, or failure, which could allow large quantities of debris to be ingested into the HPSI and Containment Spray System piping, pumps, and other components, potentially leading to clogging and failure.

(continue)

(continued)

Reducing both the risk and rate of sump blockage lowers the risk of containment sump screen failure and potential failure of operating HPSI and Containment Spray pumps. Securing one HPSI pump post RAS provides additional assurance that the secured pump will not be damaged due to debris ingestion or loss of NPSH, thereby preserving one operable HPSI pump for later use.

Some plants have separate sumps for each ECCS train. In this case securing flow from one train will preserve the other sump for use in the event that the in-service sump screens become blocked. In addition, operation of the single screen might reduce the amount of free debris available to block the other screen. Therefore, operating a single sump may extend recirculation capability, preserving the second sump screen by sacrificially clogging the first.

Disadvantages

Stopping one (1) HPSI pump during recirculation mode may slightly increase the required NPSH for the remaining running HPSI pump due to the increase in flow through the running pump. During two pump operation all HPSI flow must pass through common loop headers into the cold leg. When one HPSI pump is stopped, the reduction in overall flow also reduces the line-loss to the cold leg and thus flow will increase slightly for the remaining running HPSI pump. This increase in flow will result in a slight increase in required NPSH. This should not present a problem since the required NPSH for one HPSI pump operation is already accounted for in system design.

Typical plant licensing bases show adequate core cooling with one HPSI pump after recirculation actuation. However, since deliberate manual securing of one HPSI pump is not considered a "failure," licensees may be required to show acceptable consequences with failure of the running HPSI pump after manually stopping one of two HPSI pumps. This would mean an interruption of HPSI flow until the operator could restart the previously secured HPSI pump. Since current licensing analysis does not account for an interruption in HPSI flow due to single failure, plant specific 10 CFR 50.59 evaluation may be required to determine the acceptability of securing one HPSI pump after recirculation actuation. Best estimate analyses have been performed to determine the time after trip when the decay heat level is low enough, such that, failure of "the one" running high pressure injection pump will result in approximately 15 minutes of reaction time before core temperature begins to rise. Fifteen minutes was selected so that loss of the one remaining high pressure injection pump will allow one Safety Function Status Check interval for the operator to recognize the loss of injection flow and take corrective action to restore core cooling.

(continu)

(continued)

Best estimate analyses show that at 40 minutes after trip there is approximately 15 minutes of operator reaction time before core temperatures begin to rise. Details of this analysis are contained in Reference 48, Appendix B. Since 40 minutes is an approximate value, each plant should complete a similar plant specific best estimate analysis.

By the time that the operator is expected to reach this step (up to 1 hour post-event), the injection flow required for decay heat removal may only be 200 – 300 gpm. This will make it difficult to balance the required flow between the four injection points (50 – 75 gpm each), because SI cold leg injection flow instrument uncertainties for a harsh environment may exceed this amount. This reality supports the strategy of stopping one pump, as opposed to the strategy of throttling flow to match decay heat.

HR-2 Step Number 46 Hot and Cold Leg Injection

Intent

The intent of this step is to avoid concentrating boric acid in the reactor vessel and possible boron precipitation in the core which could restrict coolant flow through the core. This phenomena may occur if there is a large break in the hot leg and RV level can not be regained.

Method

During a large break LOCA on one of the RCS cold legs, it is assumed that all of the SI flow from the injection point associated with that cold leg goes directly out the break. In addition, some of the fluid injected into the other cold legs is directed out the break such that the water flowing to the core is just enough to make up for boil-off. Over time, this boiling in the core could concentrate the boric acid to the point where it begins to plate out on core surfaces and begins to interfere with adequate core heat removal. Therefore, the mode of SI flow is switched from “cold leg only“ to simultaneous hot and cold leg injection sometime into the event.

In this mode of operation, the HPSI pump discharge is aligned so that the total injection flow is divided equally between the hot and cold legs. Injecting to both sides of the reactor vessel will ensure that fluid from the reactor vessel (where the boric acid is being concentrated) flows out the break (regardless of the break location) and is replaced with a dilute solution of borated water from the other side of the reactor vessel.

The operator should not line up hot and cold leg injection before [2 hours] have elapsed after the start of the LOCA. The purpose of this requirement is to ensure the borated water injected to the hot leg is not entrained in the steam being released from through the break. Hence, possibly diversion of borated water from the reactor vessel is avoided. [2 hours] after start of the LOCA, core decay heat generation will have dropped sufficiently and there will be insufficient steam velocity to entrain the borated water being injected to the hot leg. The operator should line up hot and cold leg injection no later than [4 hours] after start of the LOCA to ensure that the concentration of boric acid in the reactor vessel is terminated well before the potential for boric acid precipitation occurs.

Simultaneous hot and cold leg injection is not required for small break LOCAs because the buildup of boric acid is terminated when the RCS is refilled. Once the RCS is refilled, the boric acid is dispersed throughout the RCS via natural circulation.

If entry into shutdown cooling is anticipated before the [4 hour] limit, and the criteria for entry are met, then the realignment to hot/cold leg injection is unnecessary (Reference 17).

(continue)

(continued)

After the [specified time period] following a LOCA, if any of the following RCS inventory parameters are in jeopardy, simultaneous hot and cold leg injection should be initiated:

1. RCS subcooling is less than [minimum RCS subcooling], based on CET temperature. If subcooling has not been re-gained, the RCS inventory and pressure control parameters, needed to preclude boron precipitation, do not exist. CETs are used because it is not expected that the core and loops would be coupled such that T hot could be used. In addition, the CETs are more accurate in natural circulation then the T hot RTDs.

2. Pressurizer level is less than [minimum level for inventory control]. If subcooling is greater than the minimum required and pressurizer level is greater than the minimum required, this is a good indication that the loops are re-filled. However, if pressurizer level is less than the minimum required, it is not certain how full the RCS is, and therefore, simultaneous hot and cold leg injection would be required.

3. RVLMS is [less than top of the hot leg nozzles]. If RVLMS does not indicate that RV level is greater than the top of the hot leg nozzles, the RCS loops are not filled and simultaneous hot and cold leg injection must be initiated to preclude boron precipitation.

<u>Sequence</u>

This step is placed in the guideline at the point necessary to implement the boron precipitation strategy.

(continue)

(continued)

Plant Parameters

RCS Subcooling is less than the required minimum subcooling based on representative CET temperature

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Pressurizer level greater than the minimum level for inventory control

The lower engineering limit corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The lower operational limit, nominally [35"], is approximately ([10%]) of a typical Combustion Engineering Pressurizer's range, and was chosen as the lower limit to account for some instrument and process fluid uncertainties. The lower limit is based on the lowest indication, approximately [2%] that with confidence reflects an actual Pressurizer level. Instrument uncertainties, assumed to be ± 8%, were conservatively applied to the engineering limit, yielding the lower operational limit of [10%].

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that, 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

HR-2 Step Number 47 Determine status of Acceptance Criteria

Intent

The intent of this step is to Verify HR-2 (RCS and Core Heat Removal via SG with SIS in operation) is satisfied by ALL of the following:

a. At least one SG level is within [normal control band], or being restored by feedwater.

b. [Representative] CET temperature is [less than superheated].

c. IF RAS has NOT occurred,
THEN all available charging pumps are operating.

d. IF RAS has NOT occurred,
AND LPSI termination criteria are NOT met,
THEN LPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.

e. IF HPSI termination criteria are NOT met,
THEN HPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.

Method

If the above criterion are not satisfied, then success path HR-2 is not adequate. The operator should go to another appropriate HR success path for further guidance to restore/maintain Heat Removal. Resource Assessment Trees (Section 5) may be useful in determining the appropriate success path.

If the acceptance criterion for success path HR-2 is satisfied, then success path HR-2 is successfully controlling RCS and Core Heat Removal. Heat Removal is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the Long Term Actions (Section 14).

Sequence

Safety Function Status Checklist

(continue)

(continued)

Plant Parameters

Steam Generator level within the normal control range

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

HR-3: RCS and Core Heat Removal via [Once Through Cooling]

If adequate heat removal capability via the steam generators is not available, heat can be removed from the RCS by flushing SIS flow through the core and discharging into the containment through a pressure boundary opening such as a [PORV] (or a break in the RCS if there is one).

HR-3 Step Number 1 OTC Initiation

Intent

The intent of this step is to ensure Once-Through-Cooling is established. This success path applies only to plant with PORVs.

In the event of a total loss of all feed water, if once-through-cooling (OTC) is not initiated before both SGs are lost as a heatsink, core uncovery and possible core damage will occur. The loss of SG heatsink will result in reactor coolant system (RCS) temperature and pressure increasing rapidly. RCS expansion into the pressurizer will result in RCS pressure opening the PORVs. Following a period of subcooled depressurization, two phase repressurization occurs resulting in the Primary Safety Valves (PSVs) lifting and RCS pressure remaining above High Pressure Safety Injection (HPSI) pump shutoff head. The duration of the subsequent two phase depressurization phase of the event depends on decay heat generation rate at the time feedwater was lost. However, RCS inventory will continue to be lost through the PSVs or the PORVs, with no means to replenish it and core uncovery will occur before HPSI injection is reestablished.

In order to properly implement the OTC procedure and the subsequent SG isolation procedure, these actions must be taken in advance of core uncovery. Thus, successful implementation of OTC will ensure a low temperature core covered condition. As long as OTC is effective thermally Induced Steam Generator Tube Rupture (TI-SGTR) cannot occur. However, as FW heat removal is the preferable means of heat removal during this scenario, the operator may return the plant to a feedwater cooling mode when (a) a reliable source of feedwater and feedwater deliverable is available and (b) the core exit thermocouples temperature is below 700° F(alternative indications of core covery are also acceptable).

The purpose of SG isolation following OTC initiation is then to ensure a high SG pressure in the event OTC fails and the core uncovers. It is the heatup and transport of steam in the core region to the steam generator tubes that drives the thermal creep process. This scenario is typically outside of scope of the EOPs and covered in the Severe Accident Management Guidance. In the event the core is uncovered, unisolation of the SG may cause a TI SGTR. The likelihood of the rupture will be dependent upon the time since core uncovery, and the SG flaw distribution. It should be noted that provided a reliable FW source is available and coverage of the SG tubes is expected, depressurizing the SG to admit feedwater is considered an acceptable accident management action.

Method

If adequate core heat removal via the steam generators is not available, heat can be removed by flushing SI flow through the core and discharging into the containment through a pressure boundary opening such as a [PORV] (or a break in the RCS if there is one). Once-through-cooling (OTC) is a last-resort method of core cooling if steam generator heat removal is no longer available.

(continue)

(Continued)

The actions of this step accomplish four main objectives, 1) ensure the RCS is depressurized, 2) ensure a supply of borated water to the RCS, 3) ensure an adequate vent path from the RCS, 4) verify O-T-C flow is established.

To avoid core damage, it is very important that, once the decision has been made to initiate OTC, implementing that decision becomes the top priority. Efforts to restore feedflow become secondary. Effective OTC relies on moving large quantities of relatively cool borated water through the core to remove heat. To establish flow through the RCS, the operator most first do everything possible to lower RCS pressure.

All pressurizer heaters are de-energized and all RCPs are verified to be secured (accomplished earlier in the EOP). [The secondary side of both steam generators is vented by use the TBVs (if Main condenser is available) and ADVs. The intent of this step is to cool and depressurize the RCS to aid HPSI injection.] The operator is then instructed to ensure SIAS is actuated and ensure that two full trains of SI are injecting water into the RCS. All available charging pumps should also be aligned to inject into the RCS. Charging flow is very important in the early phase of OTC initiation to ensure a supply of water to the RCS when RCS pressure may be greater than the HPSI pump shutoff head. Then, after verifying SIS is in operation, the PORVs are then opened to complete the flow path through the RCS.

