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Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Grand Gulf, Unit 1

Analysis of Core Damage Frequency from
Internal Events for Plant Operational
State 5 During a Refueling Outage

Main Report (Section 10)

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Main Report (Section 10)

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Abstract

During 1989 the Nuclear Regulatory Commission (NRC) initiated an extensive program to carefully examine the potential risks during low power and shutdown operations. Two plants, Surry (pressurized water reactor) and Grand Gulf (boiling water reactor), were selected as the plants to be studied. The program consists of two parallel projects being performed by Brookhaven National Laboratory (Surry) and Sandia National Laboratories (Grand Gulf).

The program objectives include assessing the risks of severe accidents initiated during plant operational states other than full power operation and comparing the estimated core damage frequencies, important accident sequences, and other qualitative and quantitative results with those accidents initiated during full power operation as assessed in NUREG-1150. The scope of the program includes that of a Level-3 PRA.

A phased approach was used in the Level-1 program. In Phase 1 the concept of plant operational states (POSs) was developed to allow the analysts to better represent the plant as it transitions from power operation to non power operation than was possible with the traditional Technical Specification divisions of Modes of Operation. This phase consisted of a coarse screening analysis performed for all POSs. The objective of the Phase 1 study was to identify potential vulnerable plant configurations, to characterize (on a high, medium, or low basis) the potential core damage accident scenario frequencies, and to provide a foundation for a detailed Phase 2 analysis.

In Phase 2 POS 5 (approximately Cold Shutdown as defined by Grand Gulf Technical Specifications) during a refueling outage was selected as the plant configuration to be analyzed based on the results of the Phase 1 study. The scope of the Level-1 study includes plant damage state analysis and uncertainty analysis and is documented in a multi-volume NUREG/CR report (i.e., NUREG/CR-6143). The internal events analysis is documented in Volume 2. Internal fire and internal flood analyses are documented in Volumes 3 and 4, respectively. A separate study on seismic analysis, documented in Volume 5, was performed for the NRC by Future Resources Associates, Inc. The Level-2/3 study is documented in Volume 6, and a summary of the results for all analyses is documented in Volume 1.

In the Phase 2 study, system models applicable for POS 5 conditions, comprised of POS 5 on the way down to refueling and POS 5 on the way back up from refueling, were developed and supporting thermal hydraulic analyses were performed to determine both the timing of the accidents and success criteria for systems. Initiating events that may occur during POS 5 were identified and accident sequence event trees were developed and quantified. Surviving sequences were examined for recovery potential, appropriate human recovery actions were incorporated into the sequence cut sets, and the sequences were then requantified. Those sequences surviving this preliminary recovery analysis were then reexamined during a "time window" analysis. This time window analysis allows for a more detailed representation (i.e., a more realistic incorporation of the affects of the decrease in decay heat throughout the POS and a more time-specific incorporation of equipment unavailabilities as the plant transitions from the beginning to the end of POS 5) of the potential accident sequences that could occur while the plant is in POS 5.

The mean core damage frequency of the Grand Gulf plant due to internal events for POS 5 during a refueling outage is $2.0\text{E-}06$ per year, and the 5th and 95th percentiles are $4.1\text{E-}07$ and $5.4\text{E-}06$ per year, respectively. This compares to the total core damage frequency of $4.0\text{E-}06$ per year estimated in the NUREG-1150 study of full power operations.

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List of Acronyms

ADHR	Auxiliary Decay Heat Removal
ADS	Automatic Depressurization System
ATWS	Anticipated Transient Without Scram
BNL	Brookhaven National Laboratory
BWR	Boiling Water Reactor
CCW	Component Cooling Water
CDS	Condensate
CI	Containment Isolation
CRD	Control Rod Drive
CRWST	Condensate and Refueling Water Storage Transfer System
CS	Containment Spray
CST	Condensate Storage Tank
CV	Check Valves
CVS	Containment Venting System
DBA	Design Basis Accident
DG	Diesel Generator
ECCS	Emergency Core Cooling Systems
EHC	Electro-Hydraulic Controller
EHV	Emergency Ventilation System
ENSDC	Enhanced Shutdown Cooling
EPS	Emergency Power System
FCV	Flow Control Valve
FDW	Feed Water System
FW	Fire Water
HCU	Hydraulic Control Unit
HPCS	High Pressure Core Spray
IAS	Instrument Air System
IRRAS	Integrated Reliability and Risk Analysis System
LCO	Limiting Condition of Operation
LOCA	Loss of Coolant Accident
LPCI	Low Pressure Coolant Injection
LPCS	Low Pressure Core Spray
MSIV	Main Steam Isolation Valve
MSL	Mean Sea Level
MSR	Moisture Separator Reheater
NPSHA	Net Positive Suction Head Available
NPSHR	Net Positive Suction Head Required
NRC	Nuclear Regulatory Commission
OC	Operating Condition
POS	Plant Operating State
PRA	Probabilistic Risk Assessment
PSW	Plant Service Water
PWR	Pressurized Water Reactor
RCIC	Reactor Core Isolation Cooling
RES	Research (Office of NRC)
RFPT	Reactor Feedwater Pump Turbine
RHR	Residual Heat removal
RPV	Reactor Pressure Vessel
RRS	Reactor Recirculation System
RWCU	Reactor Water Cleanup System
SDC	Shutdown Cooling System(s)
SGTS	Standby Gas Treatment System

List of Acronyms (Continued)

SL	Safety Limit
SLC	Standby Liquid Control
SP	Suppression Pool
SPC	Suppression Pool Cooling
SPMU	Suppression Pool Makeup
SPMU	Suppression Pool Makeup
SR	Surveillance Requirement
SRV	Safety Relief Valve
SSWXT	Standby Service Water Crosstie
TBCW	Turbine Building Cooling Water
TBV	Turbine Bypass Valve(s)
UFSAR	Updated Final Safety Analysis Report

Foreword

(NUREG/CR-6143 and 6144) Low Power and Shutdown Probabilistic Risk Assessment Program

Traditionally, probabilistic risk assessments (PRA) of severe accidents in nuclear power plants have considered initiating events potentially occurring only during full power operation. Some previous screening analyses that were performed for other modes of operation suggested that risks during those modes were small relative to full power operation. However, more recent studies and operational experience have implied that accidents during low power and shutdown could be significant contributors to risk.

During 1989, the Nuclear Regulatory Commission (NRC) initiated an extensive program to carefully examine the potential risks during low power and shutdown operations. The program includes two parallel projects performed by Brookhaven National Laboratory (BNL) and Sandia National Laboratories (SNL), with the seismic analysis performed by Future Resources Associates. Two plants, Surry (pressurized water reactor) and Grand Gulf (boiling water reactor), were selected as the plants to be studied.

The objectives of the program are to assess the risks of severe accidents due to internal events, internal fires, internal floods, and seismic events initiated during plant operational states other than full power operation and to compare the estimated core damage frequencies, important accident sequences and other qualitative and quantitative results with those accidents initiated during full power operation as assessed in NUREG-1150. The scope of the program includes that of a level-3 PRA.

The results of the program are documented in two reports, NUREG/CR-6143 and 6144. The reports are organized as follows:

For Grand Gulf:

NUREG/CR-6143 - Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Grand Gulf, Unit 1

- Volume 1: Summary of Results
- Volume 2: Analysis of Core Damage Frequency from Internal Events for Plant Operational State 5 During a Refueling Outage
 - Part 1: Main Report
 - Part 1A: Sections 1 - 9
 - Part 1B: Section 10
 - Part 1C: Sections 11 - 14
 - Part 2: Internal Events Appendices A to H
 - Part 3: Internal Events Appendices I and J
 - Part 4: Internal Events Appendices K to M
- Volume 3: Analysis of Core Damage Frequency from Internal Fire Events for Plant Operational State 5 During a Refueling Outage
- Volume 4: Analysis of Core Damage Frequency from Internal Flooding Events for Plant Operational State 5 During a Refueling Outage
- Volume 5: Analysis of Core Damage Frequency from Seismic Events for Plant Operational State 5 During a Refueling Outage
- Volume 6: Evaluation of Severe Accident Risks for Plant Operational State 5 During a Refueling Outage
 - Part 1: Main Report
 - Part 2: Supporting MELCOR Calculations

Foreword (Continued)

For Surry:

NUREG/CR-6144 - Evaluation of Potential Severe Accidents During Low Power and Shutdown Operations at Surry Unit-1

- Volume 1: Summary of Results
- Volume 2: Analysis of Core Damage Frequency from Internal Events During Mid-loop Operations
 - Part 1: Main Report
 - Part 1A: Chapters 1 - 6
 - Part 1B: Chapters 7 - 12
 - Part 2: Internal Events Appendices A to D
 - Part 3: Internal Events Appendix E
 - Part 3A: Sections E.1 - E.8
 - Part 3B: Sections E.9 - E.16
 - Part 4: Internal Events Appendices F to H
 - Part 5: Internal Events Appendix I
- Volume 3: Analysis of Core Damage Frequency from Internal Fires During Mid-loop Operations
 - Part 1: Main Report
 - Part 2: Appendices
- Volume 4: Analysis of Core Damage Frequency from Internal Floods During Mid-loop Operations
- Volume 5: Analysis of Core Damage Frequency from Seismic Events During Mid-loop Operations
- Volume 6: Evaluation of Severe Accident Risks During Mid-loop Operations
 - Part 1: Main Report
 - Part 2: Appendices

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10 Human Reliability Analysis

This section of the report describes the Human Reliability Analysis (HRA) performed for the detailed study of POS 5. The general methodology used for conducting the HRA and determining the Human Error Probabilities (HEPs) for the identified human actions was the Accident Sequence Evaluation Program Human Reliability Analysis Procedure (ASEP HRAP) [Swain, 1987]. The ASEP HRAP was selected for several reasons:

- (1) The HEPs obtained using the procedure are considered to be slightly conservative relative to those that would be obtained from other methodologies such as THERP [Swain and Guttman, 1983]. Conservative HEP estimates were considered desirable because existing HRA methodologies have not explicitly considered the impact of potentially unique performance influencing factors (PIFs) which might be operative during low power and shutdown (LP&S) conditions.
- (2) The ASEP HRAP was used in the full power PRA performed at the Grand Gulf Nuclear Station (GGNS) as part of NUREG/CR-1150 [USNRC, 1989]. By using the same methodology in the present study, comparisons between related full power and LP&S HEPs may be possible. Such comparisons may provide insights regarding differences in operator behavior during the different modes of operation, and in how the behavior should be quantified. In addition, the HEPs for the pre-accident human actions used in the present study were taken directly from the GGNS PRA [Drouin, et al., 1989]. Thus, at least some degree of methodological internal consistency is maintained across the HEPs for the pre- and post-accident tasks.
- (3) The ASEP HRAP is straightforward to use and has been shown to produce internally consistent HEPs that appear to reflect at least the relative potential of human failures in the nuclear power plant environment. Internal consistency would seem to be an important factor for the LP&S domain, where a complete PRA has not previously been performed.
- (4) The procedure allows for straightforward adjustments in HEPs as a function of the results from interviews with plant personnel. In

situations such as LP&S, where procedures may not be all encompassing, the results of interviews with operators and other plant personnel become a critical aspect of the HRA.

10.1 General Methodology and Scope

In general, the HRA data collection and analysis process outlined in the ASEP HRAP was followed. As noted above, however, the pre-accident human actions included in the analysis used the same HEP values that were used in the PRA of GGNS reported in NUREG/CR-4550, Vol. 6, Rev. 1. Thus, less emphasis was placed on collecting information relevant to pre-accident human action quantification. Nevertheless, procedures related to control of work on plant equipment and facilities, protective tagging systems, outage organization, shutdown protection plans, and surveillance on shutdown related systems were obtained from GGNS and examined.

To obtain information relevant to analyzing the post-accident human actions, interviews with operators and other plant personnel were conducted over a two-day period. Since the GGNS simulator was not capable of simulating most of the relevant LP&S accident sequences investigated, several current or former GGNS operators (individually or in one case a group of three) were verbally presented with various relevant scenarios and asked how they (the control room crew) would respond to the described situations. They were also asked what indications would be available to aid them in diagnosing the situation and which procedures (if any) would be relevant. While all the scenarios analyzed in the PRA could not be covered in the interviews, most of the critical operator actions analyzed were discussed with the operators. Follow-up information and additional data regarding operator actions and time requirements for specific operator actions (both inside and outside the control room), were obtained through telephone conversations with relevant plant personnel.

The general level of understanding conveyed by plant personnel about the various accident scenarios was used by the HRA analyst in determining the HEPs. In most cases, information obtained from interviews was used in conjunction with ASEP HRAP Table 8-3 in determining whether the nominal (median) HEP or the upper or lower bound value from the ASEP HRAP diagnosis model (Figure 8-1), should be used in estimating the HEP for a

particular diagnosis. In some cases, interview results indicated that operators would simply not do some of the actions included in the event trees. For example, operations personnel indicated that they would not open the MSIVs for "steaming" or "flooding" of the vessel unless there was a vacuum in the condenser. Since a vacuum in the condenser was determined to be very unlikely during POS 5, the relevant operator action was always assumed to fail.

In addition to interviews with operations personnel, outage management personnel and outage training personnel were also interviewed to obtain information concerning general LP&S practices at GGNS, crew composition during LP&S, shift scheduling, and shutdown specific training. All of the relevant GGNS Off-Normal Event Procedures (ONEPs), Emergency Procedures, and system start-up procedures were provided by the plant and used in the analysis. While a human factors analysis of the control room was not conducted, the HRA analyst for the present study had previously participated in full power mode simulator exercises at GGNS and was familiar with the displays and layout of the GGNS control room.

In deriving the HEPs, the ASEP HRAP was in general closely adhered to. Basic human error probabilities for each human action event were determined with the methodology and adjusted according to the rules for applying the Performance Shaping Factors (PSFs) described in the procedure. Deviations from the prescribed methodology were taken only when it was felt that the LP&S environment created a situation that was not well fitted to the ASEP HRAP. For example, the generally long-term scenarios studied under LP&S conditions led the HRA analyst to rarely assess "extremely high" stress, even when the procedure may have called for it, e.g., more than two primary safety systems had failed (Table 8-1, Step 10f, ASEP HRAP). Instances where the procedure was not explicitly followed are discussed in the individual HEP calculation tables (Tables 10.1.1 through 10.1.126).

10.2 Pre-Accident Human Reliability Analysis

Pre-accident human actions (i.e., those human actions which occur before the start of an accident that can interfere with the successful response to an initiating event by rendering needed systems unavailable), were considered for all the systems analyzed in this study. Most of the pre-accident actions used in this study were

the same as those used in the NUREG/CR-4550 study of GGNS and the HEPs for those events were taken directly from NUREG/CR-4550, Vol. 6, Rev.1. Additional pre-accident events added to the present study were quantified by using the highest value assigned to a comparable action identified in the NUREG/CR-4550. Table 10.2.1 displays the pre-accident human errors used in the study and their failure probabilities.

The pre-accident human actions consisted of instrumentation miscalibrations and failures in restoring systems after repair or maintenance. Detailed analyses and modeling of potential misalignments of systems (errors of commission) that could lead to initiating events or latent system unavailabilities specific to the LP&S environment were not conducted in the present study. An attempt was made, however, to include the contribution of human induced initiating events in the overall initiating event frequencies (see Section 4).

10.3 Post-Accident Human Reliability Analysis

10.3.1 Incorporation of Post-Accident Human Actions into PRA Models

In comparison with full power PRAs, the low decay heat levels present during LP&S conditions result in a relatively large number of ways by which cooling can be provided to the core. In addition, because less stringent requirements are imposed on operability by the technical specifications for shutdown conditions, the availability of plant systems is more difficult to specify. These aspects led to the use of "generic" event trees in performing the PRA. The use of generic event trees allows more or less the same event trees to be used in representing the system and operator responses to all initiating events.

The resulting event trees, however, were somewhat more complex and lengthy, and contained more complex operator diagnosis/action events than are typically found in full power PRAs. In full power PRAs, many of the operator action events simply involve the manual initiation of a system that has failed to auto-initiate. For such events, the indications and related operator diagnoses/actions are approximately the same regardless of the accident scenario in which they occur. However, in the LP&S environment many of the potential operator actions are not strictly proceduralized and not always explicitly covered in the Emergency Procedures. Moreover, diagnosis and performance of many of the operator actions is dependent on the initiator and on what

has occurred or failed to occur previously in the accident sequence. Therefore, in order to accomplish a reasonably valid HRA analysis, it was necessary to do a sequence by sequence analysis of the human actions contained in the event and fault trees and to attempt to account for the dependencies among the different operator actions.

10.3.2 Treatment of Dependencies and Non-Proceduralized Actions

Several general guidelines were used in the treatment of non-proceduralized operator diagnoses/actions and dependencies across operator actions within an accident scenario. The guidelines included the following:

- (1) In general, credit was given for operators correctly diagnosing and carrying out a non-proceduralized action if, on the basis of the site interviews, it was judged that the operators had a clear understanding of the event in question and of the requirements for responding to the event.
- (2) In most cases, credit would not be given for a non-proceduralized action if a critical human action, clearly indicated by procedure, had failed in the sequence being analyzed and the pattern of failures across the sequence suggested operator "confusion".
- (3) In determining the requirements for a particular operator diagnosis/action, any logically necessary human actions which had failed in earlier events were included in the subsequent event, e.g., manual system isolations necessary for success.
- (4) Complete or zero dependence across events in a sequence was assigned as a function of the logical relationship between those events. For example, in a given human action event, it may have been possible for an operator to use any of several systems to respond to the problem. However, if limited time was available for the event being analyzed, credit for trying all the available systems may not have been taken at that point. Therefore, any subsequent events which assumed that a particular system had or had not been used would be set to succeed or fail accordingly.

The above guidelines often required subjective judgments on the part of the HRA analyst. These judgments were based on the impressions drawn from the interviews with plant personnel, on examinations of the relevant

procedures, and on the basis of discussions with the other analysts on the PRA team. Specific assumptions concerning dependence among actions and judgements regarding the potential success of non-proceduralized actions are documented in the individual HEP calculation tables (Tables 10.1.1 through 10.1.126).

10.3.3 Results of the Post-Accident Human Reliability Analysis

Since generic event trees were used for the PRA, the operator actions asked in the analysis of the accident sequences for the different initiators were in general the same. However, because the various initiators have differing impacts on the system and therefore the nature of the accident sequences, the HEP for the same operator action could vary across initiators. Furthermore, the HEP for the same operator action could also vary within the analysis of a particular initiator as a function of the different system and operator successes and failures occurring in the different sequences. Therefore, multiple HEPs were possible for a given operator action.

In order to document which particular HEP was used for a given operator action in a given sequence for a given initiator, Tables 10.3.1 through 10.3.31 was created. These tables present for each initiator a listing of each of the operator actions included in the analysis, the associated HEP number, and a sequence locator file name. The sequence locator file provides a brief description of the sequence context in which the HEP was applied, identifies the relevant sequences, and lists the associated HEPs and error factors. The sequence locator files can be found in Appendix K.

The calculation and supporting rationale for each of the individual HEPs using the ASEP HRAP procedure is presented in Tables 10.1.1 through 10.1.126. Each HEP is numbered. A simple listing (sorted by HEP number) of each of the post-accident human actions, its mean HEP, and its associated error factor is presented in Table 10.3.32. Identical information is presented in Table 10.3.33, but the data is sorted alphanumerically by human action identifier. According to the ASEP HRAP, the HEPs obtained with the ASEP HRAP procedure are assumed to be median values from a lognormal distribution. The median values were converted to means for use in the analysis using the following formula:

$$\text{Mean} = \text{Median} \cdot \exp [\ln \text{Error Factor}]^{2/5.412}$$

10.4 Recovery Actions Analysis

The recovery phase of a PRA analysis usually involves taking credit for human actions that restore or repair failed systems; or that involve the alignment of systems that may be available to respond to the accident, but for some reason were not included in the original analysis. For example, credit for use of the plant Fire Water System to provide makeup to the vessel is often not taken in the basic PRA analysis because of the complexity and length of time required to align the system in some plants.

In the present analysis, while credit was taken for the traditional recovery actions such as restoration of LOSP, the nature of the event trees and the associated HRA analysis sometimes resulted in available systems or safety related actions not being credited during the basic analysis. Thus, where appropriate, credit for such systems and actions were applied to the surviving cut sets during the recovery analysis. The recovery related operator actions were quantified using the ASEP HRAP. A list of the recovery actions, the associated mean HEPs and error factors, and the HEP calculation numbers are presented in Table 10.4.1. The individual HEP calculations and the supporting rationale for each recovery action are found in Tables 10.1.116 through 10.1.126.

10.5 Time Windows

As part of the Time Window Analysis, the core damage sequences surviving the recovery analysis discussed in Section 10.4 were re-examined. This allowed for a more realistic modeling of the surviving POS 5 core damage sequences to account for the change in decay heat loads experienced as the unit transitions from the beginning of POS 5 to the end of POS 5 during a refueling outage. It also made possible the relaxation of the original assumptions regarding the unavailability of Train A ECCS equipment. These two aspects of the Time Window Analysis required that the values assigned to the human actions be re-examined.

As a result of this re-examination, several of the HEP calculations described in Section 10.3 were revised. The revised calculations are presented in the Section 10.5 Tables. These tables use the same HEP number as the original number given in Section 10.3, plus a revision number to uniquely identify the updated HEP being described by the table. Thus, Table 10.5.2R1.1 is revision one of Table 10.5.2.1, etc.

References for Section 10

[Swain, 1987]	A.D. Swain, "Accident Sequence Evaluation Program Human Reliability Analysis Procedure," NUREG/CR-4772, February, 1987.	[USNRC, 1989]	USNRC, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," NUREG-1150, June, 1989.
[Swain and Guttman, 1983]	A.D. Swain and H.E. Guttman, "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications," NUREG/CR-1278, SAND80-0200, August, 1983.	[Drouin, et al., 1989]	M.T. Drouin et al., "Analysis of Core Damage Frequency: Grand Gulf, Unit 1 Internal Events," NUREG/CR-4550, SAND86-2084, Vol. 6, Rev. 1, Part 1, September, 1989.

**Table 10.1.1.1
HEP 1 Calculation**

Human Action Event (1)	OPSDC (1)
Event Tree(s) (2)	SDC, ADH, TIA5H, E1B5H, E2B5H, T5D5H, E2T5H, S3-5, S3H-5,
Initiators (3)	T1, TAB5H, TIA5H, E1B5H, E2B5H, T5D5H, E2T5H, S3-5, S3H-5, TIOF5, TIHP5, TIOP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPSDC.SDC, OPSDC.TAB, OPSDCSDC.TIA, OPSDC.E2B, RESB.E1B, OPSDC.T5D, OPSDC.E2T, OISSL.S35, OISSL.S3H, OPSDC.TIF, OPSDC.TIH, OPSDC.TIO, OPSDC.TLM, OPSDC.TRP
Event Description (5)	OPSDC in this case represents the operator action to detect the loss of operating RHR/SDC loop (or ADHRS in the TAB5H sequences) and enter the appropriate procedure (Inadequate Decay Heat Removal). Under some conditions, such as a LOSP with successful diesel generator start, the event also includes the simple operator action to attempt a restart of the previously operating SDC loop.
Event Context (6)	SDC was being provided by one train of RHR (or ADHRS). The other RHR/SDC loop is assumed out for maintenance. If initially on RHR/SDC, ADHRS was not considered to be a viable option for restoring SDC because it would be inadequate for cooling during the first 24 hours after shutdown.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1)

Table 10.1.1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Loss of operating RHR/SDC loop or loss any form of SDC with a loss of the AC bus.	O	<p>In most cases (pump trip, system isolation, loss of heat sink (SSW), etc.) a loss of SDC will be alarmed. In addition, given events such as LOSP, loss of SSW, or loss of AC bus, operators are trained to know that SDC will isolate or be rendered unavailable.</p> <p>Furthermore, the ONEPs relevant to such events often note the loss of SDC. A loss of SDC will also be indicated by coolant temperature, flow, and discharge pressure changes. Operators are required by the plant to check reactor coolant temperature every 30 minutes at the chart recorder.</p>	During shutdown, SDC is a primary function and a major concern of the operators. Loss of SDC is covered during simulator training prior to each outage.

**Table 10.1.1.3
Potential Operator Action**

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
<p>A loss of SDC occurs as a random event or as a result of the initiating event. OPSDC includes operator actions to detect the loss of SDC, enter ONEP for Inadequate Decay Heat Removal and, in some cases, attempt a restart of the system from the control room (e.g., a LOSP with successful diesel generator start).</p>	<p>One</p>	<ol style="list-style-type: none"> 1. Retrieve and read relevant ONEP. 2. For some scenarios, attempt restart of previously operating RHR/SDC loop from control room. (An attempt to restart the previously operating SDC system was assumed to be an "immediate emergency action" per ASEP, Table 8-5, and was assumed to always follow a correct diagnosis of loss of SDC). 	<p>Complete dependence was assumed between the control room diagnosing the loss of SDC, attempting a restart when appropriate, and entering the relevant ONEP.</p> <p>That is, it was assumed that if a correct diagnosis was made, the evaluated actions would be performed. This assumption of dependence was based on discussions with plant personnel regarding training and procedures for a loss of SDC and on the fact that, in <u>most</u> cases, the operators need only enter the relevant procedures (also see column 3 of this table).</p>

Table 10.1.1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{α}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Detect/ Diagnose a loss of SDC	37 minutes	0	37 minutes	SEA Calculation C90-492-01-A16

Table 10.1.1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_l) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	Control Room	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Attempt restart of system if appropriate - simply turn switch to start	Control Room Panel	--	1 minute for travel & manipulation time (ASEP Table 8-1, Step 5b)	1 minute	

Table 10.1.1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Detect/Diagnose Loss of SDC	37 minutes	6 minutes	≈ 31 minutes	

Table 10.1.1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Detect/Diagnose loss of SDC	Per ASEP Table 8-3, the lower bound value from ASEP Figure 8-1 for ≈ 31 minutes diagnosis time was assigned	N/A	Median HEP = $1E-4$ Mean HEP = $8.5E-4$	Loss of SDC would certainly be a "classic" event in the LPS environment and operators at GGNS receive substantial training on the event. Interviews with operators indicated a good awareness of the relevant indicators and a need to closely monitor the relevant indicators. Thus, the criteria listed in Table 8-3 for the lower bound were met.

Table 10.1.1.8
Post-Diagnosis Action-Type Identification

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs, Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

¹ Actions assumed completely dependent with diagnosis (see Table 1-3 for rationale).

Table 10.1.1.9
Post-Diagnosis Stress-Level Identification

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

¹ Actions assumed completely dependent with diagnosis (see Table 1-3 for rationale).

Table 10.1.1.1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP ₁₂) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Detect/Diagnose loss of SDC, attempt restart of system if appropriate, enter ONEP	Diagnosis and Actions: Median = 1E-4 Mean = 8.5E-4	N/A	Median = 1E-4 Mean = 8.5E-4	1 0	Since the relevant actions were assumed to be "immediate emergency actions" and completely dependent with the diagnosis, credit for a second check was not given.

Table 10.1.2.1
HEP 2 Calculation

Human Action Event (1)	OPSDC (2)
Event Tree(s) (2)	ADH, TIA5H, E1D5H, E2D5H, T5D5H, S3-5, S3-5H, E2V5H,
Initiators (3)	T1, TIA5H,, E1D5H, E2D5H, T5D5H, S3-5, S3-5H, E2V5H, TIOF5, TIHP5, TIOP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPSDC.ADH, OPSDCADH.TIA, RESAD.E1D, OPSDCADH.E2D, OPSDC.T5D, OISSL.S35, OISSL.S3H, OPSDC.E2V, OPSDC.TIF, OPSDC.TIH, OPSDC.TIO, OPSDC.TLM, OPSDC.TRP
Event Description (5)	OPSDC in this case includes the control room crew detecting the loss of the ADHRS, entering the Inadequate Decay Heat Removal ONEP, and initiating a standby source of SDC (RHR(B)) per SOI 04-1-01-E12-1.
Event Context (6)	SDC was being provided by ADHRS, one train of RHR/SDC is in standby.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), Residual Heat Removal SOI (04-1-01-E12-1)

Table 10.1.2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A loss of ADHRS (operating mode of SDC)	0	In most cases, (pump trip, system/valve isolation, loss of heat sink, etc.) a loss of ADHRS will be alarmed. In addition, given certain initiators, operators are trained to know ADHRS will isolate or be rendered unavailable. Furthermore, ONEPS relevant to such events will usually note the loss of ADHRS; a loss of SDC will also be indicated by coolant temperature, flow, and discharge pressure changes. Operators are required by the plant to check reactor coolant temperatures every 30 minutes at the chart recorder.	During shutdown, SDC is a primary function and a major concern of the operators. Loss of SDC is covered during simulator training prior to each outage.

Table 10.1.2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A loss of ADHRS occurs as a random event, spurious isolation, or as a result of the initiating event. OPSDC in this case includes detecting the loss of ADHRS, entering IDHR ONEP, and initiating a standby source of SDC (RHR(B)) per procedure.	One	<ol style="list-style-type: none"> 1. Enter ONEP for IDHR 2. Start standby RHR/SDC loop per SOI 04-1-01-E12-1 <ul style="list-style-type: none"> - Isolation of ADHRS includes opening breaker outside control room per Step 5.15.2d - RHR initiated from control room 	The RHR/SDC initiation procedure also directs operators to place LPCI (C) in standby (following completion of other actions). While it is assumed operators will follow procedures, the control room can initiate SDC (B) prior to these steps being completed. Placing LPCI (C) in standby was assumed to be completely dependent with initiating RHR/SDC(B).

Table 10.1.2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate RHR/SDC (B)	37 minutes	0	37 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for IDHR	CR		5 minutes (Table 8-1, Step 5A)	5 minutes	See HEP 1 (OPSDC (1)), Table 1-5 for rationale.
2. Initiate RHR/SDC (B) (includes isolation of ADHRS to prevent overpressurization of low pressure piping and placement of LPCI(C) in standby)	CR	--	5 minutes	5 minutes	It was assumed that most (but not all) control room actions could occur in parallel with operator trip to open breaker (ASEP Table 8-1, Step 7).
- valve alignment and system initiation from control room	RHR (C) pump room, aux. bldg.	14 minutes	1 minute	<u>15 minutes</u> ≈ 25 minutes	Travel and performance time for opening breaker was established on the basis of discussions with plant personnel.
- open breaker outside CR as part of isolation of ADHRS					

Table 10.1.2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to align and initiate RHR/SDC (B)	37 minutes	25 minutes	12 minutes	

Table 10.1.2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis HEP (4)	Comments/ Source of Information (5)
Diagnose loss of SDC and need for standby SDC	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 12 minutes diagnosis time was assigned	N/A	Median = 0.005 Mean = 0.0133	Loss of SDC would certainly be a "classic" event in the LPS environment and operators at GGNS receive substantial training on the event. Interviews with operators indicated a good awareness of the relevant indicators and a need to closely monitor the relevant indicators. Thus, the criteria listed in Table 8-3 for the lower bound were met.

