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INDIANA MICHIGAN POWER

October 26, 1995

AEP:NRC:10820

Docket Nos.: 50-315
50-316

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Donald C. Cook Nuclear Plant Units 1 and 2
INDIVIDUAL PLANT EXAMINATION
RESPONSE TO NRC AUDIT CONCERNS AND REQUEST
FOR ADDITIONAL INFORMATION

References:

1) "Donald C. Cook Nuclear Plant, Individual Plant Examination Submittal, Response to Generic Letter 88-20," submitted to the NRC in letter AEP:NRC:1082E, May 1, 1992.

2) NRC Letter, J. Hickman to E. E. Fitzpatrick, "Review of D. C. Cook Individual Plant Examination Submittal - Internal Events," March 31, 1995.

On May 1, 1992, the Individual Plant Examination for the Donald C. Cook Nuclear Plant, Units 1 and 2, was submitted (Reference 1) to the NRC in response to Generic Letter 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities - 10CFR50.54(f)." Several rounds of questions and meetings followed in the NRC review process. As a result of that review process, NRC questions concerning the human reliability analysis (HRA) methodology were summarized in a letter (Reference 2).

Revision 1 to the Individual Plant Examination addresses these questions by modifying the HRA analysis. A summary of the revised analysis and conclusions is found in Attachment 1. As a result of the changes described herein, the new core damage frequency for Cook Nuclear Plant is 7.14E-05. To assist in understanding the types of revisions to the HRA, Attachment 2 contains a summary of

A011

the methodology changes and two typical examples of the revised human reliability calculations.

Sincerely,

E. E. Fitzpatrick

E. E. Fitzpatrick
Vice President

SWORN TO AND SUBSCRIBED BEFORE ME

THIS 20th DAY OF October 1995

Rita D Hill
Notary Public

My Commission Expires: 6-28-99

plt

Attachments

cc: A. A. Blind
G. Charnoff
H. J. Miller
NFEM Section Chief
NRC Resident Inspector - Bridgman
J. R. Padgett

ATTACHMENT 2 TO AEP:NRC:10820

Donald C. Cook Nuclear Plant
Individual Plant Examination

Human Reliability Analysis Summary of Methodology Changes and Example Calculations

This attachment includes a summary of the changes made in the human reliability analysis methodology and example calculations.

I. SUMMARY OF METHODOLOGY CHANGES

After a complete comparison of the original (Revision 0) AEPSC human reliability methods to the THERP [Reference 1] methods was performed, the AEPSC methods were updated to be more consistent with the THERP method and to reflect newer information. Below is a summary of the major inconsistencies identified and their resolution in the revised (Revision 1) human reliability analysis:

Human reliability action specific to sequences:

Revision 0: A simplifying assumption was utilized that an operator action, such as establishing primary feed and bleed, was independent of the accident sequence.

Revision 1: Sequence specific human error probabilities were calculated based on differences in timing, stress, dependence, and possible recoveries, using THERP.

Dependence Modeling:

Revision 0: Dependence modeling was used infrequently.

Revision 1: Prior human action failures were assessed for modeling of dependent failures of subsequent actions, both within a modeled action and between different modeled actions.

Performance shaping factors in diagnosis:

Revision 0: Training and stress performance shaping factors were utilized for the diagnosis error frequencies.

Revision 1: The EPRI methodology [Reference 2] was used for diagnosis, which is consistent with THERP.

Explicit consideration of timing:

Revision 0: For most cases, timing was only considered in a qualitative manner, with the diagnosis error rate being frequently based on the time needed to complete the action.

Revision 1: Timing was used to check if there was adequate time available to perform the action and any recovery actions. Workload was also considered as influencing the stress level.

Consistent use of second person checking:

Revision 0: Credit was generally taken for checking, to the extent needed to determine an acceptably accurate final result (i.e., once a human error failure path was found to be not the dominant path, further credits were not taken). Thus, known actions such as second person checking were inconsistently used.

Revision 1: These credits were only used when the checking actions were clearly proceduralized (e.g., checker initials required), or on a case by case basis when it could be shown that the person actually makes a habit of reviewing what the operator was doing.

Training performance shaping factors:

Revision 0: Training performance shaping factors were included for execution type errors to address the impact of improved training and procedures.

Revision 1: These generic training shaping factors were not used. Training was only considered on a case by case basis. Section 3.3 (attached) is an example of how operator training and practices were credited.

References

1. "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications," A. D. Swain and H. E. Guttmann, NUREG/CR-1278, 1983.

2. "An Approach to the Analysis of Operator Actions in Probabilistic Risk Assessment," EPRI TR-100259, EPRI Project 2847-01, Final Report, June, 1992.

II. EXAMPLE CALCULATIONS

The following portions from the Donald C. Cook Nuclear Plant's Human Reliability Analysis, Revision 1, are included with this attachment:

Section 3.3	High Pressure Cold Leg Recirculation (HPR) Event Tree Level HEP Calculation
Section 3.5	Depressurization to Allow Low Pressure Injection (OLI) Event Tree Level HEP Calculation
Attachment HPR	Marked up procedure pages for Section 3.3
Attachment OLI	Marked up procedure pages for Section 3.5
Figures E-8 through E-11	HPR fault trees HPR1, HPR2, HPR3 and HPR4 (only more complex fault trees, i.e., those with AND gates, are included)

Both HPR and OLI are good examples of how dependencies were treated in the analysis. The different types considered were dependencies between personnel, steps within a human failure event, and steps in different human failure events. Both cognitive and execution error dependence were considered.

The HPR fault trees are much more detailed than the majority of the HRA fault trees due to dependence with switchover to containment spray recirculation (CSR), which is performed at the same time. These switchover actions had common cognitive errors (i.e., totally dependent), and some common execution errors. These common cognitive and execution errors were quantified as totally dependent by using the same identifiers in the corresponding fault trees.

As described in Section 3.5.6, for a Medium LOCA event, OLI is required about the same time as switchover to recirculation. As many factors influence which comes first, it was conservatively assumed that OLI precedes switchover and switchover was considered totally dependent on OLI.

For more information on the assumptions used in the analysis, see Section 3.3.3 of Attachment 1 of this submittal. Results are summarized in Tables 3.3-2 and 3.3-3 of Attachment 1 of this submittal.

3.3 HPR - HIGH PRESSURE COLD LEG RECIRCULATION

3.3.1 Application

Small LOCA (SLO) with success of auxiliary feedwater (AF4) - HPRA (JMR)
SLO with failure of auxiliary feedwater (AF4) - HPRB (JMR)

Medium LOCA (MLO) with success of auxiliary feedwater (AF4) - HPRC (JMR)

Transient with Steam Conversion Systems Available (TRA) - HPRD (JAJ)
Transient without Steam Conversion Systems Available (TRS) - HPRE (JAJ)

Large Steam Line/Feedline Break (SLB) - HPRF (JAJ)

Loss of Offsite Power (LSP) - HPRG (JAJ)

Steam Generator Tube Rupture (SGR) - HPRH (JAJ)

Station Blackout (SBO) with success of AFT, success or failure of RCC, success of AFC, XHR, CNU, RRI, and AF1, and success or failure of CSI - HPRS (JMR)
SBO with success of AFT, success or failure of RCC, success of AFC, XHR, CNU, and RRI, failure of AF1, success of PBB, and success or failure of CSI - HPRT (JMR)
SBO with success of AFT, success or failure of RCC, failure of AFC, success of XHR, CNU and PBB, and success or failure of CSI - HPRU (JMR)
SBO with failure of AFT, success of XHR, CNU, and PBB, and success or failure of CSI - HPRV (JMR)

Loss of CCW or ESW with success of RCP and RR2 - HPRW (JMR)

3.3.2 Description

High pressure cold leg recirculation is required for several top events following successful ECCS high pressure injection when RWST reaches the low level setpoint of 32%. The transfer to recirculation is required to ensure a continued source of flow is available to the RCS so that core cooling is maintained following depletion of the RWST inventory. In the HPR phase, the water that is spilled from the break collects in the lower containment, flows through course and fine mesh strainers into the recirculation sump. The CCPs and SI pumps then take suction from the recirculation sump via the residual heat removal system. During the manual switchover from the injection phase to the recirculation phase, both the RHR and SI pumps discharge line cross-tie valves are shut. This provides two separate trains of injection during the recirculation phase.

3.3.3 Success Criteria and Timing Analysis

Success of this event requires one of two SI pumps and one of two CCPs to inject to one of three intact cold legs with the pump suction supplied by one of two RHR trains operating in the recirculation mode. If this top event fails, late core damage with the RCS at high pressure is postulated to occur.

The Event Tree Notebook provides justification for the time to switchover from accident initiation and the amount of time the operator has to complete the switchover based on useable volume of the RWST for each application of this top event. A summary of these success criteria times is presented below. Refer to the Event Tree Notebook for additional information.

For medium LOCA (MLO) and small LOCA (SLO), the time from accident initiation until switchover is required would be approximately 30 minutes, assuming all safeguards pumps initially operating. This assumes containment spray is actuated early in the accident. The time to switchover would be longer if there are equipment failures or if spray actuation is delayed. Once RWST level reaches 32% and switchover is initiated, the operators will have 17 minutes to complete the switchover to high pressure recirculation before any of the safeguards pumps cavitate due to air entrainment (Reference 1).

For steam generator tube rupture (SGR) events, containment spray actuation would be expected about 30 minutes following initiation of primary bleed (See Success Criteria Notebook, Table 28). Switchover to high pressure cold leg recirculation would then be required about 30 minutes after this. This relative timing would also be expected for transient events in which bleed and feed recovery is used due to unavailability of feedwater for decay heat removal. Once RWST level reaches 32% and switchover is initiated, the operators will have 17 minutes to complete the switchover to high pressure recirculation before any of the safeguards pumps cavitate due to air entrainment. This time is the same as that for MLO and SLO since containment spray actuation is expected following initiation of bleed and feed. This timing analysis is also applicable to TRA, TRS and LSP events in which bleed and feed recovery is used due to the unavailability of feedwater for decay heat removal.

For SLB events, the time from accident initiation for a large secondary break inside containment until switchover is conservatively assumed to be approximately 30 minutes. This assumes containment spray is actuated early in the accident if the break is located inside containment. Similar to MLO and SLO, once RWST level reaches 32% and switchover is initiated, the operators will have 17 minutes to complete the switchover to high pressure recirculation before any of the safeguards pumps cavitate due to air entrainment.

For SBO events, depending on the amount of RCP seal leakage and the resulting need for containment spray injection, the time at which switchover to cold leg recirculation would be required could be as short as 30 minutes after spray and high pressure injection are actuated to several hours if spray actuation is not required. The timing requirements for completing the switchover to cold leg recirculation is 17 minutes, similar to MLO and SLO, since high pressure injection may also be actuated.

For SSW and CCW events, the timing analysis is the same as that of SBO, recirculation may be required within 30 minutes of event initiation and completion of the switchover actions within 17 minutes.

3.3.4 Procedures

Upon a small LOCA causing a reactor trip and SI actuation, the operators will enter E-0. At step 25, they will transfer to E-1, and at step 14 of E-1, they will transfer to ES-1.2.

The Emergency Operating Procedure used to perform switchover to cold leg recirculation is

ES-1.3, TRANSFER TO COLD LEG RECIRCULATION, Rev. 2

ES-1.3 is entered from:

a) E-1, LOSS OF REACTOR OR SECONDARY COOLANT, Rev. 5, Step 15, on low RWST level.

b) ECA-2.1, UNCONTROLLED DEPRESSURIZATION OF ALL STEAM GENERATORS, Rev. 4, Step 9, on low RWST level.

c) Other procedures whenever RWST level reaches the switchover setpoint.

For a small LOCA with success of AFW, entry into ES-1.3 will occur from the caution statement at the beginning of ES-1.2, and the RWST low level alarm provides cognitive recovery. This transition could also be from the foldout page for E-1 and ES-1.2, but this is conservatively not credited. Although the check for RWST level is performed in different procedures, depending on the initiating event, the action is the same for all cases. The Cue Table is applicable to all listed applications.

3.3.5 Critical and Recovery Actions

The following are the primary tasks which must be completed for satisfying the success criteria of the HPR actions:

1. Monitor for low RWST level and the need for establishing cold leg recirculation (Caution statement before ES-1.2) (cognitive)

2. Reset SI (Step 1 of ES-1.3)

3. Align West RHR for recirculation (Step 4 of ES-1.3)

4. Align CCPs and SI pumps for recirculation (Step 5 of ES-1.3)

5. Align east RHR pump for recirculation (Step 6 of ES-1.3)

See Table 3.3-1, Cue Table for HPR for identification of symptoms for establishing high pressure cold leg recirculation.