A contingency step has been added (I.1) to close the PORVs and GOTO continuing actions when OTC has been initiated and for some reason all SI flow to the RCS is lost. If this occurs, OTC will not be effective for heat removal. It is not desirable to continue to remove RCS inventory out the PORVs without make up capability. Inventory control is a higher priority than heat removal. Conserve RCS inventory while efforts to regain an operable SG continue. The purpose of this strategy is to keep some inventory in the RCS, keeping the RCS close to saturation, so there will be communication between the core and the SG when an operable SG is regained.

Sequence

This step is the major mitigation action of this success path.

Plant Parameters

Steam Generator wide range level less than the minimum SG level (WR) for heat removal

The engineering limit is the point at which the steam generator starts to become ineffective as a heat sink, nominally [15%] WR level. The intent of this limit is to ensure that action is taken to line up Once-Through-Cooling (OTC), after a loss of all feedwater event, while some margin still exists to the point where the steam generator starts to become ineffective as a heat sink. This margin is necessary to ensure that OTC will be initiated prior to a complete loss of SG heat removal, and ultimately prevent core uncovery. An effective SG heatsink is defined as a SG having enough secondary inventory with steaming capability such that core decay heat can be removed without uncontrolled RCS temperature increase.

(continue)

(continued)

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

HR-3 Step Number 1A Steam Generator Isolation following OTC Initiation

Intent

In order to properly implement the OTC procedure and the subsequent SG isolation procedure, these actions must be taken in advance of core uncovery. Thus, successful implementation of OTC will ensure a low temperature core covered condition.

SG isolation following OTC initiation is a pre-emptive action taken within EOP space. Its purpose is to establish conditions in the steam generators that are not conducive to a thermally induced tube rupture (TI-SGTR) should OTC fail and core uncovery occur later on. By bottling up the SG and establishing SG pressure as high as possible, the DP across the SG tubes is minimized and they are less likely to fail in the event that they are exposed to hot primary gases following core damage.

In order to help establish OTC, the TBVs and ADVs are opened to lower primary temperature and pressure. Before SG level indication goes off scale low, the TBVs and ADVs should be closed. The purpose of SG isolation following OTC initiation is to ensure a high SG pressure in the event OTC fails and the core uncovers. It is the heatup and transport of steam in the core region to the steam generator tubes that drives the thermal creep process. This scenario is typically outside of scope of the EOPs and covered in the Severe Accident Management Guidance. In the event the core is uncovered, unisolation of the SG may cause a TI SGTR. The likelihood of the rupture will be dependent upon the time since core uncovery, and the SG flaw distribution. It should be noted that provided a reliable FW source is available and coverage of the SG tubes is expected, depressurizing the SG to admit feedwater is considered an acceptable accident management action.

Method

When steam generator level lowers to the [lowest reliable indicated level], isolate the steam generator as follows:

a. The Turbine Bypass Valves (TBVs) are closed. The atmospheric steam dump valve (ADV) setpoint is raised to a value below the [upper end of the expected post-trip band] (not all plant may have this capability).
b. The main steam isolation valves (MSIVs) are closed.
c. The main steam isolation valve bypass valves are verified closed, or closed.
d. Steam generator blowdown is isolated.
e. MS line drains located upstream of the MSIVs are isolated from the main condenser.
f. The affected steam generator safety valves are verified closed.

(continue)

(continued)

Sequence

This step should be located following OTC initiation. It is continuously applicable.

Plant Parameters

Lowest reliable indicated level

The engineering limit is the lower end of WR steam generator level indication. The intent of this limit is to ensure that action is taken to bottle up the SG prior to reaching dry out conditions and while there is still sufficient inventory to permit repressurization of the generator after isolation. The selected EOP action value should take into consideration instrument uncertainties and readability of the instrument in this range.

HR-3 Step Number 1B Maintain Steam Generator Pressure less than the MSSV Lift Setpoint

Intent

The intent of this step is to maintain isolated steam generator pressure as high as possible, without allowing the MSSVs to lift.

SG isolation following OTC initiation is a pre-emptive action taken within EOP space. Its purpose is to establish conditions in the steam generators that are not conducive to a thermally induced tube rupture (TI-SGTR) should OTC fail and core uncovery occur later on. By bottling up the SG and establishing SG pressure as high as possible, the DP across the SG tubes is minimized and they are less likely to fail in the event that they are exposed to hot primary gases following core damage.

It should be noted that the ADVs/TBVs may be reopened to order to transition from a successful OTC mode of heat removal (e.g. a covered core condition) to heat removal via the SG. If a reliable FW source becomes available and coverage of the SG tubes is expected, the ADVs may be used to depressurizing the SG to admit feedwater.

Method

SG pressure is maintained less than the [upper end of the expected post-trip band] by manual operation or local operation of the associated ADV. This action is taken to mitigate a high pressure in the isolated SG and prevent lifting a MSSV.

Should the pressure in an isolated steam generator approach the lift setpoint for the associated MSSVs, it is desirable from the perspective of positive operator control that the ADV open first. This is accomplished by manually opening the ADV, or locally opening the ADV. To minimize the un-monitored release of radioactivity, use of the atmospheric steam dump valves should be minimized.

The MSIV bypass valve might also be used to steam to the condenser. However, the effectiveness of the bypass valve is limited based on its size. If SG tube leakage is suspected, it is more desirable to steam the steam generator to the condenser if necessary than to steam directly to the environment. By steaming to the condenser some of the activity will be retained in the condenser versus to the environment (health and safety of the public) and this will provide a monitored release path via the off gas monitor.

Sequence

This step should be located following OTC initiation after the isolating the steam generator to ensure that actions are taken to prevent lifting a safety valve. It is continuously applicable.

(continue)

(continued)

Plant Parameters

Steam Generator pressure within the expected post-trip control band

The engineering limits are based on a 10°F post-trip RCS temperature control band of nominally [525 - 535°F] which was established based on engineering judgment (including, but not centered on the no-load temperature) to arrive at the SG pressure control band. The resulting nominal SG pressure band is [850 - 920 psia], with a nominal TBV setpoint of 885 psia... The intent of this application is to assist the operator in detecting a malfunction of the TBVs, MSSVs or steam bypass control system (SBCS) as soon as possible.

Steam Generator pressure less than the lowest MSSV lift setpoint

The bases for the engineering limit is the lift setpoint of the lowest MSSV, minus lift tolerance. The intent of the application is prevent lifting an MSSV which then sticks open, resulting in an uncontrolled release to the environment, because the operator can do nothing to stop it. The operational limit, [950 psia] was derived by taking the lowest MSSV setting [1000 psia.], subtracting the lift tolerance, typically ±1% (), [± 10 psi], and additional operational margin [40 psi].

HR-3 Step Number 2 Bypassing automatic MSIS Initiation

Intent

The intent of this step is to ensure that MSIS and SIAS do not actuate unnecessarily and complicate the event.

Method

During a controlled cooldown and depressurization, automatic operation of MSIS and SIAS is not wanted when it is not needed. Therefore, SIAS (low PZR Pressure) and MSIS (low SG Pressure) must be [blocked, bypassed, or lowered], if they have not actuated automatically, as the cooldown proceeds to ensure that automatic actuation does not occur unnecessarily. The preferred method for RCS cooldown is using the turbine bypass system, but an unnecessary MSIS would interrupt this flowpath and force the operator to either reset the MSIS or use the ADVs. An unnecessary SIAS would start both emergency diesel generators, [start emergency containment cooling], isolate letdown and commence emergency boration.

"CONTROLLED COOLDOWN: The operator is in control of the cooldown, i.e, the cooldown is within the designed reset capabilities of MSIS and SIAS, or the operator has the ability to stop or maintain a given pressure and temperature band."

Sequence

This step is sequenced after the directions to commence a cooldown.

Plant Parameters

None

HR-3 Step Number 3 Optimize SI

Intent

The intent of this step is to ensure that SI flow is within the limits of the design basis SI flow. That is, SI flow should be in accordance with the SI delivery curves (Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure) for the given RCS pressure and the number of running SI pumps. Typical SI system design provides two redundant trains of SI, but only one train operation is necessary to meet the intent of the this step. Therefore, it may be optimum for RCS inventory recovery purposes to have two SI trains in operation delivering flow in accordance with the two pump curve, but one train in operation (one SI pump running with flow in accordance with the one pump curve) is acceptable.

Method

After a SIAS the Safety Injection (SI) system flow rate to the RCS is a function of pressurizer pressure. This flow can be predicted using standard fluid flow calculations. The SI flow delivery curves are the results of these fluid flow calculations and can be used by the operator to determine if the SI system is performing as designed and delivering the expected flow to the RCS. Therefore, unless SI flow is deliberately throttled, SI delivery flow should always be greater than or equal to the pump curve. Therefore, SI flow within the one pump curve while two SI pumps are operating is not considered an acceptable configuration, and the problem should be investigated to determine the cause of the deviation and appropriate actions taken to restore SI flow within the limits of the curve. Deviations from the SI delivery curves may be due to valve misalignments, SI pump problems, etc.

It must be noted, however, that the safety injection flow can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and stop or throttle SI flow when SI stop and throttle criteria are met.

[Start idle charging pumps], is a plant specific RCS inventory restoration action that may be implemented depending on the design basis and the normal equipment response to a SI actuation.

(continue)

(continued)

If SI flow is not within the SI flow curve then the operator is directed to perform any of the following to restore SI flow:

- Ensure electrical power to SI pumps and valves. This step ensures that pumps and valves which actuate on a SIAS have not tripped on overload and the electrical bus which supplies the loads is still available.
- Ensure correct SI valve lineup have been established. The operator should observe control board indications and ensure that a flowpath exists from the RWST to the RCS.
- Ensure auxiliary systems are in operation which are vital to the proper operation of the SI pumps. The operator ensures the necessary systems are inservice to support the SI pumps.
- The operator is directed to start additional HPSI pumps as needed to ensure SI flow is within the [SI flow delivery curves]. The operator ensures that the pumps that are not running have electrical power, are lineup properly and that auxiliary systems are available to the pumps. Additional HPSI pumps provide additional water to satisfy RCS inventory control sooner.

Sequence

This step should be located shortly after any event sequence where a SIAS is likely.

Plant Parameters

Safety Injection flow [within the SI delivery curves]

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

HR-3 Step Number 4 Close TBVs and ADVs

Intent

The intent of this step is to ensure that the steam generator(s) are closed up prior to re-establishing feedwater flow.

Method

The TBVs and ADVs should be closed before initiating feedwater flow to a steam generator. Following a total loss of feed event and subsequent dry out of the steam generators, the steam generator tubes may have been damaged. Therefore, feed restoration should be slow and deliberate, while continually monitoring for signs of primary to secondary tube leakage.

Sequence

Prior to feed restoration steps.

Plant Parameters

None

HR-3 Step Number 5 Restore Steam Generator Inventory

Intent

The intent of this step is to continue the efforts to restore feedwater to at least one steam generator. This step is a continuation of operations which were begun in the Standard Post Trip Actions (SPTAs).

Method

These efforts may include restoring electrical power, operating valves, starting pumps, or restoring necessary auxiliary systems for feedwater system operation.

In most cases, one or both main feedwater pumps will have been supplying feedwater to the steam generators prior to the reactor trip. Since feedwater has been lost, it is likely that a problem with main feedwater initiated the event.

Efforts to restore feedwater flow focus first on the systems and methods that are the least complex and most likely to be operational. Even if a main feedwater pump is available, it may take some time to place it in service. Auxiliary feedwater is a less complex system, and if one or more electric-driven pumps are available, they represent the quickest and simplest way to restore feedwater flow.

If unable to start either electric-driven auxiliary feedwater pump, the operator should attempt to start the steam driven auxiliary feedwater pump. The steam driven auxiliary feed pump does not rely on electrical power being available. It is considered reliable and is relatively simple to place in service quickly. Operators should also be trained to operate the pump locally and to reset the overspeed trip, should it be needed.