Table 10.1.2.8
Post-Diagnosis Action Type Identification
per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs, Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Align & Initiate RHR/ SDC (B)	N/A	ONEPS clear and well-designed in regard to diagnosing and initiating standby SDC	No	Step-by-Step	Actions are clearly defined by procedure.

Table 10.1.2.9
Post-Diagnosis Stress-Level Identification
per Step 10, Table 8-1 of ASEP HRA

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Align and initiate RHR/SDC (B)	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.2.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Median = 0.005 Mean = 0.0133	--	Med. Mean 0.005 0.0133	10	Given the limited time available for diagnosing and conducting the actions (one of which was outside control room), credit for a second check was not given.
2. Align and initiate standby SDC (RHR/ SDC(B)). The straightforward, conceptually integrated set of proceduralized actions (Steps 5.15.2 and 4.2.2.e) were assumed to be completely dependent. (See comments in Column 6 for additional information).	Median = 0.02 Mean = 0.032	--	<u>0.02</u> <u>0.032</u> 0.025 0.046 Total Median HEP = 0.025 Total Mean HEP = 0.046	<u>5</u> 10	Opening of the breaker is a safety measure related to isolating ADHR and its failure or delay would not prevent successful start of SDC (B). Similarly, placing LPCI (C) in standby, which is subsequent to starting RHR/SDC(B) in the procedure, will not affect initiation or operation of SDC(B).

Table 10.1.3.1
HEP 3 Calculation

Human Action Event (1)	OPDHR (1)
Event Tree(s) (2)	L, LA, LP, LAP
Initiators (3)	T1-5, TIA5H, TDB5H, T5D5H, E1B5H, E1D5H, E2D5H, E1T5H, E1V5H, TLM5H, TRPT5, TIHP5, TIOF5
Sequence Locator Files (4)	OPDHR&.LP&, OPDHR&.TIA, OPDHR.TDB, OPDHRP.T5D, OPDHRP.E1B, OPDHRP.E1D, OPDHRP.E2D, OPDHRLP.E1T, OPDHLAP.E1V, OPDHR.TLM, OPDHR.TRP, OPDHR.TIH, OPDHRP.TIH, OPDHR.TIF
Event Description (5)	OPDHR is the operator action to control vessel level in order to avoid a "functional" loss of SDC caused by inadequate circulation between the core and the downcomer regions of the vessel. That is, even if SDC continues to operate, if vessel level becomes too low, a "disconnect" between the core and downcomer regions can occur. This will result in inadequate cooling of the core even though SDC continues to operate. The indications to the operators that the event is occurring can be subtle because temperature readings are apparently taken from the downcomer region, where the water being cooled by SDC is returned. Also, the vessel level would not be so low that any level alarms would sound. A loss of forced recirculation, or a loss of makeup (usually CRD) coupled with continued draindown, can lead to inadequate level. Only 10 minutes was allowed for the operator diagnosis and actions in OPDHR.
Event Context (6)	The important constants for the OPDHR (1) calculation (HEP 3) are that RWCU auto-isolates (an LOSP occurs or IA is lost) or the initiator was a loss of forced recirculation, a loss of (CRD) makeup, or an inadvertent overfill of the vessel that had been stopped. It was assumed that with only a loss of forced recirculation or a loss of makeup occurring, the resulting alarms would immediately lead the operators to isolation of RWCU (letdown). In the case of a recent overfill that was stopped, it was assumed that the operators would be attending to level and that any following loss of forced recirculation or makeup would also lead to an isolation of RWCU.
Applicable Procedures (7)	No specific procedures, but the Inadequate Decay Heat Removal ONEP (05-1-02-III-1) would be relevant, as would the relevant SOIs, e.g., RHR SOI (04-1-01-E12-1).

Table 10.1.3.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR caused by inadequate circulation between the core and the downcomer regions of the vessel. Level control (makeup) is needed.	O	As noted in Table 3-1, the indications for this event may be subtle because vessel temperature readings could be misleading and no level alarms would sound. However, in all the sequences covered, CRD and/or forced recirculation is lost. These events will be alarmed and if the operators are knowledgeable regarding the potential problem, these indications should suffice.	

Table 10.1.3.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A "functional" loss of SDC leads to IDHR. The operators need to diagnose the need and increase vessel level.	One	The operators need to increase RPV water level with any available injection system. CRD (if available), CDS, or an ECCS system are possible choices.	

Table 10.1.3.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	10 minutes	0	10 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.3.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
If available, increase flow with CRD. If CRD is not available and SDC is not being provided by SDC(B), use CDS. Otherwise, use an ECCS system. Note. With only 10 min. available for OPDHR, if CDS was asked and it failed, credit was not taken for both CDS and an ECCS system.	CR	--	2 minutes Since more than one system may need to be tried, 2 minutes, rather than 1 minute was assumed for conducting the activities.	2 minutes	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column. The actions involved in initiating a makeup system were assumed to be completely dependent. System initiation would be proceduralized.

Table 10.1.3.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	10 minutes	2 minutes	8 minutes	

Table 10.1.3.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to provide makeup	Per ASEP Table 8-3, the median value from Figure 8-1 for 8 minutes diagnosis time was assigned.		Med. = 0.15 Mean = 0.40	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. However, with the potential subtlety of the indicators, the absence of any explicit procedures, and the time limitations, the lower bound diagnosis value was not assumed appropriate.

Table 10.1.3.8
Post-Diagnosis Action Type Identification
per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate an injection system to provide makeup.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Dynamic. Given that the operators would have determine which system to start on their own and without much time, the actions were assumed to be dynamic, per ASEP.	

Table 10.1.3.9
Post-Diagnosis Stress-Level Identification
per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate an injection system to provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.3.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{cz}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.15 Mean = 0.40	--	Med. Mean 0.15 0.40	(10)	
2. Initiate an injection system to provide makeup and vessel level control.	Med. = 0.05 Mean = 0.081	Credit for a second check was not taken because of the time limitations.	<u>0.05</u> <u>0.081</u> 0.20 0.48 Total Median HEP = 0.20 Total Mean HEP = 0.48	<u>(5)</u> (10)	The error factor associated with the dominant HEP was assigned.

Table 10.1.4.1
HEP 4 Calculation

Human Action Event (1)	LCMK (1)
Event Tree(s) (2)	L, LA, LP, LAP, TIOP5
Initiators (3)	TIOP5, T1-5, TRPT5, TORV5, TIOF5, TIHP5, E1V5H, E1T5H, E2C-5
Sequence Locator Files (4)	LCMK.TIO, OPDHRHYD.TIO, OPDHR&.LP&, OPDHRHYD.LP, OPDHR.TRP, OPDHRHYD.TRP, OPDHRHYD.TRV, OPDHR.TIF, OPDHR.TIH, OPDHROP.TIH, OPDHRLAP.E1V, OPDHR.E1V, OPDHR.E1T, OPDHRLP.E1T, OPDHRHYD.E2C
Event Description (5)	LCMK is the operator action to recognize that makeup is greater than letdown and control makeup.
Event Context (6)	The important constants for the LCMK (1) calculation (HEP 4) is that letdown is isolated and therefore makeup (CRD) needs to be controlled. In most cases, the operators have initiated makeup (CRD) to avoid a loss of SDC created by a disconnect between the core and downcomer regions of the vessel. For the TIOP5 initiator, letdown (RWCU) has inadvertently isolated and the operators must control level. In both cases, overfill and overpressurization are of concern and the operators have 2.5 hours to realize that they need to control makeup. For HEP 4, makeup is always with CRD. Level cannot increase rapidly with CRD, relative to when makeup might be provided with CDS or an ECCS system.
Applicable Procedures (7)	No specific procedures other than EP-2, RPV Control, Rev.19.

Table 10.1.4.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Letdown is isolated, makeup is with CRD, and operators need to control level.	O	Inadvertent isolation or loss of RWCU will be alarmed. In some scenarios, the operators have isolated RWCU after it failed or RWCU has auto-isolated. In all cases, level and pressure will be increasing and operators will have approximately 2.5 hours to realize the need to control level.	

Table 10.1.4.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Letdown is isolated, makeup is with CRD, and operators need to control level.	One	The operators simply need to control flow rate and the accompanying level increase to avoid overpressurization. Makeup is with CRD.	

Table 10.1.4.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to realize that makeup is greater than letdown and control level.	150 minutes	0	150 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.4.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Control flow and level with CRD.	CR	--	1 minute	1 minute	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column. System control would be proceduralized.

Table 10.1.4.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to realize that makeup is greater than letdown and control level.	150 minutes	1 minute	Approx. 149 minutes	

Table 10.1.4.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Recognize that makeup is greater than letdown and control level.	Per ASEP Table 8-3, the median value from Figure 8-1 for 149 minutes diagnosis time was assigned.		Med. = 6.5E-5 Mean = 5.0E-4	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. No explicit procedures other than indicator based emergency procedures.

Table 10.1.4.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Control level.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step-by-step	

Table 10.1.4.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Control CRD to avoid overpressurization	N/A ¹	N/A	No ²	N/A	Moderately High	Controlling level is a straightforward operation of which all operators are familiar.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.4.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 6.5E-5 Mean = 5.0E-4	--	Med. Mean 6.5E-5 5.0E-4	(10)	
2. Control flow rate and level with CRD.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the additional time with little else of concern. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.004 0.011 Total Median HEP = 0.004 Total Mean HEP = 0.011	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEPs was assigned.

Table 10.1.5.1
HEP 5 Calculation

Human Action Event (1)	OP1SV (17)
Event Tree(s) (2)	F, FP
Initiators (3)	TDB5H, T1-5, TLM5H, E1T5H
Sequence Locator Files (4)	OPFLDFR.TDB, OPFLDHY2.EP, OPFLDHYD.TLM, OPFLDLER.E1T, OPFLDLER.TLM, OPFLDRM.E1T, OPFLDRM.TLM, OPFLDRMH.TLM
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of vessel/containment flooding when only 1 SRV can be opened. In essence, OP1SV is the same decision and actions as OPFLD (HEP 28), except that only 1 SRV, rather than the multiple SRVs indicated by procedure, will open. OP1SV is asked only in sequences where OPFLD succeeds and must occur in the same time period.
Event Context (6)	For the OP1SV (17) calculation (HEP 5), OPECS or OPDHR have succeeded, but all ECCS systems have failed or are unavailable. Thus, the operators have attempted to do the correct actions, but the systems asked have failed or been unavailable. One option available to the operators to provide level and core cooling is to flood the vessel/containment. SSWXT or FW are systems that could (potentially) be used to flood. If vessel level is too low and not increasing, EP-2 calls out for alternate level control which will eventually lead the operators to flooding. The issue is whether the operators will initiate flooding with SSWXT if only 1 SRV can be opened. OP1SV is asked only in sequences where OPFLD succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.1.5.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
ECCS systems are not available and core cooling and makeup are needed. The question is whether they will flood with only 1 SRV open.	0	In addition to numerous alarms and indications which would already be present, reactor temperature (and in some cases pressure) will be increasing). The crew has been attempting to respond to existing problems and will be aware of the need to provide core cooling in some way. Low level alarms would likely to occur during this period. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.5.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators are attempting to respond to IDHR, but no ECCS systems are available. OP1SV asks whether the operators will attempt to flood if only 1 SRV can be opened. EP-2 directs several SRVs to be opened. The question is whether they will proceed with the initiation of flooding if they can get only 1 SRV.	One	<ul style="list-style-type: none"> - Check closed MSIVs - Ensure that several (one in this case) SRVs are open - Align and initiate SSWXT for flooding 	It was assumed the SSWXT would be the operators first choice for flooding and credit was not taken for both SSWXT and FW in the sequences covered by this HEP.

Table 10.1.5.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ed}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
<p>Initiate containment flooding with only 1 SRV. This task must occur in the same time frame allowed for OPFLD. That is, it must occur in the same 23 minutes.</p> <p>Functionally, OP1SV is OPFLD, except that only 1 SRV is available. OP1SV is asked only when OPFLD succeeds.</p>	23 minutes	0	23 Minutes	<p>SEA Calculation C90-492-01-A16</p> <p>Note. There is clearly a dependency between OPFLD and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPFLD succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPFLD (HEP 28 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get several SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available.</p>

Table 10.1.5.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read EP-2 and apply to LP&S context.	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and study EP-2 is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LP&S and with the idea that some "generalization" of EP-2 to the LP&S context would be required.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for flooding containment were judged to be an integrated set of actions.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR	--	5 minutes	5 minutes	Operators at GGNS indicated that proceeding with flooding with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and flooding with 1 SRV would provide core cooling.
4. Ensure 1 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate SSWXT per RHR SOI 04-1-01-E12-1, step 6.10. Requires 2 valves to be opened.	CR	--	1 minutes (per Table 8-1, Step 5b)	<u>1 minute</u> 13 min. Total	

Table 10.1.5.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to flood with 1 SRV	23 minutes	13 minutes	10 minutes	

Table 10.1.5.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to flood with 1 SRV.	Per ASEP Table 8-3, the median value from Figure 8-1 for 10 minutes diagnosis time was assigned.		Med. = 0.1 Mean = 0.27	The site interviews indicated that the operators have a clear understanding of the needed response and the necessary actions. Thus, per ASEP HRAP, Table 8-3, the median diagnosis value would be appropriate.

Table 10.1.5.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Flood with 1 SRV.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.5.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_F < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Flood containment with SSWXT and 1 SRV open.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.5.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.1 Mean = 0.27	--	Med. Mean 0.1 0.27	(10)	
2. Initiate vessel/containment flooding with SSWXT and 1 SRV open.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations.	<u>0.02</u> <u>0.032</u> 0.12 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	<u>(5)</u> (10)	The error factor associated with the dominant HEP was assigned.

Table 10.1.6.1
HEP 6 Calculation

Human Action Event (1)	OPECS (1)
Event Tree(s) (2)	E, EA, EP, EX
Initiators (3)	T1, TIA5H, TAB5H, TDB5H, T5D5H, E1B5H, E2B5H, E1D5H, E2D5H, TORV5, TRPT5, E1V5H, E2V5H, E1T5H, E2T5H, TIOF5, TIHP5, TLM5H, TIOP5
Sequence Locator Files (4)	OPECS&.EP, OPECSHY2.EP, OPECSHYD.EP, OPCSDC12.EX, OPECSSDC5.TIA, OPECSSDC9.TIA, OPECSHY2.TIA, OPECSSDC.TAB, OPECSHYD.TDB, OPECSSDC.TDB, OPECS9.T5D, OPECSRTE.T5D, OPECSSDC.E1B, OPECSRTE.E1B, OPECSSDC.E2B, OPECSRTE.E1D, OPECSRTE.E2D, OPECSRTE.TRV, OPECSHYD.TRV, OPECSHY2.TRV, OPECSRTE.TRP, OPECSHYD.TRP, OPECSHY2.TRP, OPECSL.TRP, OPECSL5.TRP, OPECSLP.TRP, OPECSSDC.TRP, OPECSAD5.TRP, OPECSADH.TRP, OPECSHPR.TRP, OPECSAD2.E1V, OPECSADH.E1V, OPECSL5.E1V, OPECSLPE.E1V, OPECSADF.E1V, OPECSALA.E1V, OPECSHPR.E1V, OPECSAD2.E2V, OPECSADH.E2V, OPECSSDC.E1T, OPECSDCF.E1T, OPECSHPR.E1T, OPECSLPE.E1T, OPECSL5.E1T, OPECSSDC.E2T, OPECSHPR.E2T, OPRCSDC5.E2T, OPECSADH.TIF, OPECSSDC.TIF, OPECSLP.TIF, OPECSL.TIF, OPECSADH.TIH, OPECSSDC.TIH, OPECSLP.TIH, OPECSL.TIH, OPECSADH.TIO, OPECSSDC.TIO, OPECSAD5.TIO, OPECSADH.TLM, OPECSSDC.TLM, OPECSAD5.TLM, OPECSL.TLM, OPECSLP.TLM, OPECSLHY.TLM, OPECSHYD.TLM
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (1) calculation (HEP 6) are that the control room has diagnosed the loss or inadequacy of SDC (e.g., OPSDC succeeds or OPDHR succeeds, but CDS fails), they have entered the ONEP for IDHR, they realize no normal means of SDC are available (RHR (A) assumed not available per refueling outage schedule), and they are aware of the need for level control. RWCU has been isolated. The ONEP directs the operators to go ECCS water solid (LPCI, HPCS, or both are available, depending on context).
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.1.6.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Control room is aware that normal SDC unavailable or inadequate. Loss of systems were alarmed. ONEP for IDHR directs the control room to use ECCS to go water solid in this context. ONEP has been entered. Reactor coolant temperature will be rising.	

Table 10.1.6.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control is needed, IDHR ONEP directs operators to go ECCS water solid.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ol style="list-style-type: none"> 1. - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. <p>In this context LPCI (C) was assumed first choice if available, then HPCS.</p>	<p>Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system.</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.1.6.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.6.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Check closed MSIVs	CR	--	1 minute	1 minute	The three critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of proceduralized actions.
2. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
3. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 3 min. Total	

Table 10.1.6.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	23 minutes	3 minutes	20 minutes	

Table 10.1.6.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per Table 8-3, the lower bound value from Figure 8-1 for 20 minutes diagnosis time was assigned		Med. = 0.001 Mean = 0.0027	For this event, the ONEP has already been retrieved and, on the basis of interviews, operators have a clear understanding of the procedure and the requirements. Level control and core cooling is an obvious need in this context and would fall into the "classic" category, per ASEP.

Table 10.1.6.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.6.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.6.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^a	Independent Check/Correction HEP (HEP _c) (3) ^a	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.001 Mean = 0.0027	--	Med. Mean 0.001 0.0027	(10)	-
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations and because failures or problems in closing MSIVs or opening 2 SRVs would have to be considered by operators in the same time period i.e., OPMSV and OP1SV.	<u>0.02</u> <u>0.032</u> 0.021 0.035	<u>(5)</u> (5)	The error factor associated with the dominant HEP was assigned.

Table 10.1.7.1
HEP 7 Calculation

Human Action Event (1)	OP1SV (1)
Event Tree(s) (2)	E, EA, EP, EX
Initiators (3)	T1, TIA5H, TAB5H, TDB5H, T5D5H, E1B5H, E2B5H, E1D5H, E2D5H, TORV5, TRPT5, E1V5H, E2V5H, E1T5H, E2T5H, TIOF5, TIHP5, TLM5H, TIOP5
Sequence Locator Files (4)	OPECS&.EP, OPECSHY2.EP, OPECSHYD.EP, OPCSDC12.EX, OPECSSDC5.TIA, OPECSSDC9.TIA, OPECSSDC.TAB, OPECSHYD.TDB, OPECSSDC.TDB, OPECS9.T5D, OPECSRTE.T5D, OPECSSDC.E1B, OPECSRTE.E1B, OPECSSDC.E2B, OPECSRTE.E1D, OPECSRTE.E2D, OPECSRTE.TRV, OPECSHYD.TRV, OPECSHY2.TRV, OPECSRTE.TRP, OPECSHYD.TRP, OPECSHY2.TRP, OPECSL.TRP, OPECSL5.TRP, OPECSLP.TRP, OPECSSDC.TRP, OPECSAD5.TRP, OPECSADH.TRP, OPECSHPR.TRP, OPECSAD2.E1V, OPECSADH.E1V, OPECSL5.E1V, OPECSLPE.E1V, OPECSADF.E1V, OPECSALA.E1V, OPECSHPR.E1V, OPECSAD2.E2V, OPECSADH.E2V, OPECSSDC.E1T, OPECSDCF.E1T, OPECSHPR.E1T, OPECSLPE.E1T, OPECSL5.E1T, OPECSSDC.E2T, OPECSHPR.E2T, OPRCSDC5.E2T, OPECSADH.TIF, OPECSSDC.TIF, OPECSLP.TIF, OPECSL.TIF, OPECSADH.TIH, OPECSSDC.TIH, OPECSLP.TIH, OPECSL.TIH, OPECSADH.TIO, OPECSSDC.TIO, OPECSAD5.TIO, OPECSADH.TLM, OPECSSDC.TLM, OPECSAD5.TLM, OPECSL.TLM, OPECSLP.TLM, OPECSLHY.TLM, OPECSHYD.TLM
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 6), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds.
Event Context (6)	The important constants for the OP1SV (1) calculation (HEP 7) are that the control room has diagnosed the loss or inadequacy of SDC (e.g., OPSDC succeeds or OPDHR succeeds, but CDS fails), they have entered the ONEP for IDHR, they realize no normal means of SDC are available (RHR (A) assumed not available per refueling outage schedule), and they have decided to initiate ECCS water solid operation as directed by procedure (OPECS succeeds). The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.1.7.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Control room is aware that normal SDC unavailable or inadequate. Loss of systems were alarmed. ONEP for IDHR directs the control room to use ECCS to go water solid in this context. ONEP has been entered and the operators have decided to initiate ECCS water solid operation. Reactor coolant temperature will be rising. The control room gets feedback regarding the opening and closing of valves.	

Table 10.1.7.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
<p>No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs</p>	<p>One</p>	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ol style="list-style-type: none"> 1. - Check closed MSIVs - Ensure that two (one in this case) SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system.</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.1.7.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 minutes	0	23 minutes	SEA Calculation C90-492-01-A16 Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds, it was decided that the HEP for OP1SV would be determined as if it were OPECS, except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. It was assumed that the operators would make several attempts to get the second SRV open and would discuss the problem among themselves before proceeding.

Table 10.1.7.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of proceduralized actions.
2. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
3. Ensure 1 SRV open	CR	--	1 minute	1 minute	
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 8 min. Total action time	

Table 10.1.7.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	8 minutes	15 minutes	

Table 10.1.7.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned		Median = 0.03 Mean = 0.08 (EF = 10)	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.

Table 10.1.7.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No -	Step-by-Step	Actions are proceduralized.

Table 10.1.7.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.7.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.03 Mean = 0.08	--	Med. Mean 0.03 0.08	(10)	
2. Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations and because failures or problems in closing MSIVs or attempting to get 2 SRVs open would have to be considered by operators in the same time period i.e., OPMSV and OP1SV.	<u>0.02</u> <u>0.032</u> <u>0.05</u> <u>0.112</u> Total Median HEP = 0.05 Total Mean HEP = 0.112	<u>(5)</u> (10)	Since both HEPs contribute to the total HEP, the largest of the two EFs was assigned.

Table 10.1.8.1
HEP 8 Calculation

Human Action Event (1)	OPHIS (1)
Event Tree(s) (2)	E, EA, EP, EX, EAP, EAX
Initiators (3)	All
Sequence Locator Files (4)	OPHIS occurs in all files in which OPECS occurs (too numerous to list). OPHIS follows OPECS in "E" type trees and is dependent on actions taken in OPECS.
Event Description (5)	OPHIS is the operator action to use HPCS for ECCS water solid operation.
Event Context (6)	The important constants for the OPHIS (1) calculation (HEP 8) are that the operators have decided to initiate ECCS water solid operation (OPECS succeeds). OPHIS must be accomplished in the same time period as OPECS and includes deciding to use HPCS for water solid operation. Since OPHIS must be accomplished in the same time period as OPECS (23 minutes), it was decided that OPHIS would succeed only when HPCS would be the only available system for ECCS water solid operation. In other words, credit was not taken for both LPCI and HPCS in OPECS. It was decided that the time available for OPECS was inadequate to align both LPCI and HPCS and still have "adequate" time for diagnosis. Thus, credit was taken for only one of the two systems in OPECS. A low pressure system, i.e., LPCI, was assumed the system of choice, if available. If the accident sequence had rendered LPCI unavailable, then HPCS was assumed the ECCS system of choice. When LPCI was available, credit for HPCS was taken elsewhere. OPHIS was only asked when OPECS succeeded. OPHIS was set to fail (1.0) when LPCI was potentially available, but was set to succeed (0.0) when HPCS was the only available ECCS system. Since detailed ASEP calculations were not required for HEP 8, Tables 8.2 through 8.9 were not included.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Note. Tables 8.2 through 8.9 were unnecessary for HEP 8 and therefore were not included.

Table 10.1.8.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Initiate ECCS water solid operation with HPCS.	Med. = 0.0 or 1.0 Mean = 0.0 or 1.0	--	Med. = 0.0 or 1.0 Mean = 0.0 or 1.0		ASEP Table 8-1, Step 12. Failure or success of OPHIS was determined by potential availability of LPCI. See rationale under Event Context (6) in Table 8-1 (HEP 8).

**Table 10.1.9.1
HEP 9 Calculation**

Human Action Event (1)	OPMSV (1)
Event Tree(s) (2)	E, EA, EP, EX, EAP, EAX, HPSWR
Initiators (3)	All
Sequence Locator Files (4)	OPMSV occurs in all files in which OPECS occurs (too numerous to list). OPMSV follows OPECS in "E" type trees.
Event Description (5)	OPMSV is the operator action to close open MSIVs.
Event Context (6)	For the OPMSV (1) calculation (HEP 9), 4.4 minutes were assumed available to close any open MSIVs and the actions were assumed to have to occur in parallel with OPECS. These assumptions were made to ensure that for OPMSV to be successful, it would have to occur prior to the initiation of an ECCS system for water solid operation in OPECS. If the MSIVs were open, flooding could begin to occur down the open steam lines very quickly when an ECCS system was initiated. Once flooding down open steam lines occurs, a different operator action (OPSOF) is called. Using the ASEP method (specifically, ASEP Figure 8-1) and assuming it would take a minute to close any open MSIVs, the mean failure probability with only 3 min. diagnosis time is 1.0. Thus, in the "E" type trees, if the MSIVs were open, it was assumed that the operators would not close them before initiating ECCS water solid operation. Since detailed ASEP calculations were not required for HEP 9, Tables 10.1.9.2 through 10.1.9.9 were not included.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Note. Tables 10.1.9.2 through 10.1.9.9 were unnecessary for HEP 9 and therefore they were not included.

Table 10.1.9.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2) ^{op}	Independent Check/Correction HEP (HEP _{ic}) (3) ^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Close any open MSIVs before initiating ECCS system for water solid operation.	Med. = 1.0 ⁻ Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

**Table 10.1.10.1
HEP 10 Calculation**

Human Action Event (1)	OPECS (2)
Event Tree(s) (2)	E, HPSWR
Initiators (3)	T1-5, TIA5H, TAB5H, T5A5H, TDB5H, T5D5H, E1B5H, E2B5H, E1T5H, E1V5H, E2T5H, TRPT5
Sequence Description Files (4)	OPECS&.HPR, OPCSDC11.TIA, OPECSDC4.TAB, OPECSDC9.TAB, OPECSDC9.TDB, OPECSHPR.E1B, OPECSHPR.E2B, OPECSHPR.T5A, OPECSHPR.T5D, OPECSHYD.HPR, OPECSHPR.E1T, OPECSHPR.E1V, OPECSHPR.E2T, OPECSHPR.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (2) calculation (HEP 10) are that a LOSP has occurred and the Division 1 and 2 diesel generators have failed to start. The HPCS diesel is available. With the loss of both divisions of power, the operators would enter the ONEP for Loss of AC Power. Any operating SDC system (RHR/SDC or ADHRS) would fail and the operators would be aware of the need for some form of SDC. With the loss of SDC, the operators would need to enter the ONEP for IDHR. RWCU has been isolated. The ONEP directs the operators to initiate ECCS water solid operation. Only HPCS would be available.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20)

Table 10.1.10.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems would be alarmed. In the context of being in shutdown and the occurrence of a loss of AC power, operators would be aware of the need for some form of SDC. The ONEP for IDHR directs the control room to use ECCS to go water solid in this context. The operators will have to retrieve and enter the IDHR ONEP. Reactor coolant temperature will be rising.	

Table 10.1.10.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control is needed, IDHR ONEP directs operators to initiate ECCS water solid operation. HPCS is the only ECCS system available.	One--the loss of SDC is a result of the loss of power.	Per IDHR ONEP (Step 5.1.3c) 1. - Check closed MSIVs. - Ensure that two SRVs are open. - Increase RPV water level with any available injection system. In this context HPCS is the only ECCS system available.	In the site interviews, the operators clearly indicated that HPCS would be initiated. However, it is not <u>explicitly</u> called by the procedure.

Table 10.1.10.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Max. Time Available to Perform Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.10.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_t) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and Read ONEP for IDHR	CR		5 minutes (Table 8-1, Step 5a)	5 Minutes	See HEP 1 (OPSDC (1)), same table, for rationale.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The three critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of proceduralized actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 8 min. Total	

Table 10.1.10.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation	23 minutes	8 minutes	15 minutes	

Table 10.1.10.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned.		Median = 0.04 Mean = 0.106	The median value from Figure 8-1 (as opposed to the lower bound value) was selected because the amount of practice given the operators for a station blackout during LPS conditions was not clear. In addition, HPCS is not explicitly called in the procedure.

Table 10.1.10.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Clear procedures and HPCS is the only logical system available.

Table 10.1.10.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ² , the HPCS generator has started	N/A	Moderately High	HPCS is available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.10.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.04 Mean = 0.106	--	Med. Mean 0.04 0.106	(10)	
2. Initiate ECCS water solid operation per procedure.	Median = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations, the additional concerns facing the control room, and because failures or problems in closing MSIVs or opening 2 SRVs have to be considered by the operators in the same time period i.e., OPMSV and OP1SV.	<u>0.02</u> <u>0.032</u> 0.04 0.138 Total Median HEP = 0.04 Total Mean HEP = 0.138	<u>(5)</u> (10)	The error factor from the dominant HEP was used.