See Table 3.3-2, Subtask Analysis for HPR for identification of critical or relevant recovery actions associated with cold leg recirculation.

3.3.6 Assumptions

See sections 3.3.8, 3.3.9 and 3.3.10.

3.3.7 Significant Operator Interview Findings

1. Switchover to recirculation takes top priority above all other actions. Whenever the RWST level reaches 32%, they will stop what they are doing and immediately go to ES-1.3. The unit supervisor and RxO will not be interrupted with other tasks, and

others in the control room know to not get in the way.

2. The unit supervisor, who is reading the procedure, will watch each step performed by the RxO, and wait until completion of the step (i.e., until valves have transferred to correct position) before going on to the next step.

3. There will be at least two others in the control room who will be going through the procedure and ensuring that the steps are carried out completely (i.e., the extra US and the STA). The SS, ASS and BOPO may also be watching.

4. Whenever the operators start a pump or close a suction valve, they will watch the pump amps and discharge flow. This is second nature to the operators.

5. Most unit supervisors will actually start switchover before the RWST has reached 32%, so they have do not have to hurry, and will not have to deal with the confusion of the RHR pumps tripping on low-low RWST level. They are encouraged to start early.

3.3.8 Calculation of Cognitive Error

A cognitive model was used to address diagnosis type errors (Reference 21). Tables 3.3-3 and 3.3-4 contain the calculation of the cognitive human error probability, pc, that the operators fail to recognize the need for switchover to high pressure recirculation. Pc was calculated in Table 3.3-3 to be 3.1E-03, without recovery. The recovered value of pc was calculated in Table 3.3-4 to be 1.5E-04.

3.3.9 Calculation of Execution Error

For the calculation of execution errors, the tables from Chapter 20 of Reference 2 were used. (T20-x refers to Table 20-x of Reference 2.) The critical actions identified in Table 3.3-2 were reviewed to determine the dominant critical actions to be quantified. Critical actions are not dominant if they are recovered by other procedure steps or if they follow a mechanical failure because the human error probability would be multiplied by another human error probability or a mechanical failure probability. Attachment HPR is a copy of the relevant portion of ES-1.3, with dominant critical steps circled. The reasons why the other critical steps (identified in Table 3.3-2) are not dominant are also included.

3.3.9.1 Step 4, Align West RHR Pump for Recirculation:

4a Stop & lockout W RHR PP

Errors of Omission:

Omit step/page:

1.3E-03 (T20-7 #3, Assumption G)

Step 4 of procedure

Errors of Commission:

Select wrong control when it is dissimilar to adjacent controls:

negligible (Table 20-12, #1A (Item 1A has been added by Swain since NUREG/CR-1278))

The RHR trains are delineated, the ammeter is directly above the control, and no similar ammeters are on the West RHR panel.

<u>4c</u> <u>open recirc sump to W RHR/CTS pump valve</u>

Errors of Omission:

Omit step/page:

1.3E-03 (T20-7 #3, Assumption G)

Step 4 of procedure

Errors of Commission:

Select wrong control when it is dissimilar to adjacent controls:

negligible (Table 20-12, #1A (Item 1A has been added by Swain since NUREG/CR-1278))

This control is different from adjacent controls because it is metal and has a key in it.

<u>Total error probability for Steps 4a & c:</u>

1.3E-03 + 1.3E-03 = 2.6E-03

<u>4d</u> <u>Start W RHR PP</u>

Errors of Omission:

Omit step:

1.3E-03 (T20-7 #3, Assumption G)

Step 4 of procedure

Errors of Commission:

negligible, see Errors of Commission for Step 4a

3.3.9.2 Step 5. Align SI Pumps and CCPs for Recirculation

5i open SI pump suction from west RHR HX valve and
5j open SI pump suction crosstie to CCP valves

These two steps were considered as one perceptual unit. These are adjacent procedure steps and the valve controls are all right next to each other (i.e., these actions are not separated by time or location).

Errors of Omission:

Omit step/page:

1.3E-03 (T20-7 #3, Assumption G)

Step 5 of procedure

Errors of Commission:

Select wrong control on panel from array of similar appearing controls:

1.3E-03 (T20-12 #3)

All safety injection suction and discharge valves are in one area on SI control panel.

Total error probability for Step 5:

2.6E-03

3.3.9.3 Step 6. Align East RHR Pump for Recirculation:

6b Stop & lockout East RHR PP

Errors of Omission:

Omit step/page:

1.3E-03 (T20-7 #3, Assumption G)

Step 6 of procedure

Errors of Commission:

Select wrong control when it is dissimilar to adjacent controls:

negligible (Table 20-12, #1A (Item 1A has been added by Swain since NUREG/CR-1278))

The RHR trains are delineated, the ammeter is directly above the control, and no similar ammeters are on the East RHR panel.

6d   open recirc sump to East RHR/CTS pump valve

Errors of Omission:

Omit step:

1.3E-03 (T20-7 #3, Assumption G)

Step 6 of procedure

Errors of Commission:

Select wrong control when it is dissimilar to adjacent controls:

negligible   (Table 20-12, #1A (Item 1A has been added by Swain since NUREG/CR-1278))

This control is different from adjacent controls because it is metal and has a key in it.

Total error probability for Steps 6b & d:

1.3E-03 + 1.3E-03 = 2.6E-03

6e   Start East RHR PP

Errors of Omission:

Omit step:

1.3E-03 (T20-7 #3, Assumption G)

Step 6 of procedure

Errors of Commission:

negligible, see Errors of Commission for Step 6b

6f   Open CCP suction from East RHR HX valve

Errors of Omission:

Omit step:

1.3E-03 (T20-7 #3, Assumption G)

Step 6 of procedure

Errors of Commission:

Select wrong control on panel from array of similar appearing controls:

1.3E-03 (T20-12 #3)

It is clearly labeled on the boric acid charging and letdown panel. It is at the bottom left of the panel.

3.3.10 Calculation of Total Human Error Probability for Failure to Switchover to HPR

The cognitive and execution error probabilities were calculated in sections 3.3.8 and 3.3.9 to be:

pc'(HPRA) = 1.5E-04	
pe(steps 4a&c) = 2.6E-03	(without stress, dependence or recovery)
pe(step 4d) = 1.3E-03	(without stress, dependence or recovery)
pe(step 5) = 2.6E-03	(without stress, dependence or recovery)
pe(steps 6b&d) = 2.6E-03	(without stress, dependence or recovery)
pe(step 6e) = 1.3E-03	(without stress, dependence or recovery)
pe(step 6f) = 2.6E-03	(without stress, dependence or recovery)

In order for alignment of the east RHR train (step 6) to recover for an error in aligning the west train (step 4), the operators must recognize that there is not adequate flow from the west RHR pump train before aligning the high head pumps (step 5). The high head pumps are expected to fail quickly without a suction source (per operator interviews). A high level of dependence is assumed, therefore, for the operators recognizing that there is a problem with the east RHR train before they align the high head pumps in step 5. This was modelled by a high dependence failure of noticing failed step 4, so performing step 6 before step 5 (i.e., human error probability = 0.5). A high level of dependence is conservative, however, as the operator and unit supervisor will be watching pump amperes when suction sources are closed (e.g., for the high head pumps) and when the RHR pumps are started (per operator interviews). The ammeters are right above the pump controls in the control room. Also, the unit supervisor watches what the operator is doing, and waits for completion of one step before moving on to another (which can be significant, as it takes about 30 seconds for the RWST suction valves to close).

A moderate level of dependence was assumed between failure of step 4 and the initial tasks in step 6. Although steps 4 and 6 are similar, they are different procedure steps, on different pages, and unless the operators realize they failed step 4, step 5 will be performed between them. An extremely high level of stress is assigned to all step 6 actions, though, as these actions are only critical if the operators failed in step 4.

Per operator interviews, a minimum of two people will be watching the unit supervisor and operator go through the switchover using a copy of the procedure. Whenever switchover is occurring, it is top priority, and almost everything else has come to a stop. The STA does not want to get in the way, so he will be going through the procedure and watching what is going on, as well as the extra unit supervisor. The unit supervisor is not interrupted during switchover, therefore, the extra unit supervisor will be free to watch the switchover. Several more people may also be watching, but this is conservatively not credited. If it is under an hour after event initiation, the shift supervisor may still be busy with his E-plan duties. The assistant shift supervisor may be busy in his role as contingency director, and the BOPO may not be paying close enough attention to catch a mistake.

Only one recovery was given to the extra unit supervisor and STA. A low level of dependence was assumed between them and the unit supervisor and RxO because they are not interacting at all with the US and RxO; they are standing back and fulfilling a supervisory type role. This combined effort was equated to that of the shift supervisor in Table 20-4, Reference 2.

Per table 20-16, HEPs should be multiplied by two for moderately high stress for step-by-step tasks, and by 5 for extremely high stress for step-by-step tasks. Per Table 20-17, if the basic human error probability (BHEP) is greater than .01, the equations to use for low, moderate, and high dependence are: (1+19N)/20, (1+6N)/7, and (1+N)/2, respectively. Per Table 20-21, if the BHEP is less than or equal to .01, HEPs of .05, .15 and .5 should be used for low, moderate, and high dependence, respectively.

Recovery due to extra unit supervisor and STA following procedure and actions = 0.05

These parameters and assumptions are used below to determine the total human error probability for failure to switchover for high pressure recirculation under different conditions.

<u>HPRA: Switchover to high pressure recirculation upon a small LOCA and successful AFW (AF4)</u>
(CSI status is not addressed. If CSI failed, operators would have even more time to perform HPR, and it would not be required until much later into the event. The corresponding decrease in stress would be negated by the added stress the operators experience if they notice CSI has failed.)

A moderately high level of stress was assumed for steps 4 and 5. This is a procedure that is well known and practiced by the operators, and they are not concentrating on doing anything else during this procedure, as it takes top priority.

pc'(HPRA) = 1.5E-04	(HPRA-LPR-CSRHE)
pe'(steps 4a&c) = 2.6E-03 * 2 = 5.2E-03	(REC--4A&C-MHHE)
pe'(step 4d) = 1.3E-03 * 2 = 2.6E-03	(REC----4D-MHHE)
pe'(step 5) = 2.6E-03 * 2 = 5.2E-03	(REC-----5-MHHE)
pe'(steps 6b&d) = 2.6E-03 * 5 with MD	(REC--6B&D-EHHE-M)
= (1 + 6*1.3E-02)/7 = 1.5E-01	
pe'(step 6e) = 1.3E-03 * 5 = 6.5E-03	(REC----6E-EHHE)
pe'(step 6f) = 2.6E-03 * 5 = 1.3E-02	(REC----6F-EHHE)
pe'(recognize to do step 6 before step 5) = HD = 0.5	(REC-6THEN5--HE-H)
Recovery, execution errors (extra US and STA) = 0.05	(REC-US-STA--HE-L)

The total human error probability (THEP) for failing to switchover to high pressure recirculation upon a small LOCA and successful AFW (AFW) is calculated as shown in fault tree HPR1:

THEP(HPRA) = pc' + [pe'(step 4) * pe'(step 6) + pe'(step 5)] * recovery(extra US or STA)

THEP(HPRA) = 1.5E-04 + [(5.2E-03 + 2.6E-03) * (0.5 + 1.4E-01 + 6.5E-03 + 1.3E-02) + 5.2E-03] * 5.0E-02

THEP(HPRA) = 6.7E-04

HPRB: Switchover to high pressure recirculation upon a small LOCA, failure of AFW (AF4), and success of primary bleed and feed (PBF1)

(CSI status is not addressed. If CSI failed, operators would have even more time to perform HPR, and it would not be required until much later into the event. The corresponding decrease in stress would be negated by the added stress the operators experience if they notice CSI has failed.)