If unable to start any auxiliary feedwater pumps, an attempt is made to start a main feedwater pump. In the absence of auxiliary feedwater, main feedwater is the only remaining potential feedwater source that does not require an abnormal plant alignment. This is because it is expected that main feedwater will be in operation at the start of the event, and that restoring one of the pumps to service can be performed without additional plant alignments.

[If main or auxiliary feedwater cannot be restored to at least one steam generator, then all low pressure plant specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Using such sources will require that the plant be cooled down and depressurized to permit their use. That is, the pressure in the steam generators must be low enough such that the source can provide sufficient flow to the generator. Steam generator pressure is dependent upon saturation temperature in the SG which is directly related to RCS temperature.

(continue)

(continued)

Depressurization is done at the maximum controllable rate, in order to regain flow as quickly as possible. If depressurization is not performed in a timely manner, SG level may become low enough to require the use of once-through-cooling before SG pressure can be lowered enough to restore feed flow. If pressure is reduced to the limiting valve and no flow is observed, some other difficulty exists that is preventing flow, and further reduction of SG pressure would be counterproductive.

Examples of alternate low-pressure sources of feedwater are fire pumps, condensate pumps, portable pumps, etc. When developing plant procedures, alternate low-pressure sources of feedwater should be identified and their use should be indicated in the procedures. Guidelines on steam generator depressurization should be developed for those cases when the operator is relying on low pressure sources of feedwater as a backup feedwater supply. Figure 8-8 provides an example of the type of information that must be developed on a plant specific basis. The figure provides a typical steam generator dump area required to remove heat from the steam generator for various times after shutdown. The required heat removal, compared to the available heat removal capacity (e.g. atmospheric dump valves), provides the technical basis for which guidance may be developed on steam generator depressurization to permit use of alternate low-pressure sources of feedwater.]

Sequence

This action is taken immediately after actions to conserve steam generator inventory.

Plant Parameters

None

HR-3 Step Number 6 Guidelines to Prevent Feed Ring Damage During FW Restoration

Intent

The intent of this step is to provide guidance for the restoration of feedwater to the steam generator for those plants susceptible to feed ring damage. Damage to the feedring can be caused by water hammer during restoration of feedwater when SG water level is below the feedring. This latter portion of the step applies to those plants susceptible to feedring damage.

Method

If the ability to provide feedwater is restored and steam generator level is below the feedring, the operator should limit feed water flow to less than [flow that could cause water hammer] for [5 minutes].

There is no analytical correlation between feedwater flow rate and the conditions necessary to prevent feedring failure. A flow rate of [150 gpm] has been traditionally accepted as a limit by industry and the NRC for water hammer protection.

Sequence

This step should follow the point in the procedure when the ability to feed the affected SG is restored. Since feedwater may be restored at any time, it is a continuously applicable step.

Plant Parameters

Steam Generator level below the feedring

The engineering limit is based on traditionally accepted industry and NRC guidance for the prevention of water hammer damage to feed rings. With steam generator level at the bottom of the feedring, following an interruption of feedwater flow, water hammer and the resultant structural damage to the feed ring will be avoided when feedflow is restored. Operator training should stress slow restoration of feedflow to the steam generator. If the ability to accurately monitor feedflow rate to a voided SG feedring is compromised, then, the only other corroborative methods that address the intent of the bases is to rely on operator skill and judgment to very slowly re-establish feed to the voided SG feedring.

(continue)

(continued)

Feedwater flowrate less than the maximum flowrate that will not cause water hammer

The maximum MFW/AFW flowrate to a drained steam generator feed ring that can be demonstrated will not cause water-hammer damage to the feed ring of piping leading to the feed ring, nominally [150 gpm]. This limit is only applicable to plants that are equipped with feed rings which are susceptible to damage due to water-hammer. The engineering limit is based on preventing feed ring damage due to re-establishing feedwater to a voided feed ring too quickly.

Feedflow has been supplied for [5 minutes]

Five minutes is a very conservative estimate of the time required to fill a drained feed ring. Five minutes is an approximation, arrived at by assuming that the capacity of a typical feed ring to be 350 gals. 2 X 350 = 700 gals. Therefore, 700 gals of water would be required to fill a feed ring twice. At a fill rate of 150 gpm, it would take approximately 5 minutes to deliver 750 gals of water, which is more than twice the capacity of the feed ring (700 gals).

Steam Generator level within the normal control range

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

HR-3 Step Number 7 HPSI Throttle Criteria

Intent

The intent of this step is to establish the conditions that must be met before HPSI flow can be reduced following a SIAS actuation.

Method

After SIAS actuation, two full trains of SI must remain in operation at full flow, until all HPSI throttle criteria are met. For most LOCAs, the HPSI pumps will run continuously for a long period of time while RCS inventory, pressure, and heat removal control are being regained. In some cases, control of these three safety functions is not regained during the accident (i.e. large break LOCA) and the HPSI pumps run for the duration of the event recovery. Throttling of HPSI is expected when the SIAS was spurious, the leak rate can be accommodated by HPSI and charging when RCS pressure lowers, or after the leak is isolated.

HPSI throttle criteria are as follows:

a. RCS subcooling is greater than the [minimum RCS subcooling] of the RCS P/T curve. T hot should be used to determine RCS subcooling if RCPs are operating. Representative CET temperature should be used if natural circulation is in progress. Because of the location of the CETs inside the ICI tubes, the CETs are exposed to a mixture of core exit fluid and core bypass fluid during forced circulation. Since the core bypass fluid is cooler than the core exit temperature, it is common that CET temperature reads somewhat less than the loop T hot RTD. When natural circulation is in progress the CETs provide the best indication of fluid conditions adjacent to the core. The CETs do not rely on loop flow (as do the RTDs) for detecting fluid conditions adjacent to the core. With no flow in the loops, the loop RTDs may not provide adequate indication of core fluid conditions.

   Establishing the [minimum required subcooling] ensures that the fluid surrounding the core is subcooled, and provides sufficient margin for reestablishing HPSI flow if the minimum value can not be maintained. Voids (e.g. saturated conditions) may exist in some parts of the RCS (e.g. reactor vessel head). In themselves, this is not a major problem, provided that the voids do not interfere with core heat removal.

b. Pressurizer level is greater than the [minimum level for inventory control] and not lowering. A pressurizer level greater than the [minimum level for inventory control] and not lowering, in conjunction with criterion (a), is an indication that RCS inventory control is established.

c. At least one steam generator is available for RCS heat removal. A steam generator is considered available for RCS heat removal if: 1) level is within the [normal control band], 2) capable of being supplied with feedwater, and

(continue)

(continued)

3) is capable of being steamed. Feedflow may be provided by main or auxiliary feedwater. Steaming capability includes controlled steaming by: 1) turbine bypass valves, 2) atmospheric dump valves, 3) main steam safety valves. The steam generator must be available to remove heat because the HPSI will no longer be adequate to remove decay heat from the core. Now the RCS must perform that function and there must be a means of removing heat from the RCS.

d. Reactor vessel level is greater than the [top of the hot leg nozzles] using RVLMS. This provides an extra margin of core coverage, taken in conjunction with the above criterion, and serves as an additional indication that adequate RCS inventory control has been established.]

e. Reactivity Control is satisfied by boration flowrate greater than or equal to [the capacity of one charging pump] OR reactor power less than [maximum expected reactor power 15 minutes after shutdown] and stable or lowering. Therefore, it is acceptable to throttle HPSI to less than [the capacity of one charging pump] if reactor power is less than [maximum expected reactor power 15 minutes after shutdown] and stable or lowering.

The operator should realize that when HPSI is throttled, the core and RCS are going to heat up until the steam generator heat removal (RCS heat removal) can be increased by the operator. Depending upon how long the adjustment takes, the RCS fluid could expand appreciably, thereby further complicating the event recovery.

If all of the HPSI throttle criteria are met, then the operator may either throttle the HPSI injection valves or stop the HPSI pumps as necessary, provided the previously stated criteria remain met.

Sequence

This step is sequenced commensurate with the expected condition of the Inventory Control and Pressure Control Safety Functions. For example, in the LOCA ORG the step is sequenced early in the section associated with actions to be taken after the LOCA is isolated. In SGTR it is positioned after the steps which address isolating the affected steam generator and controlling the level which are of a higher priority for this event.

Plant Parameters

RCS subcooling is greater than the [minimum RCS subcooling]

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

(continue)

(continued)

Pressurizer level greater than the [minimum level for inventory control]

The lower engineering limit corresponds to the lowest level which can be accepted before the pressurizer is considered drained. The lower operational limit, nominally [35"], is approximately ([10%]) of a typical Combustion Engineering Pressurizer's range, and was chosen as the lower limit to account for some instrument and process fluid uncertainties. The lower limit is based on the lowest indication, approximately [2%] that with confidence reflects an actual Pressurizer level. Instrument uncertainties, assumed to be ± 8%, were conservatively applied to the engineering limit, yielding the lower operational limit of [10%].

Steam Generator level within the [normal control band]

The engineering limits for the normal operating steam generator level band are a lower limit corresponding to the bottom of the feed ring, and an upper limit corresponding to the top of the can deck.

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that: 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

HR-3 Step Number 8 HPSI Pump Restart Criteria

Intent

The intent of this step is to ensure that all available trains of HPSI are restored to operation if any of the HPSI throttle criteria can not be met.

Method

After the HPSI throttle/stop criteria are met and HPSI is throttled or the HPSI pumps are stopped, the operator must monitor RCS inventory and pressure control. If any of the throttle/stop criteria cannot be maintained, the operator must raise HPSI flow and/or start HPSI pumps as necessary to regain the safety functions and once again meet the HPSI throttle/stop criteria. It should be noted that this approach differs from the one that used to require full SI flow to be re-established. Industry operating experience has shown that blindly re-establishing full SI flow is unnecessary and can further complicate event recovery. Therefore, that method of re-establishing HPSI flow is no longer used.

Sequence

This step is sequenced immediately after the HPSI throttle criteria.

Plant Parameters

None

HR-3 Step Number 9 LPSI Pump Stop Criteria

Intent

The intent of this step is to prevent damaging the LPSI pumps as a result of extended operation without adequate flow through the pump.

Method

If the RCS pressure is greater than the shutoff head, the pumps will not deliver any flow to the RCS. Therefore, they should be secured. In order to minimize the time of operation at shutoff head, they should be stopped if the pressurizer pressure rises to greater than [LPSI pump shutoff head] and is controlled. The pump is secured first, followed by closing the injection valves. This sequence is intended to minimize the time of operation with no flow. The LPSI injection valves are closed to prevent unintentionally cross-connecting the HPSI system to the LPSI system in the event of a leaking check valve in a LPSI pump discharge line.

Sequence

This step is sequenced after the HPSI pump termination criteria. It is sequenced early in the procedure but after immediate actions are taken to respond to the event.

Plant Parameters

Pressurizer pressure greater than the LPSI pump shutoff head

The engineering limit is the shutoff head of the LPSI pump, nominally [200 psia].

HR-3 Step Number 10 LPSI Pump Restart Criteria

Intent

The intent of this step is to ensure that two complete trains of LPSI are restored to operation if any LPSI stop criteria can not be met.

Method

Once the LPSI pumps have been stopped and the injection valves have been closed, if the LPSI stop criteria cannot be maintained, the LPSI injection valves must be opened and the LPSI pumps must be restarted to ensure that adequate inventory and pressure control are maintained. The intent is to have one LPSI pump operating in each train with both cold leg injection valves fully open (not throttled). Once inventory control has been regained, and the LPSI stop criteria met, then LPSI pumps may be once again stopped.

This does not apply to the situation where pressurizer pressure has purposefully been reduced to less than [LPSI pump shutoff head] in a controlled manner to get the plant to SDC conditions. This does not apply when pressurizer pressure is less than [LPSI pump shutoff head] and the LPSI pumps were secured in response to RAS initiation.

Sequence

This step is sequenced immediately after the LPSI Stop criteria.