Table 10.1.11.1
HEP 11 Calculation

Human Action Event (1)	OP1SV (2)
Event Tree(s) (2)	E, HPSWR
Initiators (3)	T1-5, TIA5H, TAB5H, T5A5H, TDB5H, T5D5H, E1B5H, E2B5H, E1T5H, E1V5H, E2T5H, TRPT5
Sequence Locator Files (4)	OPECS&.HPR, OPCSDC11.TIA, OPECSDC4.TAB, OPECSDC9.TAB, OPECSSDC9.TDB, OPECSHPR.E1B, OPECSHPR.E2B, OPECSHPR.T5A, OPECSHPR.T5D, OPECSHYD.HPR, OPECSHPR.E1T, OPECSHPR.E1V, OPECSHPR.E2T, OPECSHPR.TRP
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 10), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds.
Event Context (6)	The important constants for the OP1SV (2) calculation (HEP 11) are that a LOSP has occurred and the Division 1 and 2 diesel generators have failed to start. The HPCS diesel is available. With the loss of both divisions of power, the operators would enter the ONEP for Loss of AC Power. Any operating SDC system (RHR/SDC or ADHRS) would fail and the operators would be aware of the need for some form of SDC. With the loss of SDC, the operators would need to enter the ONEP for IDHR. RWCU has been isolated. The ONEP directs the operators to initiate ECCS water solid operation. Only HPCS would be available. The operators decide to initiate ECCS water solid operation as directed by procedure (OPECS succeeds). The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20).

Table 10.1.11.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T.) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Control room is aware that normal SDC unavailable or inadequate. Loss of systems were alarmed. ONEP for IDHR directs the control room to use ECCS to go water solid in this context. ONEP has been entered and the operators have decided to initiate ECCS water solid operation. Reactor coolant temperature will be rising. The control room gets feedback regarding the opening and closing of valves.	

Table 10.1.11.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One--the loss of SDC is a result of the loss of power.	Per IDHR ONEP (Step 5.1.3c) 1. - Check closed MSIVs - Ensure that two (one in this case) SRVs are open - Increase RPV water level with any available injection system. In this context, HPCS was the only available system.	In the site interviews, the operators clearly indicated that HPCS would be initiated. However, it is not <u>explicitly</u> called by the IDHR ONEP. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table 10.1.11.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	SEA Calculation C90-492-01-A16. Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 10), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The median diagnosis value from ASEP was used because neither the use of HPCS nor proceeding with 1 SRV are explicitly called out in the IDHR ONEP. The site interviews indicated the operators would be likely to do both. The Loss of AC Power ONEP clearly indicates the use of HPCS for injection. However, not sure how much practice is given for a station blackout during LPS. Thus, the lower bound diagnosis value was not used.

Table 10.1.11.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and Read ONEP for IDHR	CR		5 minutes, (ASEP Table 8-1, Step 5a)	5 minutes	See HEP 1 (OPSDC (1)), same table , for rationale.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of proceduralized actions.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR	-	5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
4. Ensure 1 SRV open	CR	--	1 minute	1 minute	
5. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 13 min. Total action time	

Table 10.1.11.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	13 minutes	10 minutes	

Table 10.1.11.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the median value from Figure 8-1 for 10 minutes diagnosis time was assigned		Median = 0.1 Mean = 0.27 (EF = 10)	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling. They also indicated HPCS would certainly be used.

Table 10.1.11.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Some form of SDC is clearly called for and HPCS is the only available system.

Table 10.1.11.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ² , the HPCS generator is running and the system is available	N/A	Moderately High	HPCS is available and there is substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.11.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.1 Mean = 0.27	--	Med. Mean 0.1 0.27	(10)	
2. Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations and because failures or problems in closing MSIVs or attempting to get 2 SRVs open would have to be considered by operators in the same time period i.e., OPMSV and OP1SV.	<u>0.02</u> <u>0.032</u> 0.05 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	<u>(5)</u> (10)	The EF from the dominant HEP was assigned.

Table 10.1.12.1
HEP 12 Calculation

Human Action Event (1)	OPSOF (1)
Event Tree(s) (2)	HPSWR
Initiators (3)	T1-5, TIA5H, TAB5H, TDB5H, E1B5H, E2B5H, T5A5H, T5D5H
Sequence Locator Files (4)	OPECS&.HPR, OPCSDC11.TIA, OPECSDC4.TAB, OPECSDC9.TAB, OPECSDC9.TDB, OPECSHPR.E1B, OPECSHPR.E2B, OPECSHPR.T5A, OPECSHPR.T5D, OPECSHYD.HPR
Event Description (5)	OPSOF is the operator action to stop flooding through open main steam line(s).
Event Context (6)	For the OPSOF (1) calculation (HEP 12), some form of a loss of power has occurred and the diesel generator has failed to start (DV1-2 fails). HPCS is available and the operators have initiated ECCS water solid operation with HPCS. One or more of the MSIVs are open and water is running down the steam line(s). The operators must detect and terminate the flooding.
Applicable Procedures (7)	All operators would understand the need to stop flooding down the steam line(s). The Inadequate Decay Heat Removal ONEP (05-1-02-III-1) instructs the operators to check closed any open MSIVs when initiating ECCS water solid operation.

Table 10.1.12.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Undesired flooding through open MSIVs caused by intentional initiation of an injection system to increase level.	O	For the situation where level is being increased for ECCS water solid operation, the IDHR ONEP instructs the operators to check closed any open MSIVs. With the additional time, operators may recall or recheck the need to close the MSIVs and would check status lights. For any case, Level 7 and 8 alarms may cue the operators to check the position of MSIVs. Moreover, water flowing down the steam lines into the Turbine Bldg. may be noticed. Could get steam line drain valve alarms.	In the site interviews, operators indicated they would definitely want to stop flooding through MSIVs.

Table 10.1.12.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators are attempting to increase level for water solid operation and would probably be "bumping" HPCS to avoid rapid filling of the vessel. They inadvertently flood through open MSIVs.	One	The operators need to close MSIVs.	

Table 10.1.12.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Detect the flooding or the fact that the MSIVs are open, and stop the flooding down the steam lines.	20 minutes	0	20 minutes	SEA Calculation C90-492-01-A16

Table 10.1.12.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
Close MSIVs. Terminate or at least suspend injection if necessary.	CR	--	1 minute	1 minutes	<p>Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.</p> <p>The actions involved in terminating injection and closing the open MSIVs were assumed to be completely dependent. Bumping of HPCS may just be temporarily halted to reduce level and close MSIVs.</p>

Table 10.1.12.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the flooding down the steam lines and the need for its termination.	20 minutes	1 minute	19 minutes	

Table 10.1.12.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to terminate flooding down open MSIVs.	Per ASEP Table 8-3, the median value from Figure 8-1 for 19 minutes diagnosis time was assigned.		Med. = 0.01 Mean = 0.027	The site interviews indicated that the operators would understand the need to stop the flooding through open MSIVs.

Table 10.1.12.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Close open MSIVs. Terminate injection as needed.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step-by-step	

Table 10.1.12.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_E < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Close open MSIVs. Terminate injection as needed.	N/A ¹	N/A	No ²	N/A	Moderately High	Actions are straightforward and situation is not yet critical.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.12.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.01 Mean = 0.027	--	Med. Mean 0.01 0.027	(10)	
2. Terminate injection system and close open MSIVs.	Med. = 0.02 Mean = 0.032 --	Credit for a second check was not given because of the other potential concerns of the operators, e.g., the loss of power, the failure of the diesel to start, the impact of the initiator etc.	<u>0.02</u> <u>0.032</u> 0.03 0.06 Total Median HEP = 0.03 Total Mean HEP = 0.06	<u>(5)</u> (10)	Second check HEPs are multiplied by the original HEP for each action. Since both HEPs made significant contributions to the total HEP, the larger of the two error factors was assigned.

Table 10.1.13.1
HEP 13 Calculation

Human Action Event (1)	OPECS (3)
Event Tree(s) (2)	EA, EAP
Initiators (3)	T1-5, TIA5H, E1D5H, E2D5H
Sequence Locator Files (4)	OPECSEQ9.EAP, OPCADH21.TIA, OPECSA12.E1D, OPECSA07.E2D, ..
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (3) calculation (HEP 13) are that the control room has failed to diagnose the loss of SDC in 37 minutes, e.g., OPSDC fails). Thus, they have failed to enter the ONEP for IDHR. Since 37 minutes have elapsed, the operators would be very likely to check temperature and pressure on the chart recorders in the 23 minutes allowed for OPECS and they may receive additional alarms. However, the operators would have to retrieve and read the IDHR ONEP and RHR SOI, perform a series of steps to isolate the ADHRS and align LPCI(C) or (B) for injection (including a remote manual start of LPCI(C) or (B)), per RHR SOI 04-1-01-E12-1, Step 6.6 or 6.8 ("Abnormal Operations"), and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.13.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period. Reactor pressure and coolant temperature will be rising.	

Table 10.1.13.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control and vessel cooling is needed, IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3) Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> Check closed MSIVs Ensure that two SRVs are open Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.13.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{α}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.13.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/Source of Information (6)
1. Since OPSDC failed, operators still need to retrieve and read ADHR ONEP and RHR SOI	CR	--	5 minutes (Table 8-1, Step 5a)	5 minutes	See HEP 1 (OPSDC (1)), same table, for rationale.
2. Secure ADHR, per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 5 minutes, but can be done in parallel with alignment and start of LPCI (step 5 below). Thus, performance time not included.	0 minutes	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Check closed MSIVs	CR	--	1 minute, but can be done in parallel with step 5 below.	0 minutes	Steps 3 and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Ensure 2 SRVs open	CR	--	1 minute, but in parallel with step 5 below	0 minutes	
5. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2) Note. The procedure directs a "remote manual start" of LPCI pump. In the original HEP calculation, this action was erroneously assumed to require a trip outside the control room.	CR	--	15 minutes, travel and performance time. Estimated on basis of discussions with plant personnel.	<u>15 minutes</u> <u>20 minutes</u> Total time for all actions.	From the control room, the actions required to align and initiate LPCI(C) or (B) (and isolate ADHR and perform steps 3 and 4) would probably not require 15 min. Thus, the obtained HEP may be overly conservative. However, given that the operators have failed to recognize a loss of SDC in 37 min. (OPSDC fails) and must perform a set of "abnormal procedures" to isolate ADHR and align LPCI(C) or (B) in this context, the value used may not be overly conservative at all.

Table 10.1.13.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_t) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	20 minutes	3 minutes	

Table 10.1.13.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the median value from Figure 8-1 for 3 minutes diagnosis time was assigned. Given the failure of OPSDC, in conjunction with the need to perform "abnormal operations" from the RHR SOI, the lower bound was not judged to be appropriate.		Med. = 0.4 (EF = 10) Mean = 1.06 or 1.0	

Table 10.1.13.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.					Since diagnosis value is equal to a failure probability of 1.0, the action HEPs are irrelevant.

Table 10.1.13.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid						Since diagnosis value is equal to a failure probability of 1.0, the action HEPs are irrelevant.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.13.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.4 Mean = 1.06	--	Med. Mean 0.4 1.0	(10)	
2. Initiate ECCS water solid per procedure.	Not calculated given diagnosis = 1.0		Total HEP = 1.0	(10)	

Table 10.1.14.1
HEP 14 Calculation

Human Action Event (1)	OPECS (7)
Event Tree(s) (2)	EA, EAP
Initiators (3)	T1-5, TIA5H
Sequence Locator Files (4)	OPECSEQ8.EAP, OPCADH20.TIA
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (7) calculation (HEP 14) are that the control room has successfully diagnosed the loss of ADHR (OPSDC succeeds) and have attempted to start SDC(B). SDC(B) fails to start. In some sequences a LOSP occurs, but the diesels successfully start and load in all cases. With the success of OPSDC, the operators have entered the ONEP for IDHR. To initiate ECCS water solid operation, the operators must perform (or ensure that they have been performed during OPSDC) a series of steps to isolate ADHR and align LPCI(C) or (B) for injection (including a remote manual start of LPCI(C) or (B)), per RHR SOI 04-1-01-E12-1, Step 6.6 or 6.8 ("Abnormal Operations"), and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP. In aligning RHR/SDC(B) for SDC in this context, the procedures also instruct the operators to isolate ADHR and place LPCI(C) on standby. However, given the failure of SDC(B) to start, there is at least some probability that events may have precluded all steps being completed. Thus, it was conservatively assumed that the relevant actions would have to be carried-out in the time available for OPECS.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.14.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	0	Loss of systems were alarmed and the operators are already aware of the loss of SDC. In addition, the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period. Reactor pressure and coolant temperature will be rising.	

Table 10.1.14.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control and vessel cooling is needed, IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3)) Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> Check closed MSIVs Ensure that two SRVs are open Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.14.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.14.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but can be done in parallel with alignment and start of LPCI (step 4 below). Thus, performance time not included.	0 minutes	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
2. Check closed MSIVs	CR	--	1 minute, but can be done in parallel with step 4 below.	0 minutes	Steps 2 and 3 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Ensure 2 SRVs open	CR	--	1 minute, but in parallel with step 4 below	0 minutes	
4. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2) (Note. The procedure directs a "remote manual start" of LPCI pump. In the original HEP calculation, this action was erroneously assumed to require a trip outside the control room. Thus, the timing used in determining this HEP is likely to be somewhat conservative. See comments in Column 6)	CR	--	15 minutes, travel and performance time. Estimated on basis of discussions with plant personnel.	<u>15 minutes</u> 15 minutes Total time for all actions.	From the control room, the actions required to align and initiate LPCI(C) or (B), isolate ADHR, and perform steps 3 and 4) would probably not require 15 min. Thus, the obtained HEP may be somewhat conservative. (See comments in Column 1, this table)

Table 10.1.14.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	15 minutes	8 minutes	

Table 10.1.14.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 8 minutes diagnosis time was assigned.		Median = 0.02 (EF = 10) Mean = 0.053	For this event, the relevant ONEP has been retrieved and the operators have performed correctly to this point. On the basis of interviews, the operators have a clear understanding of the procedures and requirements. Level control and core cooling are obvious needs in this context and the event was judged to fall into the "classic" category per ASEP.

Table 10.1.14.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

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Table 10.1.14.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	While a LOSP occurs at some point in some sequences which use HEP 14, the diesels successfully start and load in all cases.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.14.10
Total HEP

Action (1)	Original Operator HEP (HEP ₁) (2) ^{op}	Independent Check/Correction HEP (HEP ₂) (3) ^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.02 Mean = 0.053	-- -	Med. Mean 0.02 0.053	(10)	
2. Actions Initiate ECCS water solid per procedure. 1. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. They constitute an integrated set of proceduralized actions. 2. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C) (OPECS actions assumed completely dependent)	Median = 0.02 Mean = 0.032 Median = 0.02 (EF = 5) Mean = 0.032	One of the actions in Action 1 was originally assumed to take place outside the control room and in the time available, credit for a second check did not seem appropriate. See comment in Column 6. However, given that many of the OPECS related actions were assumed to occur in parallel with the action outside the control room (and therefore a lot of time was assumed available for them), credit for a second check was given for accomplishing those actions. Second check values for action 2 were: Median = 0.2 (EF = 5) Mean = .323 Mean = 0.323	Med. Mean 0.02 0.032 Med. Mean 0.004 0.01 0.044 0.10 Total median HEP = 0.044 Total mean HEP = 0.10	(5) (5) (10)	Since it is possible that most of Action 1 would already be accomplished by the time OPECS was asked, credit for a second check would have been appropriate if it had not been assumed that one of the actions was performed outside the control room. Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for that action. Since both the diagnosis and action HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.15.1
HEP 15 Calculation

Human Action Event (1)	OP1SV (3)
Event Tree(s) (2)	EA, EAP
Initiators (3)	T1-5, TIA5H
Sequence Locator Files (4)	OPECSEQ8.EAP, OPCADH20.TIA
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 14), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds.
Event Context (6)	The important constants for the OP1SV (3) calculation (HEP 15) are that the control room has successfully diagnosed the loss of ADHR (OPSDC succeeds) and have attempted to start SDC(B). SDC(B) fails to start. In some sequences a LOSP occurs, but the diesels successfully start and load in all cases. With the success of OPSDC, the operators have entered the ONEP for IDHR. To initiate ECCS water solid operation, the operators must perform (or ensure that they have been performed during OPSDC) a series of steps to isolate ADHR and align LPCI(C) or (B) for injection (including a remote manual start of LPCI(C) or (B)), per RHR SOI 04-1-01-E12-1, Step 6.6 or 6.8 ("Abnormal Operations"), and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP. (See OPECS (7), HEP 14, for more details on event context). The operators decide to initiate ECCS water solid operation as directed by procedure (OPECS succeeds). The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20).

Table 10.1.15.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Control room is aware that normal SDC unavailable or inadequate. Loss of systems were alarmed. ONEP for IDHR directs the control room to use ECCS to go water solid in this context. ONEP has been entered and the operators have decided to initiate ECCS water solid operation. Reactor coolant temperature will be rising. The control room gets feedback regarding the opening and closing of the SRVs.	

Table 10.1.15.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
<p>No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs</p>	<p>One</p>	<p>Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3)) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two (one in this case) SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	<p>It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.</p>

Table 10.1.15.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is the same as OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	SEA Calculation C90-492-01-A16 Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 14), except for one difference. It was assumed that five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. It was assumed that the operators would make several attempts to get the second SRV open and would discuss the problem among themselves before proceeding.

Table 10.1.15.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T _L) (3)	Performance Time (T _P) (4)	Total Action Time (T _A) (5)	Comments/ Source of Information (6)
1. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 5 minutes, but can be done in parallel with alignment and start of LPCI (step 5 below). Thus, performance time not included.	0 minutes	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
2. Check closed MSIVs	CR	--	1 minute, but can be done in parallel with step 5 below.	0 minute	Steps 2, 3, and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
4. Ensure 1 SRV open	CR	--	1 minute, but in parallel with step 5 below.	0 minute	
5. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2) (Note. The procedure directs a "remote manual start" of LPCI pump. In the original HEP calculation, this action was erroneously assumed to require a trip outside the control room. Thus, the timing used in determining this HEP is likely to be somewhat conservative. See comments in Column 6)	CR	--	15 minutes, travel and performance time. Estimated on basis of discussions with plant personnel.	<u>15 minutes</u> 20 minutes Total time for all actions.	From the control room, the actions required to align and initiate LPCI(C) or (B) (and isolate ADHR and perform steps 2 and 4) would probably not require 15 min. Thus, the obtained HEP may be somewhat conservative.

Table 10.1.15.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	20 minutes	3 minutes	

Table 10.1.15.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the lower bound value from Figure 8-1 for 3 minutes diagnosis time was assigned.		Median = 0.15 Mean = 0.40 (EF = 10)	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and reasonable option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.

Table 10.1.15.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Some form of SDC is clearly indicated and for the most part the actions are proceduralized.

Table 10.1.15.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems are available and there is substantial time before core damage. Although a LOSP occurs at some point in some sequences which use HEP 15, the diesels successfully start and load in all cases.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.15.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^{op}	Independent Check/Correction HEP (HEP _c) (3) ^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Med. = 0.15 Mean = 0.4	-- -	Med. Mean 0.15 0.4	(10)	
2. Actions Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available. 1. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. They constitute an integrated set of proceduralized actions. 2. OPECS actions - open 2 SRVs (One in this case) - check closed MSIVs - start LPCI(C) (OPECS actions assumed completely dependent)	Median = 0.02 Mean = 0.032 Median = 0.02 (EF = 5) Mean = 0.032	One of the actions in Action 1 was originally assumed to take place outside the control room and in the time available, credit for a second check did not seem appropriate. See comment in Column 6. However, given that many of the OPECS related actions were assumed to occur in parallel with the action outside the control room, credit for a second check was given for accomplishing those actions. Second check values for action 2 were: Median = 0.2 (EF = 5) Mean = .323	Med. Mean 0.02 0.032 0.004 0.01 0.174 0.44 Total Median HEP = 0.17 Total Mean HEP = 0.44	(5) (5) (10)	Since it is possible that most of Action 1 would already be accomplished by the time OPECS was asked, credit for a second check would have been appropriate if it had not been assumed that one of the actions was performed outside the control room. Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for that action. Since both the diagnosis and action HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.16.1
HEP 16 Calculation

Human Action Event (1)	OPECS (8)
Event Tree(s) (2)	EA, EAP
Initiators (3)	TAB5H, TDB5H, T5A5H, E1D5H, E2D5H.
Sequence Description Files (4)	OPECSADH.TAB, OPECSADH.TDB, OPECS3.T5A, OPECSADH.E1D, OPECSADP.E1D, OPECSADH.E2D
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the needed actions.
Event Context (6)	The important constants for the OPECS (8) calculation (HEP 16) are that the operators have detected the loss of SDC (OPSDC succeeds), HPCS is the only available ECCS system, and ADHR may need to be isolated from the control room. Closing of the 8 or 9 valve from the control room is adequate to isolate ADHR. With the loss of SDC, the operators would need to enter the ONEP for IDHR. The ONEP directs the operators to initiate ECCS water solid operation.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), HPCS SOI (04-1-01-E22-1, Rev. 44), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20)

Table 10.1.16.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	Loss of systems would be alarmed. In the context of being in shutdown the operators would be aware of the need for some form of SDC and have already detected the loss of normal SDC systems and entered the IDHR ONEP. The ONEP for IDHR directs the control room to use ECCS to go water solid in this context. Reactor coolant temperature will be rising.	

Table 10.1.16.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available. The IDHR ONEP directs operators to initiate ECCS water solid operation. HPCS is the only ECCS system available.	One--the loss of SDC is a result of the initiator.	<p>1. Isolate ADHR from the control room (if necessary) by closing 8 or 9 valve.</p> <p>2. Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs. - Ensure that two SRVs are open. - Increase RPV water level with any available injection system. In this context HPCS is the only ECCS system assumed available. 	Isolation of ADHR is not directed by procedure in this context. However, on the basis of interviews with operators, it was clear that they would be aware of the need to isolate the low pressure piping if necessary. In addition, during the site interviews, the operators clearly indicated that HPCS would be initiated. However, it is not <u>explicitly</u> called by the procedure.

Table 10.1.16.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_o) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_s) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.16.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Isolate ADHR from the control room (in most cases this action would already be accomplished by the time the operators reached this point)	CR	--	1 minute	0 minutes - if action necessary, it was assumed to be done in parallel with OPECS actions listed below	Per ASEP HRAP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
4. Initiate ECCS system (HPCS)	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 3 min. Total time for actions	

Table 10.1.16.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation	23 minutes	3 minutes	20 minutes	

Table 10.1.16.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per Table 8-3, the median value from Figure 8-1 for 20 minutes diagnosis time was assigned.		Median = 0.01 Mean = 0.027	The median value from ASEP HRAP Figure 8-1 was selected because the isolation of ADHR and the use of HPCS is not explicitly called out by procedure in this context. Site interviews suggested that the operators would perform these actions.

Table 10.1.16.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements. Initiation of ECCS water solid operation is clearly indicated by the IDHR ONEP in this context.	No	Step-by-Step	

Table 10.1.16.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	HPCS is available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.16.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.01 Mean = 0.027	--	Med. Mean 0.01 0.027	(10)	
2. Initiate ECCS water solid operation per procedure (includes isolating ADHR if necessary).	Median = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations, additional concerns which might be facing the operators as a function of the specific initiators, and because failures or problems in closing MSIVs or opening 2 SRVs have to be considered by the operators in the same time period i.e., OPMSV and OP1SV.	<u>0.02</u> <u>0.032</u> 0.03 0.059 Total Median HEP = 0.03 Total Mean HEP = 0.059	<u>(5)</u> (10)	Since both the diagnosis and action HEPs made significant contributions to the total HEP, the larger of the two EFs was assigned.

Table 10.1.17.1
HEP 17 Calculation

Human Action Event (1)	OPECS (4)
Event Tree(s) (2)	EA
Initiators (3)	TAB5H, TDB5H
Sequence Locator Files (4)	OPECADH5.TAB, OPECSADH.TDB
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (4) calculation (HEP 17) are that the control room has failed to diagnose the loss of SDC in 37 minutes, e.g., OPSDC fails). Thus, they have failed to enter the ONEP for IDHR. SDC (ADHR) has failed due to the loss of the only available AC or DC bus. Since 37 minutes have elapsed, the operators would be very likely to check temperature and pressure on the chart recorders in the 23 minutes allowed for OPECS and they may receive additional alarms. However, the operators would have to retrieve and read the IDHR ONEP and HPCS SOI, isolate ADHR (not explicitly directed by procedure to do so in this context), align HPCS for injection per HPCS SOI 04-1-01-E22-1, and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), HPCS SOI (04-1-01-E22-1, Rev. 28)

Table 10.1.17.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period. Reactor pressure and coolant temperature will be rising.	

Table 10.1.17.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control and vessel cooling is needed, IDHR ONEP directs operators to initiate ECCS water solid operation (not explicitly directed to use HPCS).	One	<p>Isolate ADHR to prevent overpressurizing low pressure piping (not explicitly called by procedure)</p> <p>Per HPCS SOI (Step 5.2) Manual startup of HPCS system Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. <p>In this context HPCS is the only available ECCS system</p>	

Table 10.1.17.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.17.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Since OPSDC failed, operators still need to retrieve and read IDHR ONEP and HPCS SOI	CR	--	5 minutes (Table 8-1, Step 5a)	5 minutes	See HEP 1 (OPSDC (1)), same table, for rationale.
2. Isolate ADHR (not explicitly proceduralized) Key is to close the 8 or 9 valve to prevent overpressurization of the low pressure piping	CR	--	1 minute (Table 8-1, Step 5b)	1 minute	Given the failure of the operators to detect the loss of SDC in 37 min. and the fact that isolating ADHR is not explicitly indicated by procedure, the upper bound value for the diagnosis part of OPECS was used.
3. Check closed MSIVs	CR	--	1 minute (Table 8-1, Step 5b)	1 minute	Steps 3 and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Ensure 2 SRVs open	CR	--	1 minute (Table 8-1, Step 5b)	1 minute	
5. Align and initiate HPCS per HPCS SOI (step 5.2). HPCS is not explicitly called by IDHR ONEP, but use of any available ECCS system is indicated	CR	--	1 minute (Table 8-1, Step 5b)	<u>1 minute</u> 9 minutes Total time for all actions.	The two critical steps required to start HPCS injection when it was in standby were judged to be completely dependent

Table 10.1.17.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	9 minutes	14 minutes	

Table 10.1.17.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the upper bound value from Figure 8-1 for 14 minutes diagnosis time was assigned. Given the failure of OPSDC, in conjunction with the non-proceduralized aspects of the diagnosis, the upper bound was judged to be appropriate.		Med. = 0.4 (EF= 10) Mean = 1.06 or 1.0	

Table 10.1.17.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.					Since diagnosis value is equal to a failure probability of 1.0, the action HEPs are irrelevant.

Table 10.1.17.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid						Since diagnosis value is equal to a failure probability of 1.0, the action HEPs are irrelevant.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.17.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.4 Mean = 1.06	--	Med. Mean 0.4 1.0	(10)	
2. Initiate ECCS water solid per procedure.	Not calculated given diagnosis = 1.0		Total HEP = 1.0		

Table 10.1.18.1
HEP 18 Calculation

Human Action Event (1)	OPECS (9)
Event Tree(s) (2)	E, EP
Initiators (3)	T1-5, TIA5H, TDB5H, T5A5H, T5D5H, E1B5H, E2B5H, E1T5H, E2T5H, E1V5H, E2V5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSSDC8.SDC, OPECSLP4.EP, OPCSEL32.TIA, OPECSLP8.TIA, OPECSDC6.TIA, OPECSDC10.TIA, OPECSL.TDB, OPECS4.T5A, OPECLAP.T5D, OPECSLEP.T5D, OPECS10.T5D, OPECSDC0.E1B, OPECSDC6.E2B, OPECSDCF.E1T, OPECSDC5.E2T, OPECSADF.E1V, OPECSAD5.E2V, OPECSLHY.TLM, OPECSLP.TIF, OPECSLP.TIH, OPECSLP.TLM, OPECSLP.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constant for the OPECS (9) calculation (HEP 18) is that the control room has failed to diagnose the loss of SDC. The failure to recognize the loss of SDC can occur in either of two contexts. The first context is that SDC(B) continues to run and the operators fail to recognize the need to provide level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to a loss of CRD and/or RWCU and/or forced recirculation. RWCU has auto-isolated in these sequences. The second context is that SDC(B) fails and the operators initially fail to recognize the loss of SDC (OPSDC fails). Regardless, in both cases the E or EP tree is entered with the operators apparently unaware of the need for SDC. In OPECS (9) (HEP 18), the operators must recognize the loss of SDC and enter the IDHR ONEP. In either scenario, additional indicators would be present during the time allowed for OPECS. The IDHR ONEP directs the operators to initiate ECCS water solid operation (LPCI, HPCS, or both are available, depending on context).
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.1.18.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	In addition to numerous alarms and indications which would already be present, reactor temperature (and in some cases pressure) will be increasing). The crew is required to check the chart recorders every 30 minutes and with the additional time available for OPECS, these checks should occur. Furthermore, a low level alarm would also be likely to occur during this period. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.1.18.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. In some sequences, however, HPCS is the choice due to the initiator, e.g., T5A5H (loss of SSW).</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.1.18.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.18.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.1.18.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	23 minutes	8 minutes	15 minutes	

Table 10.1.18.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned.		Med. = 0.04 Mean = 0.106	For this event, the operators have failed to diagnose the loss of SDC in spite of several indications (OPSDC or OPDHR have failed). Given these previous failures, it was judged that the lower bound diagnosis value would not be appropriate even though the site interviews indicated that the operators have a clear understanding of the procedure and the requirements.

Table 10.1.18.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.18.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _E <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.18.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.04 Mean = 0.106	--	Med. Mean 0.04 0.106	(10)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations and because failures or problems in closing MSIVs or opening 2 SRVs would have to be considered by operators in the same time period i.e., OPMSV and OPISV.	<u>0.02</u> <u>0.032</u> <u>0.06</u> <u>0.138</u> Total Median HEP = 0.06 Total Mean HEP = 0.138	<u>(5)</u> (10)	The error factor associated with the dominant HEP was assigned.