For this scenario, the operators will transition from Step 18 of E-0 to FR-H.1 to complete PBF. Due to adverse containment conditions, the operators will immediately go to step 18 of FR-H.1. They should still be in FR-H.1 when RWST level reaches 32%. The caution statement after step 25 of FR-H.1 will be their cue to monitor the RWST level, with cognitive recovery provided by the alarm. It is assumed that the RxO monitoring the RWST level will have a high work load, as they will be busy with PBF and subsequent actions in FR-H.1. The only change in pc' from pc'(HPRA) will be to tree b. The new end path will be i due to the high work load, which is not recovered.

pc'(HPRB) = 7.5E-04 + 3.0E-07
pc'(HPRB) = 7.5E-04 (HPRB-LPR-CSRHE)

The extremely high level of stress from primary bleed and feed is conservatively assumed to still exist. Otherwise, the actions have the same failure probabilities as HPRA.

pe'(steps 4a&c) = 2.6E-03 * 5 = 1.3E-02	(REC--4A&C-EHHE)
pe'(step 4d) = 1.3E-03 * 5 = 6.5E-03	(REC----4D-EHHE)
pe'(step 5) = 2.6E-03 * 5 = 1.3E-02	(REC-----5-EHHE)
pe'(steps 6b&d) = 2.6E-03 * 5 with MD	(REC--6B&D-EHHE-M)
= (1 + 6*1.3E-02)/7 = 1.5E-01	
pe'(step 6e) = 1.3E-03 * 5 = 6.5E-03	(REC----6E-EHHE)
pe'(step 6f) = 2.6E-03 * 5 = 1.3E-02	(REC----6F-EHHE)
pe'(recognize to do step 6 before step 5) = HD = 0.5	(REC-6THEN5--HE-H)
Recovery, execution errors (extra US and STA) = 0.05	(REC-US-STA--HE-L)

The total human error probability (THEP) for failing to switchover to high pressure recirculation upon a small LOCA, failure of AFW (AF4), and success of PBF is calculated as shown in fault tree HPR2:

THEP(HPRB) = pc' + [pe'(step 4) * pe'(step 6) + pe'(step 5)] * recovery(extra US or STA)

THEP(HPRB) = 7.5E-04 + [(1.3E-02 + 6.5E-03) * (0.5 + 1.4E-01 + 6.5E-03 + 1.3E-02) + 1.3E-02] * 5.0E-02

THEP(HPRB) = 2.0E-03

HPRC: Switchover to high pressure recirculation upon a medium LOCA and successful AFW (AF4)
(CSI status is not addressed. If CSI failed, operators would have even more time to perform HPR, and it would not be required until much later into the event. The corresponding decrease in stress would be negated by the added stress the operators experience if they notice CSI has failed.)

This is the exact same scenario as HPRA, except for the size of the LOCA. For this event, however, this difference in LOCA size is irrelevant, as the timing and flow through the procedures should be the same.

The total human error probability (THEP) for failing to switchover to high pressure recirculation upon a medium LOCA and successful AFW (AFW) is the same as HPRA:

THEP(HPRC) = THEP(HPRA) = 6.7E-04

HPRD: Switchover to high pressure recirculation after a transient with steam conversion systems available (TRA), followed by loss of auxiliary feedwater (AF1), a loss of alternate secondary cooling sources (AFW from the other Unit and main feedwater-MF1, and SG depressurization combined with condensate-OA5), and success of primary feed and bleed (PBT). In this scenario, the operator initiates a LOCA when primary feed and bleed is started. Because of this, switchover to recirculation will occur approximately 30 minutes after Containment Spray Injection actuates. Containment Spray Injection actuates a short time after the rupture disk on the primary pressure relief tank blows out. This timing is similar to the development in the small LOCA event tree (SLO) on the path where high pressure injection (HP2) succeeds and auxiliary feedwater (AF4) succeeds, leading to high pressure recirculation about a half hour later. Thus, equation HPRD equals HPRA, and fault tree HPR1 is used.

For the branch where primary bleed and feed succeeds, but containment spray injection fails, HPRD is also assigned because the development is similar to that described above, only the containment spray injection fails to actuate extending the timing.

HPRE: Switchover to high pressure recirculation after a transient with failure of steam conversion systems (TRS), followed by loss of auxiliary feedwater (AF1), and success of primary feed and bleed (PBT). In this scenario, the operator initiates a LOCA when primary feed and bleed is started. Because of this, switchover to recirculation will occur approximately 30 minutes after Containment Spray Injection actuates. Containment Spray Injection actuates a short time after the rupture disk on the primary pressure relief tank blows out. This timing is similar to the development in the small LOCA event tree (SLO) on the path where high pressure injection (HP2) succeeds and auxiliary feedwater (AF4) succeeds, leading to high pressure recirculation about a half hour later. Thus, equation HPRE equals HPRA, and fault tree HPR1 is used.

For the branch where primary bleed and feed succeeds, but containment spray injection fails, HPRE is also assigned because the development is similar to that described above, only the containment spray injection fails to actuate extending the timing.

HPRF: Switchover to high pressure recirculation after a large steam/feedwater line break (SLB), followed by successful high pressure injection (HP3) and successful isolation of the faulted SG (MS1) but loss of auxiliary feedwater (AFS), countered by success of primary feed and bleed (PBS). In this scenario, the operator initiates a LOCA when primary feed and bleed is started. Because of this, switchover to recirculation will occur approximately 30 minutes after Containment Spray Injection actuates. Containment Spray Injection actuates a short time after the rupture disk on the primary pressure relief tank blows out. This timing is similar to the development in the small LOCA event tree (SLO) on the path where high pressure injection (HP2) succeeds and auxiliary feedwater (AF4) succeeds, leading to high pressure recirculation about a half hour later. Thus, equation HPRF equals HPRA, and fault tree HPR1 is used.

For the branch where primary bleed and feed succeeds, but containment spray injection fails, HPRF is also assigned because the development is similar to that described above, only the containment spray injection fails to actuate extending the timing.

HPRG: Switchover to high pressure recirculation after a transient loss of offsite power (LSP), followed by loss of auxiliary feedwater (AF1), and success of primary feed and bleed (PBL). In this scenario, the operator initiates a LOCA when primary feed and bleed is started. Because of this, switchover to recirculation will occur approximately 30 minutes after Containment Spray Injection actuates. Containment Spray Injection actuates a short time after the rupture disk on the primary pressure relief tank blows out. This timing is similar to the development in the small LOCA event tree (SLO) on the path where high pressure injection (HP2) succeeds and auxiliary feedwater (AF4) succeeds, leading to high pressure recirculation about a half hour later. However, there may be one train equipment unavailable depending on the diesel generator (DG) response. If two diesel generators succeed, then HPR equals HPRA. If only one diesel generator succeeds, then HPR equals HPRA (in timing) but with only one train available. Although the case for the two DG success is more likely (~95%), the case of success of only one DG (~5%) leads to more restrictive modeling and has conservatively been applied. Thus, equation HPRG equals HPRA Steps 4 and 5, as calculated in fault tree HPR4.

For the branch where primary bleed and feed succeeds, but containment spray injection fails, HPRG is also assigned because the development is similar to that described above, only the containment spray injection fails to actuate extending the timing.

HPRH: Switchover to high pressure recirculation after a steam generator tube rupture (SGR), followed by loss of all auxiliary feedwater (AF2 and AF3), and success of primary feed and bleed (PBG). In this scenario, the operator initiates a LOCA inside of containment when primary feed and bleed is started. Because of this, switchover to recirculation will occur approximately 30 minutes after Containment Spray Injection actuates. Containment Spray Injection actuates a short time after the rupture disk on the primary pressure relief tank blows out. This timing is similar to the development in the small LOCA event tree (SLO) on the path where high pressure injection (HP2) succeeds and auxiliary feedwater (AF4) succeeds, leading to high pressure recirculation about a half hour later. Thus, HPRH equals HPRA, and fault tree HPR1 is used.

HPRS: Switchover to high pressure recirculation upon a SBO and success of AFT, success or failure of RCC, success of AFC, XHR, CNU, RRI, and AF1, and success or failure of CSI

Dependency upon CSI failure is not evaluated, because THEP for CSI is mostly due to errors of omission, which are independent for steps on different pages, with the remainder due to cognitive failures. If the operators failed to actuate CSI, switchover to recirculation is not necessary for 1.5 hours after this CSI failure. In this time, there are no other system failures. This amount of time, with no other major operator tasks, negates any cognitive dependency.

Early failure of RCS cooldown (RCC) is not addressed separately, as this action was performed several hours earlier (long before power restoration), errors of commission were due to the AEO (who will not be involved in HPR), and there have been numerous successes since this time. This early failure should not cause a higher level of stress at this time. RCC failure just mandated earlier power restoration, which was successful.

Per the Event Tree Notebook (Reference 1), with the containment spray and high head ECCS pumps injecting, there is 17 minutes available for switchover, and switchover will not be required until at least 30 minutes following completion RRI and CSI.

For this scenario, everything has been successful following power restoration, and at least 30 minutes have elapsed since operators finished RRI and CSI. Power has been back for an hour, and things are under control. The operators will transfer to E-1 (LOSS OF REACTOR OR SECONDARY COOLANT) at the end of ECA-0.2 (i.e., step 14).

The cue for the operators to monitor RWST level will be Step 15 of E-1. A low work load can be assumed at this time and recovery with the alarm can also be credited. This results in a value for pc' equal to that for HPRA. (The end state for tree e is all that changes (from b to c), but the value remains the same (3.0E-03).)

pc'(HPRS) = pc'(HPRA)

As things are under control, recovery due to the extra US/STA can be credited.

Therefore, the total human error probability for failing to switchover to high pressure recirculation upon a SBO and success of AFT, success or failure of RCC, success of AFC, XHR, CNU, RRI, and AF1, and success or failure of CSI is the same as that from HPRA.

THEP(HPRS) = THEP(HPRA)

Fault tree HPR1 is used.

HPRT: Switchover to high pressure recirculation upon a SBO and success of AFT, success or failure of RCC, success of AFC, XHR, CNU, and RRI, failure of AF1, success of PBB, and success or failure of CSI

Although the event tree displays PBB occurring before CSI, the operators must complete CSI before they transfer to any FRPs (i.e., PBF). Therefore, as these paths include success of PBF, there is no dependence to consider.

Failure of the containment spray system is not addressed separately. If CTS failed, operators would have even more time to perform HPR, and it would not be required until much later into the event (i.e., 2 hours following power recovery). The corresponding decrease in stress would be negated by the added stress the operators experience if they notice CTS has failed.

Early failure of RCS cooldown (RCC) is not addressed separately, as this action was performed several hours earlier (long before power restoration), errors of commission were due to the AEO (who will not be involved in HPR), and there have been numerous successes since this time. This early failure should not cause a higher level of stress at this time. RCC failure just mandated earlier power restoration, which was successful.

For this scenario, the operators will transition to FR-H.1 following completion of Step 10 of ECA-0.2. For hydrogen control, the operators may transfer to FR-Z.1 (per caution statement before step 27 of FR-H.1) and then return to FR-H.1. Eventually, the operators will leave FR-H.1 to transfer E-1 or to switchover to recirculation (ES-1.3). The caution statement in FR-H.1 (before step 26) should be their cue to monitor RWST level, with cognitive recovery provided by the alarm. It is assumed that the operator monitoring RWST level will have a high work load, as they will be busy with FR-H.1 and FR-Z.1. This results in a pc' equal to that for HPRB:

pc'(HPRT) = pc'(HPRB)

The extremely high level of stress from primary bleed and feed is conservatively assumed to still exist.

Therefore, the THEP for failing to switchover to high pressure recirculation upon a SBO and success of AFT, success or failure of RCC, success of AFC, XHR, CNU, and RRI, and failure of AF1, success of PBB, and success or failure of CSI is the same as HPRB.

THEP(HPRT) = THEP(HPRB)

Fault tree HPR2 is used.

HPRU: Switchover to high pressure recirculation upon a SBO, success of AFT, success or failure of RCC, failure of AFC, success of XHR and CNU, success of PBB, and success or failure of CSI

See writeup for HPRT. Fault tree HPR2 is used.

This is the same scenario as described in HPRT. AFW has been lost (worse case scenario) for a couple hours before power recovery, and PBB must be initiated right after completion of CSI (i.e., step 10 of ECA-0.2).

Early failure of RCS cooldown (RCC) is not addressed separately, as this action was performed several hours earlier (long before power restoration), errors of commission were due to the AEO (who will not be involved in HPR), and there have been numerous successes since this time. This early failure should not cause a higher level of stress at this time. RCC failure just mandated earlier power restoration, which was successful.

HPRV: Switchover to high pressure recirculation upon a SBO, failure of AFT, success of XHR and CNU, success of PBB, and success or failure of CSI

Although the event tree displays PBB occurring before CSI, the operators must complete CSI before they transfer to any FRPs (i.e., PBF). Therefore, as this path includes success of PBF, there is no dependence to consider.

Failure of the containment spray system is not addressed separately. If CTS failed, operators would have even more time to perform HPR, and it would not be required until much later into the event (i.e., 2 hours following power recovery). The corresponding decrease in stress would be negated by the added stress the operators experience if they notice CTS has failed.