Plant Parameters
None

HR-3 Step Number 11 OTC Termination

Intent

The intent of this step is to permit termination of O-T-C when the specified criteria have been met.

Method

IF ALL the following criteria are satisfied:

1. At least one SG has wide range level greater than [SG level for terminating O-T-C], with feed and steam flow capability,
2. CET temperature is less than [saturation temperature corresponding to PSVs/PORVs lift pressure], and not rising,
3. RVLMS indicates [top of the hot leg nozzles]
4. PORVs are not required to be open for Success Path PC-2, PORVs

THEN once-through-cooling may be terminated by closing both PORVs:]

If the PORVs will not close or seat properly, then the PORV block valves should be closed if pressurizer pressure is less than the [expected PORV closure pressure.]

The operator should then implement appropriate Heat Removal and Pressure Control success path(s).

Sequence

This step is sequenced immediately after the LPSI Stop criteria.

Plant Parameters

Representative CET temperature less than the saturation temperature for the PSVs or [PORVs]

The engineering limit is based on the saturation temperature corresponding to the lift setpoint of the primary code safety valves, nominally (2500 psia, ±3%), [or lift pressure for PORVs]. This yields a corresponding saturation temperature of approximately 664°F. It is recognized that RCS pressure can be ≥2500 psia ±3%, with CET temperature being less than 668°F, if the plant is in a transient condition (e.g. rising pressurizer level squeezing the pressurizer steam bubble).

(continue)

(continued)

However, if the main steam safety valves are adequately removing RCS heat, and at least one steam generator has adequate inventory and feed, the core exit temperature should never exceed 664°F (assuming ±3% tolerance for the primary code safety valves). The intent of the engineering limit is to provide indication that the core is being adequately cooled by the Steam Generators (SGs).

Steam Generator level required prior to terminating O-T-C

The Engineering Limit: is the steam generator level equivalent to 1/3 on the height of the tubes being covered. The intent of this step is to ensure that an effective steam generator heat sink is available. One-third tube coverage is considered adequate to remove decay heat either via natural circulation or forced flow conditions. The operational limit, nominally [30%], is intended to increase the likelihood that natural circulation can be maintained following termination of OTC, even if a temporary interruption of feedwater should occur.

Reactor vessel level greater than the top of the hot leg nozzles

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the hot leg nozzles. The intent of the operational limit is to ensure that: 1) adequate RCS inventory control has been established, i.e. the core is covered, plus 2) provide extra margin in the plenum to ensure that the hot legs are covered to support natural circulation, prior to stopping or throttling HPSI, or securing from Once-Through-Cooling. Both verifications are based on RVLMS indications, and are taken in conjunction with other indications of adequate inventory control.

HR-3 Step Number 12 Ensure Adequate Suction for SI Pumps

Intent

The intent of this step is to verify that RWT water is exiting from the RCS rupture and ending up in the containment sump. This is necessary to ensure an adequate source of water when RAS initiates.

Method

If the LOCA is located inside containment, a lowering trend of RWT level should correspond to an rising trend of containment sump level. If a lowering trend in RWT level cannot be correlated to an rising containment sump level, then the LOCA is probably outside of containment.

The contingency actions direct the operator to verify that the LOCA is outside containment, initiate CIAS, initiate actions to start normal makeup and notify [plant management].

A LOCA outside of containment may result in insufficient water in the containment sump to support HPSI pump operation following a RAS. The operator should initiate actions to makeup to the RWST via the normal means. However, this method of makeup may be much slower that the drain down to the RCS. Therefore, depending on the size of the break, initiating normal makeup may prolong the time to RAS, provide additional time to isolate the leak and more time to [align an alternate source of makeup as directed by the Technical Support Center]. This event is outside the design bases of the plant.

If possible, for LOCAs outside containment, RWST level should be maintained above the [RAS setpoint] by replenishment from available sources. This will avert an undesirable RAS, which would align the HPSI pumps to a dry containment sump and cause air binding of the pumps.

Sequence

This step is located after the SIS pumps have been started, to remind the operator to continuously watch [RWST] levels, to ensure proper activation of RAS.

(continue)

(continued)

Plant Parameters

Refueling Water Storage Tank level less than the RAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for RAS, [nominally 10%]. The intent of the application is to prompt the operator to verify that RAS occurred automatically or to manually initiate RAS if it did not. The upper allowable value for this trip is set low enough to ensure RAS does not initiate before sufficient water is transferred to the containment sump. Premature recirculation could damage or disable the recirculation system if recirculation begins before the sump has enough water to prevent air entrainment in the suction. The lower allowable value is high enough to transfer suction to the containment sump prior to emptying the RWT and to prevent air entrainment during the transfer. Switchover from RWT to the Containment sump must occur before the RWT empties to prevent damage to the ECCS pumps and a loss of core cooling capability. For similar reasons, switchover must not occur before there is sufficient water in the Containment sump to support pump suction.

HR3 Step Number 13 RAS Initiation Criteria

Intent

The intent of this step is to ensure that RAS is initiated when required and that the associated equipment and systems function as designed.

Method

For breaks located inside containment, if the refueling water tank level lowers to [RAS setpoint], then the operator should perform the following:

a. The operator first verifies that RAS has automatically initiated. If it did not, then the operator should manually initiate RAS. Recirculation is actuated either automatically or manually in order to maintain a continuous flow of safety injection fluid to the RCS (required for inventory control) and a continuous flow of containment spray water (required for containment temperature and pressure control).

b. The operator then verifies that the LPSI pumps stop, since (by design) they are not required for RAS. If they do not stop, the operator should secure them.

c. The operator then verifies that the ESF pump suction valves from the containment sump are open. This will provide a suction flowpath for the operating ESF pumps. If the valves do not open automatically, then the operator should open them.

d. After verifying (a) through (e), the operator should close the RWT outlet valves one at a time. In addition, for events where high containment pressure is present, the check valves in the RWT outlet line may be forced shut and the RWT fluid will remain unavailable while the containment is pressurized.

e. The operator then ensures that the HPSI pump minimum recirculation flow valves are closed to prevent contaminated containment sump water from returning to the RWT.

[f. All charging pumps are [disabled] to prevent low suction pressure trip while charging pumps are taking suction on RWT post RAS. [disabled] in this context is the plant specific method to prevent use or auto-start of charging pumps after RAS. Generally, the term “pull-to-lock” conveys the intent, but plant specific terms should be used.]

(continue)

(continued)

[g. The auto-start function for all idle CS pumps and associated discharge valve should be disabled when RAS is initiated. The [CSAS] signal may have been reset and aligned for auto actuation prior to RAS. Post RAS, automatic actuation should be disabled. The purpose of this action is to prevent an unintended start of CS pumps that were intentionally secured earlier in the procedure. As a result of switching to containment sump recirculation, containment pressure may temporarily spike before settling out at a new equilibrium value. For plants with a relatively low CS actuation setpoint, the increase in containment pressure may be sufficient to re-actuate CS and start the idle CS pumps. This is undesirable because it goes against strategies to minimize flow through the sump screens after RAS and avoid equipment operations that would increase the potential for debris transport and accumulation on the sump screens.]

Sequence

This step is sequenced after the step to monitor the RWT level and is fairly late in the steps. Reaching the RAS setpoint should take some time and therefore this step should not have to be early in the sequence.

Plant Parameters

Refueling Water Storage Tank level less than the RAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for RAS, [nominally 10%]. The intent of the application is to prompt the operator to verify that RAS occurred automatically or to manually initiate RAS if it did not. The upper allowable value for this trip is set low enough to ensure RAS does not initiate before sufficient water is transferred to the containment sump. Premature recirculation could damage or disable the recirculation system if recirculation begins before the sump has enough water to prevent air entrainment in the suction. The lower allowable value is high enough to transfer suction to the containment sump prior to emptying the RWT and to prevent air entrainment during the transfer. Switchover from RWT to the Containment sump must occur before the RWT empties to prevent damage to the ECCS pumps and a loss of core cooling capability. For similar reasons, switchover must not occur before there is sufficient water in the Containment sump to support pump suction.

HR-3 Step Number 14 HPSI Pump Minimum Flow Criteria

Intent

The intent is to ensure that after RAS has actuated, sufficient flow is maintained through each high pressure safety pump such that damage to the pump does not occur (since the HPSI mini-flow recirc valves are closed after RAS).

After the switch to recirculation, the HPSI pump flows are monitored in order to ensure that HPSI pump minimum flow requirements per pump) for pump protection are met. One HPSI pump should be left operating at all times, unless the termination criteria are met. In addition, pumps may be restarted as necessary to meet other procedural requirements as long as the minimum flow criteria are met.

Method

The operator checks HPSI flow greater than the [minimum required HPSI pump flow] to be assured that HPSI pump minimum flow requirements are met. The exact method used to accomplish this is plant specific.

A check may also be made that HPSI pumps are not in a runout condition at this time. Pump discharge pressure and pump amp's are used for this indication.

The primary concern is hydraulic instability and damage to pump components including the pump seals as the result of heat buildup in low flow conditions. As the heating effects can be cumulative and are dependent on temperature, pressure and flow conditions, an exact time to failure is not possible. However, generally manufacturers will specify minimum flow rates for various lengths of time at which pump damage is not anticipated.

Another consideration is the accuracy of the instrument used to determine the total flow as well as individual pump flow. The minimum flow based on the accuracy of the instrumentation may be higher than required to actually preclude pump damage.

Sequence

This step is sequenced after the step for verifying recirculation actuation. It ensures that sufficient flow is maintained through the HPSI pumps after the recirculation minimum flow line is isolated. Pump damage is not expected to be imminent with flow less than the minimum required. That is, as noted above, damage is dependent on several variables in particular the time at the flow condition. Except in extremely low flow conditions and excluding air binding of a pump it can be assumed that low flow for up to two hours can be accommodated. These are general statements and specific manufacturers recommendations should be adhered to.

(continue)

(continued)

Plant Parameters

Minimum required HPSI pump flowrate

The engineering limit is based on the minimum required flowrate through a HPSI pump that will avoid pump damage during continuous minimum flow operation, nominally [30 gpm]. The intent of the operational limit is to ensure that the HPSI pump is secured when the flowrate through the pump decreases to less than the minimum required for continuous minimum flow operation. This will ensure continued operability and availability of the HPSI pumps by avoiding over heating and subsequent pump damage.

Step Number 14A Post RAS HPSI Stop Criteria

Intent

The intent of this step is to permit securing one HPSI pump following RAS if two HPSI trains are not needed for core heat removal. This action reduces the total ECCS flow through the containment sump screens in order to reduce debris buildup on the screens. It also establishes a protected train for use at a later time if needed. This instruction is applicable post RAS only. It does not replace or alter the standard HPSI stop/throttle criteria which is available before and after RAS..

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action in their EOPs if it is determined to be risk beneficial with respect to containment sump blockage.] (Reference 48)

Method

d. Verify both HPSI trains are in operation. It is assumed that they are operating normally and delivering design flow rate to the core as determined by the [SI flow delivery curves]. With both trains in service at this time after the trip, there may be more safety injection flow than is needed to cool the core. Therefore, it is likely that one HPSI pump may be secured. The adequacy of core heat removal is made by assessing core conditions, i.e. representative CET Temperature less than [superheat], and reactor vessel level greater than [bottom of the hot leg]. To ensure that there will be sufficient time for the operator to recognize and respond to a failure of the remaining operating pump, an additional criteria based on the time from shutdown is also included. The time requirement is based on the time for successful fifteen minute operator response which is a typical time needed to complete of a round of safety function status checks.

e. If these conditions are met, then one HPSI pump may be secured. The other pump is then monitored to ensure continued normal operation. If at any time, any of the termination criteria can not be maintained, the standby pump must be restarted or flow increased as necessary to ensure adequate core cooling is maintained.

f. Predetermine the optimal strategy for securing pumps. Select the preferred CS train (A or B) and the preferred HPSI train (A or B) to be secured first when the termination criteria are satisfied. Consider such factors as: pump power supplies, suction valve and piping configuration and sump design (split vs. common). An optimal configuration would include one CS pump and one HPSI pump with the same power supply, with a common suction line and common sump penetration or sump section. In this way the reliability of the standby pumps is enhanced.