Table 10.1.19.1
HEP 19 Calculation

Human Action Event (1)	XTIEB
Event Tree(s) (2)	SDC, ADH, TIA5H,
Initiators (3)	T1-5, TIA5H
Sequence Locator Files (4)	OPXTIE.T1, OPXTIE.TIA
Event Description (5)	XTIEB is the operator action to cross-tie the HPCS diesel generator (DG3) to provide power to train 2 systems.
Event Context (6)	For the XTIEB calculation (HEP 19), a LOSP has occurred (and in some cases a loss of IA) and the backup diesel generator fails to start (DV1-2 fails). The HPCS system is unavailable and by procedure the operators are allowed to cross-tie DG3 to train 2.
Applicable Procedures (7)	Loss of AC Power ONEP (05-1-02-I-4)

Table 10.1.19.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
An LOSP with a failure of DG 2 to start. HPCS is unavailable. Operators must diagnose and carry-out the actions to cross-tie DG 3 to train 2.	O	The LOSP and the failure of the diesel to start will be clearly indicated. The unavailability of HPCS could be determined in several ways. The Loss of AC Power ONEP, which will be entered, instructs the operators to perform the cross-tie if HPCS is unavailable.	In the site interviews the operators indicated that the cross-tie would be the obvious choice.

Table 10.1.19.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
An LOSP with a failure of DG 2 to start. HPCS is unavailable. Operators must diagnose and carry-out the actions to cross-tie DG 3 to train 2.	One	The operators need cross-tie DG 3 to train 2 and add the new loads.	

Table 10.1.19.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{od}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to perform the cross-tie.	60 minutes	0	60 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.19.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Perform the DG 3 to train 2 cross-tie	Outside CR		30 minutes	30 minutes	<p>On the basis of measurements taken at GGNS for NUREG/CR-4550, it was determined that the actions outside the control room would require approximately 30 minutes.</p> <p>Adding the new loads from the control room was determined to require approximately 5 minutes.</p> <p>Travel and performance times are grouped under the performance time column.</p>
2. Add new loads	CR	--	5 minutes	5 minutes	

Table 10.1.19.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to perform the cross-tie.	60 minutes	35 minutes	Approx. 25 minutes	

Table 10.1.19.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to perform cross-tie.	Per ASEP Table 8-3, the upper bound value from Figure 8-1 for 25 minutes diagnosis time was assigned.		Med. = 0.02 Mean = 0.053	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. The upper bound diagnosis value was used to stay consistent with NUREG/CR-4550 which indicated inadequate practice of the scenario.

Table 10.1.19.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Perform cross-tie and add loads.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step-by-step	Procedure is straightforward.

Table 10.1.19.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	T_E < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Perform cross-tie and add loads.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.19.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^{op}	Independent Check/Correction HEP (HEP _c) (3) ^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.02 Mean = 0.053	--	Med. Mean 0.02 0.053	(10)	
2. Perform cross-tie	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the criticality of the task. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01		Second check HEPs are multiplied by the original HEP for each action.
3. Add loads	Med. = 0.02 Mean = 0.032	Given the pressing need to restore the loads and the presence of procedures to guide the restorations, credit for a second check was given. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.028 0.073 Total Median HEP = 0.028 Total Mean HEP = 0.073	<u>(5)</u> (10)	Since both the diagnosis and action HEPs made significant contributions to the total HEP, the larger of the error factors was assigned.

Table 10.1.20.1
HEP 20 Calculation

Human Action Event (1)	OPSDC (3)
Event Tree(s) (2)	SDC, ADH, TIA5H, E1B5H, E2B5H, E1D5H, E2D5H, T5D5H, S3-5, S3H-5, E2V5H, E2T5H
Initiators (3)	T1-5, TIA5H, T5D5H, E1B5H, E2B5H, E1D5H, E2D5H, E1T5H, E1V5H, S3-5, S3H-5, E2V5H, E2T5H, TIOF5, TIHP5, TIOP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPXTIE.T1, OPXTIE.TIA, OPSDC.E2B, OPSDC.T5D, RESB.E1B, RESAD.E1D, OPSDCADH.E2D, OPSDC.T5D, RESC.E1T, RESC.E1V, OPSDC.E2T, OPSDC.E2V, OISSL.S35, OISSL.S3H, OPSDC.TIF, OPSDC.TIH, OPSDC.TIO, OPSDC.TLM, OPSDC.TRP
Event Description (5)	OPSDC in this case includes the control room crew diagnosing the loss of SDC, realizing that SDC(B) will auto-isolate on high pressure (135 psi) when the cross-tie of the HPCS diesel generator to train 2 is completed, and entering the Inadequate Decay Heat Removal ONEP.
Event Context (6)	<p>For the OPSDC (3) calculation (HEP 20), a LOSP has occurred and the available diesel generator (DG 2) has failed to start. HPCS is unavailable and the operators are attempting to cross-tie DG 3 to train 2. SDC has been lost and the operators must realize that SDC(B) will auto-isolate on high pressure when the cross-tie is completed and therefore will not be available. If the operators fail to make this diagnosis, they may fail to realize the need to enter the IDHR ONEP and initiate ECCS water solid operation (OPECS). OPSDC and OPECS must occur more or less in parallel with the cross-tie (XTIEB). Thus, a failure to make the correct diagnosis in OPSDC is assumed to fail OPECS because the operators may waste the time available for initiating ECCS water solid operations if they assume SDC(B) will be available.</p> <p>OPSDC in this context constitutes a diagnosis action only and with the time available (37 min.), the ASEP method gives an HEP of 0.01. However, on the basis of the limited indicators available to the operators and on the results of the site interviews with the operators, the PRA/HRA analysts did not have much confidence in the validity of the obtained HEP. Based on "engineering judgment", a very conservative HEP of 0.6 was assigned for OPSDC in this case. This value was basically a screening value and when the sequences asking XTIEB and OPSDC were quantified with this value, none survived. Thus, a more realistic value for OPSDC in this context was not needed. Since the detailed ASEP calculations were not relevant for HEP 20, Tables 10.1.20.2 through 10.1.20.9 were not included.</p>
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-020-III-1), Residual Heat Removal SOI (04-1-01-E120-1)

Note. Tables 10.1.20.2 through 10.1.20.9 were unnecessary for HEP 20 and therefore were not included.

Table 10.1.20.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
OPSDC in this case consists only of a diagnosis. See Table 10.1.20-1, for the rationale for the assignment of a mean HEP value of 0.6.	Mean = 0.6	-	Mean = 0.6		

Table 10.1.23.1
HEP 23 Calculation

Human Action Event (1)	OPEC, LCHPC (1), LC-LP (1)
Event Tree(s) (2)	R, RA, RP, RAP
Initiators (3)	All transients
Sequence Locator Files (4)	All files beginning with OPEC, e.g., OPECRAP.E1D
Event Description (5)	OPEC is the operator action to initiate an ECCS system for refill to control level. LCHPC and LC-LP are operator actions to control HPCS or LP-CI, respectively, once they have been initiated in order to avoid overfill or overpressurization of RHR/SDC components.
Event Context (6)	<p>For the scenarios for which HEP 23 applies, OPEC is completely dependent on OPDHR. OPDHR is the operator action to control level and OPEC had to occur in the same time period as OPDHR (10 minutes). If CDS was unavailable and OPDHR succeeded, then OPEC succeeded (OPEC set to 0). The assumption was that if CDS was not available, then the operators would attempt to use an ECCS system to control level. However, if CDS was available, it was assumed that the operators would attempt to use CDS to control level and OPEC was set to fail (1.0). Credit was not taken in OPDHR-OPEC for both CDS and a ECCS system. With only 10 minutes available for the diagnosis and action, credit for the initiation of only one system was taken.</p> <p>If OPEC succeeded and the system used was HPCS, then LCHPC was asked. If LPCI was used, then LP-LC was asked. The question was whether the operators would in fact control level and not let the system overfill or overpressurize once they had initiated HPCS or LPCI to control level. LPHPC and LC-LP were judged to be completely dependent on OPEC in the sense that if OPEC succeeded, then LPHPC or LC-LP would succeed. Given that the operators had decided to use an ECCS system, it was assumed that they would control level. The operators are aware of the injection rates of the ECCS systems and it was assumed that they would not just walk away and forget to control level after initiating one of these systems. Since detailed ASEP calculations were not required for HEP 23, Tables 10.1.23.2 through 10.1.23.9 were not included.</p>
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1), EP-2 (RPV Control, Rev. 19).

Note. Tables 10.1.23.2 through 10.1.23.9 were unnecessary for HEP 23 and therefore were not included.

Table 10.1.23.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Initiate an ECCS system for level control (OPLEC) and control level to avoid overfill or overpressurization (LPHPC and LP-LC).		--	If OPDHR succeeds and CDS not asked, then OPLEC = 0 (success). If CDS was asked, then OPLEC = 1.0 (fails). If OPLEC succeeds, the LPHPC or LC-LP succeeds (HEP = 0)		ASEP Table 8-1, Step 12. See Event Context (6) in Table 23-1 (HEP 23).

**Table 10.1.25.1
HEP 25 Calculation**

HRA

Human Action Event (1)	OPVNT
Event Tree(s) (2)	EC, ECP, EX, ECX, FCAC
Initiators (3)	All initiators (Transients and LOCAS)
Sequence Locator Files (4)	All files beginning with OPICT, e.g., OPICTE.E1T, with the exception of files labeled OPICTCAU, e.g., OPICTCAU.TIF
Event Description (5)	OPVNT is the operator action to vent containment.
Event Context (6)	<p>For OPVNT (HEP 25), the operators have successfully initiated ECCS water solid operation to provide SDC. However, SPC and CS have failed and eventually containment pressure and temperature will begin to rise. The operators will need to vent to remove heat buildup in containment, if possible. As containment pressure increases, the operators will enter EP-3, (Containment Control) and venting will eventually be indicated.</p> <p>Note 1. Venting requires both trains of power and IA to be available. For sequences where this was not the case, OPVNT was assumed to fail (HEP = 1.0).</p> <p>Note 2. In FCAC tree, OPVNT has 54 hours available. Since this exceeds the mission time of 24 hours, the relevant sequences did not need to be quantified any further.</p>
Applicable Procedures (7)	EP-3 (Containment Control), 05-S-01-EP-2 (Attachment 13, Containment Venting), Inadequate Decay Heat Removal ONEP (05-1-02-III-1).

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Table 10.1.25.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T.) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators have initiated ECCS water solid operation. Inadequate SP cooling results in heat buildup in containment, leading to the need to vent containment.	O	With the failure of SPC and CS under water solid operation, the operators will be monitoring containment conditions. Containment temperature and pressure will be monitored, along with SP and drywell temperature. These indicators will lead the operators to enter EP-3.	

Table 10.1.25.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
With no SP cooling or CS under water solid operation, containment venting is needed to reduce temperature (heat buildup) in containment.	One	The operators will follow 05-S-01-EP-2 (Attachment 13, Containment Venting), which directs the operators to jumper four relays to defeat the vent path isolation interlocks (two are located in the main control room and two in the upper control room) and then open 6 valves from the main control room.	

Table 10.1.25.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to vent containment.	11 hours	Approximately 1.5 to 2 hours before indicators for entering EP-3 would be reached.	9 hours	SEA Calculation C90-492-01-A16

Table 10.1.25.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
<p>1. Jumpering relays and opening valves to vent.</p> <p>Note. In scenarios where a LOCA signal has occurred, IA would have to be restored. It was assumed that if the operators decided to vent in these scenarios, they would restore IA if necessary. More than adequate time would be available.</p>	Main and upper control rooms.	--	--	<p>Travel and performance time was conservatively estimated to be approximately one hour (power is available).</p> <p>1 hour</p>	
<p>2. Accomplish potential actions required for dumping SPMU for SP cooling (OPSPM) and providing additional makeup either to SPMU or directly to the SP (SPMKP).</p> <p>Note. The actions for OPSPM and SPMKP had to be accomplished in the same time period as OPVNT. Thus, the time estimated to be required for these events was subtracted from the time available for OPVNT</p>	In worse case, actions could be required outside CR	--	4 hours	<p><u>4 hours</u> 5 hours total action time</p>	The time assumed to be required for OPSPM and SPMKP is very conservative. Given the generally long time frame for OPVNT, OPSPM, and SPMKP, substantial diagnosis time will be available.

Table 10.1.25.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to vent containment.	9 hours	5 hours	Approx. 4 hours	-

Table 10.1.25.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to vent containment.	Per ASEP Table 8-3, the median value from Figure 8-1 for 4 hours diagnosis time was assigned.		Med. = 4.0E-5 Mean = 3.4E-4	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. The procedures are clear.

Table 10.1.25.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Jumper relays and open valves. Restore IA if necessary.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step-by-step Actions are proceduralized.	

Table 10.1.25.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_m <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Vent containment	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time available before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.25.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 4.0E-5 Mean = 3.4E-4	--	Med. Mean 4.0E-5 3.4E-4	(10)	
2. Jumper relays, open valves, and restore IA if necessary. These straightforward, proceduralized actions were assumed to be completely dependent.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available and the presence of feedback that would alert the operators to any failures. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.004 0.011 Total Median HEP = 0.004 Total Mean HEP = 0.011	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEPs was assigned.

Table 10.1.26.1
HEP 26 Calculation

HRA

Human Action Event (1)	OPSPM and SPMUN
Event Tree(s) (2)	EC, ECP, EX, and ECX for OPSPM. ECN, ECNP, and ECNPL for SPMUN.
Initiators (3)	All initiators (Transients and LOCAS)
Sequence Locator Files (4)	All files beginning with OPICT, e.g., OPICTE.EIT, with the exception of files labeled OPICTCAU, e.g., OPICTCAU.TIF and all files beginning with SPMUN, e.g. SPMUN.ECN.
Event Description (5)	OPSPM and SPMUN are the operator actions to dump SPMU to provide additional level and cooling to the SP. SPMUN applies to sequences where the SPMU dump must be accomplished without AC power.
Event Context (6)	For OPSPM and SPMUN (HEP 26), the operators have successfully initiated ECCS water solid operation to provide SDC or are steaming the vessel with HPCS. However, SPC and CS have failed and eventually the SP will need additional level and cooling. The operators will need to dump SPMU. As SP water level decreases, the operators will enter EP-3, (Containment Control) and an SPMU dump will be indicated. In the sequences where SPMUN is asked, AC power is not available and the SPMU dump valves will have to be opened locally.
Applicable Procedures (7)	EP-3 (Containment Control), SPMU EOI (04-1-01-E30-1)

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Table 10.1.26.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators have initiated ECCS water solid operation. Inadequate SP cooling and SP level loss results in the need to dump SPMU.	O	With the failure of SPC and CS under water solid operation or steaming, the operators will be monitoring containment conditions. SP temperature will be increasing and level will be dropping. Low SP level will be alarmed. These indicators will lead the operators to enter EP-3 and will indicate the need to provide makeup to the SP.	

Table 10.1.26.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
With no SP cooling or CS under water solid operation or steaming, SPMU will be needed to provide adequate level and cooling to the SP.	One	The operators will follow EP-3 and the SPMU SOI, which directs the operators to open two valves per train to initiate SPMU. Success with one train is all that is needed. During LPS, SPMU is isolated to avoid an inadvertent dump. The operators will have to override the isolation. Section 5.2 of the SPMU SOI provides the procedure. Without AC power, the operators will have to open two 30 in. valves manually using a handwheel engagement lever. The valves are located about 60 ft. above the SP. Flow can be established within 10 minutes according to GGNS personnel. Several hours would be available.	On the basis of discussions with plant personnel (by telephone), conditions would not be so adverse that flow from the SPMU could not be established manually in the time available.

Table 10.1.26.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{α}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to initiate SPMU.	11 hours	Approximately 1.5 to 2 hours before indicators for entering EP-3 would be reached.	9 hours	SEA Calculation C90-492-01-A16

Table 10.1.26.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Override SPMU isolation and open valves. Will require closing of opened (red tagged) breakers for 1 train. If no power is available, the operators will have to manually open two valves with the handwheel.	Outside control room in Control Bldg. for closing breakers. The operators will have to enter containment to manually open SPMU valves.	--	--	Travel and performance time was <u>very</u> conservatively estimated to be approximately 4 hours. This would be a "worst case" scenario. Total action time = 4 hours	

Table 10.1.26.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need initiate SPMU.	9 hours	4 hours	Approx. 5 hours	

Table 10.1.26.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate SPMU.	Per ASEP Table 8-3, the median value from Figure 8-1 for 5 hours diagnosis time was assigned.		Med. = 3.0E-5 Mean = 2.5E-4	Telephone conversations with plant personnel indicated that the operators would be aware of the problem of concern and have a clear understanding of the requirements. The procedures are clear.

Table 10.1.26.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate SPMU.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step-by-step Actions are proceduralized.	

Table 10.1.26.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate SPMU	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time available before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.26.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2) ^{op}	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 3.0E-5 Mean = 2.5E-4	—	Med. Mean 3.0E-5 2.5E-4	(30)	
2. Override SPMU isolation and open valves from the control room or use handwheel to open valves manually.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available and the presence of feedback that would alert the operators to any failures. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.0104</u> 0.004 0.0106 Total Median HEP = 0.004 Total Mean HEP = 0.011	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.1.27.1
HEP 27 Calculation

Human Action Event (1)	SPMKP and SPMKN
Event Tree(s) (2)	EC, ECP, EX, and ECX for SPMKP. ECN, ECNP, ECNPL, and SNP for SPMKN.
Initiators (3)	All initiators (Transients and LOCAS)
Sequence Locator Files (4)	All files beginning with OPICT, e.g., OPICTE.E1T, with the exception of files labeled OPICTCAU, e.g., OPICTCAU.TIF and all files beginning with SPMUN, e.g. SPMUN.ECN. SPMUN is also found in OPSTM.SNP.
Event Description (5)	SPMKP and SPMKN are the operator actions to provide makeup to SPMU (for dumping SPMU again to the SP) or directly to the SP, to compensate for boil off from the SP. SPMKN applies to sequences where the makeup from the CST must be obtained without AC power.
Event Context (6)	<p>For SPMKP and SPMKN (HEP 27), the operators have successfully initiated ECCS water solid operation to provide SDC or are steaming the vessel with HPCS. However, SPC and CS have failed and eventually the SP will need additional level and cooling. The operators have already decided to initiate SPMU, but will need additional makeup eventually to compensate for boil off. If operators successfully diagnosed the need to dump SPMU (OPSPM or SPMUN succeeds), it was assumed that they would also be aware that additional makeup might be needed. Thus, the diagnosis parts of SPMKP and SPMKN were assumed to be completely dependent on OPSPM and SPMUN, respectively. In sequences where power and IA is lost (sort of the worst case), nitrogen tanks may be required to open 3 or 4 AOVs, e.g., AOV 47, AOV 131, AOV 130. XV 46 will have to be manually opened.</p> <p>Note. In the SNP tree, when SPMKN is asked, steaming is occurring out the MSIVs and only 35 minutes would be available to accomplish SPMKN. This is insufficient time given that power is lost. Thus, in the SNP tree only, SPMUN is set to 1.0.</p>
Applicable Procedures (7)	EP-3 (Containment Control), SPMU EOI (04-1-01-E30-1)

Table 10.1.27.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators have initiated ECCS water solid operation. Inadequate SP cooling and SP level loss results in the need to dump SPMU.	O	With the failure of SPC and CS under water solid operation or steaming, the operators will be monitoring containment conditions. SP temperature will be increasing and level will be dropping. Low SP level will be alarmed. These indicators will lead the operators to enter EP-3 and will indicate the need to provide makeup to the SP. Once the operators have made the initial decision to dump SPMU, it was assumed that they would also realize the need to provide additional makeup for later. Moreover, if the SP began heating up and losing level again, the indicators as before would occur.	

Table 10.1.27.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
With no SP cooling or CS under water solid operation or steaming, additional makeup beyond a single SPMU dump will be needed to provide adequate level and cooling to the SP.	One	The operators will have to open a series of valves to provide makeup from the CST to SPMU or to provide the makeup directly to the SP. If power and IA are lost, operators would have to use nitrogen bottles to open several AOVs.	

Table 10.1.27.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to initiate SPMU.	11 hours	Approximately 1.5 to 2 hours before indicators for entering EP-3 would be reached.	9 hours	SEA Calculation C90-492-01-A16

Table 10.1.27.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
In the worst case, the operators would have to obtain nitrogen bottles to open several AOVs. In most cases the valve openings required to obtain makeup to the SP from the CST could be done from the control room.	In some cases, outside the control room in the Aux. or Control Bldgs.	--	--	Travel and performance time was <u>very</u> conservatively estimated to be approximately 4 hours. In these scenarios, there would be plenty of time to accomplish the necessary actions. Total action time = 4 hours	

Table 10.1.27.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
SPMKP and SPMKN were assumed to be completely dependent on OPSPM and SPMUN, respectively. Thus, diagnosis time is not relevant for the HEP calculation.	--	--	--	In any case, diagnosis time would be substantial and the diagnosis HEP would be negligible compared to the action HEP obtained with ASEP HRAP.

Table 10.1.27.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
SPMKP and SPMKN were assumed to be completely dependent on OPSPM and SPMUN, respectively. Thus, diagnosis time is not relevant for the HEP calculation.			<p>Med. = 0</p> <p>Mean = 0</p> <p>If OPSPM or SPMUN succeed, then the diagnosis part of SPMKP or SPMKN will also succeed.</p>	

Table 10.1.27.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Open valves to provide additional makeup for SPMU.	N/A	No explicit procedures, but once the decision was made, the actions would be straightforward.	No	Step-by-step	

Table 10.1.27.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	$T_P < 2h$ After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Open valves to provide additional makeup for the SP.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time available before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.27.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0 Mean = 0	--	Med. Mean 0 0		OPSPM or SPMUN has already succeeded. The diagnosis was assumed to be completely dependent on these successes.
2. Align valves to provide makeup from the CST to SPMU or to the SP. If power is lost, some valves may need to be opened locally with the hand wheel. If IA is lost, AOVs may need to be opened manually using nitrogen bottles to provide the "air".	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because the additional makeup may not be provided until late in the time available and there may not be sufficient time to correct any errors since many of the activities may have taken place outside the control room.	<u>0.02</u> <u>0.032</u> 0.02 0.032 Total Median HEP = 0.02 Total Mean HEP = 0.032	<u>(5)</u> (5)	The error factor associated with the dominant HEP (only HEP in this case) was assigned.

Table 10.1.28.1
HEP 28 Calculation

Human Action Event (1)	OPFLD (1)
Event Tree(s) (2)	F, FP
Initiators (3)	All transients
Sequence Locator Files (4)	All files beginning with OPFLD, e.g., OPFLDE.E1T
Event Description (5)	OPFLD is the operator decision and action to flood the vessel/containment in order to provide some form of SDC.
Event Context (6)	For the OPFLD (1) calculation (HEP 28), OPECS or OPDHR have succeeded, but all ECCS systems have failed or are unavailable. Thus, the operators have attempted to do the correct actions, but the systems asked have failed or been unavailable. One option available to the operators to provide level and core cooling is to flood the vessel/containment. SSWXT or FW are systems that could (potentially) be used to flood. If vessel level is too low and not increasing, EP-2 calls out for alternate level control which will eventually lead the operators to initiate flooding.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.1.28.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T.) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
ECCS systems are not available and core cooling and makeup are needed. The question is whether will flood with SSWXT or FW.	O	In addition to numerous alarms and indications which would already be present, reactor temperature (and in some cases pressure) will be increasing). The crew has been attempting to respond to existing problems and will be aware of the need to provide core cooling in some way. Low level alarms would likely to occur during this period.	-

Table 10.1.28.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators are attempting to respond to IDHR, but no ECCS systems are available. OPFLD asks whether the operators will attempt to flood with SSWXT or FW.	One	<ul style="list-style-type: none"> - Check closed MSIVs - Ensure that some SRVs are open - Align and initiate SSWXT for flooding 	It was assumed the SSWXT would be the operators first choice for flooding and credit was not taken for both SSWXT and FW in the sequences covered by this HEP.

Table 10.1.28.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ca}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_s) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate flooding	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.28.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read EP-2 and apply to LP&S context.	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and study EP-2 is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LP&S and with the idea that some "generalization" of EP-2 to the LP&S context would be required.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for flooding were judged to be an integrated set of actions.
3. Ensure some SRVs are open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate SSWXT per RHR SOI 04-1-01-E12-1, step 6.10. Requires 2 valves to be opened.	CR	--	1 minutes (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.1.28.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_A) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment	23 minutes	8 minutes	15 minutes	

Table 10.1.28.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment.	Per ASEP Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned.		Med. = 0.04 Mean = 0.106	Flooding in response to IDHR during LP&S is not explicitly called out by procedure. However, it is at least indirectly indicated in EP-2 and the site interviews indicated that the operators have a clear understanding of the needed response and the necessary actions. Thus, per ASEP HRAP, Table 8-3, the median diagnosis value would be appropriate.

Table 10.1.28.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Flood containment.	N/A	Actions are specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.28.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Flood with SSWXT.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.28.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{cz}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.04 Mean = 0.106	--	Med. Mean 0.04 0.106	(10)	
2. Initiate flooding with SSWXT.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations.	<u>0.02</u> <u>0.032</u> 0.06 0.138 Total Median HEP = 0.06 Total Mean HEP = 0.138	<u>(5)</u> (10)	The error factor associated with the dominant HEP was assigned.

Table 10.1.29.1
HEP 29 Calculation

Human Action Event (1)	OPSTM (1)
Event Tree(s) (2)	S, SP, SNP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	All files beginning with OPSTM, e.g., OPSTMFD3.SP, with the exception of OPSTMHYD.ECN, OPSTMSNP.SNP, OPSTMSNP.E1T, OPSTM51.TIH, OPSTM51.TIF, OPSTM81.TIH, and OPSTM81.TIF.
Event Description (5)	OPSTM is the operator decision to initiate steaming of the core.
Event Context (6)	OPSTM (1) (HEP 29) applies in numerous sequences. It represents the operators decision to steam the vessel to provide core cooling when other actions they have taken have been unsuccessful. For example, in many sequences they have attempted to initiate ECCS water solid operation (OPECS succeeds), but the systems have failed. The critical aspect of HEP 29 is that the operators have demonstrated an awareness of the problem. While steaming of the vessel is a non-proceduralized action, the operators will essentially be steaming the core by default at this point. They will need to ensure 1 SRV is opened and eventually they will need to provide some form of makeup, which they have already been attempting to accomplish. Several systems may be used for steaming, e.g., CRD, CDS, SSWXT, and FW.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-29-02-III-1)

Table 10.1.29.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
The operators have attempted to respond to IDHR. For any of several reasons, their attempts have failed, e.g., ECCS fails. OPSTM asks whether or not the operators will consciously decide to steam the vessel. The operators need to ensure that 1 SRV is open.	O	Operators have been attempting to respond to IDHR. Thus they are aware that vessel temperature is going up. They are in fact steaming by default and need only open 1 SRV. There are no particular indicators that specify steaming.	<p>BWRs basically operate by steaming. Thus, it is not an "unusual" response to the problem.</p> <p>Note. Even if the operators have decided not to go water solid with only 1 SRV available (OP1SV fails in E tree), they may still decide to steam with 1 SRV. If they initially fail to get 1 SRV open, it was assumed they could still decide to attempt steaming.</p>

Table 10.1.29.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Previous attempts to provide SDC have failed. The operators may decide to steam the vessel.	One	Check open 1 SRV	Complete dependence was assumed between the control room consciously deciding to steam the vessel and checking open 1 SRV. In most of the sequences in which this HEP is applied, the SRV is already open. Thus, steaming is occurring by default. Interviews with operators indicated that they would not open MSIVs for steaming unless they had a vacuum in the condenser. Cannot assume a vacuum exists in the condenser during POS 5. Therefore, deciding to steam was assumed to entail ensuring that 1 SRV was open.

Table 10.1.29.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_i) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
A decision to steam is all that is asked in this event.	23 minutes	0	23 minutes	SEA Calculation C90-492-029-A16

Table 10.1.29.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_t) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
No action required. Checking open 1 SRV was assumed to part of the decision to steam. In most cases the necessary SRV is already open.	Control Room	--	--	--	Initiation of a makeup system is not immediately required. Eventually makeup is required and system success is asked later in the tree.

Table 10.1.29.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Consciously decide to steam the vessel.	23	0 minutes	23 minutes	-

Table 10.1.29.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to steam the vessel.	Per ASEP HRAP Table 8-3, the upper bound value from ASEP Figure 8-1 for 23 minutes diagnosis time was assigned.	N/A	Median = 0.04 Mean = 0.106	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. However, since it is not proceduralized and apparently not covered specifically in training, it is not clear that all operators would consciously decide to steam. Thus, without additional information, per ASEP HRAP Table 8-3, the upper bound diagnosis value was indicated.

Table 10.1.29.8
Post-Diagnosis Action-Type Identification

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs, Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

¹ Actions assumed completely dependent with diagnosis (see Table 10.1.29.3 for rationale).

Table 10.1.29.9
Post-Diagnosis Stress-Level Identification

Action (1)	T_R < 2h After IE (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

¹ Actions assumed completely dependent with diagnosis (see Table 10.1.29.3 for rationale).

Table 10.1.29.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Decide to steam the vessel.	Diagnosis and Actions: Median = 0.04 Mean = 0.106	N/A	Median = 0.04 Mean = 0.106	10	

Table 10.1.30.1
HEP 30 Calculation

Human Action Event (1)	OPSOF (2)
Event Tree(s) (2)	OF, OFP
Initiators (3)	All transients, H1-5H, J2-5
Sequence Locator Files (4)	OPSOF.OFP, OPSOFFLD.OFP, OPSOF.T5A, OPSOF.T5D, OPSOF.TAB, OPSOF.TDB, OPSOF.TIA, OPSOF2.TIA OPSOF9.TIA, OPSOF.E1B, OPSOF.E2B, OPSOF.E1T, OPSOF2.E1T, OPSOF.E2T, OPSOF.E1V, OPSOF.E2V, OPSOF.TIF, OPSOF.TIH, OPSOF.TLM, OPSOF.TRP, OPSOF.H15, OPSOF.J2
Event Description (5)	OPSOF is the operator action to stop flooding through open main steam line(s).
Event Context (6)	For the OPSOF (2) calculation (HEP 30), the operators have initiated some form of vessel injection, e.g., for water solid operation or flooding of containment, one or more of the MSIVs are open, and water is running down the steam line(s). The operators must detect the flooding, stop the injection system, and close the MSIVs.
Applicable Procedures (7)	All operators would understand the need to stop flooding down the steam line(s). The Inadequate Decay Heat Removal ONEP (05-1-02-III-1) instructs the operators to check closed any open MSIVs when initiating ECCS water solid operation.