An extemely high level of stress is assumed, as a blackout with failure of the TDAFP is a severe incident for the operators, and switchover is required fairly early in the accident (about 2 hours from loss of power). (This level of stress is also assumed because it follows PBB.) As described in HPRT, a high work load is assumed for the RxO for calculation of pc'.

Therefore, the THEP for failing to switchover to high pressure recirculation upon a SBO, failure of AFT, success of XHR and CNU, success of PBB, and success or failure of CSI is the same as HPRT.

THEP(HPRV) = THEP(HPRT) = THEP(HPRB)

Fault tree HPR2 is used.

HPRW: Switchover to high pressure recirculation upon a loss of CCW or ESW and success of RCP and RR2

(CSI status is not addressed. If CSI failed, operators would have even more time to perform HPR, and it would not be required until much later into the event. The corresponding decrease in stress would be negated by the added stress the operators experience if they notice CSI has failed.)

HPR will not be required until very late into the event. Since the RCPs were tripped, seal failure is not actually expected until an hour or two into the event (see RCP, Section 3.25.2), at which time the containment sprays will be actuated. With both containment spray pumps operating, it takes at least 35 more minutes to reach the RWST low level. A charging pump is started (i.e., RR2A) within 30 minutes of the restoration of CCW/ESW. As a result, HPR is expected after a charging pump has been started in RR2A.

At this point, things are well under control. The small LOCA through the seals is under control and CCW/ESW has been restored. A low work load is considered for the operators by the time HPR is needed. The operators will probably still be in OHP 4022.016.004 when HPR is required, since they will not leave it until after the RCS is cooled and depressurized enough to start RHR. There is not a procedure step to warn the operators to monitor RWST level, but the operators know to monitor this. Only cognitive tree b applies (data not attended to) to this situation. End path 1 from tree b results in a cognitive value of 7.5E-04. No recovery is applied to this value. (Note: the path for high work load was conservatively followed, so this cognitive failure probability can be used for other scenarios.)

pc(HPRW) = 7.5E-04 (HPRW-CSR-COGHE)

It is assumed that only one train of CCW/ESW has been restored, so HPR recovery with the second train is not credible. The operators will go to Attachment A or B of ES-1.3 via step 2 or 3, since both trains of RHR/CCW are not available. The steps in these attachments are similar to the main procedure, except they will align the high head pumps to the one available train of RHR. The critical actions are still the same, with only the step numbers being different. Therefore, for simplicity, the same identifiers are used as before. (Steps 2 and 3 do not need to be evaluated because the operators would be well aware that both trains are not available, and an EOM of step 2 would be recovered by step 3 (as they are on different pages).) Due to the low work load and since things are under control, recovery with the extra US or STA is warranted.

pc(HPRW) = 7.5E-04	(HPRW-CSR-COGHE)
pe'(steps 4a&c) = 2.6E-03 * 2 = 5.2E-03	(REC--4A&C-MHHE)
pe'(step 4d) = 1.3E-03 * 2 = 2.6E-03	(REC----4D-MHHE)
pe'(step 5) = 2.6E-03 * 2 = 5.2E-03	(REC-----5-MHHE)
Recovery, execution errors (extra US and STA) = 0.05	(REC-US STA--HE-L)

The total human error probability for failing to switchover to high pressure recirculation upon a loss of CCW or ESW and success of RCP and RR2 is calculated as shown in fault tree HPR3:

THEP(HPRW) = pc' + [pe'(step 4) + pe'(step 5)] * recovery(extra US or STA)

THEP(HPRW) = 7.5E-04 + [(5.2E-03 + 2.6E-03) + 5.2E-03] * 5.0E-02

THEP(HPRW) = 1.4E-03

3.3.11 HPR Fault Trees Summary

The basic events and cutsets (with support system failures (i.e., SUBs) set equal to 1.0E-03) for the HPR fault trees are listed below.

Fault tree HPR1
(used for HPRA, HPRC, HPRD, HPRE, HPRF, HPRH, HPRS)

```
VER 1.6
 hpr1.cut                                                                         Ver. 1.71  7/25/95   9:07:40
  10     11  1.670E-03  0.000E+00  1.000E-09
                 1  HPRA-LPR-CSRHE          1.5000E-04       0.0000E+00
                 2  REC-US-STA--HE-L        5.0000E-02       0.0000E+00
                 3  REC--4A&C-MHHE          5.2000E-03       0.0000E+00
                 4  REC----4D-MHHE          2.6000E-03       0.0000E+00
                 5  REC-----5-MHHE          5.2000E-03       0.0000E+00
                 6  REC-6THEN5--HE-H        5.0000E-01       0.0000E+00
                 7  REC--6B&D-EHHE-M        1.5000E-01       0.0000E+00
                 8  REC----6E-EHHE          6.5000E-03       0.0000E+00
                 9  REC----6F-EHHE          1.3000E-02       0.0000E+00
                10  SUB-HPR                 1.0000E-03       0.0000E+00
                 1.      1.00E-03    1     SUB-HPR
                 2.      2.60E-04    2     REC-US-STA--HE-L     REC-----5-MHHE
                 3.      1.50E-04    1     HPRA-LPR-CSRHE
                 4.      1.30E-04    3     REC-US-STA--HE-L     REC--4A&C-MHHE       REC-6THEN5--HE-H
                 5.      6.50E-05    3     REC-US-STA--HE-L     REC----4D-MHHE       REC-6THEN5--HE-H
                 6.      3.90E-05    3     REC-US-STA--HE-L     REC--4A&C-MHHE       REC--6B&D-EHHE-M
                 7.      1.95E-05    3     REC-US-STA--HE-L     REC----4D-MHHE       REC--6B&D-EHHE-M
                 8.      3.38E-06    3     REC-US-STA--HE-L     REC--4A&C-MHHE       REC----6F-EHHE
                 9.      1.69E-06    3     REC-US-STA--HE-L     REC----4D-MHHE       REC----6F-EHHE
                10.      1.69E-06    3     REC-US-STA--HE-L     REC--4A&C-MHHE       REC----6E-EHHE
                11.      8.45E-07    3     REC-US-STA--HE-L     REC----4D-MHHE       REC----6E-EHHE
```

Fault tree HPR2
used for HPRB, HPRT, HPRU, HPRV

```
VER 1.6
 hpr2.cut                                                                         Ver. 1.71  7/25/95   9:07:41

  10     11  3.049E-03  0.000E+00  1.000E-09
                 1  HPRB-LPR-CSRHE          7.5000E-04       0.0000E+00
                 2  REC-US-STA--HE-L        5.0000E-02       0.0000E+00
                 3  REC--4A&C-EHHE          1.3000E-02       0.0000E+00
                 4  REC----4D-EHHE          6.5000E-03       0.0000E+00
                 5  REC-----5-EHHE          1.3000E-02       0.0000E+00
                 6  REC-6THEN5--HE-H        5.0000E-01       0.0000E+00
                 7  REC--6B&D-EHHE-M        1.5000E-01       0.0000E+00
                 8  REC----6E-EHHE          6.5000E-03       0.0000E+00
                 9  REC----6F-EHHE          1.3000E-02       0.0000E+00
                10  SUB-HPR                 1.0000E-03       0.0000E+00
                 1.      1.00E-03    1     SUB-HPR
                 2.      7.50E-04    1     HPRB-LPR-CSRHE
                 3.      6.50E-04    2     REC-US-STA--HE-L     REC-----5-EHHE
                 4.      3.25E-04    3     REC-US-STA--HE-L     REC--4A&C-EHHE       REC-6THEN5--HE-H
                 5.      1.63E-04    3     REC-US-STA--HE-L     REC----4D-EHHE       REC-6THEN5--HE-H
                 6.      9.75E-05    3     REC-US-STA--HE-L     REC--4A&C-EHHE       REC--6B&D-EHHE-M
                 7.      4.88E-05    3     REC-US-STA--HE-L     REC----4D-EHHE       REC--6B&D-EHHE-M
                 8.      8.45E-06    3     REC-US-STA--HE-L     REC--4A&C-EHHE       REC----6F-EHHE
                 9.      4.23E-06    3     REC-US-STA--HE-L     REC----4D-EHHE       REC----6F-EHHE
                10.      4.23E-06    3     REC-US-STA--HE-L     REC--4A&C-EHHE       REC----6E-EHHE
                11.      2.11E-06    3     REC-US-STA--HE-L     REC----4D-EHHE       REC----6E-EHHE
```

Fault tree HPR3
used for HPRW

```
VER 1.6
 hpr3.cut                                                  Ver. 1.71  7/25/95   9:07:41

   6     5  2.398E-03  0.000E+00  1.000E-09
              1  SUB-HPR              1.0000E-03     0.0000E+00
              2  HPRW-CSR-COGHE       7.5000E-04     0.0000E+00
              3  REC-US-STA--HE-L     5.0000E-02     0.0000E+00
              4  REC--4A&C-MHHE       5.2000E-03     0.0000E+00
              5  REC----4D-MHHE       2.6000E-03     0.0000E+00
              6  REC-----5-MHHE       5.2000E-03     0.0000E+00
              1.     1.00E-03    1     SUB-HPR
              2.     7.50E-04    1     HPRW-CSR-COGHE
              3.     2.60E-04    2     REC-US-STA--HE-L     REC-----5-MHHE
              4.     2.60E-04    2     REC-US-STA--HE-L     REC--4A&C-MHHE
              5.     1.30E-04    2     REC-US-STA--HE-L     REC----4D-MHHE
```

Fault tree HPR4
used for HPRG

```
VER 1.6
 hpr4.cut                                                  Ver. 1.71  7/25/95   9:07:42

   6     5  1.799E-03  0.000E+00  1.000E-09
              1  SUB-HPR              1.0000E-03     0.0000E+00
              2  HPRA-LPR-CSRHE       1.5000E-04     0.0000E+00
              3  REC-US-STA--HE-L     5.0000E-02     0.0000E+00
              4  REC--4A&C-MHHE       5.2000E-03     0.0000E+00
              5  REC----4D-MHHE       2.6000E-03     0.0000E+00
              6  REC-----5-MHHE       5.2000E-03     0.0000E+00
              1.     1.00E-03    1     SUB-HPR
              2.     2.60E-04    2     REC-US-STA--HE-L     REC-----5-MHHE
              3.     2.60E-04    2     REC-US-STA--HE-L     REC--4A&C-MHHE
              4.     1.50E-04    1     HPRA-LPR-CSRHE
              5.     1.30E-04    2     REC-US-STA--HE-L     REC----4D-MHHE
```

TABLE 3.3-1 - CUE TABLE FOR HPR (High Pressure Cold Leg Recirculation) - SLO			
DIAGNOSIS	**CUE**	**SUCCESS CRITERIA**	**LOCATION**
Respond to RWST low level alarm	Alarm annunciator light	Respond to 1 of 1 alarm	Control room - SPY panel
Monitor RWST level	RWST level < 32%	Recognize symptoms requiring transfer to cold leg recirculation	Control room - SPY panel and BA panel

TABLE 3.3-2 - SUBTASK ANALYSIS FOR HPR (High Pressure Cold Leg Recirculation) - MLO, SLO, SGR, TRA, TRS, SLB, LSP, SBO, SSW, CCW

PROCEDURE		ACTION	INDICATION/ FEEDBACK	LOCATION	POTENTIAL ERRORS
NUMBER	STEP				
EOP ES-1.3, Rev. 2	1	Reset SI	SI status	Control room	Omit action
					Select wrong control for SI reset button
EOP ES-1.3, Rev. 2	4a	Stop 1 of 1 west RHR pump	Pump status	Control room	Omit action
					Select wrong controls for west RHR pump
EOP ES-1.3, Rev. 2	4b	Close 1 of 1 west RHR pump suction valve (1-IMO-320) Close 1 of 1 west RHR pump discharge crosstie valve (1-IMO-324)	Valve position	Control room	Omit actions
					Select wrong valve controls
EOP ES-1.3, Rev. 2	4c	Open 1 of 1 recirc sump valve to west RHR pump	Valve position	Control room	Omit action
					Select wrong controls for recirc sump valve

TABLE 3.3-2 - SUBTASK ANALYSIS FOR HPR (High Pressure Cold Leg Recirculation) - MLO, SLO, SGR, TRA, TRS, SLB, LSP, SBO, SSW, CCW