(continue)

(continued)

Alternate Methods

Post-RAS, some plants require subcooled injection to the suction of the HPSI pumps to maintain sufficient NPSH and prevent cavitation. By design, the subcooled injection is provided by the containment spray pumps since containment spray is cooled via CCW in the spray/SDC HTX. The cumulative effect of running one HPSI pump and one containment spray pump post-RAS may increase the total flow through the containment sump screens.

For plants requiring containment spray flow injection to the HPSI pumps, the need for subcooled flow may be reduced if HPSI pump discharge flow is also reduced proportionately. This will reduce the overall flow through the sump screens. Therefore, some plants may find it more beneficial to throttle both HPSI pumps post-RAS versus securing one HPSI. This is an acceptable alternate method of reducing flow through containment sump screens if plant staff has determined an overall beneficial effect. However, if this method is use, consider the following:

a. One HPSI pump at design flow (not throttled) is within the design bases and flow loss out the break is considered in the safety analyses.
b. If HPSI is throttled, core conditions must be monitored closely since there is no way to determine the proportion of flow actually reaching the core.
c. If diesel failure occurs and the subsequent loss of one HPSI pump, operators must promptly adjust throttling flow to ensure sufficient core cooling with the remaining running HPSI pump.

Sequence

This step is sequenced after verifying that HPSI pump flow is greater than the minimum required to protect the pump. It is a continuously applicable step that may be used at any time that the relative criteria are satisfied.

Plant Parameters

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and to corroborate core covered or core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower indicating limit, RVLMS level indication, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to cover the core, support adequate core cooling, and prevent core damage.

(continue)

(continued)

Reactor Vessel level greater than the top of active fuel region

The engineering limit is the elevation in the Reactor Vessel Plenum region that is equivalent to the top of the active fuel. However, the lowest sensor in the Reactor Vessel Level Monitoring System (RVLMS) is typically located just above the top of the fuel alignment plate. Nominal operating value is the lowest-reading sensor in the RVLMS.

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

Supplimental Information from an engineering evaluation performed on this strategy (Reference 48)

Advantages

In order for the operator to secure one train of HPSI after initiating sump recirculation it is assumed that two trains of HPSI are in operation at the time of RAS and running normally; in addition, other specific criteria are met. During large break LOCA, all of the standard HPSI stop/throttle criteria may not be met. Yet, it may still be preferable to stop one HPSI pump after RAS, if the plant-specific risk of containment sump blockage is significant. Since most plants only require one HPSI pump to meet licensing requirements, securing all but one HPSI pump after RAS still provides adequate core cooling consistent with the analytical bases. In addition, the normal HPSI Stop/Throttle criteria are still available to the operator prior to and after RAS.

Securing one HPSI pump reduces the total flow through the sump screens and thereby reduces the rate of debris transport to the screen surface and reduces the risk of blockage. The amount and size of debris collected at the containment sump screens is a function of screen size, the flow volume through the screens and the overall inflow to the containment sump. Greater volumetric flow is more likely to “sweep” debris to the containment sump screens and thereby increase the risk of blockage. The flow contribution of one HPSI pump is relatively small (less than 1/10) compared to containment spray pump. However, any flow reduction should reduce the risk of blockage.

PWR sump screens were typically designed assuming relatively small structural loads from the differential pressure associated with 50% debris blockage. Consequently, PWR sump screens may not be capable of accommodating the substantial structural loadings that may occur due to debris beds that cover the entire screen surface. Inadequate structural reinforcement of a sump screen may result in its deformation, damage, or failure, which could allow large quantities of debris to be ingested into the HPSI and Containment Spray System piping, pumps, and other components, potentially leading to clogging and failure.

(continue)

(continued)

Reducing both the risk and rate of sump blockage lowers the risk of containment sump screen failure and potential failure of operating HPSI and Containment Spray pumps. Securing one HPSI pump post RAS provides additional assurance that the secured pump will not be damaged due to debris ingestion or loss of NPSH, thereby preserving one operable HPSI pump for later use.

Some plants have separate sumps for each ECCS train. In this case securing flow from one train will preserve the other sump for use in the event that the in-service sump screens become blocked. In addition, operation of the single screen might reduce the amount of free debris available to block the other screen. Therefore, operating a single sump may extend recirculation capability, preserving the second sump screen by sacrificially clogging the first.

Disadvantages

Stopping one (1) HPSI pump during recirculation mode may slightly increase the required NPSH for the remaining running HPSI pump due to the increase in flow through the running pump. During two pump operation all HPSI flow must pass through common loop headers into the cold leg. When one HPSI pump is stopped, the reduction in overall flow also reduces the line-loss to the cold leg and thus flow will increase slightly for the remaining running HPSI pump. This increase in flow will result in a slight increase in required NPSH. This should not present a problem since the required NPSH for one HPSI pump operation is already accounted for in system design.

Typical plant licensing bases show adequate core cooling with one HPSI pump after recirculation actuation. However, since deliberate manual securing of one HPSI pump is not considered a "failure," licensees may be required to show acceptable consequences with failure of the running HPSI pump after manually stopping one of two HPSI pumps. This would mean an interruption of HPSI flow until the operator could restart the previously secured HPSI pump. Since current licensing analysis does not account for an interruption in HPSI flow due to single failure, plant specific 10 CFR 50.59 evaluation may be required to determine the acceptability of securing one HPSI pump after recirculation actuation. Best estimate analyses have been performed to determine the time after trip when the decay heat level is low enough, such that, failure of "the one" running high pressure injection pump will result in approximately 15 minutes of reaction time before core temperature begins to rise. Fifteen minutes was selected so that loss of the one remaining high pressure injection pump will allow one Safety Function Status Check interval for the operator to recognize the loss of injection flow and take corrective action to restore core cooling.

(continue)

(continued)

Best estimate analyses show that at 40 minutes after trip there is approximately 15 minutes of operator reaction time before core temperatures begin to rise. Details of this analysis are contained in Reference 48, Appendix B. Since 40 minutes is an approximate value, each plant should complete a similar plant specific best estimate analysis.

By the time that the operator is expected to reach this step (up to 1 hour post-event), the injection flow required for decay heat removal may only be 200 – 300 gpm. This will make it difficult to balance the required flow between the four injection points (50 – 75 gpm each), because SI cold leg injection flow instrument uncertainties for a harsh environment may exceed this amount. This reality supports the strategy of stopping one pump, as opposed to the strategy of throttling flow to match decay heat.

HR-3 Step Number 15 Determine status of Acceptance Criteria

Intent

After implementing the above actions, Heat Removal is satisfied if the following conditions exits:

a. [Representative] CET temperatures [less than superheated].

b. IF RAS has NOT occurred,
THEN all available charging pumps are operating.

c. IF RAS has NOT occurred,
AND LPSI termination criteria are NOT met,
THEN LPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.

d. IF HPSI termination criteria are NOT met,
THEN HPSI flow into the RCS is adequate. REFER TO Figure 13.13, Typical Acceptable SIS Flow versus RCS Pressure.

e. Pressurizer pressure is less than [SBLOCA plateau pressure] or lowering.

Method

If the above criterion are not satisfied, then success path HR-3 is not adequate. The operator should go to another appropriate HR success path for further guidance to restore/maintain Heat Removal. Resource Assessment Trees (Section 5) may be useful in determining the appropriate success path.

If the acceptance criterion for success path HR-3 is satisfied, then success path HR-3 is successfully controlling RCS and Core Heat Removal. Heat Removal is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the Long Term Actions (Section 14).

Sequence

Safety Function Status Checklist

(continue)

(continued)

Plant Parameters

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

Representative CET temperature is NOT superheated

The engineering limit is based on the saturation temperature of the RCS. The intent of the engineering limit is to provide an indication that can be used by the operator to assess the status of adequate core heat removal and corroborate core covered and core uncovered with the aid of RVLMS. A superheated core indicates that core uncovery is occurring, and that core heat removal is inadequate. For cases when pressurizer level is below the lower limit, RVLMS indication that the core is covered, in conjunction with subcooled representative CET temperature, indicates that RCS inventory is sufficient to support adequate core cooling and prevent core damage.

Pressurizer pressure is less than the [maximum pressure plateau for SBLOCA]

The engineering limit is based on establishing a generic plant condition at which the first two RCPs are tripped as part of the trip two/leave two (T2/L2) RCP trip strategy. The maximum pressure plateau for SBLOCA was selected because it is: consistent with a LOCA event, deterministic (the value can be determined for each plant via analysis), and easily recognizable once determined. The goal of the T2/L2 RCP trip strategy is to take advantage of the operational flexibility gained from continued RCP operation; while addressing the important concern of preparing the RCS for a particular LOCA event where continued RCP operation may result in increase inventory loss. The nominal SBLOCA pressure plateau is generally near the HPSI pump shutoff head (1300 psi).

SAFETY FUNCTION: **Containment Temperature and Pressure Control**
SUCCESS PATH: **Containment Fans (Normal Mode); CTPC-1**
RESOURCE TREE: **Tree G**

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. **Ensure containment cooling fans operating in normal {ctpc1}** Ensure all available Containment cooling fans are operating in the normal mode.	
* 2. **Ensure containment air recirculation fans are operating {ctpc1}** Ensure all available normal Containment air recirculation systems are operating.	
* 3. **Verification of Acceptance Criteria {ctpc1}** Verify CTPC-1 (Containment Fans Normal Mode) is satisfied by **BOTH** of the following conditions being satisfied: • Containment temperature less than [saturated vapor temperature corresponding to CIAS setpoint]. • Containment pressure less than [maximum expected normal containment pressure].	3.1 **IF** the Containment Pressure and Temperature safety function is still in jeopardy, **THEN** GO TO the next appropriate Containment Pressure and Temperature success path.

* Continuously Applicable Step or Non-Sequential Step
\# Hold Point step

SUPPLEMENTARY INFORMATION CTPC-1:

This sections contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. During some events, the containment fan coolers may be required to operate in the emergency mode even though the containment temperature and pressure are not increasing. [This will occur during events which generate a CIAS on low pressurizer pressure, but do not include an inside containment break.]

SAFETY FUNCTION: **Containment Temperature and Pressure Control**
SUCCESS PATH: **Containment Fans (Emergency Mode); CTPC-2**
RESOURCE TREE: **Tree G**

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. **Ensure containment Emergency Cooling Fans are operating {ctpc2}** **IF** Containment pressure is greater than [CIAS setpoint], **THEN** a Ensure CIAS is initiated. b Ensure all available containment emergency cooling systems are operating.	
* 2. **Ensure containment air recirculation fans are operating {ctpc2}** Ensure all available normal and emergency containment air recirculation systems are operating.	

* Continuously Applicable Step or Non-Sequential Step
# Hold Point step

* 3. **Verification of Acceptance Criteria {ctpc2}** 3

Verify CTPC-2 (Containment Fans-Emergency Mode) is satisfied by **ALL** of the following conditions being satisfied:

- The required number of containment emergency cooling fans are in operation.
- Containment temperature less than [saturated vapor temperature corresponding to CSAS setpoint].
- Containment pressure less than [CSAS setpoint].

.1 **IF** the Containment Pressure and Temperature safety function is still in jeopardy,
THEN GO TO the next appropriate Containment Pressure and Temperature success path.

* Continuously Applicable Step or Non-Sequential Step
# Hold Point step

SUPPLEMENTARY INFORMATION CTPC-2

This sections contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. For those plants which use charcoal filters in the containment fan coolers for iodine removal, operation of the filtered fan units may be desirable in the event of an iodine buildup in containment.

   [A CCAS may be manually initiated at containment pressure less than the CCAS setpoint. This would be appropriate if the containment pressure were increasing, or if the fan coolers were inoperable in the normal mode.]