Table 10.1.30.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Undesired flooding through open MSIVs caused by intentional initiation of an injection system to increase level.	O	For the situation where level is being increased for ECCS water solid operation, the IDHR ONEP instructs the operators to check closed any open MSIVs. With the additional time, operators may recall or recheck the need to close the MSIVs. For any case, Level 7 and 8 alarms may cue the operators to check the position of MSIVs. Moreover, water flowing down the steam lines into the Turbine Bldg. may be noticed. Could get steam line drain valve alarms.	In the site interviews, operators indicated they would definitely want to stop flooding through MSIVs.

Table 10.1.30.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators are attempting to increase level and inadvertently flood down open MSIVs.	One	The operators need to stop injection and close MSIVs.	

Table 10.1.30.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Detect the flooding or the fact that the MSIVs are open, and stop the flooding.	20 minutes	0	20 minutes	SEA Calculation C90-492-01-A16

Table 10.1.30.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
Terminate injection and close MSIVs.	CR	--	2 minutes	2 minutes	<p>Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.</p> <p>The actions involved in terminating injection and closing the open MSIVs were assumed to be completely dependent. It was assumed that a correct diagnosis would indicate that both actions should occur.</p>

Table 10.1.30.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the flooding down the steam lines and the need for its termination.	20 minutes	2 minutes	18 minutes	

Table 10.1.30.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to terminate flooding down open MSIVs.	Per ASEP Table 8-3, the median value from Figure 8-1 for 18 minutes diagnosis time was assigned.		Med. = 0.015 Mean = 0.04	The site interviews indicated that the operators would understand the need to stop the flooding through open MSIVs.

Table 10.1.30.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Terminate injection and close open MSIVs.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step-by-step	

Table 10.1.30.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Terminate injection and close open MSIVs.	N/A ¹	N/A	No ²	N/A	Moderately High	Actions are straightforward and situation is not yet critical.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.30.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.015 Mean = 0.04	—	Med. Mean 0.015 0.04	(10)	
2. Terminate injection system and close open MSIVs.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because once the diagnosis was made, the operators would get clear feedback regarding the failure of any of the necessary actions and they would be attending to the indicators. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> <u>0.019</u> <u>0.05</u> Total Median HEP = 0.019 Total Mean HEP = 0.05	<u>(5)</u> (10)	Second check HEPs are multiplied by the original HEP for each action. Since both HEPs made significant contributions to the total HEP, the larger of the two error factors was assigned.

Table 10.1.31.1
HEP 31 Calculation

Human Action Event (1)	RESB, RESAD, RESCS (1)
Event Tree(s) (2)	E1B5H, E1D5H, E1T5H, E1V5H
Initiators (3)	E1B5H, E1D5H, E1T5H, E1V5H
Sequence Locator Files (4)	RESB.E1B, RESAD.E1D, RESC.E1T, RESC.E1V
Event Description (5)	RESB is the operator action to recognize the need and unisolate RHR/SDC loop B, RESAD is the operator action to recognize the need and unisolate ADHR, and RESCS is the operator action to recognize need and unisolate the SDC common suction line.
Event Context (6)	HEP 31 applies to sequences where the initiator leads to a loss of SDC that may be restorable. The operators recognize the loss of SDC (OPSDC succeeds) and RESB, RESAD, and RESCS asks whether the operators recognize the potential and attempt to restore the operating SDC system. Restoration may involve the simple opening of a valve that spuriously closed, e.g., 6, 8 or 9 valve. This action must occur in the same time period as that allowed for OPSDC.
Applicable Procedures (7)	None

Table 10.1.31.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A potentially restorable loss of SDC occurs.	O	In most cases (pump trip, system isolation, loss of heat sink (SSW), etc.) a loss of SDC will be alarmed. A loss of SDC will also be indicated by coolant temperature, flow, and discharge pressure changes. Operators are required by the plant to check reactor coolant temperature every 30 minutes at the chart recorder. A spurious valve closure will be indicated by a valve position light in the control room.	

Table 10.1.31.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A potentially restorable loss of SDC occurs, e.g., spurious closure of valve.	One	Operators must determine where the isolation occurred by examining valve positions on the control panel and unisolate. It was assumed that the unisolation activities could require a trip outside the control room and manual opening of the valves.	

Table 10.1.31.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to unisolate SDC and perform required actions.	37 minutes	0	37 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.31.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. After diagnosing the loss of SDC, the operators will have to scan control room panels to determine where the isolation occurred. This activity might be considered part of the diagnosis. However, it was decided that the time that might be required for scanning should be subtracted from the time available to decide what has happened and what must be done.	CR	--	5 minutes	5 minutes	It was assumed that the operators could scan the relevant control panels and identify the potential problem within 5 minutes. Note that travel and manipulation (performance) times in the control room were determined using ASEP HRA P Table 8-1, Step 5b, and are grouped under the performance time column. The scanning process was, however, included as part of the diagnosis process and not considered an independent action.
2. Unisolate the SDC system.	Possibly outside control room	--	15 minutes	<u>15 minutes</u> 20 minutes Total time for actions.	The time to unisolate SDC was estimated on basis of discussions with plant personnel. Since the unisolation could be done from the CR in most cases, the assumption of 15 minutes represents a "worse case" scenario.

Table 10.1.31.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose problem and the need to attempt to unisolate SDC.	37 minutes	20 minutes	Approx. 17 minutes	

Table 10.1.31.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to unisolate SDC	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 17 minutes diagnosis time was assigned.		Med. = 0.02 Mean = 0.053	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. While no explicit procedures apply, the potential causes of an isolation of SDC are fairly straightforward and the possible actions would not be complicated, e.g., opening a valve. Thus, the median diagnosis value was judged appropriate per ASEP HRAP, Table 8-3.

Table 10.1.31.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Unisolate SDC by opening 6, 8 or 9 valve.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step-by-step	

Table 10.1.31.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Unisolate SDC by opening 6, 8 or 9 valve.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.31.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.02 Mean = 0.053	--	Med. Mean 0.02 0.053	(10)	
2. Unisolate SDC by opening 6, 8, or 9 valve.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the limited time and the possibility that the action might take place outside the control.	<u>0.02</u> <u>0.032</u> 0.04 0.085 Total Median HEP = 0.04 Total Mean HEP = 0.085	<u>(5)</u> (10)	Since both HEPs made significant contributions to the overall HEP, the larger of the two error factors was assigned.

Table 10.1.33.1
HEP 33 Calculation

Human Action Event (1)	OPFLD (2)
Event Tree(s) (2)	F, FX, FAX, FNP
Initiators (3)	T1-5, TDB5H, T5A5H, E1B5H, E2B5H
Sequence Locator Files (4)	OPFLD.FNP, OPFLDADH.TDB, OPFLD.T5A, OPFLD.E1B, OPFLD.E2B
Event Description (5)	OPFLD is the operator decision and action to flood the vessel/containment in order to provide some form of SDC.
Event Context (6)	For the OPFLD (2) calculation (HEP 33), OPECS, OPDHR, or at least OPSDC have succeeded. The problem in these sequences is that all ECCS systems are unavailable for one reason or another, and SSWXT is unavailable also. Thus, in the flooding trees, FW is the only available system for flooding. However, on the basis of estimates to align the FW system for injection, it was concluded that the 23 minutes allowed for OPFLD would be insufficient to complete the task. Therefore, OPFLD was set to 1.0 (failure) in the relevant sequences. Since detailed ASEP HRAP calculations were not required for HEP 33, Tables 10.1.33.2 through 10.1.33.9 were not included.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), and Injection with Fire Protection Water System (05-S-01-EP2, ATTCH. 26).

Note. Tables 10.1.33.2 through 10.1.33.9 were unnecessary for HEP 33 and therefore they were not included.

Table 10.1.33.10
Total HEP

Action (1)	Original Operator HEP (HEP_o) (2)	Independent Check/Correction HEP (HEP_c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Flood vessel/containment with FW	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table 10.1.34.1
HEP 34 Calculation

Human Action Event (1)	OPMSV (2)
Event Tree(s) (2)	F
Initiators (3)	T1-5, TDB5H, TIA5H
Sequence Locator Files (4)	OPFLD.FP, OPFLDFR.TDB, OPFLD.TIA
Event Description (5)	OPMSV is the operator action to close open MSIVs.
Event Context (6)	For the OPMSV (2) calculation (HEP 34), it was assumed that if the MSIVs were open and the operators failed to close them before initiating containment flooding (OPFLD success), then they would not close them until water started flowing down the steam lines. Since the action for the operators to stop flooding down the steam lines is asked in OPSOF, and OPMSV in these sequences must occur in the same time period as OPSOF, OPMSV was set to 1.0 (failure). Thus, the question of stopping flooding down the steam lines is addressed in OPSOF, as was intended. Since detailed ASEP HRAP calculations were not required for HEP 34, Tables 10.1.34.2 through 10.1.34.9 were not included.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Note. Tables 10.1.34.2 through 10.1.34.9 were unnecessary for HEP 34 and therefore they were not included.

Table 10.1.34.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Close any open MSIVs.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table 10.1.35.1
HEP 35 Calculation

Human Action Event (1)	OPDHR (2)
Event Tree(s) (2)	L, LA
Initiators (3)	T5D5H, E1B5H, E1D5H, E2D5H, E1T5H, E1V5H
Sequence Locator Files (4)	OPDHR.TDB, OPDHR.T5D, OPDHR.E1B, OPDHR.E1D, OPDHR.E2D, OPDHR.E1T, OPDHR.E1V
Event Description (5)	OPDHR is the operator action to control vessel level in order to avoid a "functional" loss of SDC caused by inadequate circulation between the core and the downcomer regions of the vessel. That is, even if SDC continues to operate, if vessel level becomes too low, a "disconnect" between the core and downcomer regions can occur. This will result in inadequate cooling of the core even though SDC continues to operate. The indications to the operators that the event is occurring can be subtle because temperature readings are apparently taken from the downcomer region, where the water being cooled by SDC is returned. Also, the vessel level would not be so low that any level alarms would sound. A loss of forced recirculation, or a loss of makeup (usually CRD) coupled with continued draindown, can lead to inadequate level. Only 10 minutes was allowed for the operator diagnosis and actions in OPDHR.
Event Context (6)	The important constants for the OPDHR (2) calculation (HEP 35) are that RWCU has not been isolated by a LOSP or loss of IA. Moreover, any losses of forced recirculation or CRD or RWCU are either artifacts of the initiator (e.g., a loss of CCW) or are unrelated to the initiator and occur as random events.
Applicable Procedures (7)	No specific procedures, but the Loss of CCW ONEP (05-1-02-V-1, Rev. 11) and the Inadequate Decay Heat Removal ONEP (05-1-02-III-1) would be relevant, as would the relevant SOIs, e.g., RHR SOI (04-1-01-E12-1).

Table 10.1.35.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR caused by inadequate circulation between the core and the downcomer regions of the vessel. Level control (makeup) is needed.	O	As noted in Table 35.1, the indications for this event may be subtle because vessel temperature readings could be misleading and no level alarms would sound. However, in all the sequences covered, CRD and/or forced recirculation is lost. These events will be alarmed and if the operators are knowledgeable regarding the potential problem, these indications should suffice.	

Table 10.1.35.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A "functional" loss of SDC leads to IDHR. The operators need to diagnose the need and increase vessel level.	One	The operators need to increase RPV water level with any available injection system. CRD (if available), CDS, or an ECCS system are possible choices.	

Table 10.1.35.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	10 minutes	0	10 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.35.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate RWCU, and in some sequences the operators may need to stop CRD, forced recirculation, and RWCU.	CR	--	2 minutes	2 minutes	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
2. If available, increase flow with CRD. If CRD is not available and SDC is not being provided by SDC(B), use CDS. Otherwise, use an ECCS system. Note. With only 10 min. available for OPDHR, if CDS was asked and it failed, credit was not taken for both CDS and an ECCS system.	CR	--	2 minutes Since more than one system may need to be tried, 2 minutes, rather than 1 minute was assumed for conducting the activities.	2 minutes	The actions involved in initiating a makeup system were assumed to be completely dependent. System initiation would be proceduralized.

Table 10.1.35.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to isolate RWCU and increase level to avoid inadequate core cooling.	10 minutes	4 minutes	6 minutes	

Table 10.1.35.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to isolate RWCU and provide makeup.	Per ASEP Table 8-3, the median value from Figure 8-1 for 6 minutes diagnosis time was assigned.		Med. = 0.2 Mean = 0.533	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. However, with the potential subtlety of the indicators, the absence of any explicit procedures, and the time limitations, the lower bound diagnosis value was not assumed appropriate.

Table 10.1.35.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Isolate RWCU and initiate an injection system to provide makeup.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Dynamic. Given that the operators would have determine which systems to start and isolate on their own and without much time, the actions were assumed to be dynamic, per ASEP.	

Table 10.1.35.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _F < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate an injection system to provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.35.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.2 Mean = 0.533	--	Med. Mean 0.2 0.533	(10)	
2. Isolate RWCU and in some sequences stop CRD and forced recirculation.	Med. = 0.05 Mean = 0.081	Credit for a second check was not taken because of the time limitations.	0.05 0.081	(5)	
3. Initiate an injection system to provide makeup and vessel level control.	Med. = 0.05 Mean = 0.081	Credit for a second check was not taken because of the time limitations.	<u>0.05</u> <u>0.081</u> 0.30 0.695 Total Median HEP = 0.30 Total Mean HEP = 0.70	<u>(5)</u> (10)	Since all the HEPs make significant contributions to the total HEP, the larger error factor was assigned.

Table 10.1.37.1
HEP 37 Calculation

Human Action Event (1)	OPECS (11)
Event Tree(s) (2)	E, EA
Initiators (3)	T5D5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSL32.T5D, OPECSLEA.T5D, OPECSL.TIF, OPECSL.TIH, OPECSL.TLM, OPECSL.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (11) calculation (HEP 37) are that SDC(B) or ADHR has continued to run and forced recirculation and/or CRD and/or RWCU are lost. RWCU must be manually isolated from the control room to stop draindown, i.e., no auto-isolation. The operators initially fail to diagnose the need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. With SDC continuing to operate, the operators failing to diagnose the functional loss of SDC and the need for level control during the time for OPDHR, RWCU (letdown) needing to be isolated, and ADHR needing to be isolated in some sequences, OPECS is somewhat more demanding in these scenarios than in some others.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.37.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period as level decreases as a result of RWCU (letdown) not being isolated. Reactor pressure and coolant temperature will be rising. However, the coolant temperature of the core may not be apparent since the sensors sample the water in the recirculation areas which are being cooled by SDC in this scenario.	

Table 10.1.37.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Due to the "functional" loss of SDC, operators must enter the IDHR ONEP and diagnose the need to initiate ECCS water solid operation.	One	<p>A. Realize the need and isolate RWCU to stop letdown.</p> <p>B. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>C. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.37.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.37.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read the IDHR ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent. In addition, in the present case the functional loss of SDC may be subtle and the needed response is not explicitly indicated in the IDHR ONEP. Thus, some "interpretation" will be required.
2. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but when the action is necessary, it was assumed to be done in parallel with alignment and start of LPCI (action 6 below) and the other OPECS actions.	0 minutes	Isolating ADHR and aligning LPCI (action 6 below) were judged to be an integrated set of actions and were assumed to be completely dependent. They are successive steps in a procedure specifically written to cover switching from ADRS to LPCI (RHR SOI (04-1-01-E12-1, Step 6.6 or 6.8)
4. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 4 and 5 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
5. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
6. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	3 minutes - includes time for isolating ADHR when required.	3 minutes 11 minutes (approx.) Total time for all actions.	

Table 10.1.37.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_t) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes -	11 minutes	12 minutes	

Table 10.1.37.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation in context of a "functional" loss of SDC and determine what the appropriate actions should be.	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 12 minutes diagnosis time was assigned.		Median = 0.06 (EF = 10) Mean = 0.16	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the failure of OPDHR, the need to diagnose the need to isolate RWCU and the potential subtlety of the "functional" loss of SDC without explicit procedures, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.1.37.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements. However, see comments in Column 6 of this table.	No	Dynamic	Given the limited amount of time for OPECS and the fact that some of the actions are not explicitly procedure based, the operators responses to the event were assumed to be dynamic per ASEP HRAP Table 8-1, Step 10, Items, a,b,c.

Table 10.1.37.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.37.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.06 Mean = 0.16	--	Med. Mean 0.06 0.16	(10)	
2. Actions 1. Isolate RWCU (letdown). 2. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. 3. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.05 Mean = 0.081 Median = 0.05 Mean = 0.081 Median = 0.05 Mean = 0.081	Given the number of actions and the limited time available, credit for second checks was not given	Med. Mean 0.05 0.081 Med. Mean 0.05 0.081 Med. Mean <u>0.05</u> <u>0.081</u> 0.21 0.40 Total median HEP = 0.21 Total mean HEP = 0.40	(5) (5) (5) (10)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Since both the diagnosis and actions HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.38.1
HEP 38 Calculation

Human Action Event (1)	OP1SV (6)
Event Tree(s) (2)	E, EA
Initiators (3)	T5D5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSL32.T5D, OPECSLEA.T5D, OPECSL.TIF, OPECSL.TIH, OPECSL.TLM, OPECSL.TRP
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decisions and actions as OPECS (HEP 37), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds and must occur in the same time period.
Event Context (6)	The important constants for the OP1SV (6) calculation (HEP 38) are that SDC(B) or ADHR has continued to run and forced recirculation and/or CRD and/or RWCU are lost. RWCU must be manually isolated from the control room to stop draindown, i.e., no auto-isolation. The operators initially fail to diagnose the need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. With SDC continuing to operate, the operators failing to diagnose the functional loss of SDC and the need for level control during the time for OPDHR, RWCU (letdown) needing to be isolated, and ADHR needing to be isolated in some sequences, OP1SV (OPECS) is somewhat more demanding in these scenarios than in some others. The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.38.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period as level decreases as a result of RWCU (letdown) not being isolated. Reactor pressure and coolant temperature will be rising. However, the coolant temperature of the core may not be apparent since the sensors sample the water in the recirculation areas which are being cooled by SDC in this scenario. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.38.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Due to the "functional" loss of SDC, operators have entered the IDHR ONEP and diagnosed the need to initiate ECCS water solid operation, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	<p>A. Realize the need and isolate RWCU to stop letdown.</p> <p>B. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>C. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.38.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ed}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	SEA Calculation C90-492-01-A16 Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 18 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, given the earlier failures of the operators and the fact that proceeding with 1 SRV is not explicitly indicated by procedure, the median diagnosis value from ASEP, Figure 8-1, rather than the lower bound value, was assigned.

Table 10.1.38.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read the IDHR ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent. In addition, in the present case the functional loss of SDC may be subtle and the needed response is not explicitly indicated in the IDHR ONEP. Thus, some "interpretation" will be required.
2. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but when the action is necessary, it was assumed to be done in parallel with alignment and start of LPCI (action 7 below) and the other OPECS actions.	0 minutes	Isolating ADHR and aligning LPCI (action 7 below) were judged to be an integrated set of actions and were assumed to be completely dependent. They are successive steps in a procedure specifically written to cover switching from ADRS to LPCI (RHR SOI (04-1-01-E12-1, Step 6.6 or 6.8)
4. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 4, 5 and 6 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
5. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR	--	5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
6. Ensure 1 SRVs open	CR	--	1 minute	1 minute	
7. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	3 minutes - includes time for isolating ADHR when required.	<u>3 minutes</u> 16 minutes (approx.) Total time for all actions.	

Table 10.1.38.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	16 minutes	7 minutes	

Table 10.1.38.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to proceed with ECCS water solid operation with only 1 SRV open.	Per ASEP Table 8-3, the median value from Figure 8-1 for 7 minutes diagnosis time was assigned.		Median = 0.15 (EF = 10) Mean = 0.40	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the failure of OPDHR, the need to diagnose the need to isolate RWCU, the potential subtlety of the "functional" loss of SDC without explicit procedures, and the fact that only 1 SRV opened, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.1.38.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements. However, see comments in Column 6 of this table.	No	Dynamic	Given the limited amount of time for OP1SV and the fact that some of the actions are not explicitly procedure based, the operators' responses to the event were assumed to be dynamic per ASEP Table 8-1, Step 10, Items, a,b,c.

Table 10.1.38.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_F <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.38.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.15 Mean = 0.40	--	Med. Mean 0.15 0.40	(10)	
2. Actions 1. Isolate RWCU (letdown). 2. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. 3. OPECS actions - proceed with 1 open SRV - check closed MSIVs - start LPCI(C)	Median = 0.05 Mean = 0.081 Median = 0.05 Mean = 0.081 Median = 0.05 Mean = 0.081	Given the number of actions and the limited time available, credit for second checks was not given	Med. Mean 0.05 0.081 Med. Mean 0.05 0.081 Med. Mean <u>0.05</u> <u>0.081</u> 0.30 0.64 Total median HEP = 0.30 Total mean HEP = 0.64	(5) (5) (5) (10)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Since both the diagnosis and actions HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.39.1
HEP 39 Calculation

Human Action Event (1)	OPECS (12)
Event Tree(s) (2)	E, EA
Initiators (3)	T5D5H, E1D5H, E2D5H
Sequence Locator Files (4)	OPECS.T5D, OPECS21.T5D, OPECSALB.E1D, OPECSALB. E2D
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constant for the OPECS (12) calculation (HEP 39) is that the operators have recognized a loss of SDC (OPSDC succeeds) in the context of the initiator. In some sequences, after recognizing the loss of SDC, SDC(B) is started. The operators then initially fail to diagnose (in 10 min.) a need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. In other sequences, after recognizing the loss of SDC and aligning SDC(B), SDC(B) fails to start. Regardless, in all the relevant sequences, the operators have been actively engaged in responding to the occurring problems. They must now diagnose the need to isolate RWCU and initiate ECCS water solid operation with LPCI (C) or (B) or HPCS. RWCU (letdown) does not auto-isolate in any of the relevant sequences. ADHR is isolated.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44), HPCS SOI (04-1-01-E22-1, Rev. 28), and in some cases, Loss of Component Cooling Water ONEP (05-1-02-V1, Rev. 11).

Table 10.1.39.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T.) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period as level decreases as a result of RWCU (letdown) not being isolated. Reactor pressure and coolant temperature will be rising. The IDHR ONEP has been entered due to the initial loss of SDC and operators should be monitoring and considering the need for core cooling.	

Table 10.1.39.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. Operators have entered the IDHR ONEP. They must diagnose the need to initiate ECCS water solid operation.	One	<p>A. Realize the need and isolate RWCU to stop letdown.</p> <p>B. Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP.

Table 10.1.39.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.39.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
2. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 2 and 3 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
4. Initiate LPCI (C) or (B) or HPCS per SOIs	CR	--	1 minute	<u>1 minute</u> 4 minutes (approx.) Total time for all actions.	Note. ADHR is isolated by procedure in attempting to align SDC(B).

Table 10.1.39.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	4 minutes	19 minutes	

Table 10.1.39.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be. Includes diagnosing need to isolate RWCU.	Per ASEP Table 8-3, the median value from Figure 8-1 for 19 minutes diagnosis time was assigned.		Median = 0.01 (EF = 10) Mean = 0.026	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the failure of OPDHR in some sequences and the need to diagnose the need to isolate RWCU the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.1.39.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.39.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.39.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^a	Independent Check/Correction HEP (HEP _c) (3) ^a	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.01 Mean = 0.026	--	Med. Mean 0.01 0.026	(10)	Total HEPs are the sum of the individual HEPs from the diagnosis and actions.
2. Actions A. Isolate RWCU (letdown). B. OPECS actions - open 2 SRVs - check closed MSIVs C. Initiate LPCI(C), (B), or HPCS	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the number of actions and the limited time available, credit for second checks was not given	Med. Mean 0.02 0.032 Med. Mean 0.02 0.032 Med. Mean <u>0.02</u> <u>0.032</u> 0.07 0.122 Total median HEP = 0.07 Total mean HEP = 0.12	(5) (5) (5) (10)	In some sequences covered by these HEPs, LPCI(C), (B), or HPCS is used depending on the context. To be conservative in regards to the context differences, the initiation of the ECCS system was treated as a separate action from the other OPECS actions in determining the total HEP. Since both the diagnosis and actions HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.40.1
HEP 40 Calculation

Human Action Event (1)	OP1SV (7)
Event Tree(s) (2)	E, EA
Initiators (3)	T5D5H, E1D5H, E2D5H
Sequence Locator Files (4)	OPECS.T5D, OPECS21.T5D, OPECSALB.E1D, OPECSALB. E2D
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decisions and actions as OPECS (HEP 39), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds and must occur in the same time period.
Event Context (6)	The important constant for the OP1SV (7) calculation (HEP 40) is that the operators have recognized a loss of SDC (OPSDC succeeds) in the context of the initiator. In some sequences, after recognizing the loss of SDC, SDC(B) is started. The operators then initially fail to diagnose (in 10 min.) a need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. In other sequences, after recognizing the loss of SDC, the operators are unable to get SDC(B) started. Regardless, in all the relevant sequences, the operators have been actively engaged in responding to the occurring problems. They must now diagnose the need to isolate RWCU and initiate ECCS water solid operation with LPCI (C) or (B) or HPCS, but with only 1 SRV. RWCU (letdown) does not auto-isolate in any of the relevant sequences. ADHR is isolated. The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44), HPCS SOI (04-1-01-E22-1, Rev. 28), and in some cases, Loss of Component Cooling Water ONEP (05-1-02-V1, Rev. 11).

Table 10.1.40.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period as level decreases as a result of RWCU (letdown) not being isolated. Reactor pressure and coolant temperature will be rising. The IDHR ONEP has been entered due to the initial loss of SDC and operators should be monitoring and considering the need for core cooling. The control room receives feedback regarding the opening and closing of SRVs.	

Table 10.1.40.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. Operators have entered the IDHR ONEP and diagnosed the need to initiate ECCS water solid operation, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs.	One	<p>A. Realize the need and isolate RWCU to stop letdown.</p> <p>B. Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs (1 in this case) are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP.

Table 10.1.40.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{α}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
<p>Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.</p>	23 min.	0 minutes	23 min.	<p>SEA Calculation C90-492-01-A16</p> <p>Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 18 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, given the earlier failures of the operators and the fact that proceeding with 1 SRV is not explicitly indicated by procedure, the median diagnosis value from ASEP, Figure 8-1, rather than the lower bound value, was assigned.</p>

Table 10.1.40.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
2. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 2, 3, and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR	--	5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
4. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
5. Initiate LPCI (C) or (B) or HPCS per SOIs	CR	--	1 minute	<u>1 minute</u> 9 minutes (approx.) Total time for all actions.	

Table 10.1.40.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	9 minutes	14 minutes	

Table 10.1.40.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to proceed with ECCS water solid operation with only 1 SRV available and determine what the appropriate actions should be. Includes diagnosing need to isolate RWCU.	Per ASEP Table 8-3, the median value from Figure 8-1 for 14 minutes diagnosis time was assigned.		<p>Median = 0.08 (EF = 10)</p> <p>Mean = 0.213</p> <p>Note. Apparently an error was made in reading Figure 8-1 in determining the median HEP for 14 minutes. Approximately 0.05 would be a better "reading" of the median value from Figure 1. Thus, the HEP for the diagnosis may be slightly conservative.</p>	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the failure of OPDHR in some sequences, the need to diagnose the need to isolate RWCU, and the failure to get 2SRVs opened, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.1.40.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.40.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.40.10
Total HEP

Action (1)	Original Operator HEP (HEP ₁) (2) ^o	Independent Check/Correction HEP (HEP ₂) (3) ^c	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to proceed with ECCS water solid operation and determine relevant actions (1SRV)	Median = 0.08 Mean = 0.213	--	Med. Mean 0.08 0.213	(10)	Total HEPs are the sum of the individual HEPs from the diagnosis and actions.
2. Actions A. Isolate RWCU (letdown). B. OPECS actions - ensure 1 SRV open - check closed MSIVs C. Initiate LPCI(C), (B), or HPCS	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the number of actions, the problems with the SRVs, and the limited time available, credit for second checks was not given	Med. Mean 0.02 0.032 Med. Mean 0.02 0.032 Med. Mean <u>0.02</u> <u>0.032</u> 0.14 0.31 Total median HEP = 0.14 Total mean HEP = 0.31	(5) (5) (5) (10)	In some sequences covered by these HEPs, LPCI(C), (B), or HPCS is used depending on the context. To be conservative in regards to the context differences, the initiation of the ECCS system was treated as a separate action from the other OPECS actions in determining the total HEP. Since both the diagnosis and actions HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

**Table 10.1.41.1
HEP 41 Calculation**

Human Action Event (1)	OPIS (1)
Event Tree(s) (2)	P, PP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	Multiple files which begin with OPSTH, e.g., OPSTHSTM.E1B.
Event Description (5)	OPIS is the operator diagnosis and action to isolate SDC from overpressurization if the auto-isolation on pressure fails.
	OPIS (1) (HEP 41) applies in sequences where the operators have failed to perform actions that are clearly indicated by procedure. For example, in most of the relevant sequences, the initiation of ECCS water solid operation would be clearly indicated by the context and by the IDHR ONEP, but the operators have failed to attempt this action (OPECS fails). Since OPSTM is not a proceduralized action, it was decided that if the operators had failed to follow procedure and therefore may not be aware of the problem, then credit could not be taken deciding to steam the vessel, which is not proceduralized and for which the amount of time available is limited. With the operators failing to steam at low pressure, steaming at high pressure is asked in the P tree. SDC should auto-isolate at 135 psi. The operators action to isolate SDC if the auto-isolation fails (OPIS) must occur in the same time period as OPSTM and given the previous pattern of operator actions, it is not clear that the operators would decide to isolate SDC at this point. Thus, OPIS was set to fail (1.0) in these sequences. Auto-isolation of SDC on low level is asked later in the tree. Since detailed ASEP HRAP calculations were not required for HEP 41, Tables 10.1.41.2 through 10.1.41.9 were not included.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1)

Note. Tables 10.1.41.2 through 10.1.41.9 were unnecessary for HEP 41 and therefore they were not included.