PROCEDURE		ACTION	INDICATION/ FEEDBACK	LOCATION	POTENTIAL ERRORS
NUMBER	STEP				
EOP ES-1.3, Rev. 2	4d	Start 1 of 1 west RHR pump	Pump status	Control room	Omit action Select wrong controls for west RHR pump
EOP ES-1.3, Rev. 2	5a, c	Reset and close 2 of 2 CCP miniflow valves	Valve switches	Control room	Omit actions Select wrong controls for CCP miniflow valves
EOP ES-1.3, Rev. 2	5d	Verify 2 of 2 North SI pump isolation valves open (1-ICM-260, 1-IMO-316)	Valve switches	Control room	Omit actions Check wrong status lights
EOP ES-1.3, Rev. 2	5e	Verify 2 of 2 south SI pump isolation valves open (1-ICM-265, 1-IMO-326)	Valve switches	Control room	Omit actions Check wrong status lights
EOP ES-1.3, Rev. 2	5f	Close 2 of 2 SI pump discharge crosstie valves (1-IMO-270, 1-IMO-275)	Pump status	Control room	Omit action Select wrong controls for crosstie valves

TABLE 3.3-2 - SUBTASK ANALYSIS FOR HPR (High Pressure Cold Leg Recirculation) - MLO, SLO, SGR, TRA, TKS, SLB, LSP, SBO, SSW, CCW

PROCEDURE		ACTION	INDICATION/ FEEDBACK	LOCATION	POTENTIAL ERRORS
NUMBER	STEP				
EOP ES-1.3, Rev. 2	5h	Close 2 of 2 SI pump recirculation valves to RWST (1-IMO-262, 1-IMO-263)	Valve switches	Control room	Omit actions
					Select wrong controls for SI pump recirc valves
EOP ES-1.3, Rev. 2	5i	Open 1 of 1 SI pump suction valve from west RHR Hx (1-IMO-350)	Valve switches	Control room	Omit actions
					Select wrong controls for SI pump suction valve
EOP ES-1.3, Rev. 2	5j	Open 2 of 2 SI pump suction crosstie valves to CCP (1-IMO-361, 1-IMO-362)	Valve switches	Control room	Omit actions
					Select wrong controls for SI pump suction valves
EOP ES-1.3, Rev. 2	5l	Close 1 of 1 SI pump suction valve from RWST (1-IMO-261)	Valve switch	Control room	Omit action
					Select wrong controls for SI pump suction valve

TABLE 3.3-2 - SUBTASK ANALYSIS FOR HPR (High Pressure Cold Leg Recirculation) - MLO, SLO, SGR, TRA, TRS, SLB, LSP, SBO, SSW, CCW					
PROCEDURE		ACTION	INDICATION/ FEEDBACK	LOCATION	POTENTIAL ERRORS
NUMBER	STEP				
EOP ES-1.3, Rev. 2	5m	Close 2 of 2 CCP suction valves from RWST (1-IMO-910, 1-IMO-911)	Valve switches	Control room	Omit 1 of 2 actions
					Select wrong controls for CCP suction valves
EOP ES-1.3, Rev. 2	5n	Verify 1 of 2 CCPs running in recirc mode	Pump status	Control room	Omit 2 of 2 actions
					Select wrong controls for CCPs
EOP ES-1.3, Rev. 2	5o	Verify 1 of 2 SI pumps running in recirc mode	Pump status	Control room	Omit 2 of 2 actions
					Select wrong controls for SI pump
EOP ES-1.3, Rev. 2	6b	Stop 1 of 1 east RHR pump	Pump status	Control room	Omit action
					Select wrong controls for east RHR pump

TABLE 3.3-2 - SUBTASK ANALYSIS FOR HPR (High Pressure Cold Leg Recirculation) - MLO, SLO, SGR, TRA, TRS, SLB, LSP, SBO, SSW, CCW					
PROCEDURE		ACTION	INDICATION/ FEEDBACK	LOCATION	POTENTIAL ERRORS
NUMBER	STEP				
EOP ES-1.3, Rev. 2	6c	Close 1 of 1 east RHR pump suction valve (i-IMO-310) Close 1 of 1 east RHR pump discharge crosstie valve (1-IMO-314)	Valve position	Control room	Omit actions Select wrong valve controls
EOP ES-1.3, Rev. 2	6d	Open 1 of 1 recirc sump valve to east RHR/CTS pump (1-ICM-305)	Valve position	Control room	Omit action Select wrong controls for recirc sump valve
EOP ES-1.3, Rev. 2	6e	Start 1 of 1 east RHR pump	Pump status	Control room	Omit action Select wrong controls for east RHR pump
EOP ES-1.3, Rev. 2	6f	Open 1 of 1 CCP suction valve from east RHR Hx (1-IMO-340)	Valve position	Control room	Omit action Select wrong controls for CCP suction valve

TABLE 3.3-3
WORKSHEET FOR CALCULATION OF p_c

Scenario: Small LOCA with success of ECCS high pressure injection (HP2), success of RCS cooldown using AFW (AF4), and success of containment spray injection (CSI)

HI: HPR - Switchover to high pressure cold leg recirculation

Cue(s): RWST at low level (alarm)

Duration of time window available for action (T_W): 340 Seconds.
17 min - 680 sec = 340 sec (per Reference 26, actions take 680 sec)

Approximate start time for T_W: 30 min

Procedure and step governing HI: Caution statement at beginning of ES-1.2

A. Initial Estimate of p_c

	p_c Failure Mechanism	Branch	HEP
p_ca:	Availability of information	a/b	neg.
p_cb:	Failure of attention The RxO should not have much distracting him at this point following a small LOCA (per operator interviews).	d	1.5E-4
p_cc:	Misread/miscommunicate data no data communicated - just instruction to watch level	n/a	n/a
p_cd:	Information misleading	a	neg.
p_ce:	Skip a step in procedure Caution statement is italicized and in all CAPS.	b	3.0E-3
p_cf:	Misinterpret instruction	a	neg.
p_cg:	Misinterpret decision logic	k	neg.
p_ch:	Deliberate violation	a	neg.

Sum of p_ca through p_ch = **Initial p_c** 3.1E-3

Total reduction in T_W = ______ min.

Effective T_W = ______ min.

Check here if recovery credit claimed on page 2: xx

Notes:
There are two RWST level indicators for the operators to use, a chart recorder and an indicator that is very easy to read.

TABLE 3.3-4
WORKSHEET FOR CALCULATION OF p_c RECOVERY FACTORS

Scenario: Small LOCA with success of ECCS high pressure injection (HP2), success of RCS cooldown using AFW (AF4), and success of containment spray injection (CSI)

HI: HPR - Switchover to high pressure cold leg recirculation

B. Recovery Factors Identified:

Alarm at low RWST level (did not credit this for b, because credit for alarm already in tree

C. Recovery Factors Applied to p_c

p_c Failure Mechanism	Initial HEP	Recovery Factor	Multiply by:	Final Value
$p_c a$				
$p_c b$	1.5E-4			1.5E-4
$p_c c$				
$p_c d$				
$p_c e$	3.0E-03	alarm T20-23(1)	.0001	3.0E-7
	This is probably the only alarm going off, and at time much later than the initial alarms, so it will get more attention. Also, this red dot alarm is trained on as a high priority alarm.			
$p_c f$				
$p_c g$				
$p_c h$				

Sum of recovered $p_c a$ through $p_c h$ = **Recovered p_c** 1.5E-4

Time at which all recovery factors effective t=30 min

3.5 OLI - DEPRESSURIZATION TO ALLOW LOW PRESSURE INJECTION

3.5.1 Application

Medium LOCA (MLO) with failure of high pressure injection (HP2) - OLIA (JMR)

3.5.2 Description

Following the occurrence of a medium LOCA, if the high head pumps fail to start or fail to provide adequate cooling (HP2), the operators, by following emergency operating procedures, would be directed to depressurize the primary system to below the shutoff head of the RHR pumps to allow the RHR pumps to inject water to the core. The most effective means to perform this action is a rapid secondary depressurization (Reference 4a). If the RCPs are not all running, other actions include starting RCPs to provide forced two-phase flow through the core and/or opening the pressurizer PORVs to depressurize the RCS.

3.5.3 Success Criteria and Timing Analysis

Success of this event requires 450 gpm ($240x10^3$ PPH per EOPs) of AFW flow for the duration of the accident. Success criteria of improved core cooling and increasing vessel inventory is achieved by actions of dumping steam from at least two of four steam generators and/or at least two of three pressurizer PORVs. These actions will allow for the start (or verify running) of at least one of two RHR pumps.

The MLO Event Tree description in the Event Tree Notebook provides a detailed description of the timing analysis assumed for meeting the success criteria of this event. The success criteria is based on the identification of inadequate core cooling (ICC) symptoms (high core exit TC indication) at around 30 minutes following MLO event initiation (Reference 25, MLO-35 example). Upon identification of ICC symptoms, the operators should be ready to perform the rapid cooldown with little time delay and then perform the remaining actions. Operator actions are provided in EOP FR-C.1.

3.5.4 Procedures

The Emergency Operating Procedure used to perform this task is FR-C.1, RESPONSE TO INADEQUATE CORE COOLING, Rev. 4.

FR-C.1 is entered from F-0.2, Core COOLING Critical Safety Function Status Tree on a RED condition.

For this event, entry into FR-C.1 will occur from the STA recognizing the red path from F-0.2. Operators will review the red path summary from the foldout pages when they transfer to E-1 from step 25 of E-0 and when they transfer to ES-1.2 from step 14 of E-1, but this is conservatively not credited.

3.5.5 Critical And Recovery Actions

The following are the primary tasks which must be completed for success of the MLO event tree OLI top event:

1. Recognize core exit TC indications greater than 1200°F on the F-0.2, CORE

COOLING Critical Safety Function Status Tree or on the red path summary (Item 2b on foldout) (cognitive)

2. Start RHR pumps (Step 5 of FR-C.1) (Per operator interviews, the RHR pumps will probably still be running, but starting them is conservatively modelled.)

3. Initiate RCS cooldown at maximum rate using SG steam relief valves (conservatively not taking credit for condenser steam dump) (Step 13 of FR-C.1)

See Table 3.5-1, Cue Table for OLI for identification of symptoms for OLI actions

See Table 3.5-2, Subtask Analysis For OLI for identification of critical or relevant recovery actions for OLI.

3.5.6 Assumptions

This action will be required at about the same time that switchover to recirculation will be required. Many factors influence which will come first, therefore, it is conservatively assumed that OLI precedes LPR and CSR. (This is conservative because OLI has a much higher THEP than LPR or CSR.)

3.5.7 Significant Operator Interview Findings

1. The STA will monitor the core exit thermocouple temperatures using the plant process computer, unless conditions are abnormal, upon which they will also monitor indication on the control room back panels.

2. The RCPs would be running when the operators reach step 12 of FR-C.1. (They will only stop the RCPs upon a medium LOCA if RCS pressure is less than 1250 psig and high head injection is available.) Since the pumps are already running when they reach this step ("Check if RCPs Should Be Started"), they will go on to step 13. Therefore, they will not open the pressurizer PORVs (RNO column for step 12).

3. The RHR pumps will probably still be running when the operators enter FR-C.1.

3.5.8 Calculation of Cognitive Error

A cognitive model was used to address diagnosis type errors (Reference 21). Table 3.5-3 contains the calculation of the cognitive human error probability, pc, that the STA fails to recognize the red path core cooling conditions. Pc was calculated in Table 3.5-3 to be 6.0E-03. Recovery was not applied to this value.

3.5.9 Calculation of Execution Error

For the calculation of execution errors, the tables from Chapter 20 of Reference 2 were used. (T20-x refers to Table 20-x of Reference 2.) The critical actions identified in Table 3.5-2 were reviewed to determine the dominant critical actions to be quantified. Critical actions are not dominant if they are recovered by other procedure steps or if they follow a mechanical failure because the human error probability would be multiplied by another human error probability or a mechanical failure probability. Attachment OLI is a copy of the relevant portion of FR-H.1, with dominant critical steps circled. The reasons why the other critical steps (identified in Table 3.5-2) are not dominant are also included.

Step 13. Initiate RCS Cooldown to 200°F:

13b Manually dump steam from intact SG(s) using steam relief valves

Errors of Omission:

Omit step/page:

4.2E-03 (T20-7 #4, Assumption G)

Step 13 of procedure

Errors of Commission:

Select wrong control when it is dissimilar to adjacent controls:

1.3E-03 (Table 20-12, #3)

The level and relief valve controls for the steam generators are well marked and different from adjacent controls on the steam generator panels. The only truly credible failure would be selecting the level control rather than the relief control.