SAFETY FUNCTION: **Containment Temperature and Pressure Control**
SUCCESS PATH: **Containment Spray; CTPC-3**
RESOURCE TREE: **Tree G**

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. **Ensure Containment Spray Actuation {jc2locactpc3}** **IF** containment pressure is greater than [CSAS setpoint], **THEN**: a. Ensure CSAS is initiated. b. Verify that each containment spray system is delivering at least [design flowrate] to containment spray headers.	
1.A [Early Termination of Containment Spray pump(s)] [**IF** CS pumps are operating **AND ALL** of the following conditions are satisfied: • Containment pressure is less than [containment design pressure], • [The required number of containment cooling fans are in operation], • Safety injection is actuated and flow within [SI delivery curves], **THEN** stop one CS pump at a time until only one pump remains in operation: a. Stop Containment Spray Pump. b. Verify containment pressure maintained less than [containment design pressure].]	1.A.1 [Take action to restore full CS flow to containment. a) Start CS pump(s).]

* Continuously Applicable Step or Non-sequential Step
\# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
2. **Containment Spray Termination Criteria {jc9loca}**	
IF CS pump(s) are operating **AND ALL** of the following conditions are satisfied: • Containment pressure is less than [CSAS reset pressure] and stable or lowering • Containment Spray is **NOT** required for Containment cooling • Containment Spray is **NOT** required for iodine removal **THEN** stop Containment Spray: a) Reset [CSAS]. b) Stop the Containment Spray Pump. c) Close the Containment Spray Header Isolation Valve. d) Align the system for automatic CSAS operation.	
* 3. **Verification of Acceptance Criteria {ctpc3}**	
Verify CTPC-3 (Containment Spray) is satisfied by either of the following conditions: Condition 1: a. The required number of Containment Spray systems in operation. b. Containment pressure is less than [design pressure]. Condition 2: a. The required combination of Containment Spray systems and	3.1 **IF** the Containment Pressure and Temperature safety function is still in jeopardy, **THEN** REFER TO CTPC Continuing Actions.

* Continuously Applicable Step or Non-sequential Step
# Hold Point Step

INSTRUCTIONS	CONTINGENCY ACTIONS
Containment Emergency Cooling systems in operation.	
b. Containment pressure is less than [design pressure] .	

* Continuously Applicable Step or Non-sequential Step
\# Hold Point Step

SUPPLEMENTARY INFORMATION CTPC-3:

This sections contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. For those plants which use the containment spray system (CSS) in conjunction with the iodine removal system (IRS), operation of the CSS may be desirable in the event of an iodine buildup in containment.

   Since iodine may be released to the containment atmosphere at various times following event initiations, (e.g. released directly from the core in a large LOCA; re-evolved from iodine plated out on containment surfaces; or released during reactor vessel venting to the containment) and since the CSS is activated automatically on containment pressure, its actuation may not correspond to the time of peak containment iodine levels (if it is actuated at all). The CSS may be run to reduce containment airborne iodine to acceptable or minimum levels unless the following indicate otherwise:

   If there were a leak in containment below sump water level, it might be more desirable to leave the iodine atmospherically suspended. [If sump water is highly radioactive, it may not be desirable to circulate it outside the containment.]

2. [If containment spray is actuated, there may be a need for the use of hydrogen recombiners. Therefore, for plants which utilize external hydrogen recombiners, the appropriate personnel should be directed to begin preparations to make the recombiners available and aligned for use. Use of the recombiners may be required by subsequent steps in order to satisfy the combustible gas control safety function (Reference 16).]

CONTINUING ACTIONS FOR CONTAINMENT TEMPERATURE AND PRESSURE CONTROL

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. **IF** Containment Temperature and Pressure are still in jeopardy, **THEN** pursue Containment Temperature and Pressure Control and other jeopardized safety functions simultaneously.	
* 2. **Evaluate further actions {ctpcca}** Evaluate further conditions and actions to restore Containment Temperature and Pressure control: a. The urgency of other jeopardized safety functions. b. The rate of change of containment temperature and pressure and potential for damage to the containment. c. The feasibility of restoring a success path by restoring **ALL** of the following: • Vital auxiliaries necessary to operate systems or components in the success paths • Manual operation of valves • Use of alternate components to implement a success path	

Last Page Bookmark Follows this Hidden Text

* Continuously Applicable Step or Non-Sequential Step
# Hold Point Step

Containment Temperature and Pressure Control Bases

Bases for Containment Temperature and Pressure Control:

The purpose of the Containment Temperature and Pressure control safety function is to prevent damage to the containment building which provides a barrier to fission product release to the general public.

To establish Containment Temperature and Pressure Control, the following three methods are available:

CTPC-1: Containment Temperature and Pressure Control via Containment Fans (Normal Mode)

CTPC-2: Containment Temperature and Pressure Control via Containment Fans (Emergency Mode)

CTPC-3: Containment Temperature and Pressure Control via Containment Spray

The bases for the operator actions required for implementing each of the methods listed are detailed as follows:

CTPC-1: Containment Temperature and Pressure Control via Containment Fans (Normal Mode):

For those events which do not result in the operation of the containment fan coolers in the emergency mode, Containment Temperature and Pressure Control should be maintained by operation of the fan coolers in the normal mode.

Step Number 1 CTPC-1, Ensure containment cooling fans operating in normal

Intent

The intent of this step is to ensure that all available normal containment cooling and ventilation systems are in operation.

Method

Ensure all available containment cooling fans are operating in the normal mode. Normal operation is defined by plant specific system design. The following items should be considered when developing the plant specific version of this instruction:

a. Ensure cooling water flow through cooling coils. The operator should ensure that component cooling water is lined up to the containment normal cooling coils by control board valve line up verification and flow instrument checks.

b. Ensure availability of heat sink . The operator should verify that service water is supplying in service component cooling water heat exchangers.

c. Ensure fans operating in normal mode. The operator should verify that containment cooling fans are operating in the normal mode by checking control switch position and flow indication.

Sequence

This is the first step in the procedure.

Plant Parameters

None

Step Number 2 CTPC-1, Ensure normal containment air recirculation fans are operating

Intent

The intent of this step is to ensure that all available containment air recirculation fans are operating.

Method

Ensure all available normal containment air recirculation systems are operating. The operator should check that all normal containment air recirculation fans are lined up for normal operation.

Sequence

N/A

Plant Parameters

None

Step Number 3 CTPC-1, Determine status of the Acceptance Criteria

Intent

For the containment fans in normal mode success path, containment temperature should not reach the [saturated vapor temperature corresponding to CIAS setpoint]. The [maximum expected normal containment pressure] is based on the containment pressure alarm setpoint.

Method

The operation of containment cooling fans in the normal mode is the preferred method of controlling containment temperature and pressure. Operation of additional containment cooling and air recirculation systems (e.g. CEDM coolers, reactor cavity coolers, [dome air circulators], etc.) can also be utilized to aid in Containment Temperature and Pressure Control.

The acceptance criteria are designed to ensure that a normal containment environment exists. High containment pressure (above the alarm setpoint), or higher than normal containment temperature are indications that more than a relatively uncomplicated reactor trip has occurred.

If the above criteria are not satisfied, then the success path CTPC-1 is not successfully controlling containment temperature and pressure. The operator should go to an appropriate Containment Temperature and Pressure success path.

If the acceptance criteria for success path CTPC-1 are satisfied, then success path CTPC-1 is successfully controlling containment temperature and pressure. Containment temperature and pressure is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement LONG TERM ACTIONS.

Sequence

N/A

(continue)

(continued)

Plant Parameters

Containment Pressure less than the maximum expected normal containment pressure

The engineering limit is based on the high containment pressure alarm setpoint, which is typically near the high end of the normal containment pressure band, nominally [1.5 psig]. The intent of this application is to alert the operator to a possible high energy line break in the containment, and to prompt further evaluation of instantaneous containment pressure changes.

Containment atmospheric temperature less than the saturated vapor temperature corresponding to the CIAS setpoint

This engineering limit is based on the plant-specific temperature at which pressure transmitters located in containment may start to be significantly affected by harsh containment conditions, and the saturated vapor temperature corresponding to the CIAS setpoint, nominally [180°F]. This application is a corroborative indication used to back up the nominal [1.5 psig] high containment pressure alarm value.

CTPC-2: Containment Temperature and Pressure Control via Containment Fans Emergency Mode):

For those events which do not result in the actuation of the containment spray system, but for which operation of fan coolers in the normal mode is not adequate, then operation of fan coolers in the emergency mode may be required to maintain Containment Temperature and Pressure Control.

Step Number 4 CTPC-2 Ensure containment cooling fans operating in Emergency Mode

Intent

The intent of this step is to ensure that all available containment cooling and ventilation systems are operating in the Emergency Mode.

Method

If containment pressure increases to [CIAS setpoint] or greater, then [at least three] containment fan coolers should automatically be operating in the emergency mode.

Ensure all available containment cooling fans are operating in the emergency mode. Emergency operation is defined by plant specific system design. The following items should be considered when developing the plant specific version of this instruction:

a. Ensure cooling water flow through cooling coils. The operator should ensure that component cooling water is lined up to the containment normal cooling coils by control board valve line up verification and flow instrument checks.

b. Ensure availability of heat sink . The operator should verify that service water is supplying in service component cooling water heat exchangers.

c. Ensure fans operating in emergency mode. The operator should verify that containment cooling fans are operating in the emergency mode by checking control switch position and flow indication.

Sequence

This is the first step in the procedure.

Plant Parameters

None

Step Number 5 CTPC-2, Ensure normal containment air recirculation fans are operating

Intent

The intent of this step is to ensure that all available containment air recirculation fans are operating.

Method

Ensure all available normal containment air recirculation systems are operating. The operator should check that all normal containment air recirculation fans are lined up for normal operation.

Sequence

N/A

Plant Parameters

None

Step Number 6 CTPC-2, Determine status of the Acceptance Criteria

Intent

For the containment fans in Emergency Mode success path, containment pressure should not reach the [CSAS setpoint]. All available containment cooling fans should be operating in the emergency mode.

Method

The operation of containment cooling fans in the emergency mode is a method of controlling containment temperature and pressure if containment sprays have not actuated and the normal mode of fan cooling is not sufficient. Operation of additional containment cooling and air recirculation systems (e.g. CEDM coolers, reactor cavity coolers, [dome air circulators], etc.) can also be utilized to aid in Containment Temperature and Pressure Control.

If the above criteria are not satisfied, then the success path CTPC-2 is not successfully controlling containment temperature and pressure. The operator should go to an appropriate Containment Temperature and Pressure success path.

If the acceptance criteria for success path CTPC-2 are satisfied, then success path CTPC-2 is successfully controlling containment temperature and pressure. Containment temperature and pressure is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement LONG TERM ACTIONS.

Sequence

N/A

Plant Parameters

Containment Pressure less than the CSAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for CSAS, nominally [10.0 psig]. The operational limit is the same as the engineering limit. The engineering limit establishes the increasing containment pressure at which automatic containment pressure/temperature controls activate to remove heat from the containment atmosphere, thereby ensuring that containment pressure remains below design pressure, independent of operator action. The intent of the application is to prompt the operator to verify automatic Containment Spray actuation or to manually initiate CSAS if it did not actuate when required.

CTPC-3: CONTAINMENT TEMPERATURE AND PRESSURE CONTROL VIA CONTAINMENT SPRAY:

The containment spray system removes heat from the containment by spraying water droplets throughout the containment atmosphere. This condenses steam and cools the air, subsequently reducing containment pressure.

Step Number 7 Step Number 1 CTPC-3, Ensure Containment Spray Actuation

Intent

The intent of this step is to ensure that the containment spray system is activated to mitigate the containment pressure transient.

The Containment Spray system is designed to maintain containment pressure below design pressure and provide a redundant means for containment heat removal to the containment cooling fans (which were ensured to be operating in the previous step). In addition, the containment spray water is used for scrubbing the iodine from the containment atmosphere, thereby minimizing radioactivity release to the environment.