Table 10.1.41.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Operator decision to isolate SDC from overpressurization, after failing to follow clear procedures in what appears to be an obvious situation.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

**Table 10.1.42.1
HEP 42 Calculation**

Human Action Event (1)	OPSTH (1)
Event Tree(s) (2)	P, PP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	All files beginning with OPSTH, e.g., OPSTHSRV.E1B
Event Description (5)	OPSTH is the operator decision and action to initiate steaming of the core at high pressure.
Event Context (6)	OPSTH (1) (HEP 42) represents the operator decision to steam the core at high pressure. OPSTH is asked in sequences where the operators have either failed to attempt to steam at low pressure (OPSTM fails) or attempted to steam at low pressure but could not get an SRV open in the relief mode. With the vessel "bottled-up," the operators can decide to steam at high pressure with 1 SRV on its safety set point. Steaming at high pressure would delay the core uncovering until SDC could be restored. The operators would have up to 4 hours to make the decision to steam at high pressure and provide makeup with CRD or HPCS. In cases where IA has isolated and CRD is the only available choice, the operators would have to restore IA.
Applicable Procedures (7)	EP-2 (RPV Control), Inadequate Decay Heat Removal ONEP (05-42-02-III-1)

Table 10.1.42.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Normal means of SDC are gone and a means of preventing the core from uncovering is needed. The operators failed to steam at low pressure and with no SRVs open, the operators will begin to steam at high pressure by default. They have 4 hours to provide makeup.	O	Low level 3 alarms will sound and temperature and pressure will begin to increase. SDC is gone and should be alarmed. SRVs will open on their safety set points eventually. Emergency Procedures, e.g. EP-2, indicate the need for level control. By providing makeup, the operators will have a substantial amount of time for restoring SDC.	BWRs basically operate by steaming and operators at GGNS indicated that steaming at high pressure would be a viable option that would provide time for determining and alleviating existing problems.

Table 10.1.42.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Normal SDC is gone and the operators have failed to steam at low pressure. By providing makeup they will steam the vessel at high pressure.	One	<p>1. In some cases letdown will have to be isolated.</p> <p>2. Start a high pressure injection system (CRD or HPCS). In some cases, IA may have to be restored to be able to use CRD.</p>	Site interviews with operators indicated that steaming at high pressure would be a viable option when other means of SDC had failed. Operators appeared to be knowledgeable about the process and the necessary actions. However, the process is not explicitly described in the relevant procedures.

Table 10.1.42.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate steaming at high pressure.	4 hours	0	4 hours	SEA Calculation C90-492-042-A16

Table 10.1.42.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_l) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate letdown (if necessary).	CR or locally	--	Conservatively, 1 hour	1 hour	Performance time estimates includes any necessary travel time. Given the time available for OPSTH, time is not really an issue.
2. Initiate CRD or HPCS per SOI. If IA has isolated, restoration will be required if CRD is to be used	CR or possibly outside CR if IA must be restored.	--	Conservatively, 1 hour	1 hour	Restoring IA (if necessary) and starting CRD were assumed to be completely dependent.

Table 10.1.42.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_A) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Steam the vessel at high pressure.	4 hours	2 hours	2 hours	

Table 10.1.42.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to steam the vessel at high pressure.	Per ASEP HRA Table 8-3, the upper bound value from ASEP HRA Figure 8-1 for 2 hours diagnosis time was assigned.	N/A	Median = 0.002 Mean = 0.005	Interviews with operators indicated a good awareness of the notion of steaming the vessel at high pressure. However, since it is not proceduralized and apparently not covered specifically in training, it is not clear that all operators would decide to steam at high pressure. Nevertheless, in the particular sequences covered here, the operators are basically steaming at high pressure by default and need only provide makeup and isolate letdown. which would seem to be obvious. However, with no explicit procedures or training, per ASEP HRA Table 8-3, the upper bound diagnosis value was assigned.

Table 10.1.42.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Start high pressure injection system and isolate letdown if necessary.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.42.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	$T_R < 2h$ After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Start high pressure injection system and isolate letdown if necessary.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.42.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Decide to steam vessel at high pressure.	Median = 0.002 Mean = 0.005		Med. Mean 0.002 0.005	(10)	
2. Isolate letdown if necessary.	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the time available. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01	(5)	Second check HEPs are multiplied by the original HEP for each action.
3. Initiate high pressure injection system (CRD or HPCS). Includes unisolating IA if necessary.	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the time available. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.01 0.025 Total Median HEP = 0.01 Total Mean HEP = 0.025	<u>(5)</u> (5)	The error factor associated with the dominant HEPs was assigned.

Table 10.1.46.1
HEP 46 Calculation

Human Action Event (1)	OPECS (13)
Event Tree(s) (2)	EA
Initiators (3)	T5D5H
Sequence Locator Files (4)	OPECS22.T5D
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (13) calculation (HEP 46) are that the initiator is followed by a random loss of ADHR. The operators fail to diagnose the loss of SDC in the 37 minutes allowed for OPSDC (OPSDC fails). RWCU (letdown) must be manually isolated from the control room to stop draindown, i.e., no auto-isolation. The operators must diagnose the need to initiate ECCS water solid operation. ADHR will have to be isolated to prevent overpressurization of the low pressure piping. Since 37 minutes have elapsed, the operators would be very likely to check temperature and pressure on the chart recorders in the 23 minutes allowed for OPECS and they may receive additional alarms. However, the operators would have to retrieve and read the IDHR ONEP and RHR SOI, isolate RWCU, perform a series of steps to isolate the ADHRS and align LPCI(C) or (B) for injection, and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.46.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period as level decreases as a result of RWCU (letdown) not being isolated. Reactor pressure and coolant temperature will be rising. However, the coolant temperature of the core may not be apparent since the sensors sample the water in the recirculation areas which are being cooled by SDC in this scenario.	

Table 10.1.46.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A loss of CCW is followed at some point by a random loss of ADHR. Operators must enter the IDHR ONEP and diagnose the need to initiate ECCS water solid operation.	One	<p>A. Realize the need and isolate RWCU to stop letdown.</p> <p>B. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3)) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>C. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.46.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.46.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T _L) (3)	Performance Time (T _P) (4)	Total Action Time (T _A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read the IDHR ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but when the action is necessary, it was assumed to be done in parallel with alignment and start of LPCI (action 6 below) and the other OPECS actions.	0 minutes	Isolating ADHR and aligning LPCI (action 6 below) were judged to be an integrated set of actions and were assumed to be completely dependent. They are successive steps in a procedure specifically written to cover switching from ADRS to LPCI (RHR SOI (04-01-E12-1, Step 6.6 or 6.8)
4. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 4 and 5 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
5. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
6. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	3 minutes - includes time for isolating ADHR when required.	3 minutes 11 minutes (approx.) Total time for all actions.	

Table 10.1.46.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	11 minutes	12 minutes	

Table 10.1.46.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation (after failing to do so in 37 minutes) and determine what the appropriate actions should be.	Per ASEP Table 8-3, the median value from Figure 8-1 for 12 minutes diagnosis time was assigned.		Median = 0.08 (EF = 10) Mean = 0.213	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the failure of OPSDC, the need to diagnose the need to isolate RWCU, and the need to isolate ADHR, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.1.46.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.46.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.46.10
Total HEP

Action (1)	Original Operator HEP (HEP ₁) (2) ^{op}	Independent Check/Correction HEP (HEP ₂) (3) ^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.08 Mean = 0.213	--	Med. Mean 0.08 0.213	(10)	
2. Actions 1. Isolate RWCU (letdown). 2. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. 3. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the number of actions and the limited time available, credit for second checks was not given	Med. Mean 0.02 0.032 Med. Mean 0.02 0.032 Med. Mean <u>0.02</u> <u>0.032</u> 0.14 0.31 Total median HEP = 0.14 Total mean HEP = 0.31	(5) (5) (5) (10)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Since both the diagnosis and actions HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.47.1
HEP 47 Calculation

Human Action Event (1)	OP1SV (8)
Event Tree(s) (2)	EA
Initiators (3)	T5D5H
Sequence Locator Files (4)	OPECS22.T5D
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decisions and actions as OPECS (HEP 46), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds and must occur in the same time period.
Event Context (6)	The important constants for the OP1SV (8) calculation (HEP 47) the initiator is followed by a random loss of ADHR. The operators fail to diagnose the loss of SDC in the 37 minutes allowed for OPSDC (OPSDC fails). RWCU (letdown) must be manually isolated from the control room to stop draindown, i.e., no auto-isolation. The operators must diagnose the need to initiate ECCS water solid operation with only 1 SRV available. ADHR will have to be isolated to prevent overpressurization of the low pressure piping. Since 37 minutes have elapsed, the operators would be very likely to check temperature and pressure on the chart recorders in the 23 minutes allowed for OPECS and they may receive additional alarms. However, the operators would have to retrieve and read the IDHR ONEP and RHR SOI, isolate RWCU, perform a series of steps to isolate the ADHRS and align LPCI(C) or (B) for injection, and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP. The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.47.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period as level decreases as a result of RWCU (letdown) not being isolated. Reactor pressure and coolant temperature will be rising. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.47.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A random loss of ADHR has occurred and operators have entered the IDHR ONEP. They have diagnosed the need to initiate ECCS water solid operation, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	<p>A. Realize the need and isolate RWCU to stop letdown.</p> <p>B. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3)) Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>C. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> Check closed MSIVs Ensure that two SRVs (1 in this case) are open Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.47.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	SEA Calculation C90-492-01-A16 Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 46 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, given the earlier failures of the operators and the fact that proceeding with 1 SRV is not explicitly indicated by procedure, the median diagnosis value from ASEP, Figure 8-1, rather than the lower bound value, was assigned.

Table 10.1.47.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	—	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read the IDHR ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Isolate letdown (RWCUI)	CR	—	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	—	1 - 3 minutes, but when the action is necessary, it was assumed to be done in parallel with alignment and start of LPCI (action 7 below) and the other OPECS actions.	0 minutes	Isolating ADHR and aligning LPCI (action 7 below) were judged to be an integrated set of actions and were assumed to be completely dependent. They are successive steps in a procedure specifically written to cover switching from ADRS to LPCI (RHR SOI (04-1-01-E12-1, Step 6.6 or 6.8)
4. Check closed MSIVs	CR	—	1 minute	1 minute	Steps 4, 5 and 6 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
5. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR	—	5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
6. Ensure 1 SRVs open	CR	—	1 minute	1 minute	
7. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	—	3 minutes - includes time for isolating ADHR when required.	<u>3 minutes</u> 16 minutes (approx.) Total time for all actions.	

Table 10.1.47.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	16 minutes	7 minutes	-

Table 10.1.47.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to proceed with ECCS water solid operation with only ! SRV open.	Per ASEP Table 8-3, the median value from Figure 8-1 for 7 minutes diagnosis time was assigned.		Median = 0.18 (EF = 10) Mean = 0.479	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the failure of OPSDC, the need to diagnose the need to isolate RWCU, and the need to isolate ADHR, and the fact that only 1 SRV opened, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.1.47.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.47.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.47.10

Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.18 Mean = 0.479	--	Med. Mean 0.18 0.479	(10)	
2. Actions 1. Isolate RWCU (letdown). 2. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. 3. OPECS actions - proceed with 1 open SRV - check closed MSIVs - start LPCI(C)	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the number of actions and the limited time available, credit for second checks was not given	Med. Mean 0.02 0.032 Med. Mean 0.02 0.032 Med. Mean <u>0.02</u> <u>0.032</u> 0.24 0.57 Total median HEP = 0.24 Total mean HEP = 0.57	(5) (5) (5) (10)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Since both the diagnosis and actions HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.48.1
HEP 48 Calculation

Human Action Event (1)	SDCUI (3)
Event Tree(s) (2)	ADEP, ADEPP, ADEPS
Initiators (3)	TAB5H, TDB5H
Sequence Locator Files (4)	SDCUI.TAB, SDCUI.TDB
Event Description (5)	SDCUI is the operator decision and action to unisolate and use RHR/SDC or ADHR following depressurization during a HYDRO test.
Event Context (6)	SDCUI (3) (HEP 54) represents the operators decision and actions to provide SDC after depressurization during a HYDRO test. In the relevant scenarios, a DC or AC is lost and multiple systems isolate and will be need to be recovered before SDC can be started. Forced recirculation is lost and/or RWCU in the recirculation mode is lost. Either the operators depressurize the vessel or SRVs open on their safety set points and at least one fails to close, resulting in depressurization. SDC is needed and the operators have 8.7 hours to diagnose the need and align a normal means of SDC. RHR is not available, so operators will have to align ADHR. Prior to starting ADHR, however, the operators will have to cut into the IA system and manually open an air valve to restore IA, unisolate PSW (requires opening 3 valves locally), and restore TBCU (since on BOP, no local action required). The Loss of AC Power ONEP directs the operators to the Automatic Isolations procedure (05-1-02-III-5) to recover isolations.
Applicable Procedures (7)	Loss of AC Power ONEP (05-1-02-I-4), Automatic Isolations (05-1-02-III-5), RHR SOI (04-1-01-E12-1), Inadequate Decay Heat Removal ONEP (05-48-02-III-1)

Table 10.1.48.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Loss of AC or DC bus in HYDRO test. Depressurization of the vessel occurs and SDC is needed.	O	A loss of the buses will be alarmed. They will enter the Loss of AC Power ONEP and IDHR ONEP. A loss of systems related to cooling during POS 5 will also be alarmed. A stuck open SRV will also be indicated, as will the vessel pressure loss.	In these scenarios, the need for SDC will be clear. Determining the relevant actions would appear to be non-trivial, but much of it is proceduralized.

Table 10.1.48.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
The vessel has depressurized during a HYDRO test after a loss of AC or DC bus. The operators will need to provide a normal means of SDC. Level is high enough for natural recirculation, but several systems will have to be restored in order to provide SDC.	One	<ol style="list-style-type: none"> 1. Unisolate IA 2. Unisolate PSW 3. Restore TBCW 4. Align and initiate an SDC system. 	Alignment of SDC is a frequently performed action during LP&S conditions. It is proceduralized. The other actions will require some operator thought and planning. The need for the restorations will be indicated by procedure, but the operators may need to determine exactly which valves to open etc.

Table 10.1.48.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Accomplish necessary actions to provide normal SDC.	8.7 hours	0	8.7 hours	SEA Calculation C90-492-048-A16

Table 10.1.48.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_t) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Unisolate IA	Outside control room. Cut into IA valve to manually open.	--	2 hour	2 hour	Travel and performance time estimates are combined under the performance time column. Performance times are conservative estimates based on discussions with the systems analysts.
2. Unisolate PSW	Outside CR. Open at least three valves locally.	--	2 hour	2 hour	
3. Restore TBCW	CR		1 minute	1 minutes	
4. Align (unisolate) and start SDC system.	CR	--	5 minutes	5 minutes	Per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.

Table 10.1.48.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Realize the need to make necessary recoveries and initiate SDC.	8.7 hours	Approx. 4-hours	At least 4 hours	

Table 10.1.48.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Realize the need to make necessary recoveries and initiate SDC.	Per ASEP HRAP Table 8-3, the median value from ASEP HRAP Figure 8-1 for 4 hours diagnosis time was assigned.	N/A	Median = 4.0E-5 Mean = 3.4E-4	HYDRO tests are performed late in shutdown and the operators know SDC is needed if depressurization occurs. Determining which systems to unisolate will be guided by the Loss of Power ONEP, but the operators may have to determine exactly how to go about doing the unisolations since the buses are lost.

Table 10.1.48.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Unisolate or restore necessary systems and start SDC.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.48.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	T_P <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Unisolate or restore necessary systems and start SDC.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage and several safety systems available.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.48.10
Total HEP

Action (1)	Original Operator HEP (HEP ₁) (2) ^{op}	Independent Check/Correction HEP (HEP ₂) (3) ²	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Realize the need to make necessary recoveries and initiate normal means of SDC.	Median = 4.0E-5 Mean = 3.4E-4		Med. Mean 4.0E-5 3.4E-4	(30)	
2. Unisolate IA	Median = 0.02 Mean = 0.032	Credit for a second check on each the 4 sets of actions (actions 2 - 5) was given. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01	(5)	Second check HEPs are multiplied by the original HEP for each action.
3. Unisolate PSW	Median = 0.02 Mean = 0.032	See above	0.004 0.01	(5)	
4. Restore TBCW	Median = 0.02 Mean = 0.032	See above	0.004 0.01	(5)	
5. Align and start SDC system.	Median = 0.02 Mean = 0.032	See above	<u>0.004</u> <u>0.01</u> <u>0.016</u> <u>0.04</u> Total Median HEP = 0.016 Total Mean HEP = 0.04	(5) (5)	The error factor from the dominant HEPs was assigned.

Table 10.1.49.1
HEP 49 Calculation

Human Action Event (1)	OPSTM (2)
Event Tree(s) (2)	S, SP, SNP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	All files beginning with OPSTE, e.g., OPSTE51.E2B and files OPSTMHYD.ECN, OPSTMSNP.SNP, and OPSTMSNP.E1T.
Event Description (5)	OPSTM is the operator decision to initiate steaming of the core.
	OPSTM (2) (HEP 49) applies in numerous sequences. It represents the operators decision to steam the vessel to provide core cooling when they have failed to perform actions that are clearly indicated by procedure. For example, in many sequences, the initiation of ECCS water solid operation would be indicated by the context and by the IDHR ONEP, but the operators have failed to attempt this action (OPECS fails). Since OPSTM is not a proceduralized action, it was decided that if the operators had failed to follow procedure and therefore may not be aware of the problem, then credit could not be taken deciding to steam the vessel, which is not proceduralized and for which the amount of time available is limited. Thus, OPSTM was set to fail (1.0) in these sequences. If OPSTM fails, the P tree is entered and the question of the operators deciding to steam at high pressure is asked (OPSTH). Significant more time is available for this (OPSTH) operator decision and action, and credit is taken for the operators doing something at this point. Since detailed ASEP HRA calculations were not required for HEP 49, Tables 10.1.49.2 through 10.1.49.9 were not included.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1)

Note. Tables 10.1.49.2 through 10.1.49.9 were unnecessary for HEP 49 and therefore they were not included.

Table 10.1.49.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Operator decision to steam the vessel after failing to follow clear procedures.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table 10.1.50.1
HEP 50 Calculation

Human Action Event (1)	OPECS (14)
Event Tree(s) (2)	E, EA, EP, EAP
Initiators (3)	T1-5, TIA5H, E1B5H, T5D5H, TRPT5, TPRV5, E1T5H, E1V5H
Sequence Locator Files (4)	OPECSLAP.EAP, OPECSHY2.EP, OPECSHYD.TIA, OPECSLEA.TIA, OPECSL5.E1B, OPECSLPE.E1D, OPECSHYD.T5D, OPECSHY2.TRP, OPECSL5.TRP, OPECSHY2.TRV, OPECSLPE.E1T, OPECSLPE.E1V, OPECSL5.E1T, OPECSL5.E1V
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (14) calculation (HEP 50) are that the operators have recognized a loss of SDC (OPSDC or SDCUI succeeds) in the context of the initiator and have successfully started SDC(B). In some cases the operators have restored an inadvertent isolation of SDC(B) (RESB succeeds). The operators then initially fail to diagnose (in 10 min.) a need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. Regardless, in all the relevant sequences, the operators have been actively engaged in responding to the occurring problems. ADHR has been isolated and RWCU has auto-isolated. The operators must diagnose the need to initiate ECCS water solid operation with LPCI (C) or HPCS.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44), HPCS SOI (04-1-01-E22-1, Rev. 28).

Table 10.1.50.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for initiation of ECCS water solid operation.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. Reactor pressure and coolant temperature will be rising. The IDHR ONEP has been entered due to the initial loss of SDC and operators should be monitoring and considering the need for core cooling.	

Table 10.1.50.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. Operators have entered the IDHR ONEP. They must diagnose the need to initiate ECCS water solid operation.	One	Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) assumed to be the first choice if available, then HPCS.	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP.

Table 10.1.50.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.50.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 1, 2, and 3 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
4. Initiate ECCS system per SOIs	CR	--	1 minute	<u>1 minute</u> 3 minutes (approx.) Total time for all actions.	Note. ADHR is isolated by procedure in attempting to align SDC(B) in OPSDC.

Table 10.1.50.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	3 minutes	20 minutes	

Table 10.1.50.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the median value from Figure 8-1 for 20 minutes diagnosis time was assigned.		Median = 0.01 (EF = 10) Mean = 0.027	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the operators failure to initially diagnose the need for level control (OPDHR fails) and the fact that the "functional" loss of SDC in this case could be subtle in regards to detection, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.1.50.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.50.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.50.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.01 Mean = 0.027	--	Med. Mean 0.01 0.027	(10)	Total HEPs are the sum of the individual HEPs from the diagnosis and actions.
2. Actions Initiate ECCS water solid operation per procedure - open 2 SRVs - check closed MSIVs - initiate LPCI(C) or HPCS	Median = 0.02 Mean = 0.032	Given the the limited time available, credit for second checks was not given. In addition, failures or problems in closing MSIVs or opening two SRVs would have to be considered by the operators in the same time period.	Med. Mean <u>0.02</u> <u>0.032</u> 0.03 0.059 Total median HEP = 0.03 Total mean HEP = 0.059	<u>(5)</u> (10)	Since both the diagnosis and actions HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.51.1
HEP 51 Calculation

Human Action Event (1)	OP1SV (9)
Event Tree(s) (2)	E, EA, EP, EAP
Initiators (3)	T1-5, TIA5H, E1B5H, T5D5H, TRPT5, TPRV5, E1T5H, E1V5H
Sequence Locator Files (4)	OPECSLAP.EAP, OPECSHY2.EP, OPECSHYD.TIA, OPECSLEA.TIA, OPECSL5.E1B, OPECSLPE.E1D, OPECSHYD.T5D, OPECSHY2.TRP, OPECSL5.TRP, OPECSHY2.TRV, OPECSLPE.E1T, OPECSLPE.E1V, OPECSL5.E1T, OPECSL5.E1V
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 50), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds.
Event Context (6)	The important constants for the OP1SV (9) calculation (HEP 51) are that the operators have recognized a loss of SDC (OPSDC or SDCUI succeeds) in the context of the initiator and have successfully started SDC(B). In some cases the operators have restored an inadvertent isolation of SDC(B) (RESB succeeds). The operators then initially fail to diagnose (in 10 min.) a need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. Regardless, in all the relevant sequences, the operators have been actively engaged in responding to the occurring problems. ADHR has been isolated and RWCU has auto-isolated. The operators have decided to initiate ECCS water solid operation as directed by procedure (OPECS succeeds). The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.1.51.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. Reactor pressure and coolant temperature will be rising. The IDHR ONEP has been entered due to the initial loss of SDC and operators should be monitoring and considering the need for core cooling. The control room gets feedback regarding the opening and closing of valves.	

Table 10.1.51.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	Per IDHR ONEP (Step 5.1.3c) 1. Check closed MSIVs 2. Ensure that two (one in this case) SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS.	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system. LPCI is referred to in IDHR ONEP. LPCI is initiated from 04-1-01-E12-1, Step 5.4.2. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table 10.1.51.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 minutes	0	23 minutes	<p>SEA Calculation C90-492-01-A16</p> <p>Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds, it was decided that the HEP for OP1SV would be determined as if it were OPECS, except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. It was assumed that the operators would make several attempts to get the second SRV open and would discuss the problem among themselves before proceeding.</p>

Table 10.1.51.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of proceduralized actions.
2. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
3. Ensure 1 SRV open	CR	--	1 minute	1 minute	
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 8 min. Total action time	

Table 10.1.51.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	8 minutes	15 minutes	

Table 10.1.51.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned		Median = 0.03 Mean = 0.08 (EF=10)	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.

Table 10.1.51.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Actions are proceduralized.

Table 10.1.51.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.51.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.03 Mean = 0.08	--	Med. Mean 0.03 0.08	(10)	
2. Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations and because failures or problems in closing MSIVs open would have to be considered by operators in the same time period. Other problems related to the initiator may also be requiring their attention.	<u>0.02</u> <u>0.032</u> 0.05 0.112 Total Median HEP = 0.05 Total Mean HEP = 0.112	<u>(5)</u> (10)	Since both HEPs contribute to the total HEP, the largest of the two EFs was assigned.

Table 10.1.52.1
HEP 52 Calculation

Human Action Event (1)	SDCUI (1)
Event Tree(s) (2)	ADEP, ADEPP, ADEPS
Initiators (3)	T1-5, TRPT5, TIOP5, TLM5H, E2C-5
Sequence Locator Files (4)	SDCUI.ADP, SDCUI.TRP, SDCUI.TIO, SDCUI.TLM, SDCUI.E2C, SDCUI.TIA
Event Description (5)	SDCUI is the operator decision and action to unisolate and use RHR/SDC or ADHR following depressurization during a HYDRO test.
Event Context (6)	SDCUI (1) (HEP 52) represents the operators decision and actions to provide SDC after depressurization during a HYDRO test. In the relevant scenarios, either forced recirculation is lost or RWCU in the recirculation mode is lost. Either the operators depressurize the vessel or SRVs open on their safety set points and at least one fails to close, resulting in depressurization. SDC is needed and the operators have 8.7 hours to diagnose the need and align a normal means of SDC.
Applicable Procedures (7)	RHR SOI (04-1-01-E12-1), Inadequate Decay Heat Removal ONEP (05-52-02-III-1)

Table 10.1.52.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
RWCU or forced recirculation is lost during a HYDRO test. Depressurization of the vessel occurs and SDC is needed.	O	A loss of forced recirculation or RWCU will be alarmed. A stuck open SRV will also be indicated, as will the vessel pressure loss.	

Table 10.1.52.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
The vessel has depressurized during a HYDRO test and the operators will need to provide a normal means of SDC. Level is high enough for natural recirculation, so all that is needed for these scenarios is SDC (RHR/SDC or ADHR).	One	Align and initiate an SDC system.	Alignment of SDC is a frequently performed action during LP&S conditions. It is proceduralized.

Table 10.1.52.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Align and initiate an SDC system.	8.7 hours	0	8.7 hours	SEA Calculation C90-492-052-A16

Table 10.1.52.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_l) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Align (unisolate) and start SDC system.	Control Room	--	5 minutes	5 minutes	

Table 10.1.52.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Realize the need to initiate SDC.	8.7 hours	5 minutes	At least 8 hours	

Table 10.1.52.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to align and initiate SDC.	Per ASEP HRAP Table 8-3, the median value from ASEP HRAP Figure 8-1 for 8 hours diagnosis time was assigned.	N/A	Median = 2.0E-5 Mean = 1.7E-4	HYDRO tests are performed late in shutdown and the operators know SDC is needed if depressurization occurs.

Table 10.1.52.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Unisolate and start SDC.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.52.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _E < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Unisolate and start SDC.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage and several safety systems available.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.52.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose need to align and start a normal means of SDC.	Median = 2.0E-5 Mean = 1.7E-4		Med. Mean 2.0E-5 1.7E-4	(30)	
2. Align and start SDC system.	Median = 0.02 Mean = 0.032	Credit for a second check and third check was given. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	<u>0.0008</u> <u>0.0033</u> 8.2E-4 3.5E-3 Total Median HEP = 8.2E-4 Total Mean HEP = 3.5E-3	(5) (5)	Second check HEPs are multiplied by the original HEP for each action. Third check HEPs are multiplied by the result obtained from applying the second check. The error factor from the dominant HEP was assigned.

Table 10.1.54.1
HEP 54 Calculation

Human Action Event (1)	SDCUI (2)
Event Tree(s) (2)	ADEP, ADEPP, ADEPS
Initiators (3)	T5D5H, TORV5
Sequence Locator Files (4)	SDCUI.T5D, SDCUI.TRV
Event Description (5)	SDCUI is the operator decision and action to unisolate and use RHR/SDC or ADHR following depressurization during a HYDRO test.
Event Context (6)	SDCUI (2) (HEP 54) represents the operators decision and actions to provide SDC after depressurization during a HYDRO test. In the relevant scenarios, either forced recirculation is lost or RWCU in the recirculation mode is lost. Either the operators depressurize the vessel or SRVs open on their safety set points and at least one fails to close, resulting in depressurization. SDC is needed and the operators have 8.7 hours to diagnose the need and align a normal means of SDC. For some sequences the operators may also need to isolate RWCU and in others, an SDC valve may need to be opened locally.
Applicable Procedures (7)	RHR SOI (04-1-01-E12-1), Inadequate Decay Heat Removal ONEP (05-54-02-III-1)

Table 10.1.54.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
RWCU or forced recirculation is lost during a HYDRO test. Depressurization of the vessel occurs and SDC is needed. In some cases, RWCU needs to be isolated.	O	A loss of forced recirculation or RWCU will be alarmed. A stuck open SRV will also be indicated, as will the vessel pressure loss.	

Table 10.1.54.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
The vessel has depressurized during a HYDRO test and the operators will need to provide a normal means of SDC. Level is high enough for natural recirculation, so all that is needed for these scenarios is SDC (RHR/SDC or ADHR) and in some cases isolation of RWCU.	One	1. Align and initiate an SDC system. 2. Isolate RWCU	Alignment of SDC is a frequently performed action during LP&S conditions. It is proceduralized.

Table 10.1.54.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_o) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_s) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Align and initiate an SDC system and isolate RWCU.	8.7 hours	0	8.7 hours	SEA Calculation C90-492-054-A16

Table 10.1.54.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_t) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Align (unisolate) and start SDC system.	Most of the time from the CR. Time for a trip outside the CR was included.	--	30 minute	30 minute	Per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
2. Isolate RWCU.	CR	--	1 minutes	1 minutes	

Table 10.1.54.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Realize the need to initiate SDC and isolate RWCU.	8.7 hours	31 minutes	At least 8 hours	

Table 10.1.54.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to align and initiate SDC.	Per ASEP HRAP Table 8-3, the median value from ASEP HRAP Figure 8-1 for 8 hours diagnosis time was assigned.	N/A	Median = 2.0E-5 Mean = 1.7E-4	HYDRO tests are performed late in shutdown and the operators know SDC is needed if depressurization occurs.

Table 10.1.54.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Unisolate and start SDC and isolate RWCU id necessary.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	-

Table 10.1.54.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Unisolate and start SDC.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage and several safety systems available.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.54.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose need to align and start a normal means of SDC.	Median = 2.0E-5 Mean = 1.7E-4		Med. Mean 2.0E-5 1.7E-4	(30)	
2. Isolate RWCU (if necessary)	Median = 0.02 Mean = 0.032	Credit for a second check and third check was given. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	0.0008 0.0033	(5)	Second check HEPs are multiplied by the original HEP for each action. Third check HEPs are multiplied by the result obtained from applying the second check.
3. Align and start SDC system.	Median = 0.02 Mean = 0.032	Credit for a second check and third check was given. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	<u>0.0008</u> <u>0.0033</u> 1.6E-3 6.8E-3 Total Median HEP = 1.6E-4 Total Mean HEP = 6.8E-3	<u>(5)</u> (5)	The error factor from the dominant HEP was assigned.