3.5.10 Calculation of Total Human Error Probability for Failure to Depressurize (OLI)

The cognitive and execution error probabilities were calculated in sections 3.5.8 and 3.5.9 to be:

pc'(OLIA) = 6.0E-03
pe(OLI) = 5.5E-03 (without stress or dependence)

OLIA: Depressurize and Start RHR following a medium LOCA

An extremely high level of stress is assumed for red path recoveries. Per table 20-16, HEPs should be multiplied by two for moderately high stress for step-by-step tasks, and by 5 for extremely high stress for step-by-step tasks.

pc'(OLIA) = 6.0E-03 (OLI-----COG-HE)
pe'(OLIA) = 5.5E-03 * 5 = 2.8E-02 (OLI---13B-EHHE)

The total human error probability (THEP) for failing to depressurize following a medium LOCA and failure of high pressure injection is:

THEP(OLIA) = pc' + pe'

THEP(OLIA) = 6.0E-03 + 2.8E-02 = 3.4E-02

The corresponding fault tree is OLI1.

3.5.11 OLI Fault Trees Summary

The basic events and cutsets (with support system failures (i.e., SUBs) set equal to 1.0E-03) for the OLI fault tree are listed below.

Fault Tree OLI1
used for OLIA

```
VER 1.6
 oli1.cut                                                              Ver. 1.71  7/25/95   9:07:00

   2     2  3.383E-02  0.000E+00  1.000E-08
              1  OLI-----COG-HE          6.0000E-03      0.0000E+00
              2  OLI---13B-EHHE          2.8000E-02      0.0000E+00
              1.      2.80E-02     1     OLI---13B-EHHE
              2.      6.00E-03     1     OLI-----COG-HE
```

TABLE 3.5-1 - CUE TABLE FOR OLI
(Depressurization and Low Pressure Injection) - MLO

DIAGNOSIS	CUE	SUCCESS CRITERIA	LOCATION
Identify symptoms of inadequate core cooling on foldout page or on F-0.2, Core Cooling Status Tree	Core exit temperature > 1200°F - RED path	Recognize red path for core exit temperature > 1200°F, and transfer to FR-C.1	Control room

TABLE 3.5-2 - SUBTASK ANALYSIS FOR OLI (Depressurization and Low Pressure Injection) - MLO					
PROCEDURE		ACTION	INDICATION/ FEEDBACK	LOCATION	POTENTIAL ERRORS
NUMBER	STEP				
EOP FR-C.1, Rev. 4	5a (RNO)	Start RHR pumps	pump status	Control room	Omit action
					Select wrong controls for RHR pumps
EOP FR-C.1, Rev. 4	13b (RNO)	Dump steam at maximum rate using SG steam relief valves	steam relief valve position indication	Control room	Omit actions
					Select wrong controls for steam relief valves

TABLE 3.5-3
WORKSHEET FOR CALCULATION OF p_c

Scenario: Medium LOCA with success of accumulators and failure of high pressure injection

HI: OLI - Depressurization to allow low pressure injection

Cue(s): Red path conditions - foldout page or status tree

Duration of time window available for action (T_W): ________________ Seconds.

Approximate start time for T_W: 15 minutes

Procedure and step governing HI: F-0.2 Status Tree Red Path (i.e., STA)

A. Initial Estimate of p_c

	p_c Failure Mechanism	Branch	HEP
p_ca:	Availability of information	n/a	n/a
p_cb:	Failure of attention (assume low workload for STA) (per interview, STA will be watching computer screen for core exit thermocouple temperatures until things look abnormal, then they will check indicator on back panel -- per G. Parry, use front panel path for this tree)	e	3.0E-3
p_cc:	Misread/miscommunicate data	n/a	n/a
p_cd:	Information misleading	n/a	n/a
p_ce:	Skip a step in procedure (Status trees are monitored in particular order, and paths are graphically distinct using different colors and line types.)	b	3.0E-3
p_cf:	Misinterpret instruction	a	neg.
p_cg:	Misinterpret decision logic	k/l	neg.
p_ch:	Deliberate violation	a	neg.

Sum of p_ca through p_ch = **Initial p_c** 6.0E-03

Total reduction in T_W = ______ min.
Effective T_W = ______ min.

Check here if recovery credit claimed on page 2: ____

Notes:
Due to inconsistent useage of the foldout pages (per operator interviews), credit is conservatively not given to the US recognizing the red path from the foldout pages.

Attachment HPR

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

CAUTION:

- *ECCS RECIRCULATION FLOW TO RCS MUST BE MAINTAINED AT ALL TIMES.*
- *THE CONTAINMENT SUMP LEVEL (1-NLA-310/1-NLI-311) SHOULD BE GREATER THAN 97% OR THE CONTAINMENT LEVEL (1-NLI-320/1-NLI-321) SHOULD BE GREATER THAN 3% TO OPERATE ECCS IN THE RECIRCULATION MODE.*
- *ANY PUMPS TAKING SUCTION FROM THE RWST SHOULD BE STOPPED UPON RECEIPT OF THE RWST LEVEL LOW-LOW/RHR PUMP TRIP ALARM (ANN 105 DROP 24).*
- *FOLLOWING SI RESET, AUTOMATIC REINITIATION OF SI WILL NOT OCCUR UNTIL REACTOR TRIP BREAKERS ARE CLOSED.*
- *IF OFFSITE POWER IS LOST AFTER SI RESET, MANUAL ACTION MAY BE REQUIRED TO RESTART SAFEGUARDS EQUIPMENT.*
- *IF UNIT WAS IN MODE 4 AT THE ONSET OF THE TRANSIENT, THEN 1-RH-104E AND 1-RH-104W SHOULD BE VERIFIED OPEN.*
- *SWITCHOVER TO RECIRCULATION MAY CAUSE HIGH RADIATION IN THE AUXILIARY BUILDING.* | CS-1

NOTE:

- *FRPs should not be implemented prior to the completion of step 6.*
- *Foldout page should be open.*

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
R 1.	Reset SI Recovered by Steps 4c & 6d - will not be able to open sump valves unless have reset SI.	
___ 2.	Check RHR Pumps - BOTH OPERABLE	IF neither RHR pump is OPERABLE, THEN go to ECA-1.1, LOSS OF EMERGENCY COOLANT RECIRCULATION, Step 1. IF East RHR pump is INOPERABLE, THEN go to Attachment A. IF West RHR pump is INOPERABLE, THEN go to Attachment B.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
___ 3.	Check CCW Pumps - BOTH OPERABLE	IF East CCW pump is INOPERABLE, THEN: a. Stop the East RHR pump and place in PULL-TO-LOCK. b. Go to Attachment A. IF West CCW pump is INOPERABLE, THEN: a. Stop the West RHR pump and place in PULL-TO-LOCK. b. Go to Attachment B.

CAUTION: WHEN CONTROL POWER IS RESTORED FOR VALVE OPERATION, THE CONTROL POWER MUST BE LEFT ON SO ASSOCIATED INTERLOCKS WILL BE OPERABLE.

___ 4. Align West RHR And CTS Pumps For Recirculation:

a. Stop the following pumps and place in PULL-TO-LOCKOUT position:

- West RHR pump
- West CTS pump

b. Close the following valves concurrently:

- R 1-IMO-320, West RHR pump suction valve Recovered by 4c - due to interlock.
- 1-IMO-225, West CTS pump suction valve from RWST
- 1-IMO-324, West RHR pump discharge crosstie valve normally closed (through injection and recirculation)

This Step continued on the next page.

HPR-2

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
	c. Restore control power and open 1-ICM-306, Recirc sump to West RHR/CTS pump valve	c. Perform the following: 1) Open 1-IMO-225, West CTS pump suction valve from RWST. 2) IF West CTS pump was previously running, THEN restart the West CTS pump. IF NOT, THEN place the West CTS pump in NEUTRAL. 3) Go to Attachment B.
	d. Start the West RHR pump	d. IF the West RHR pump can NOT be started, THEN: 1) IF West CTS pump was previously running, restart the West CTS pump. IF NOT, THEN place West CTS pump in NEUTRAL. 2) Go to Attachment B.
	e. Check West CTS pump status - PREVIOUSLY RUNNING 1) Restart the West CTS pump 2) Verify ESW to/from West CTS heat exchanger valves - OPEN: • 1-WMO-715 • 1-WMO-717	e. Place West CTS pump in NEUTRAL

HPR-3

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

CAUTION: • *IF THE SI PUMP MINIFLOW VALVES ARE CLOSED, THEN THE SI PUMPS SHOULD BE STOPPED WHENEVER RCS PRESSURE APPROACHES THEIR SHUTOFF HEAD.*

• *IF RCS PRESSURE INCREASES TO 2000 PSIG, THEN A PRZ PORV SHOULD BE OPENED, AS NECESSARY, TO REDUCE RCS PRESSURE AND MAINTAIN MINIMUM CCP FLOW.*

NOTE: *Minimum total BIT flow for CCP cooling is:*
- *for 1 CCP - 150 gpm (160 gpm for adverse containment)*
- *for 2 CCPs - 275 gpm (280 gpm for adverse containment)*

___ 5. Align SI Pumps And CCPs For Recirculation:

R a. Reset both CCP miniflow valves: Recovered by 5c

- 1-QMO-225
- 1-QMO-226

b. Check total BIT flow - GREATER THAN MINIMUM NEEDED FOR CCP COOLING

b. Perform the following:

1) Stop all but one CCP.

2) IF total BIT flow is greater than 150 gpm (160 gpm for adverse containment), THEN go to step 5c.

IF NOT, THEN open the associated CCP miniflow valve and go to step 5d.

WHEN RCS pressure is less than 1700 psig, THEN close all CCP miniflow valves.

c. Close both CCP miniflow valves:

- 1-QMO-225
- 1-QMO-226

These valves close upon SI signal initiation and only reopen when RCS pressure goes above 2000 psi (ie- they should already be closed).

This Step continued on the next page.

HPR-4

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
	d. Check the following valves for the North SI pump - OPEN • 1-ICM-260, North SI pump discharge to cold legs 1 & 4 normally open valve -AND- • 1-IMO-316, RHR and SI to RCS cold legs valve normally open valve	d. Manually open valves. • 1-ICM-260 • 1-IMO-316 IF either valve remains closed, THEN stop the North SI pump. Go to step 5g.
	e. Check the following valves for the South SI pump - OPEN • 1-ICM-265, South SI pump discharge to cold legs 2 & 3 normally open valve -AND- • 1-IMO-326, RHR and SI to RCS cold legs valve normally open valve	e. Manually open valves. • 1-ICM-265 • 1-IMO-326 IF either valve remains closed, THEN stop the South SI pump. Go to step 5g.
	f. Close SI discharge crosstie valves: • 1-IMO-270 • 1-IMO-275	These valves only need to be closed for a pipe rupture. Pipe rupture frequencies are insignificant.
	g. Check each SI pump flow - GREATER THAN 70 GPM: • 1-IFI-260 • 1-IFI-266	g. Stop affected SI pump(s). WHEN RCS pressure is less than 1425 psig (1150 psig for adverse containment), THEN start SI pump(s).
R	h. Restore control power and close SI pumps recirc to RWST valves: • 1-IMO-262 • 1-IMO-263	Recovered by Steps 5i and 6f due to interlocks.
	(i) Open 1-IMO-350, SI pump suction from West RHR HX valve	i. Locally open 1-IMO-350. DO NOT PROCEED UNTIL 1-IMO-350 IS OPEN.

This Step continued on the next page.

HPR-5

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
	j. Open SI pump suction crosstie to CCP valves: • 1-IMO-361 • 1-IMO-362	
	k. Verify 1-IMO-360, SI pump suction crosstie CCPs - OPEN normally open valve	
	l. Restore control power and close 1-IMO-261, SI pump suction from RWST	Only critical upon check valve failure, which is negligible
	m. Close CCP suction from RWST valves: • 1-IMO-910 • 1-IMO-911	Only critical upon check valve failure, which is negligible
	n. Check CCPs - BOTH RUNNING	n. IF CCPs were stopped because of RWST low-low level, THEN perform the following: 1) Start one CCP. 2) Check total BIT flow - greater than 150 gpm (160 gpm for adverse containment) IF NOT, THEN open associated miniflow valve and go to step 5o. 3) Check RCS pressure - less than 1700 psig IF NOT, THEN go to step 5o. WHEN RCS pressure is less than 1700 psig, THEN restart all CCPs. 4) Start second CCP.

This Step continued on the next page.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
	o. Check SI pumps - BOTH RUNNING	o. IF SI pumps were stopped because of RWST low-low level, THEN perform the following: 1) Check RCS pressure - less than 1425 psig (1150 psig for adverse containment) IF NOT, THEN go to step 6. WHEN RCS pressure is less than 1425 psig (1150 psig for adverse containment, THEN do step 5o. 2) Check SI pump discharge crosstie valves - closed: • 1-IMO-270 -OR- • 1-IMO-275 3) IF SI pump discharge crosstie is isolated, THEN start both SI pumps. IF NOT, THEN start only one SI pump.