If containment spray is actuated, there may be a need for the use of hydrogen recombiners. Therefore, for plants which utilize external hydrogen recombiners, the appropriate personnel should be directed to begin preparations to make the recombiners available and aligned for use. Use of the recombiners may be required by subsequent steps in order to satisfy the combustible gas control safety function (Reference 16).

When containment sprays are actuated, the conditions created in the containment may generate Hydrogen. Hydrogen may be generated by the reaction of boric acid (from containment spray flow) and metals in the containment. Aluminum and zinc are two metals which are reactive with boric acid. The reaction rates of boric acid and aluminum and zinc are a function of temperature. Therefore, if the containment spray system has been spraying boric acid onto zinc and aluminum surfaces in a high temperature environment, then conditions exist for the generation of hydrogen in the containment.

Method

a. The containment spray system is automatically actuated at a containment pressure of [CSAS setpoint] or greater. If containment pressure reaches [CSAS setpoint], then the operator should verify actuation. If CSAS does not actuate automatically, then the operator should manually actuate CSAS.

b. Following CSAS, both containment spray systems should start and deliver design flowrate to each containment spray header. The operator should verify that CS header flowrate is as expected to confirm proper pump operation and correct valve line up.

(continue)

(continued)

Sequence

Once it is determined that the LOCA is inside containment, and containment pressure is greater than the CSAS setpoint, the Containment Spray System must be verified to be in operation. [Some plants have external hydrogen recombiners that require considerable preparation to make ready for operation. If this is the case, preparations should start early in the procedure.

Plant Parameters

Containment Pressure greater than the CSAS setpoint

The basis for the engineering limit is the same as the basis for the technical specification setpoint for CSAS, nominally [10.0 psig]. The operational limit is the same as the engineering limit. The engineering limit establishes the increasing containment pressure at which automatic containment pressure/temperature controls activate to remove heat from the containment atmosphere, thereby ensuring that containment pressure remains below design pressure, independent of operator action. The intent of the application is to prompt the operator to verify automatic Containment Spray actuation or to manually initiate CSAS if it did not actuate when required.

Step Number 8 Step Number 1A, Early Containment Spray Termination Criteria

Intent

The intent of this step is to secure unneeded containment spray pumps as early as possible after it has been confirmed that they have performed their safety function (Reference 48). The overall objective is to:

- Reduce the demand on the RWT,
- Delay the time to the start of containment recirculation during small breaks,
- Reduce the flow rate to the sump when containment recirculation begins,
- Reduce the pressure differential across the sump screens if there is a build up of debris.

[This is a plant specific instruction. Each plant must consider the advantages and disadvantages as they apply to their plant specific design and incorporate this action if it is determined to be risk beneficial with respect to containment sump blockage.]

A large break LOCA will reach peak containment pressure and temperature within five minutes. As the break size decreases the time to reach peak conditions will increase but the magnitude of the peaks will decrease. This makes it easier for the active heat removal systems to accomplish their safety functions. During a large break LOCA, securing the spray pumps has only a small effect on the time to RAS actuation. Smaller breaks commensurately increase this time interval. Verifying that containment temperature and pressure have peaked and are decreasing ensures that enough time has elapsed for containment spray to have accomplished its safety function prior to securing spray pump(s).

Proper operation of safety injection ensures that no core damage has occurred. If core damage has not occurred, there is no source term, so that containment spray is not required to meet the dose source term assumptions. Under these conditions, securing containment spray will not affect the analysis of record dose calculation. However, the requirement for containment spray for Iodine removal is a plant specific criterion.

Securing the containment spray pumps leaves the containment fan coolers (CFCs) as the only active containment heat removal system. A loss of offsite power has the potential to reduce this containment heat removal capability by half. The CFC effectiveness defines how much time is available to restart the idle spray pump in the event that the operating pump fails. For the Reference CE Plant, time is infinite because soon after blowdown 2 of 4 CFCs can continue to reduce containment pressure and temperature after switching to containment recirculation. Analysis shows that the CFCs will maintain containment pressure and temperature control. Failure of half the CFCs does not challenge the containment pressure and temperature safety functions.

(continue)

(continued)

Plant specific implementation of this step should include loss of one train of CFCs while containment spray pumps are secured. The results should demonstrate there is adequate time to start an idle spray pump and maintain the pressure and temperature below the current peak values in the AOR.

Method

a. Specify the criteria for early termination of containment spray.

- Both (all required) containment spray trains are operating as per design. That is, all required pumps started and associated discharge valves opens on the appropriate ESFAS signal(s). Both trains are delivering design flow rate,
- Containment pressure has peaked and is now less than [containment design pressure] and lowering,
- The required combination of one containment spray train and containment emergency fan coolers is in operation. 'Required' is defined as having sufficient capacity to provide 100% of containment design cooling,
- Safety Injection has actuated and flow is within the delivery curves. Verifying proper operation of safety injection confirms that no core damage has occurred. Therefore, containment spray would not be required to meet the dose source term assumptions, i.e. iodine removal,
- Containment spray is not required to maintain containment temperature less than the [EEQ requirement]. The maximum containment temperature limit associated with Equipment Environmental Qualification (EEQ) is a plant specific requirement,
- Then:

  1) Secure one containment spray train at a time until the minimum required combination of containment spray trains and containment emergency fan coolers is in operation.

  2) If containment pressure can not be controlled and maintained below containment design pressure, restart the idle train(s) as necessary.

a. Predetermine the optimal strategy for securing pumps. Select the preferred CS train (A or B) and the preferred HPSI train (A or B) to be secured first when the termination criteria are satisfied.

(continue)

(continued)

Consider such factors as: pump power supplies, suction valve and piping configuration and sump design (split vs. common). An optimal configuration would include one CS pump and one HPSI pump with the same power supply, with a common suction line and common sump penetration or sump section. In this way the reliability of the standby pumps is enhanced.

Sequence

This instruction should be located early in the procedure after verification that containment spray has actuated per design.

Plant Parameters

Containment pressure is less than [containment design pressure]

The engineering limit is based on the containment design pressure. This limit is consistent with the FSAR design criteria and the limiting pressure assumed in the accident analysis for high energy line releases inside containment.

Safety Injection flow within the SI delivery curves

The engineering limit is based on the minimum design SI flow assumed in the LOCA safety analysis for the HPSI and LPSI pumps. This analysis establishes the flow and discharge head requirements at the design point for the HPSI pump.

Step Number 2, CTPC-3, Containment Spray Termination Criteria

Intent

The intent of this step is to specify when and how the containment spray system should be secured following a valid actuation by the CSAS. The step is intended to allow stopping containment spray if it is no longer needed. The actions direct stopping one train at a time. This method gives the crew time to evaluate the response of containment conditions to stopping containment spray. If it is found that containment conditions are not responding favorably, then containment spray may continue in accordance with the cooling requirements necessary to maintain acceptable containment conditions.

Method

It is desirable to secure containment spray flow as soon as it can be determined that it is no longer required for any of the reasons described below. Prolonged operation of sprays into the containment increases the probability of electrical grounds, shorts and other equipment malfunctions occurring.

Containment spray system operation may be terminated when all of the following conditions are satisfied:

1. The Containment Spray pumps are operating and delivering water to the spray headers inside containment. It is assumed that containment spray was initiated on a valid CSAS signal or because the CSAS setpoint had been exceeded.
2. Containment pressure has been reduced to less than the CSAS reset pressure and is under control (stable) or lowering. This provides some assurance that containment spray is no longer required. If containment pressure is stable below the CSAS setpoint, it should also be at a low value. Otherwise, if it is just below the CSAS setpoint, it may barely be keeping up with the heat generation, and CSAS will probably reinitiate shortly after termination.
3. The containment spray flow is no longer required for containment cooling. This determination is made by evaluating the availability and operability of all normal and emergency containment cooling systems. There should be compelling evidence that the available containment heat removal systems will be able to effectively control containment pressure and avoid repressurization.
4. Spray flow is no longer required for iodine removal. The following factors should be considered when making this determination: 1) the quantity of radioactive iodine in the containment atmosphere, 2) the severity of fission product release to the containment atmosphere, 3) the integrity of the containment boundary and, 4) the length of time that the iodine cleanup system has been in service.

(continue)

(continued)

The containment [high range] radiation monitors are used to ensure that radiation levels inside containment have lowered and are trending in the conservative direction and that containment spray is no longer needed for iodine removal. If the TSC is manned and the containment high range radiation alarms are actuated when this step is reached, they may still suggest that containment sprays be terminated (as long as all of the other criteria are met) after determining that the radiological consequences would remain acceptable.

Once the decision to secure containment sprays has been made, one train should be secured at a time. Prior to securing the second train, the operator should verify that containment pressure and temperature remain under control (stable) or continue to lower. The spray pump is secured first, followed by closing the containment spray header isolation valve. This sequence ensures that the spray pump is not operated without a flow path. The Containment Spray System should then be realigned for automatic operation so it will automatically actuate if containment pressure rises to the CSAS setpoint.

Sequence

This step should be located soon after instructions to verify containment spray actuation.

Plant Parameters

Containment pressure less than the CSAS reset pressure

The bases for the engineering limit is the same as the bases for the technical specification value for resetting the Containment Spray Actuation System (CSAS), nominally [7.0 psig]. The reset value represents the containment pressure at which the Containment Spray System may be secured, the CSAS logic may be reset, and the Containment Spray System may be returned to a normal standby configuration. The intent of this instrument application is to restore containment spray to a standby status as soon as possible to minimize the effects of the spray on equipment inside containment, but not so early so as to unnecessary challenge to the actuation logic and actuate CSAS.

Step Number 9 Step Number 3, CTPC-3, Determine status of the Acceptance Criteria

Intent

For the Containment Spray success path, containment pressure should remain less than the [containment design pressure]. And the required number of containment spray systems should be in operation and each delivering [design flowrate], or the required combination of containment spray systems and containment emergency cooling systems should be in operation.

Method

If the above criteria are not satisfied, then the success path CTPC-3 is not successfully controlling containment temperature and pressure. The operator should go to Continuing Actions for Containment Temperature and Pressure control.

If the acceptance criteria for success path CTPC-3 are satisfied, then success path CTPC-3 is successfully controlling containment temperature and pressure. Containment temperature and pressure is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement LONG TERM ACTIONS.

Sequence

N/A

Plant Parameters

Containment pressure is less than [containment design pressure]

The engineering limit is based on the containment design pressure. This limit is consistent with the FSAR design criteria and the limiting pressure assumed in the accident analysis for high energy line releases inside containment.

Containment Spray pump flow at design flowrate

The engineering limit is based on the minimum required Containment spray flow needed to remove the design basis Containment heat load assumed in the accident analyses for LOCA or MSLB DBA. Containment spray flow in each header equal to or greater than the engineering limit ensures that each spray header is providing 50% of design requirements for containment heat removal. The intent of the operational limit is to provide the operator with criteria for verification that adequate containment spray flow exists after CS system actuation and to prompt the operator to investigate possible causes of degraded system flow if it is below the expected value.

Continuing Actions for Containment Temperature and Pressure Control:

If the Containment Temperature and Pressure Control safety function is still in jeopardy, then the operator must continue to attempt to establish Containment Temperature and Pressure Control while pursuing other jeopardized safety functions. Actions should be based on the results of evaluating the possible risks to plant personnel and the public, the urgency of other safety functions in jeopardy, the rate of change of containment temperature and pressure, and the feasibility of restoring equipment to restore success paths.

INSTRUCTIONS | CONTINGENCY ACTIONS

* 1. **Determine present status of the plant {lta}**

Determine present plant status by observing **ALL** of the following:

- Present RCS conditions (inventory, temperature, pressure, radioactivity levels, etc.)
- Success paths in use for fulfilling each safety function
- Adequacy of core cooling
- Plant area radiation levels
- Rates of radioactivity release to the environment

* 2. **Restore Offsite Power {law49looplta}**

IF offsite power is lost,
THEN restore power to in-plant loads:

[a. Coordinate restoration of offsite power with system dispatcher.]