Table 10.1.56.1
HEP 56 Calculation

Human Action Event (1)	RM-LT
Event Tree(s) (2)	L, LA, LP,
Initiators (3)	All transients
Sequence Locator Files (4)	RM-LT.E1B, RM-LT.TIO OPDHR&.LP&, OPDHR&.TIA, OPDHR.TDB, OPDHRP.T5D, OPDHRP.E1B, OPDHRP.E1D, OPDHRP.E2D, OPDHRLP.E1T, OPDHRLAP.E1V, OPDHR.TIH, OPDHROP.TIH, OPDHR.TIF, OPDHR.TDB, OPDHR.T5D, OPDHR.E1B, OPDHR.E1D, OPDHR.E2D, OPDHR.E1T, OPDHR.E1V, OPDHR&.LP&, OPDHR&.TIA, OPDHR.TDB, OPDHRP.T5D, OPDHRP.E1B, OPDHRP.E1D, OPDHRP.E2D, OPDHRLP.E1T, OPDHRLAP.E1V, OPDHR.TLM, OPDHR.TRP, OPDHR.TIH, OPDHROP.TIH, OPDHR.TIF, OPDHRHYR.TIO, OPDHRHYR.TLM, OPDHRHYR.TRP, OPDHRHYR.TRV
Event Description (5)	RM-LT is the operator action to restore makeup in the long term after a loss of all makeup (RWCU) and letdown (CRD). The objective is to compensate for vessel leakage. The operators have 10 hours to provide makeup with an ECCS system.
Event Context (6)	For the RM-LT calculation (HEP 56), CRD is lost, but SDC and forced recirculation continues to run. OPDHR succeeds. That is, the operators have isolated letdown (RWCU) and attempted to initiate CDS. However, CDS fails or is unavailable. With no makeup, the operators need to use an ECCS system to provide makeup in the long term to compensate for vessel leakage. Operators have done everything correctly to this point.
Applicable Procedures (7)	No specific procedures, but the Inadequate Decay Heat Removal ONEP (05-1-02-III-1) would be relevant, as would the relevant SOIs, e.g., RHR SOI (04-1-01-E12-1).

Table 10.1.56.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Gradual loss of level due to leakage. Level control (makeup) is needed.	O	The operators have done everything correctly to this point and are aware of the systems which have been lost and isolated. The loss of CDS will be alarmed and the operators should check level numerous times over a 10 hour period. The situation clearly indicates the need to have some form of makeup available and to ensure level stays at the appropriate level.	

Table 10.1.56.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Gradual loss of level due to leakage. Level control (makeup) is needed.	One	The operators need to increase RPV water level with an ECCS system.	

Table 10.1.56.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	10 hours	The loss of CDS (at time 0) will indicate the need for level control. Level losses will be indicated at least within 5 hours. Conservatively assumed 5 hours.	5 hours	SEA Calculation C90-492-01-A16

Table 10.1.56.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Control level with an ECCS system.	CR	--	2 minute	2 minutes	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column. The actions involved in initiating a makeup system were assumed to be completely dependent. System initiation would be proceduralized.

Table 10.1.56.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	5 hours	2 minutes	Approx. 5 hours	

Table 10.1.56.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to provide makeup	Per ASEP Table 8-3, the median value from Figure 8-1 for 5 hours diagnosis time was assigned.		Med. = 3.0E-5 Mean = 2.5E-4	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements.

Table 10.1.56.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate an injection system to provide makeup.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step-by-step	

Table 10.1.56.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate an injection system to provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.56.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 3.0E-5 Mean = 2.5E-4	--	Med. Mean 3.0E-5 2.5E-4	(30)	
2. Initiate an injection system to provide makeup and vessel level control.	Med. = 0.02 Mean = 0.032	Credit for a second and a third check were given because of the substantial time available with little else of concern. The operators have done everything correctly to this point. HEPs for failure to provide a second and third check were: Med. = .2 Mean = .323	<u>8.0E-4</u> <u>3.3E-3</u> 8.3E-4 3.6E-3 Total Median HEP = 8.3E-4 Total Mean HEP = 3.6E-3	<u>(5)</u> (5)	Second and third check HEPs are multiplied with the original HEP for each action. The error factor associated with the dominant HEPs was assigned.

Table 10.1.57.1
HEP 57 Calculation

Human Action Event (1)	OPIS (2)
Event Tree(s) (2)	P, PP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	Multiple files beginning with OPSTH, e.g., OPSTHSRV.PP
Event Description (5)	OPIS is the operator diagnosis and action to isolate SDC from overpressurization if the auto-isolation on pressure fails.
Event Context (6)	<p>In the sequences relevant to OPIS (2) (HEP 57), the operators have been attempting to follow procedure, but for any of several reasons have not been successful. For example, in some sequences the operators attempt to initiate ECCS water solid operation per the IDHR ONEP (OPECS succeeds), but 2 SRVs fail to open. The operators either fail to open 1 SRV (OP1SV) and proceed with going water solid or 1 SRV (1SRVB) fails to open and they can't go water solid. In either case, they did successfully diagnose the need to initiate water solid operation and tried to open two SRVs. With no SRVs open, the operators should be aware of the fact that pressure will be going up. The low pressure piping needs to be isolated at 135 psi (auto isolation at 135 psi) and the operators should receive an alarm prior to 135 psi. In addition, if the auto-isolation fails, the operators should get an isolation failure signal. Thus, in scenarios like this, where the operators are attempting to follow procedure, whether or not they consciously decide to steam at low pressure (OPSTM fails or succeeds), they should have some probability of realizing the need to manually isolate the low pressure piping (OPIS) if the auto-isolation fails (RHRIP). OPIS must be done in the same time period as OPSTM (23 minutes). SDC must be isolated if the operators decide to steam at high pressure (OPSTH).</p> <p>Note. In some sequences, SDC has been isolated (e.g., by the initiator) prior to entering the P tree where OPIS is asked. For these sequences, OPIS was set to succeed (0).</p>
Applicable Procedures (7)	EP-2 (RPV Control), Inadequate Decay Heat Removal ONEP (05-57-02-III-1)

Table 10.1.57.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Normal means of SDC are gone and a means of preventing the core from uncovering is needed. One option is to steam at high pressure. However, with pressure increasing, the operators will need to ensure that SDC isolates to prevent overpressurizing the low pressure system.	5 minutes	Vessel pressure will be increasing. The low pressure piping needs to be isolated at 135 psi (auto-isolation at 135 psi) and the operators should receive an alarm prior to 135 psi. In addition, if the auto-isolation fails, the operators should get an isolation failure signal. SRVs will open on their safety set points eventually.	When at full power, the Technical Specifications indicate that the low pressure piping should auto-isolate at 135 psi.

Table 10.1.57.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Normal SDC is gone and pressure is increasing. The operators need to ensure SDC isolates to prevent overpressurization.	One	Manually close valves to isolate SDC low pressure piping.	Site interviews with operators indicated that (at least for now) the auto-isolation of low pressure piping remains in place during LP&S conditions and that the operators are aware of the potential for overpressurization of the low pressure piping.

Table 10.1.57.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Isolate SDC if it fails to auto-isolate.	23 minutes	5 minutes (Auto-isolation signals may not occur right at the beginning of the time window. Signals should occur within the first 5 minutes).	18 minutes	SEA Calculation C90-492-057-A16

Table 10.1.57.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_l) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Isolate SDC if auto-isolation fails.	CR	--	1 minute	1 minute	Per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each critical action.

Table 10.1.57.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Isolate SDC if auto-isolation fails.	18 minutes	1 minute	17 minutes	

Table 10.1.57.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Isolate SDC if auto-isolation at 135 psi fails.	Per ASEP HRAP Table 8-3, the median value from ASEP HRAP Figure 8-1 for 17 minutes diagnosis time was assigned.	N/A	Median = 0.02 Mean = 0.053	Given the Technical Specifications for full power, the fact that GGNS policy currently specifies that the auto-isolation remain in place during shutdown, and the staffs apparent awareness of the potential problem conveyed during the site interviews, per ASEP HRAP Table 8-3, the upper median diagnosis value was assigned.

Table 10.1.57.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Isolate SDC from the CR.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.57.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Isolate SDC.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.57.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Decide to isolate SDC if auto-isolation on high pressure fails.	Median = 0.02 Mean = 0.053		Med. Mean 0.02 0.053	(10)	
2. Isolate SDC.	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the indications and because the control room has been performing correctly in the relevant sequences. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004 0.01</u> <u>0.024 0.063</u> Total median HEP = 0.024 Total mean HEP = 0.063	<u>(5)</u> (10)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.1.58.1
HEP 58 Calculation

Human Action Event (1)	OPDHR (3)
Event Tree(s) (2)	L, LP,
Initiators (3)	T1-5, T5D5H, TLM5H, TRPT5, TIOP5, TORV5, E2C-5
Sequence Locator Files (4)	OPDHR&.LP&, OPDHR&.TIA, OPDHRHYD.TIA OPDHR.TDB, OPDHRP.T5D, OPDHRP.E1B, OPDHRP.E1D, OPDHRP.E2D, OPDHRLP.E1T, OPDHRLP.E1V, OPDHR.TLM, OPDHR.TRP, OPDHR.TIH, OPDHRP.TIH, OPDHR.TIF, OPDHRHYD.E2C, OPDHRHYD.LP, OPDHRHYD.TIO, OPDHRHYD.TLM, OPDHRHYD.TRP, OPDHRHYD.TRV
Event Description (5)	OPDHR is the operator action to control vessel level in order to avoid a "functional" loss of SDC caused by inadequate circulation between the core and the downcomer regions of the vessel. That is, even if SDC continues to operate, if vessel level becomes too low, a "disconnect" between the core and downcomer regions can occur. This will result in inadequate cooling of the core even though SDC continues to operate. The indications to the operators that the event is occurring can be subtle because temperature readings are apparently taken from the downcomer region, where the water being cooled by SDC is returned. Also, the vessel level would not be so low that any level alarms would sound. A loss of forced recirculation, or a loss of makeup (usually CRD) coupled with continued draindown, can lead to inadequate level. Only 10 minutes was allowed for the operator diagnosis and actions in OPDHR.
Event Context (6)	The important constants for the OPDHR (3) calculation (HEP 58) are that the control was conducting a HYDRO test when the initiator occurred. The initiator directly impacts the systems that create the potential "disconnect problem." An SRV opens on its safety set point and fails to close, resulting in vessel depressurization. The operators recognize the need for SDC and successfully initiate SDC(B) (SDCUI succeeds). RWCU assumed isolated or controlled. The operators had 8.7 hours to accomplish SDCUI. At this point the operators have done everything correctly and have had ample time to consider potential problems. With the recognized loss of SDC, the IDHR ONEP would be pulled. Given the previous events, the operators would be attending to level and related concerns.
Applicable Procedures (7)	No specific procedures, but the Inadequate Decay Heat Removal ONEP (05-1-02-III-1) would be relevant, as would the relevant SOIs, e.g., RHR SOI (04-1-01-E12-1).

Table 10.1.58.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR caused by inadequate circulation between the core and the downcomer regions of the vessel. Level control (makeup) is needed.	O	As noted in Table 10.1.58.1, the indications for this event may be subtle because vessel temperature readings could be misleading and no level alarms would sound. However, in all the sequences covered, CRD and/or forced recirculation is lost. These events will be alarmed and if the operators are knowledgeable regarding the potential problem, these indications should suffice. Moreover, given the previous events, operators will have had ample time to consider potential problems and relevant signals.	

Table 10.1.58.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A "functional" loss of SDC leads to IDHR. The operators need to diagnose the need and increase vessel level.	One	The operators need to increase RPV water level with any available injection system. CRD (if available), CDS, or an ECCS system are possible choices.	

Table 10.1.58.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ca}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	10 minutes	0	10 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.58.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
If available, increase flow with CRD. If CRD is not available and SDC is not being provided by SDC(B), use CDS. Otherwise, use an ECCS system. Note. With only 10 min. available for OPDHR, if CDS was asked and it failed, credit was not taken for both CDS and an ECCS system.	CR	--	1 minute	1 minute	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column. The actions involved in initiating a makeup system were assumed to be completely dependent. System initiation would be proceduralized.

Table 10.1.58.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	10 minutes	1 minutes	9 minutes	

Table 10.1.58.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to provide makeup	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 9 minutes diagnosis time was assigned.		Med. = 0.01 Mean = 0.027	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. The lower bound diagnosis value was judged appropriate in these scenarios because of the successes of the operators and the time available after the initiator to consider potential problems that could arise. Essentially, more time is available because of the fact that they were in HYDRO test.

Table 10.1.58.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate an injection system to provide makeup.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Dynamic. Given that the operators would have determine which system to start on their own, the actions were assumed to be dynamic, per ASEP.	

Table 10.1.58.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate an injection system to provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.58.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.01 Mean = 0.027	--	Med. Mean 0.01 0.027	(10)	
2. Initiate an injection system to provide makeup and vessel level control.	Med. = 0.05 Mean = 0.081	Credit for a second check was not taken because of the time limitations.	<u>0.05</u> <u>0.081</u> 0.06 0.108 Total Median HEP = 0.06 Total Mean HEP = 0.108	<u>(5)</u> (10)	Since both HEPs contribute to the total HEP, the larger error factor was assigned.

Table 10.1.59.1
HEP 59 Calculation

Human Action Event (1)	OPECS (15)
Event Tree(s) (2)	EA
Initiators (3)	E1D5H, E1V5H
Sequence Locator Files (4)	OPECSALA.E1D, OPCECSALA.E1V
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (15) calculation (HEP 59) are that the control room has successfully diagnosed the loss of ADHR (OPSDC succeeds) and have successfully restored ADHR (RESAD or RESCS succeeds). However, at some point in the scenario, forced recirculation and/or CRD are lost. RWCU continues to run and needs to be isolated to stop draindown. The operators fail to diagnose the need to provide level control to avoid a disconnect between the core and the downcomer which leads to a "functional" loss of SDC (OPDHR fails). The operators need to diagnose the need to isolate RWCU, isolate ADHR, and initiate ECCS water solid operation. Thus, the operators must perform a series of steps to isolate RWCU, isolate ADHR, align LPCI(C) or (B) for injection (including a remote manual start of LPCI(C) or (B)), per RHR SOI 04-1-01-E12-1, Step 6.6 or 6.8 ("Abnormal Operations"), and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP. In aligning LPCI(C) for injection in this context, the procedures instruct the operators to isolate ADHR.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.59.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for initiation of ECCS water solid operation to provide core cooling.	0	Loss of systems were alarmed and the operators have already responded to the initial loss of SDC. With the success of OPSDC, the IDHR ONEP would have been entered. In addition, the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm could very likely occur during this time period. Reactor coolant temperature will be rising and level would be dropping.	

Table 10.1.59.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Due to the functional loss of SDC, the normal means of SDC are inadequate. Level control and vessel cooling is needed. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>1. Realize the need and isolate RWCU to stop draindown.</p> <p>2. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <p style="padding-left: 40px;">A. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3))</p> <p style="padding-left: 40px;">B. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f)</p> <p>Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <p style="padding-left: 40px;">1. Check closed MSIVs</p> <p style="padding-left: 40px;">2. Ensure that two SRVs are open</p> <p style="padding-left: 40px;">3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS.</p>	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.59.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.59.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T _L) (3)	Performance Time (T _P) (4)	Total Action Time (T _A) (5)	Comments/ Source of Information (6)
1. Isolate letdown (RWCU)	CR	--	1 minute, but assumed done in parallel with step 5 below.	0 minutes	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
2. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but can be done in parallel with alignment and start of LPCI (step 5 below). Thus, performance time not included.	0 minutes	
3. Check closed MSIVs	CR	--	1 minute, but can be done in parallel with step 5 below.	0 minutes	Steps 3 and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Ensure 2 SRVs open	CR	--	1 minute, but in parallel with step 5 below	0 minutes	
5. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2) (Note. The procedure directs a "remote manual start" of LPCI pump. In the original HEP calculation, this action was erroneously assumed to require a trip outside the control room. Thus, the timing used in determining this HEP is likely to be somewhat conservative. See comments in Column 6)	CR	--	15 minutes, travel and performance time. Estimated on basis of discussions with plant personnel.	<u>15 minutes</u> 15 minutes Total time for all actions.	From the control room, the actions required to isolate RWCU, align and initiate LPCI(C) or (B), isolate ADHR, and perform steps 3 and 4 would probably not require 15 min. Thus, the obtained HEP may be somewhat conservative. (See comments in Column 1, this table).

Table 10.1.59.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	15 minutes	8 minutes	

Table 10.1.59.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 8 minutes diagnosis time was assigned.		Median = 0.15 (EF = 10) Mean = 0.40	For this event, the relevant ONEP has been retrieved and the operators have performed several correct actions. In addition, on the basis of interviews, the operators have a clear understanding of the procedures and requirements. However, in these sequences the operators initially fail to detect the "functional loss of SDC and the indications for the problem may be subtle. Moreover, the core/downcomer disconnect problem is not explicitly indicated in the IDHR ONEP procedure. Thus, use of the lower bound diagnosis value did not seem appropriate.

Table 10.1.59.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.59.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.59.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.15 Mean = 0.40	--	Med. Mean 0.15 0.40	(10)	
2. Actions A. Isolate RWCU (letdown). B. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. They constitute an integrated set of proceduralized actions. C. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.02 Mean = .032 Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	One of the actions in Action B (LPCI initiation) was originally assumed to take place outside the control room and in the time available, credit for a second check did not seem appropriate. See comment in Column 6. However, given that the isolation of RWCU and many of the OPECS related actions were assumed to occur in parallel with the action outside the control room (and therefore a lot of time was assumed available for them), credit for a second check was given for accomplishing those actions. Second check values for action 2 were: Median = 0.2 Mean = 0.323	Med. Mean 0.004 0.01 Med. Mean 0.02 0.032 Med. Mean <u>0.004 0.01</u> 0.178 0.45 Total median HEP = 0.178 Total mean HEP = 0.45	(5) (5) (5) (10)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for that action. Since both the diagnosis and action HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.60.1
HEP 60 Calculation

Human Action Event (1)	OP1SV (10)
Event Tree(s) (2)	EA
Initiators (3)	E1D5H, E1V5H
Sequence Locator Files (4)	OPECSALA.E1D, OPCECSALA.E1V
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 59), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds.
Event Context (6)	The important constants for the OP1SV (10) calculation (HEP 60) are that the control room has successfully diagnosed the loss of ADHR (OPSDC succeeds) and have successfully restored ADHR (RESAD or RESCS succeeds). However, at some point in the scenario, forced recirculation and/or CRD are lost. RWCU continues to run and needs to be isolated to stop draindown. The operators fail to diagnose the need to provide level control to avoid a disconnect between the core and the downcomer which leads to a "functional" loss of SDC (OPDHR fails). The operators need to diagnose the need to isolate RWCU, isolate ADHR, and initiate ECCS water solid operation. Thus, the operators must perform a series of steps to isolate RWCU, isolate ADHR, align LPCI(C) or (B) for injection (including a remote manual start of LPCI(C) or (B)), per RHR SOI 04-1-01-E12-1, Step 6.6 or 6.8 ("Abnormal Operations"), and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP. The operators have decided to initiate ECCS water solid operation as directed by procedure (OPECS succeeds), but only 1 SRV will open. The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.60.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	0	Loss of systems were alarmed and the operators have already responded to the initial loss of SDC. With the success of OPSDC, the IDHR ONEP would have been entered. In addition, the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm could very likely occur during this time period. Reactor coolant temperature will be rising and level would be dropping. The control room gets feedback regarding the opening and closing of the SRVs.	

Table 10.1.60.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Due to the functional loss of SDC, the normal means of SDC are inadequate. Level control and vessel cooling is needed. The IDHR ONEP directs operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs.	One	<p>1. Realize the need and isolate RWCU to stop draindown.</p> <p>2. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <p style="padding-left: 40px;">A. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3))</p> <p style="padding-left: 40px;">B. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f)</p> <p>Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <p style="padding-left: 40px;">1. Check closed MSIVs</p> <p style="padding-left: 40px;">2. Ensure that two SRVs (in this case 1 SRV) are open</p> <p style="padding-left: 40px;">3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS.</p>	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.60.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is the same as OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	<p>SEA Calculation C90-492-01-A16</p> <p>Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 59), except for one difference. It was assumed that five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. It was assumed that the operators would make several attempts to get the second SRV open and would discuss the problem among themselves before proceeding.</p>

Table 10.1.60.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T _L) (3)	Performance Time (T _P) (4)	Total Action Time (T _A) (5)	Comments/ Source of Information (6)
1. Isolate letdown (RWCU)	CR	--	1 minute, but assumed done in parallel with step 6 below.	0 minutes	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
2. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but can be done in parallel with alignment and start of LPCI (step 6 below). Thus, performance time not included.	0 minutes	
3. Check closed MSIVs	CR	--	1 minute, but can be done in parallel with step 6 below.	0 minutes	Steps 3, 4, and 5 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Make several attempts to get second SRV open and discuss proceeding with 1 SRV.	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
5. Ensure 1 SRV open	CR	--	1 minute, but in parallel with step 6 below	0 minutes	
6. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2) (Note. The procedure directs a "remote manual start" of LPCI pump. In the original HEP calculation, this action was erroneously assumed to require a trip outside the control room. Thus, the timing used in determining this HEP is likely to be somewhat conservative. See comments in Column 6)	CR	--	15 minutes, travel and performance time. Estimated on basis of discussions with plant personnel.	<u>15 minutes</u> 15 minutes Total time for all actions.	From the control room, the actions required to isolate RWCU, align and initiate LPCI(C) or (B), isolate ADHR, and perform steps 3 and 5 would probably not require 15 min. Thus, the obtained HEP may be somewhat conservative. (See comments in Column 1, this table).

Table 10.1.60.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV available.	23 minutes	20 minutes	3 minutes	

Table 10.1.60.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with 1 SRV and determine what the appropriate actions should be.	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 3 minutes diagnosis time was assigned.		Median = 0.15 (EF= 10) Mean = 0.40	<p>Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and reasonable option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.</p> <p>The use of the lower bound diagnosis value is somewhat inconsistent with diagnosis HEPs selected in other similar contexts in this HRA analysis. However, the use of the median value would have produced an HEP of 1.0, which was judged to be inappropriate given the successful operator actions in these scenarios and the fact that the interviews suggested that the operators would be willing to proceed with 1 SRV. Thus, the lower bound value was assigned.</p>

Table 10.1.60.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	Some form of SDC is clearly indicated and for the most part the actions are proceduralized.

Table 10.1.60.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.60.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation with 1 SRV and determine relevant actions	Median = 0.15 Mean = 0.40	—	Med. Mean 0.15 0.40	(10)	
2. Actions A. Isolate RWCU (letdown). B. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. They constitute an integrated set of proceduralized actions. C. OPECS actions - open 1 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.02 Mean = .032 Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	One of the actions in Action B (LPCI initiation) was originally assumed to take place outside the control room and in the time available, credit for a second check did not seem appropriate. See comment in Column 6. However, given that the isolation of RWCU and many of the OPECS related actions were assumed to occur in parallel with the action outside the control room (and therefore a lot of time was assumed available for them), credit for a second check was given for accomplishing those actions. Second check values for action 2 were: Median = 0.2 Mean = 0.323	Med. Mean 0.004 0.01 Med. Mean 0.02 0.032 Med. Mean <u>0.004 0.01</u> 0.178 0.45 Total median HEP = 0.178 Total mean HEP = 0.45	(5) (5) (5) (10)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for that action. Since both the diagnosis and action HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.61.1
HEP 61 Calculation

Human Action Event (1)	OPECS (16)
Event Tree(s) (2)	E, EP
Initiators (3)	J2-5
Sequence Locator Files (4)	OPECS.J25
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (16) calculation (HEP 61) are that a break in the SDC line has occurred outside containment. MV 8 or 9 auto-isolates on low level (level 3), which results in isolation of the break and SDC. If LOSP also occurs, the diesels start and load (DV1-2 succeeds). Level 3 alarms (RPV level below 11.4) will cause the operators to enter EP-2, which will direct them to restore level. The RHR pump trip alarms and closure of MV 8 or 9 will indicate a loss of SDC and the corresponding IDHR to the operators. The operators will then enter the IDHR ONEP, which will instruct them to initiate ECCS water solid operation.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.1.61.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	Low level 3 alarm, RHR pump trip alarm, and closure of MV 8 or 9. In addition, the crew is required to check the chart recorders (level, temperature, pressure) every 30 minutes and with the additional time available for OPECS, these checks should occur. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.1.61.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	Per IDHR ONEP (Step 5.1.3c) <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. LPCI is initiated from 04-1-01-E12-1, Step 5.4.2. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table 10.1.61.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ω}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.61.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.1.61.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	23 minutes	8 minutes	15 minutes	

Table 10.1.61.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned. (See comments in Column 5 of this table).		Med. = 0.04 Mean = 0.106	<p>The site interviews indicated that the operators have a clear understanding of the procedure and the requirements. However, given the concerns arising from the occurrence of the LOCA, the median diagnosis value from ASEP, Figure 8-1, rather than the lower bound was judged appropriate.</p> <p>Note. Upon further review, given the indications present, the fact that the operators would have two different procedures guiding them, and the operators understanding of the situation based on the site interviews, it was judged that the lower bound value would have been more appropriate (per ASEP) in this instance. It was decided that where important, the resulting difference in HEP value would be considered during the recovery analysis.</p>

Table 10.1.61.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.61.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.61.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.04 Mean = 0.106	--	Med. Mean 0.04 0.106	(10)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the occurrence of a LOCA, the time limitations and because failures or problems in closing MSIVs or opening 2 SRVs would have to be considered by operators in the same time period.	<u>0.02</u> <u>0.032</u> 0.06 0.138 Total Median HEP = 0.06 Total Mean HEP = 0.138	<u>(5)</u> (10)	The error factor associated with the dominant HEP was assigned.

Table 10.1.63.1
HEP 63 Calculation

Human Action Event (1)	OP1SV (12)
Event Tree(s) (2)	E, EA, EP
Initiators (3)	A5, S1-5, S2-5, S2H-5, H1-5H
Sequence Locator Files (4)	OPECSISO.A5, OPECSISO.S15, OPECSISO.S2-5, OPECSISO.S2H-5, OPECSISO.H15
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 64), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds and must occur in the same time period.
Event Context (6)	For the OP1SV (12) calculation (HEP 63), either 1) a break in the feedwater line has occurred outside containment and check valves isolate the break or 2) a diversion to the SP through RHR/SDC occurs. In either case, level 3 is reached (the feedwater lines are below level 3), MV 8 or 9 auto-isolates on low level, and the SDC pumps trip. Thus, SDC(B) or ADHR are lost. Level 3 alarms (RPV level below 11.4) will cause the operators to enter EP-2, which will direct them to restore level. The RHR pump trip alarms and closure of MV 8 or 9 will indicate a loss of SDC and the corresponding IDHR to the operators. The operators will then enter the IDHR ONEP, which will instruct them to initiate ECCS water solid operation. LPCI(C) or (B) and HPCS are potentially available. The operators decide to initiate ECCS water solid operation as directed by procedure (OPECS succeeds). The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1),

Table 10.1.63.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	The ONEP for-IDHR directs the control room to initiate ECCS to water solid operation in this context. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.63.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two (one in this case) SRVs are open - Increase RPV water level with any available injection system. In this context, LPCI(C) was assumed the system of choice. HPCS would also be available. 	<p>It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system.</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.1.63.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	SEA Calculation C90-492-01-A16. Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 64 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, proceeding with 1 SRV is not indicated by procedure.

Table 10.1.63.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T _t) (3)	Performance Time (T _p) (4)	Total Action Time (T _a) (5)	Comments/ Source of Information (6)
1. Retrieve and Read ONEP for IDHR	CR		5 minutes, (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV.	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
4. Ensure 1 SRV open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
5. Initiate ECCS system (includes isolating letdown (RWCU) at some point in non-LOSP sequences, see Column 6, this Table)	CR	--	2 minute	<u>2 minute</u> 14 min. Total action time	Initiation of ECCS system would require some realignment per SOI. These actions were assumed to be completely dependent. Isolation of RWCU is also included in this step. Even though RWCU continues to run in the non-LOSP sequences, letdown and makeup are still matched since CRD also continues to run. Thus, no hurry on isolation of RWCU. RWCU auto-isolates in the LOSP sequences.

Table 10.1.63.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	14 minutes	9 minutes	-

Table 10.1.63.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the lower bound value from Figure 8-1 for 9 minutes diagnosis time was assigned. (See comments in Column 5 of this table).		Med. = 0.018 Mean = 0.0479 (EF=10)	<p>Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option even though it is not explicitly called by procedure. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling. Also, given that EP-2 directs the operators to start injection with ECCS, it becomes even more unlikely that the operators would stop ECCS just because cannot get 2 SRVs.</p> <p>Given the indications present, the fact that the operators would have two different procedures guiding them, and the operators understanding of the situation based on the site interviews, it was judged that the lower bound value was appropriate (per ASEP) in this instance.</p>

Table 10.1.63.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Some form of SDC is clearly called for and indicated by procedure.

Table 10.1.63.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several safety systems are available and there is substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.63.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.018 Mean = 0.0479	—	Med. Mean 0.018 0.048	(10)	
2. Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the occurrence of a LOCA, and the time limitations.	<u>0.02</u> <u>0.032</u> 0.038 0.08 Total Median HEP = 0.038 Total Mean HEP = 0.08	<u>(5)</u> (10)	Since both HEPs make significant contributions to the Total HEP, the larger factor assigned.

Table 10.1.64.1
HEP 64 Calculation

Human Action Event (1)	OPECS (17)
Event Tree(s) (2)	E, EA, EP
Initiators (3)	A5, S1-5, S2-5, S2H-5, H1-5H
Sequence Locator Files (4)	OPECSISO.A5, OPECSISO.S15, OPECSISO.S2-5, OPECSISO.S2H-5, OPECSISO.H15
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	For the OPECS (17) calculation (HEP 64), either 1) a break in the feedwater line has occurred outside containment and check valves isolate the break or 2) a diversion to the SP through RHR/SDC occurs. In either case, level 3 is reached (the feedwater lines are below level 3), MV 8 or 9 auto-isolates on low level, and the SDC pumps trip. Thus, SDC(B) or ADHR are lost. Level 3 alarms (RPV level below 11.4) will cause the operators to enter EP-2, which will direct them to restore level. The RHR pump trip alarms and closure of MV 8 or 9 will indicate a loss of SDC and the corresponding IDHR to the operators. The operators will then enter the IDHR ONEP, which will instruct them to initiate ECCS water solid operation. LPCI(C) or (B) and HPCS are potentially available.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.1.64.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	Low level 3 alarm, RHR pump trip alarm, and closure of MV 8 or 9. In addition, the crew is required to check the chart recorders (level, temperature, pressure) every 30 minutes and with the additional time available for OPECS, these checks should occur. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.1.64.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system.</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.1.64.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{∞}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.64.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system per SOI (includes isolating letdown (RWCU) at some point in non- LOSP sequences, see Column 6, this Table)	CR	--	2 minutes (per Table 8-1, Step 5b)	<u>2 minutes</u> 9 min. Total	Initiation of ECCS system would require some realignment per SOI. These actions were assumed to be completely dependent. Isolation of RWCU is also included in this step. Even though RWCU continues to run in the non-LOSP sequences, letdown and makeup are still matched since CRD also continues to run. Thus, no hurry on isolation of RWCU. RWCU auto- isolates in the LOSP sequences.