HPR-7

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
6	Align East RHR And CTS Pumps For Recirculation:	
	a. Check RWST Level - LESS THAN 10%	a. Continue with step 7. WHEN RWST level drops to 10%, THEN do steps 6b through 6h.
	b. Stop the following pumps and place in PULL-TO-LOCKOUT position: • East RHR pump • East CTS pump	
	c. Close the following valves concurrently: R • 1-IMO-310, East RHR pump suction valve Recovered by Step 6d due to interlock • 1-IMO-215, East CTS pump suction from RWST valve • 1-IMO-314, East RHR pump discharge crosstie valve Normally closed (through injection and recirculation)	
	d. Restore control power and open 1-ICM-305, Recirc sump to East RHR/CTS pump valve	d. Restore control power and close 1-IMO-390, RHR pumps suction from RWST. Go to step 7.
	e. Start the East RHR pump	e. Go to step 6g.
	f. Open 1-IMO-340, CCP suction from East RHR HX valve	
	g. Check East CTS pump - PREVIOUSLY RUNNING 1) Restart the East CTS pump 2) Verify ESW to/from East CTS heat exchanger valves - OPEN • 1-WMO-711 • 1-WMO-713	g. Place East CTS pump in NEUTRAL
	h. Restore control power and close 1-IMO-390, RHR pumps suction from RWST	

HPR-8

Attachment OLI

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
___ 4.	Verify ECCS Valve Alignment - PROPER EMERGENCY ALIGNMENT BY STATUS LIGHTS • 1-SML-11A,B,C • 1-SML-12A,B,C	Manually align valves as necessary.

___ 5.	Verify ECCS Flow In All Systems:
	• BIT flow - ON SCALE:
	  • 1-IFI-51
	  • 1-IFI-52
	  • 1-IFI-53
	  • 1-IFI-54
	• SI pump flow - ON SCALE:
	  • 1-IFI-260
	  • 1-IFI-266
	• RHR HX outlet flow - ON SCALE:
	  • 1-IFI-310 or 311
	  • 1-IFI-320 or 321
		Perform the following:
		a. Start all available ECCS pumps:
		  • CCPs
		  • SI pumps
		  R • RHR pumps - recovered by step 14 (may already be running)
		b. Establish BIT flow from the positive displacement pump (PDP):
		  1) Locally open PDP suction and discharge valves:
		    • 1-CS-304
		    • 1-CS-306
		  2) Start the PDP.
		  3) Adjust 1-QRV-251, CCP flow control valve to allow PDP flow to the BIT.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

NOTE: Normal conditions are desired but not required for starting the RCPs.

per operator interviews, RCP's would still be running, so they would skip this step

___ 12. Check if RCPs Should Be Started:

a. Core exit TCs - GREATER THAN 1200°F.
   - RNO: a. Go to Step 13.

b. Check if an idle RCS cooling loop is available:
   - Narrow range SG level - GREATER THAN 6% (22% FOR ADVERSE CONTAINMENT)
   - RCP in associated loop - AVAILABLE AND NOT OPERATING

   RNO: b. Perform the following:
   1) Open all PRZ PORVs and block valves.
   2) IF core exit TCs remain greater than 1200°F, THEN open other RCS vent paths to containment:
      a) PRZ vent path valves:
         - 1-NSO-61 and 1-NSO-62

           -OR-

         - 1-NSO-63 and 1-NSO-64
      b) Reactor head vent path valves:
         - 1-NSO-21 and 1-NSO-22

           -OR-

         - 1-NSO-23 and 1-NSO-24
   3) Go to Step 13.

c. Start RCP in one idle RCS cooling loop.

d. Return to Step 12a.

1-5

OLI-2

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

CAUTION: DURING COOLDOWN, STEAM FLOW OF GREATER THAN 1.42×10^6 PPH ON TWO OR MORE SGs WILL RESULT IN A STEAMLINE ISOLATION.

NOTE:

- *Partial uncovering of SG tubes is acceptable in the following steps.*
- *Both steam dump control selector switches should be momentarily placed in BYPASS INTERLOCK when Tavg decreases to 541°F.*

13. Initiate RCS Cooldown To 200°F:

a. Transfer condenser steam dump to steam pressure mode

b. Dump steam to condenser from intact SG(s) at maximum rate

   RESPONSE NOT OBTAINED: b. Manually or locally dump steam from intact SG(s) at maximum rate using steam relief valves.

c. Check RCS hot leg temperatures - DECREASING

   RESPONSE NOT OBTAINED: c. Cooldown using faulted or ruptured SG(s).

OLI-3

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
___ 14.	Verify ECCS Flow: • BIT flow - ON SCALE • 1-IFI-51 • 1-IFI-52 • 1-IFI-53 • 1-IFI-54 -OR- • SI pump flow - ON SCALE • 1-IFI-260 • 1-IFI-266 -OR- • RHR HX outlet flow - ON SCALE • 1-IFI-310 or 311 • 1-IFI-320 or 321	Continue efforts to establish ECCS flow. <u>IF</u> BIT flow is <u>NOT</u> on scale <u>AND</u> core exit T/Cs are greater than 1200°F, <u>THEN</u> perform the following: a. Request an immediate Unit 2 shutdown. b. Request Unit 2 establish charging pump operation with suction from the RWST. c. <u>WHEN</u> Unit 2 charging is available and aligned to the RWST, <u>THEN</u> establish BIT flow from Unit 2. Refer to Attachment A.

Recovery for Step 5, since Charging and SI pumps have failed.