[b. Restore power to the in-plant electrical distribution system.]

[c. Re-start normal station equipment.]

* Continuously Applicable Step or Non-Sequential Step

INSTRUCTIONS | CONTINGENCY ACTIONS

* 3. **Determine if cooldown should continue {lta}**

Determine if RCS cooldown should continue:

a. **IF** the release rate of radioactivity to the environment is in excess of [release limits],
THEN ensure RCS cooldown is in progress. REFER TO the HR success path in use.

b. **IF** the available condensate inventory is dropping and approaching [minimum availability requirement to support a cooldown],
THEN ensure RCS cooldown is in progress. REFER TO the HR success path in use.

c. **IF** the continued availability of **ANY** of the following vital auxiliaries is threatened:

- Electrical power
- Compressed air
- Service water

THEN ensure RCS cooldown is in progress. REFER TO the HR success path in use.

d. **IF** necessary repairs can only be performed in cold shutdown,
THEN ensure RCS cooldown is in progress. REFER TO the HR success path in use.

* Continuously Applicable Step

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. **Ensure equipment availability to support cooldown {lta}**	
Ensure equipment availability and plant conditions to support RCS cooldown.	4.1 **IF** equipment or systems needed for RCS cooldown are **NOT** available, **THEN** establish plant conditions to support making the necessary repairs.
* 5. **SDC Entry Conditions {law29loaflta}**	5.1 **IF** containment sump recirculation capability is lost, **AND ALL** of the following SDC entry conditions are established:
IF ALL of the following SDC entry conditions are established: • Pressurizer level is greater than [heater cutoff setpoint] • RCS subcooling is greater than or equal to [minimum RCS subcooling] • Pressurizer pressure is less than [SDC entry pressure] • RCS Th is less than [SDC entry temperature] • RCS activity will **NOT** result in unacceptable radiological consequences outside containment **THEN** GO TO SDC operating instructions.	• [Representative] CET Temperature [less than superheat], • Pressurizer pressure is less than [SDC entry pressure] • RCS Th is less than [SDC entry temperature] • Reactor Vessel level is greater than [center line of the hot leg], **THEN** establish SDC. GO TO SDC operating instructions.
6. **Maintain Long Term Cooling {lta}**	
IF SDC entry conditions can **NOT** be established, **THEN** maintain long term cooling as directed by TSC.	

Last Page Bookmark Follows this Hidden Text

* Continuously Applicable Step

Long Term Actions Bases

Since the FRG may be implemented in the course of a variety of events, which may or may not be diagnosed, the Long Term Actions strategy must be flexible. Since the detailed course of actions to be taken will depend on the nature of the event(s), considerable reliance on [the Technical Support Center] for guidance is used in the Long Term Actions. The basic strategy is as follows:

- Continuously perform the FRG Safety Function Status Check and ensure acceptance criteria remain satisfied
- Determine whether or not to continue plant cooldown
- Maintain the ability to perform a plant cooldown
- If necessary, continue the cooldown, establish SDC entry conditions and implement shutdown cooling in accordance with plant operating procedures
- Continuously attempt to diagnose the event

Long Term Actions Bases

Step Number 1. LTA Determine present status of the plant

Intent

Determining the plant status is necessary in order to make sound judgments concerning the subsequent actions to be taken. Evaluating a detailed plant status will also provide some diagnostic information. The possibility of making repairs to equipment, and what repairs are necessary should also be considered.

Method

Determine present plant status by observing **ALL** of the following:

a. Present RCS conditions (inventory, temperature, pressure, radioactivity levels, etc.)

b. Success paths in use for fulfilling each safety function.

c. Adequacy of core cooling.

d. Plant area radiation levels.

e. Rates of radioactivity release to the environment.

Sequence

Not applicable

Plant Parameters

None

Long Term Actions Bases

Step Number 2. LTA Restore Offsite Power

Intent

The intent of this step is to restore offsite power to the in-plant electrical distribution system and restart normal station loads.

The restoration of offsite power will enhance the plant's operational stability and flexibility by permitting the use of non-vital equipment and components such as use of the RCPs and the main condenser. Therefore, while the crew is ensuring that all safety functions are being satisfied, the restoration of non-vital [6.9 kV] AC power should be continued. The actions necessary to restore offsite power should continue until power is restored.

Method

The method to accomplish the intent is given by the instruction:

IF offsite power is available, THEN restore offsite AC power to the in-plant electrical distribution system and restore normal power to station loads. How offsite power is restored and who accomplishes it are very plant specific. For example, restoration may require coordination with the system dispatcher at some plants.

The plant specific implementation of this step may make reference to other plant procedures that deal with the restoration offsite power to the station distribution system for purposes of restoring the normal shutdown electrical distribution system lineup. Once offsite power is brought into the plant, normal loads may be started.

Sequence

This step is placed after the major mitigation and plant stabilization steps.

Plant Parameters

None

Long Term Actions Bases

Step Number 3. LTA Determine if cooldown should continue

Intent

To determine if plant conditions require that a cooldown be continued.

Method

The rate of radiological releases to the environment should be considered in order to minimize the offsite dose due to the event. This is accomplished by: a) minimizing the rate of release (e.g., by dumping steam to the condenser rather than to the atmosphere), and b) by minimizing the duration of the releases by entering shutdown cooling as soon as possible.

Consideration of the condensate inventory and the continuing availability of vital auxiliaries should be made in order to ensure that the cooldown can be completed. The initiation of a cooldown should not be delayed if the ability to cooldown is in jeopardy. A cooldown should be initiated in time to ensure that the shutdown cooling system can be placed into operation before the condensate inventory is depleted or the ability to control valves and/or other equipment is lost (e.g., due to a loss of electrical power or compressed air supplies).

Continued cooldown may be required in order to make repairs to the plant. If the need to complete the cooldown is not urgent, a delay in the cooldown and/or a slower cooldown rate may be appropriate.

Sequence

Not applicable

Plant Parameters

None

Step Number 4. LTA Ensure equipment availability to support the cooldown

Intent

To ensure equipment availability and plant conditions to support RCS cooldown.

Method

Plant specific.

Sequence

Not applicable

Plant Parameters

None

Step Number 5. LTA SDC Entry Conditions

Intent

The intent of this step is to establish shutdown cooling entry conditions and go to the appropriate procedure for SDC initiation.

Post RAS Contingency Action:

The intent of this step is to attempt to go on shutdown cooling as soon as conditions permit. This option is attractive (especially for small breaks) because it does not require a large volume of RCS makeup and it eliminates the need for injection flow out the break to cool the reactor. All that is needed is sufficient make up to replace boil off and maintain RCS level equal to or greater than the center of the hot leg.

However, there are several issues that must be considered prior to attempting it. For example: 1) the ability to maintain RCS level equal to or greater that the center line of the hot leg needs to be established, 2) if RCS is at saturated conditions, pump cavitation may make it difficult to maintain suction, 3) system alignment to support SDC may make it necessary to enter high radiation areas (potential for failed fuel), 4) the SDC alignment will impact the availability of one CS flow path and one HPSI flowpath, 5) once into it, it may be very difficult to back out because of local high radiation areas. Therefore, implementation of this option deserves careful consideration before launching into it.

Method

The following conditions should be exist prior to establishing SDC. It is implied that, all of the entry conditions are stable or trending to further within the entry conditions.

a. pressurizer level control should be established and verified by a level greater than [heater cutoff setpoint].

b. RCS subcooling should be at least [minimum RCS subcooling],

c. RCS pressure should be less than [SDC entry pressure]

d. RCS hot leg temperature should be less than [SDC entry temperature].

e. RCS activity level should be within acceptable limits. Before the shutdown cooling system is operated, the RCS activity levels must be considered since the RCS fluid will now be circulated outside of the containment building. Establishing the plant on shutdown cooling will result in the RCS coolant outside containment. If high activity is present. Such circulation has the potential for release to the environment. If the potential for significant releases exists, it may be more desirable to continue using the established method of cooling the plant. In addition, access to equipment where the coolant will be circulated must also be considered.

If the RCS cannot be depressurized, then voiding may be causing RCS pressure to remain high. Elimination of voids is addressed in other steps of the guideline.

(continue)

(continued)

Post RAS Contingency Action:

The following minimum conditions should be met prior to establishing SDC. It is desirable that all of the entry conditions are stable or trending to further within the entry conditions. However this situation with no way to recirculate and inject the containment sump water, it may be necessary to attempt it even if conditions are not ideal.

a. The minimum RCS inventory for successful SDC pump operation is at the centerline of the hot leg. If the operator is successful in getting SDC in service, he may still require intermittent RCS makeup from some source to maintain the required level. Some options to consider are:

- Intermittent HPSI pump operation on the containment sump
- Periodic injection from a refilled RWT.
- Periodic injection for an alternate source.
- Controlled periodic release of available SIT inventory

b. RCS pressure should be at or below the [SDC entry pressure] to protect the integrity of shutdown cooling piping, which is not rated for the higher pressures which could exist in the RCS.

c. RCS hot leg temperature should be at or below the [SDC entry temperature]. It may be saturated. This may lead to flashing in the pump suction, erratic pump discharge pressure and flowrate. SDC pumps are typically robust and can withstand a significant amount of cavitation (plant specific). The risk of pump damage may be acceptable based on the options available the risk of core damage.

d. Before the shutdown cooling system is operated, the RCS activity levels must be considered since the RCS fluid will now be circulated outside of the containment building. If high activity is present. Such circulation has the potential for release to the environment. If the potential for significant releases exists, it may be more desirable to continue using the established method of cooling the plant. In addition, access to equipment where the coolant will be circulated must also be considered. Access may be dose prohibitive due to failed fuel.

Sequence

This step is sequenced after the safety functions are under control. It provides an exit point for the guideline.

Long Term Actions Bases

Plant Parameters

Pressurizer level greater than the heater cutoff setpoint

The engineering limit is based on keeping the pressurizer heaters covered to preserve the normal means of RCS pressure control following a reactor trip. The pressurizer heaters are used to maintain RCS pressure, and keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in loss of single phase flow. The heater cutoff value is nominally [100"] decreasing.

RCS subcooling is greater than the required minimum subcooling

The engineering limit is based on avoiding saturated conditions (e.g. subcooling = 0°F) in the reactor coolant system, by ensuring some margin to saturation always exists. The lower engineering limit does not include instrument uncertainties, process uncertainties, or operational margin. The lower operational limit is nominally [20°F], which does provide some allowance for uncertainties.

Pressurizer pressure less than the Shutdown Cooling entry pressure

The upper engineering limit is based on the shutdown cooling system design pressure. The shutdown cooling system may be placed in operation when the RCS has been depressurized to the point that the shutdown cooling system will not be exposed to pressures greater than its design pressure. The operational limit, nominally [300 psia] (including the instrument uncertainties) should be less than the setpoint of the permissive interlock which prevents opening of the shutdown cooling suction line isolation valves.

RCS hot leg temperature less than the Shutdown Cooling entry temperature

The upper engineering limit is based on the design temperature of the shutdown cooling system components, nominally [300]°F. The shutdown cooling system may be placed in operation when hot leg temperature is less than [300]°F.

Long Term Actions Bases

Step Number 6. LTA Maintain Long term cooling

Intent

The intent of this step is to direct the operator to maintain long term cooling if SDC entry conditions can not be established in the event of an un-isolated LOCA.

Method

If SDC operation is determined to be appropriate, then the SDC is initiated. If SDC entry conditions can not be met or maintained, then the operators are directed maintain long term cooling. Any successful means of long term cooling is acceptable. For example; single phase natural circ, two phase cooling, or Once-Trough-Cooling out the break.

One of the above methods of maintaining the RCS Heat Removal safety function should be in force based on previous steps in the guideline.

Sequence

This step is sequenced after SDC entry instructions.

Plant Parameters

None