OLI-4

FIGURE E-8
HPR1 FAULT TREE

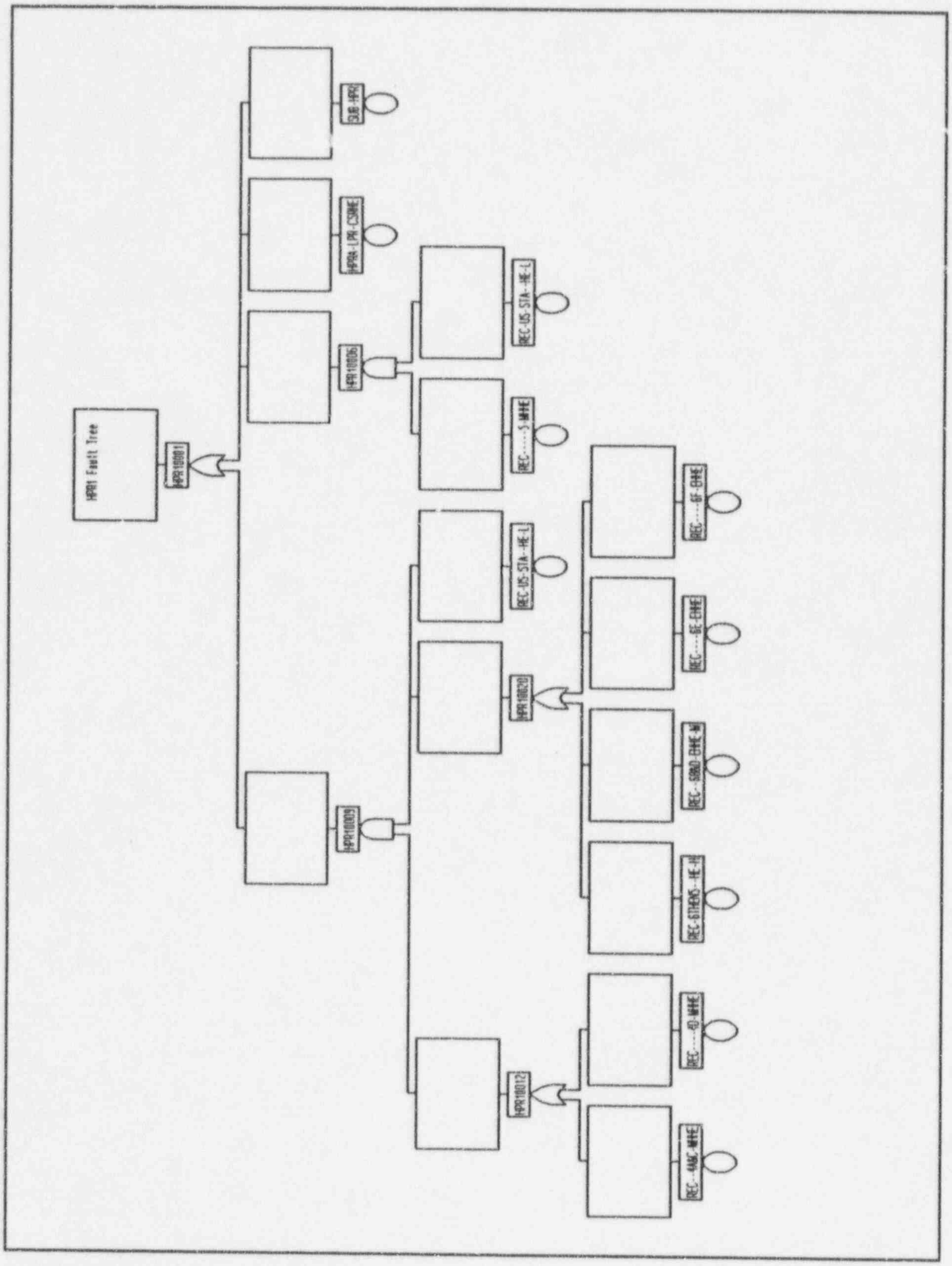


FIGURE E-9
HPR2 FAULT TREE

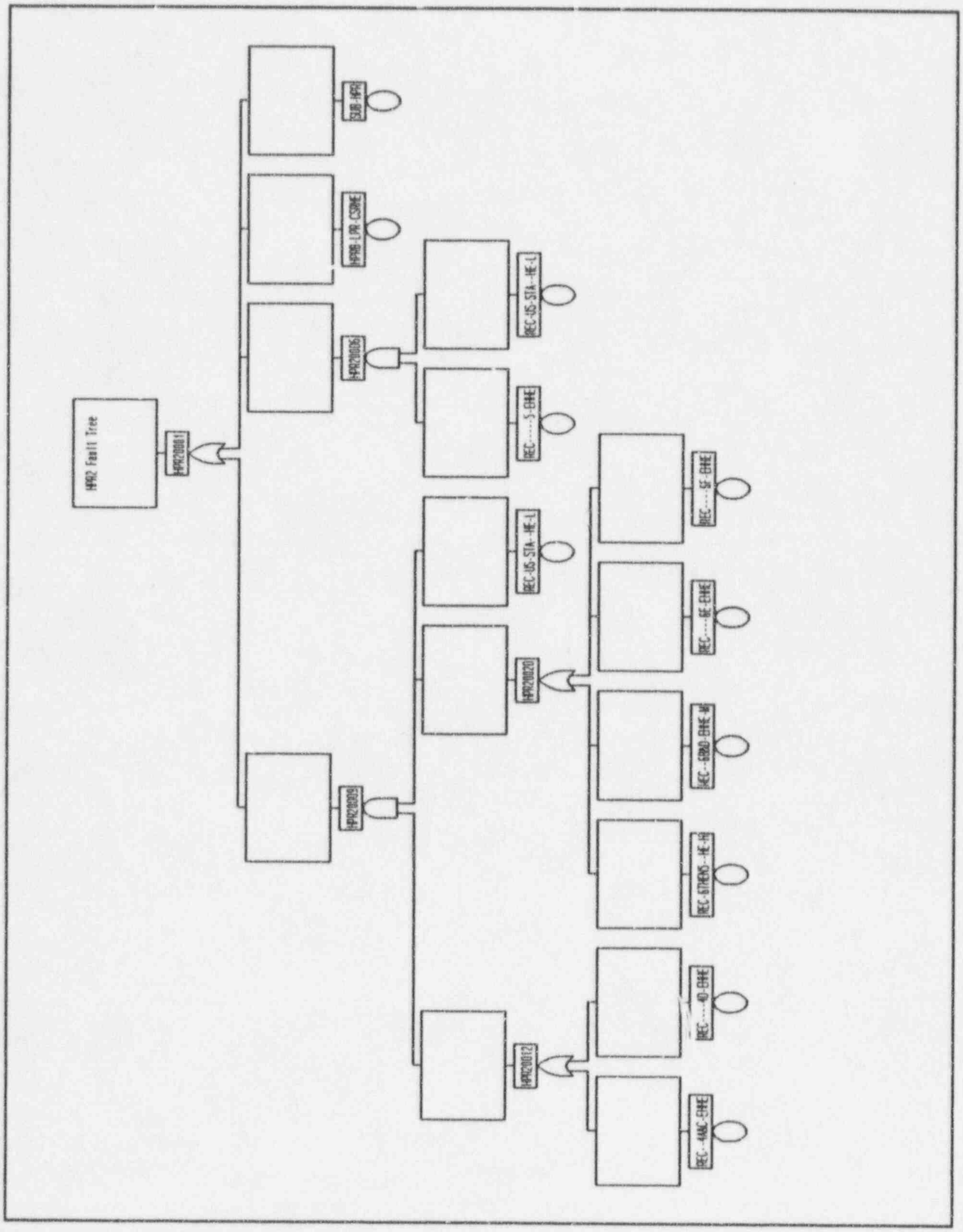


FIGURE E-10
HPR3 FAULT TREE

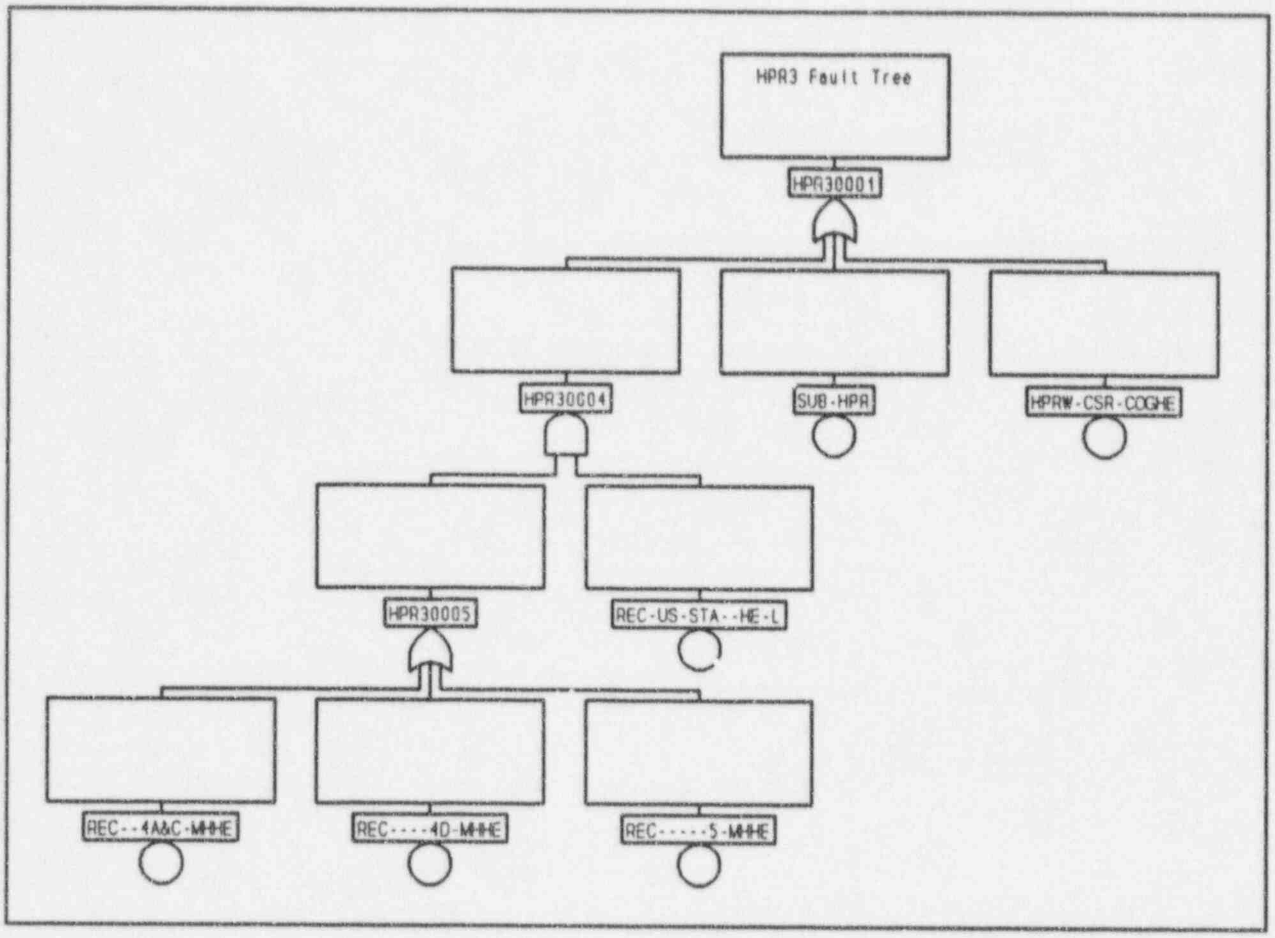
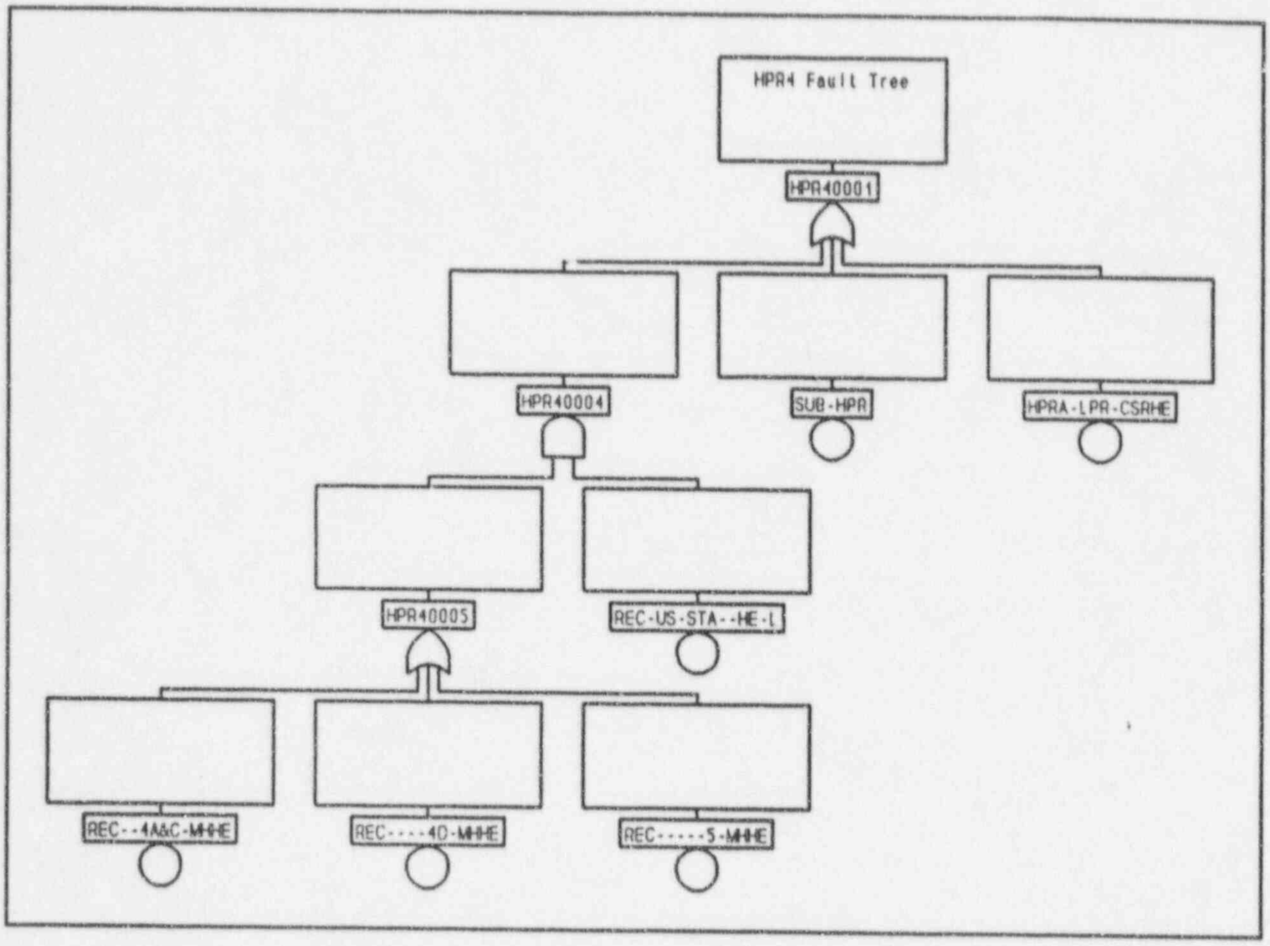


FIGURE E-11
HPR4 FAULT TREE



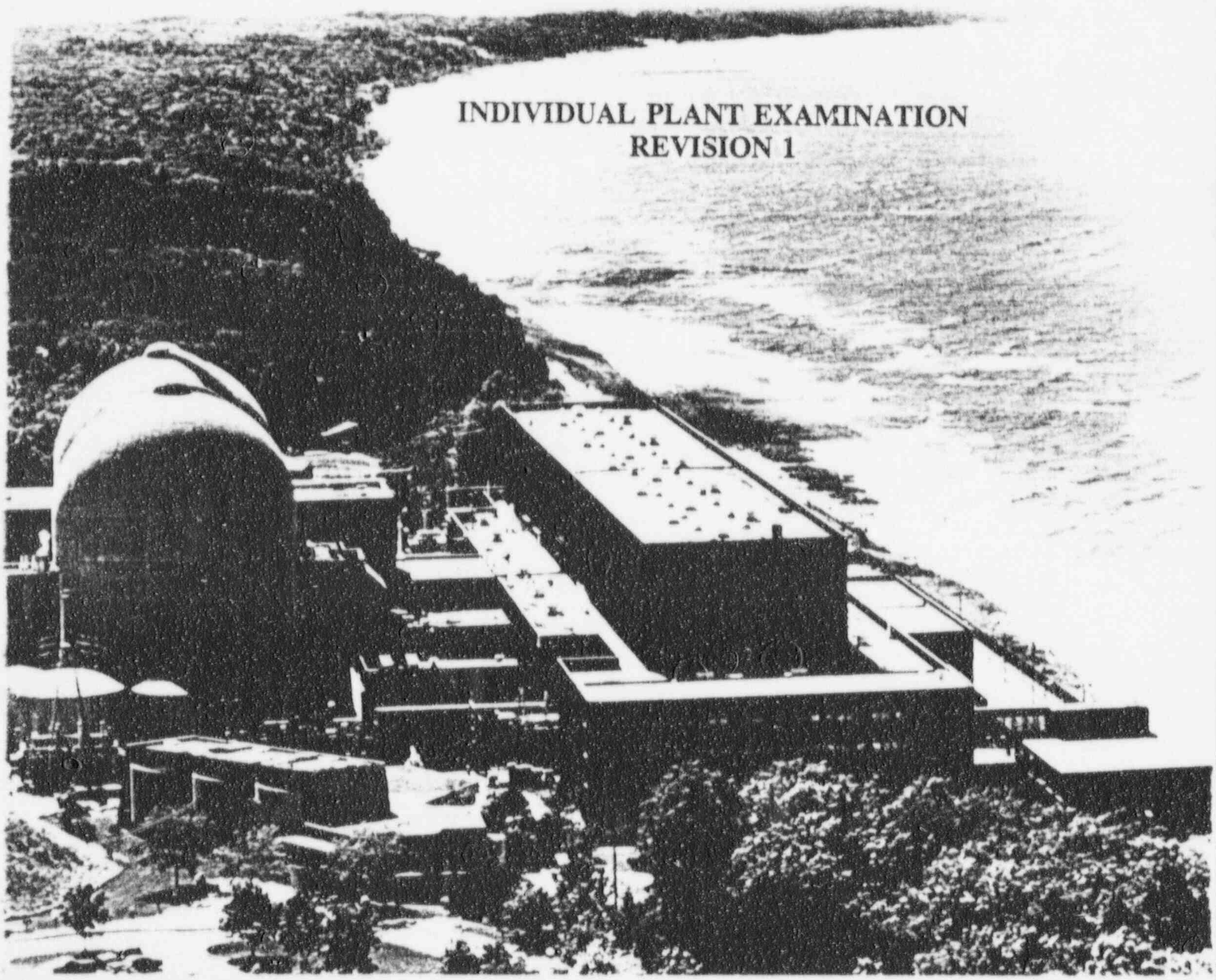
ATTACHMENT 1 TO AEP:NRC:10820

Donald C. Cook Nuclear Plant
Individual Plant Examination

Individual Plant Examination
Revision 1

COOK NUCLEAR PLANT

Bridgman, Michigan



INDIVIDUAL PLANT EXAMINATION
REVISION 1