Table 10.1.64.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	23 minutes	9 minutes	14 minutes	

Table 10.1.64.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 14 minutes diagnosis time was assigned. (See comments in Column 5 of this table).		Med. = 0.004 Mean = 0.0106	The site interviews indicated that the operators have a clear understanding of the procedure and the requirements. Moreover, given the numerous and clear indicators present and the fact that the operators would have two different procedures guiding them, it was judged that the lower bound value would be appropriate (per ASEP) in this instance.

Table 10.1.64.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.64.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₉₀ <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.64.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{cz}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.004 Mean = 0.0106	--	Med. Mean 0.004 0.0106	(10)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the occurrence of a LOCA, the time limitations and because failures or problems in closing MSIVs or opening 2 SRVs would have to be considered by operators in the same time period.	<u>0.02</u> <u>0.032</u> 0.024 0.043 Total Median HEP = 0.024 Total Mean HEP = 0.043	<u>(5)</u> (10)	Since both HEPs make significant contributions to the Total HEP, the larger error factor was assigned.

**Table 10.1.65.1
HEP 65 Calculation**

Human Action Event (1)	OPSPM (2)
Event Tree(s) (2)	A5IN, A5INH, S1HIN
Initiators (3)	A5, A5HY, S1H-5
Sequence Locator Files (4)	OPSPM.A5, OPSPM.AHY, OPSPM.S1H
Event Description (5)	OPSPM is the operator action to initiate SPMU.
Event Context (6)	<p>The context for OPSPM (2) is a large or intermediate LOCA. Reactor level has dropped rapidly and ECCS pumps are initiated automatically. The operators have only 13 min. to realize what is happening and initiate the SPMU dump before ECCS isolates on low SP level. The problem is that during LP&S, the SPMU system is made unavailable by opening the breakers for the SPMU valves and placing the mode switch in refuel etc. This is done to prevent an inadvertent dump of SPMU during the time people are likely to be inside containment. Thus, in the present context the operators are faced with a large or intermediate LOCA and will be required to perform an action outside the control room in the Auxiliary building. Operators will have to travel to one of two rooms to close the relevant breakers (they should be red tagged) and return the mode switch etc. to the appropriate position in the control room. It was judged that in the context of a large or intermediate LOCA, 13 min. would most likely be an insufficient amount of time to make the correct diagnosis and accomplish the actions. The instructions for dumping SPMU are not reached until very late in EP-2 and the procedures do not "directly and immediately" address the situation in the context of LP&S. Thus, the upper bound value from Table 8-1 of ASEP would have to be used. Even if it is generously assumed that the breakers could be closed in 5 min., 8 min. for the diagnosis produces an HEP of 1.0. Therefore, OPSPM was set to 1.0 (failure) in this situation. Since detailed ASEP calculations were not required for HEP 65, Tables 10.1.65.2 through 10.1.65.9 were not included.</p>
Applicable Procedures (7)	EP-2 (RPV Control), SPMU SOI (04-1-01-E30-1)

Note. Tables 10.1.65.2 through 10.1.65.9 were unnecessary for HEP 65 and therefore were not included.

Table 10.1.65.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Initiate SPMU	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

**Table 10.1.66.1
HEP 66 Calculation**

Human Action Event (1)	OPFLL (1)
Event Tree(s) (2)	FAM, FS,
Initiators (3)	A5, A5HY, S1-5, S1H-5
Sequence Locator Files (4)	OPFLL.A5, OPFLL.AHY, OPFLL.S15, OPFLL.S1H
Event Description (5)	OPFLL is the operator decision and action to inject into the vessel and flood containment following a LOCA in POS 5.
Event Context (6)	For the OPFLL (1) calculation (HEP 66), a large or intermediate LOCA inside containment has occurred. The crew is initially on RHR/SDC(B) or ADHRS for SDC. Since the most likely break inside containment would be in the recirculation line, level 2 would be reached and ECCS would auto-actuate in less than a minute from the break. It was calculated that the operators would be unable to initiate SPMU prior to a too low SP water level (see HEP 65), resulting in the loss of ECCS. With reactor level dropping to 2/3 core height and low SP level signals, EP-2 instructs the operators to use any of several systems for injection/containment flooding and in this context, SSWXT is the only option modeled (FW inadequate). With 38 minutes available prior to core damage, it is likely operators would determine the need for vessel/containment flooding with SSWXT.
Applicable Procedures (7)	EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.1.66.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A large or intermediate LOCA has occurred and the ECCS systems are not available. Makeup is needed and SSWXT is available for vessel/containment flooding.	0	In addition to numerous alarms and indications of decreasing level which would already be present, reactor temperature (and in some cases pressure) will be increasing). SP low level alarms would occur.	

Table 10.1.66.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A large or intermediate LOCA has occurred and the ECCS systems are not available. Makeup is needed and SSWXT is available for vessel/containment flooding.	One	Open two valves from the CR to initiate SSWXT for flooding	SSWXT must be used. FW inadequate and too long to align.

Table 10.1.66.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{∞}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate flooding	38 minutes	0	38 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.66.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Examine EP-2 and RHR SOI	CR	--	2 minutes	2 minutes	
2. Initiate SSWXT per RHR SOI 04- 1-01-E12-1, step 6.10. Requires 2 valves to be opened.	CR	--	1 minutes (per Table 8-1, Step 5b)	<u>1 minute</u> 3 min. Total	

Table 10.1.66.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment	38 minutes	3 minutes	35 minutes	

Table 10.1.66.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment with SSWXT.	Per ASEP Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned.		Med. = 7.0E-4 Mean = 1.9E-3	While a LOCA is certainly a "well recognized classic event" and the site interviews indicated that the operators have a clear understanding of the needed response and the necessary actions, the lower bound value for the diagnosis was not used because of the likely high stress levels and the fact that some selection of the relevant parts of EP-2 would be required because they are in shutdown. Thus, the median diagnosis value from Figure 8-1 of ASEP HRAP was used.

Table 10.1.66.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Flood the vessel/ containment.	N/A	Actions are specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.66.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Flood with SSWXT.	N/A ¹	No	No ²	N/A	Extremely High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.66.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 7.0E-4 Mean = 1.9E-3	--	Med. Mean 7.0E-4 1.9E-3	(10)	Since all HEPs made significant contributions to the total HEP, the largest error factor was assigned.
2. Initiate vessel/containment flooding with SSWXT.	Med. = 0.05 Mean = 0.081 (values reflect extremely high stress)	Credit for second and third checks were given. See comments in Column 6. Second and third check HEPs were: Med. = .2 Mean = .323	<u>0.002</u> <u>0.008</u> 0.0027 0.01 Total Median HEP = 0.0027 Total Mean HEP = 0.01	<u>(5)</u> (10)	Given that the core could be partially uncovered and SSWXT may be all they have to prevent core damage. Credit for second and third checks is appropriate. Second check HEPs are multiplied by the original HEP for each action and third check HEP is multiplied by the result.

Table 10.1.66.1
HEP 66 Calculation

Human Action Event (1)	OPFLL (1)
Event Tree(s) (2)	FAM, FS,
Initiators (3)	A5, A5HY, S1-5, S1H-5
Sequence Locator Files (4)	OPFLL.A5, OPFLL.AHY, OPFLL.S15, OPFLL.S1H
Event Description (5)	OPFLL is the operator decision and action to inject into the vessel and flood containment following a LOCA in POS 5.
Event Context (6)	For the OPFLL (1) calculation (HEP 66), a large or intermediate LOCA inside containment has occurred. The crew is initially on RHR/SDC(B) or ADHRS for SDC. Since the most likely break inside containment would be in the recirculation line, level 2 would be reached and ECCS would auto-actuate in less than a minute from the break. It was calculated that the operators would be unable to initiate SPMU prior to a too low SP water level (see HEP 65), resulting in the loss of ECCS. With reactor level dropping to 2/3 core height and low SP level signals, EP-2 instructs the operators to use any of several systems for injection/containment flooding and in this context, SSWXT is the only option modeled (FW inadequate). With 38 minutes available prior to core damage, it is likely operators would determine the need for vessel/containment flooding with SSWXT.
Applicable Procedures (7)	EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.1.66.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A large or intermediate LOCA has occurred and the ECCS systems are not available. Makeup is needed and SSWXT is available for vessel/containment flooding.	0	In addition to numerous alarms and indications of decreasing level which would already be present, reactor temperature (and in some cases pressure) will be increasing). SP low level alarms would occur.	

Table 10.1.66.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A large or intermediate LOCA has occurred and the ECCS systems are not available. Makeup is needed and SSWXT is available for vessel/containment flooding.	One	Open two valves from the CR to initiate SSWXT for flooding	SSWXT must be used. FW inadequate and too long to align.

Table 10.1.66.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate flooding	38 minutes	0	38 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.66.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Examine EP-2 and RHR SOI	CR	--	2 minutes	2 minutes	
2. Initiate SSWXT per RHR SOI 04- 1-01-E12-1, step 6.10. Requires 2 valves to be opened.	CR	--	1 minutes (per Table 8-1, Step 5b)	<u>1 minute</u> 3 min. Total	

Table 10.1.66.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment	38 minutes	3 minutes	35 minutes	

Table 10.1.66.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment with SSWXT.	Per ASEP Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned.		Med. = 7.0E-4 Mean = 1.9E-3	While a LOCA is certainly a "well recognized classic event" and the site interviews indicated that the operators have a clear understanding of the needed response and the necessary actions, the lower bound value for the diagnosis was not used because of the likely high stress levels and the fact that some selection of the relevant parts of EP-2 would be required because they are in shutdown. Thus, the median diagnosis value from Figure 8-1 of ASEP HRAP was used.

Table 10.1.66.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Flood the vessel/ containment.	N/A	Actions are specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.66.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Flood with SSWXT.	N/A ¹	No	No ²	N/A	Extremely High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.66.10
Total HEP

Action (1)	Original Operator HEP (HEP_o) (2)^a	Independent Check/Correction HEP (HEP_c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 7.0E-4 Mean = 1.9E-3	--	Med. Mean 7.0E-4 1.9E-3	(10)	Since all HEPs made significant contributions to the total HEP, the largest error factor was assigned.
2. Initiate vessel/containment flooding with SSWXT.	Med. = 0.05 Mean = 0.081 (values reflect extremely high stress)	Credit for second and third checks were given. See comments in Column 6. Second and third check HEPs were: Med. = .2 Mean = .323	<u>0.002</u> <u>0.008</u> 0.0027 0.01 Total Median HEP = 0.0027 Total Mean HEP = 0.01	<u>(5)</u> (10)	Given that the core could be partially uncovered and SSWXT may be all they have to prevent core damage. Credit for second and third checks is appropriate. Second check HEPs are multiplied by the original HEP for each action and third check HEP is multiplied by the result.

Table 10.1.67.1
HEP 67 Calculation

Human Action Event (1)	OPLDM (1)
Event Tree(s) (2)	S2-5, S2-H5
Initiators (3)	S2-5, S2-H5
Sequence Locator Files (4)	OPLDM.S25, OPLDM.S2H
Event Description (5)	OPLDM is the operator action in response to a small LOCA (that cannot be isolated) to isolate letdown and increase makeup with CDS to match flow out the break. Action must be accomplished before SDC isolates on level 3. CRD is inadequate.
Event Context (6)	The context for OPLDM (2) is a small LOCA that is not isolated. The operators need to isolate letdown and increase flow with CDS before level 3 isolation of SDC. CRD alone is inadequate because the flow may not match break and in any case more makeup will be needed to provide adequate (natural) recirculation. Thus, makeup and SDC are needed. The problem is that CDS injects through the feedwater line which is also the injection path for SDC(B). Telephone interviews with plant personnel indicated that while there were no interlocks to prevent injection with both systems, no one knew what the effect might be. Given no procedures or training for this and very little time (15 minutes), the HEP for OPLDM was set to 1.0 (failure) in this situation. Level control with ECCS is asked later. Since detailed ASEP HRAP calculations were not required for HEP 67, Tables 10.1.67.2 through 10.1.67.9 were not included.
Applicable Procedures (7)	EP-2 (RPV Control)

Note. Tables 10.1.67.2 through 10.1.67.9 were unnecessary for HEP 67 and therefore were not included.

Table 10.1.67.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Provide makeup with CDS in response to an unisolated small LOCA.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0	-	

Table 10.1.68.1
HEP 68 Calculation

Human Action Event (1)	OPSRV (1)
Event Tree(s) (2)	FS
Initiators (3)	S1-5, S1H-5, S2-5, S2H-5, S3-5
Sequence Locator Files (4)	OPFLL.S15, OPFLL.S1H, OPFLL.S25, OPFLL.S2H, OPFLL8.S25, OPFLL8.S2H
Event Description (5)	OPSRV is the operator decision and action to open at least 1 SRV for a medium or small LOCA.
Event Context (6)	For the OPSRV (1) calculation (HEP 68), a medium, small or small-small LOCA inside containment has occurred. For any of several reasons, ECCS is unavailable and per EP-2 the operators have initiated vessel/containment flooding (OPFLL succeeds). In order to avoid repressurizing the vessel in the context of an intermediate or small LOCA and to facilitate containment flooding, the operators will need to ensure at least 1 SRV is open (OPSRV). Opening SRVs is indicated in several relevant places in EP-2 and operators have approximately 110 min. to diagnose and accomplish the action. In addition to the procedures, and given the accident, the operators will be carefully monitoring the critical parameters such pressure.
Applicable Procedures (7)	EP-2 (RPV Control, Rev. 19)

Table 10.1.68.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A medium or small LOCA has occurred, the ECCS systems are not available, and the operators have initiated vessel/containment flooding with SSWXT. Operators need to open at least 1 SRV to prevent pressurizing the vessel.	0	Increasing pressure would be indicated and the operators are instructed to open SRVs in EP-2.	

Table 10.1.68.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A medium or small LOCA has occurred, the ECCS systems are not available, and the operators have initiated vessel/containment flooding with SSWXT. The operators need to open at least 1 SRV.	One	Open SRVs from the CR.	

Table 10.1.68.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Open SRVs to prevent vessel pressurization.	1.9 hours	0	1.9 hours	SEA Calculation C90-492-01-A16

Table 10.1.68.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Open at least 1 SRV..	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 1 min. Total	

Table 10.1.68.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_A) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment	1.9 hours	1 minute	Approx. 110 minutes	

Table 10.1.68.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to open at least 1 SRV to avoid pressurizing the vessel.	Per ASEP Table 8-3, the median value from Figure 8-1 for 110 minutes diagnosis time was assigned.		Med. = 6.0E-5 Mean = 5.1E-4	The need to open an SRV would be obvious and it is indicated in EP-2.

Table 10.1.68.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Open SRV	N/A	Actions are specified by procedure.	No	Step-by-Step	

Table 10.1.68.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Open SRV	N/A ¹	Medium or Small LOCA	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.68.10
Total HEP .

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{cz}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 6.0E-5 Mean = 5.1E-4	--	Med. Mean 6.0E-5 5.1E-4	(30)	
2. Open SRV to prevent vessel pressurization while flooding vessel/containment with SSWXT in response to medium or small LOCA.	Med. = 0.02 Mean = 0.032	Credit for second and third checks were given because of the time available and because as pressure went up the operators would check the SRVs. Second and third check HEPs were: Med. = .2 Mean = .323	<u>0.008</u> <u>0.003</u> 0.008 0.004 Total Median HEP = 0.011 Total Mean HEP = 0.004	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned.

Table 10.1.69.1
HEP 69 Calculation

Human Action Event (1)	OPMSV (6)
Event Tree(s) (2)	FS
Initiators (3)	S1-5, S2-5, S3-5
Sequence Locator Files (4)	OPFLL.S15, OPFLL.S25, OPFLL.S35, OPFLL8.S25
Event Description (5)	OPMSV is the operator action to close open MSIVs to prevent flooding or steaming down the steam lines.
Event Context (6)	For the OPMSV (6) calculation (HEP 69), a medium, small or small-small LOCA inside containment has occurred. For any of several reasons, ECCS is unavailable and per EP-2 the operators have initiated vessel/containment flooding (OPFLL succeeds) and have attempted to open at least 1 SRV to prevent repressurizing the vessel in the context of an intermediate or small LOCA and to facilitate containment flooding. The operators will also need to ensure that any open MSIVs are closed to prevent flooding down the steam lines. EP-2 instructs the operators to close any open MSIVs when RPV level is greater than - 167 inches.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.1.69.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators are flooding the vessel/containment and need to close any open MSIVs to prevent flooding down steam lines.	O	Level will be rising and EP-2 instructs the operators to close open MSIVs when level exceeds - 167 inches. Operators have entered EP-2 and have decided to flood. Should get some high level alarms prior to reaching steam lines.	

Table 10.1.69.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators are flooding the vessel/containment and need to close any open MSIVs to prevent flooding down steam lines.	One	Close open MSIVs from the control room	

Table 10.1.69.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Close any open MSIVs	35 minutes	0	35 Minutes	SEA Calculation C69-492-01- A16

Table 10.1.69.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Close any open MSIVs. At the most, 18 MSIVs could be open.	CR	--	2 minutes	2 minutes	

Table 10.1.69.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Close open MSIVs	35 minutes	2 minutes	33 minutes	

Table 10.1.69.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Close any open MSIVs.	Per ASEP HRAP Table 8-3, the lower bound value from Figure 8-1 for 33 minutes diagnosis time was assigned.		Med. = 0.0001 Mean = 0.0008	The operators have decided to flood and have probably entered EP-2, where they are instructed to close any open MSIVs when level exceeds -167 inches. Site interviews indicated that the operators would not want water running down the steam lines and that they would be likely to check the position of the MSIVs. Level alarms would indicate increasing level. Thus, per ASEP HRAP, Table 8-3, the lower bound value was judged appropriate.

Table 10.1.69.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Close any open MSIVs	N/A	Actions are specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

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Table 10.1.69.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	T _E < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Close MSIVs.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage and operators have been performing correctly.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.69.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2) ^{op}	Independent Check/Correction HEP (HEP _{cz}) (3) ^{cz}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.0001 Mean = 0.0008	--	Med. Mean 0.0001 0.0008	(30)	
2. Close any open MSIVs to prevent flooding down steam lines.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available and the fact that the operators would want to be sure the MSIVs were closed once they realized they were open. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004 0.0104</u> <u>0.0041 0.011</u> Total Median HEP = 0.0041 Total Mean HEP = 0.011	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.1.70.1
HEP 70 Calculation

Human Action Event (1)	OPSPM (3)
Event Tree(s) (2)	S15NF, S1HNF
Initiators (3)	S2-5, S2H-5, S3-5, S3H-5
Sequence Locator Files (4)	OPSPM.S25, OPSPM.S2H, OPSPM.S35, OPSPM.S3H
Event Description (5)	OPSPM is the operator actions to initiate SPMU to provide additional level and cooling to the SP.
Event Context (6)	<p>OPSPM is the operator action to initiate SPMU in the context of a small or small-small LOCA inside containment. Reactor level has dropped and ECCS pumps will initiate automatically at level 2. The operators have at least 45 min. to realize what is happening and restore SPMU before ECCS isolates on low SP level. Several alarms will sound to indicate that level is dropping. One problem is that during LP&S the SPMU system is made unavailable by opening the breakers for the SPMU valves and placing the mode switch in refuel etc. This is done to prevent an inadvertent dump during the time people are likely to be inside secondary containment. Thus, operators will be required to perform an action outside the control room in the Auxiliary Building. Operators will have to travel to one of two rooms to close the relevant breakers (they should be red tagged) and return the mode switch etc. to the appropriate position in the control room. Once the SPMU system is restored to normal, the dump will occur automatically. The instructions for dumping SPMU in this context will be found by the operators in EP-2 and EP-3. While the procedures do not point out the need to restore, the status of the SPMU valves will be indicated by red tags in the control room. With the time available the EPs will (eventually, if not directly) lead the operators to the appropriate actions.</p>
Applicable Procedures (7)	EP-2 (RPV Control), EP-3 (Containment Control), SPMU EOI (04-1-01-E30-1)

Table 10.1.70.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
ECCS pumps have started in response to a small LOCA. SPMU is needed.	O	ECCS pumps have initiated on low level and will be alarmed. Low SP level will be alarmed. These indicators will lead the operators to enter EP-3 and will indicate the need to provide makeup to the SP.	

Table 10.1.70.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
ECCS pumps have started in response to a small LOCA. SPMU is needed.	One	The operators will follow EP-3 and the SPMU SOI, which directs the operators to open two valves per train to initiate SPMU. Success with one train is all that is needed. During LP&S, SPMU is isolated to avoid an inadvertent dump. The operators will have to override the isolation. Section 5.2 of the SPMU SOI provides the procedure.	On the basis of discussions with plant personnel (by telephone), the necessary actions are straightforward and the control would be aware of the fact that SPMU is isolated.

Table 10.1.70.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_o) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_s) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to unisolate and initiate SPMU.	45 minutes	0	45 minutes	SEA Calculation C90-492-01-A16

Table 10.1.70.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Override SPMU isolation by closing breakers and repositioning the SPMU mode switch.	Outside control room in Control Bldg. for closing breakers.		Travel and performance time was estimated to be approximately 15 minutes.	15 minutes	Travel and performance time estimate was based on telephone conversations with plant personnel and on the examination of plant drawings regarding breaker locations relative to the CR.
2. Open SPMU valves	CR	--	1 minute	1 minute	

Table 10.1.70.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to unisolate and initiate SPMU.	45 minutes	Approx. 15 min.	Approx. 30	

Table 10.1.70.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate SPMU.	Per ASEP Table 8-3, the upper bound value from Figure 8-1 for 30 minutes diagnosis time was assigned.		Med. = 0.01 Mean = 0.027	The median value from Figure 8-1 may have been more appropriate than the upper bound. However, the amount of training the operators receive for such a scenario was not determined and it is possible that at least part of the available time would be focused on attempts to isolate the break. Thus, the upper bound diagnosis value was conservatively assigned.

Table 10.1.70.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate SPMU.	N/A	Interviews indicated that the operators would understand the needed actions and how to accomplish them. The actions are proceduralized.	No	Step-by-step Actions are proceduralized.	

Table 10.1.70.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_R <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate SPMU	N/A ¹	N/A	No ²	N/A	Moderately High	Other systems still available for injection.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.70.10
Total HEP

Action (1)	Original Operator HEP (HEP₁) (2)^{op}	Independent Check/Correction HEP (HEP₂) (3)^{cz}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.01 Mean = 0.027	—	Med. Mean 0.01 0.027	(10)	
2. Override SPMU isolation and reposition mode switch.	Med. = 0.02 Mean = 0.032	Credit for a second check was given for both sets of operator actions because of the time available and the presence of feedback that would alert the operators to any failures. The HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01	(5)	Second check HEPs are multiplied by the original HEP for each action.
3. Open SPMU valves from the control room .	Med. = 0.02 Mean = 0.032	Second check HEPs were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.018 0.047 Total Median HEP = 0.018 Total Mean HEP = 0.047	<u>(5)</u> (10)	Since all HEPs made significant contributions to the total HEP, the largest error factor was assigned.

Table 10.1.71.1
HEP 71 Calculation

Human Action Event (1)	OPICT
Event Tree(s) (2)	EC, ECP, EX, ECX, ECAC, ECNP, ECNPL, FC, FCP, FCAC
Initiators (3)	All initiators (Transients and LOCAS)
Sequence Locator Files (4)	All files beginning with OPICT, e.g., OPICTE.E1T, with the exception of files labeled OPICTCAU, e.g., OPICTCAU.TIF. OPICT is also found in some files beginning with SPMUN.
Event Description (5)	OPICT is the operator action to close an open containment.
Event Context (6)	For OPICT (HEP 71), the operators have successfully initiated ECCS water solid operation to provide SDC. If containment is open, it was assumed that the operators would want it closed. However, in the present scenarios, only 6.4 hours would be available for closing an open containment. On the basis of discussions with plant personnel, it was determined that up to 12 hours could be required to close the large equipment hatch. Thus, OPICT was set to fail in all scenarios. Credit was taken for closing the lower personnel locks during recovery. Since detailed ASEP HRAP calculations were not required for HEP 71, Tables 10.1.71.2 through 10.1.71.9 were not included.
Applicable Procedures (7)	EP-3 (Containment Control), Inadequate Decay Heat Removal ONEP (05-1-02-III-1).

Note. Tables 10.1.71.2 through 10.1.71.9 were unnecessary for HEP 71 and therefore were not included.

Table 10.1.71.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Close an open containment.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table 10.1.73.1
HEP 73 Calculation

Human Action Event (1)	OPCMT, OPSTL, and OPVNT (in trees containing OPCMT, e.g., FC).
Event Tree(s) (2)	For OPCMT and OPVNT, trees FC, FCAC, FCACP, FCACX, FCP, FCX, FCACN, and FCN. For OPSTL, trees PISOL, PISLP, and PISLX
Initiators (3)	All
Sequence Locator Files (4)	N/A
Event Description (5)	OPCMT is long-term opening of containment. OPVNT is venting of containment. OPSTL is operator's steaming of core in HYDRO.
Event Context (6)	-- The time available to perform OPCMT (54 hours), OPSTL (33 hours), and OPVNT (54 hours, when it occurs in trees with OPCMT) exceeds the mission time of 24 hours. Thus, none of the sequences with these events needed to be analyzed and no HEPs were computed. Since detailed ASEP HRAP calculations were not required for HEP 73, Tables 10.1.73.2 through 10.1.73.9 were not included.
Applicable Procedures (7)	N/A

Note. Tables 10.1.73.2 through 10.1.73.9 were unnecessary for HEP 73 and therefore were not included.

Table 10.1.73.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Sequences with OPCMT, OPSTL, and OPICT in trees with OPCMT did not be analyzed.	Not analyzed	N/A	Not analyzed		

**Table 10.1.74.1
HEP 74 Calculation**

Human Action Event (1)	ISSSL
Event Tree(s) (2)	S3-5, S3H-5
Initiators (3)	S3-5, S3H-5
Sequence Locator Files (4)	OISSSL.S35, OISSSL.S3H
Event Description (5)	ISSSL is the operator action to detect and isolate a recirculation pump seal leak before level 3 is reached and SDC auto-isolates.
Event Context (6)	<p>ISSSL (HEP 74) is the operator action to detect and isolate a recirculation pump seal leak before level 3 is reached and SDC isolates. In addition, operators must also isolate letdown and increase make-up in the same time period, i.e., before level 3 is reached (OPLDM). Level for natural recirculation can be established by isolating letdown and providing makeup with CRD or CDS. Recirculation pump seal leakage is well instrumented and procedures direct operators to first consider a pump seal leak if unidentified leakage occurs and/or drywell pressure increases. Operators will receive a level 4 alarm that will indicate that level is dropping and that a leak may be present. The level 4 alarm will also indicate the need to isolate letdown and provide additional make-up. Operators are aware that SDC will isolate at level 3.</p> <p>Since the OPLDM actions must occur in the same time period as ISSSL (37 minutes), a single HEP was derived which includes the relevant actions for the two events. Thus, if ISSSL fails, then OPLDM also fails.</p>
Applicable Procedures (7)	EP-2 (RPV Control, Rev. 19)

Table 10.1.74.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Recirculation pump seal leak occurs. Operators need to isolate the leak, isolate letdown, and provide makeup.	O	Recirculation pump seal leakage is well instrumented and procedures direct operators to first consider a pump seal leak if unidentified leakage occurs and/or drywell pressure increases. Operators will receive a level 4 alarm that will indicate that level is dropping and that a leak may be present. The level 4 alarm will also indicate the need to isolate letdown and provide additional make-up. Operators are aware that SDC will isolate at level 3.	

Table 10.1.74.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Recirculation pump seal leak occurs. Operators need to isolate the leak, isolate letdown, and provide makeup.	One	<ul style="list-style-type: none"> - Close valves to isolate leak. - Isolate letdown (RWCU). - Increase RPV water level with CRD or CDS. 	

Table 10.1.74.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Operators need to isolate the leak, isolate letdown, and provide makeup.	37 minutes	0	37 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.74.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Close valves to isolate leak.	CR	--	1 minute	1 minutes	Per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action at the main control panels.
2. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	
3. Provide makeup with CRD or CDS.	CR	--	1 minute	<u>1 minute</u> 3 min. Total	One CRD pump would probably already be running. Both CRD pumps would be required.

Table 10.1.74.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose recirculation pump seal leak and need to isolate the leak, isolate letdown, and provide makeup.	37 minutes	3 minutes	Approx. 33 minutes	

Table 10.1.74.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose recirculation pump seal leak and need to isolate the leak, isolate letdown, and provide makeup.	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 33 minutes diagnosis time was assigned.		Med. = 7.0E-4 Mean = 5.9E-3	Information regarding indications and operator response to a recirculation pump seal leak was based on discussions with the nuclear engineers and systems analysts working on the PRA. While the lower bound may have been appropriate, the fact that the data was not confirmed with plant personnel led to the use of the median value.

Table 10.1.74.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Operators need to isolate the leak, isolate letdown, and provide makeup.	N/A	Actions specified by procedure.	No	Step-by-Step	

Table 10.1.74.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _m < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Operators need to isolate the leak, isolate letdown, and provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.74.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^a	Independent Check/Correction HEP (HEP _c) (3) ^a	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 7.0E-4 Mean = 5.9E-3	--	Med. Mean 7.0E-4 5.9E-3	(30)	
2. Isolate recirculation pump seal leak.	Med. = 0.02 Mean = 0.032	Credit for a second check was given for each of the three actions because of the substantial time available before a critical situation would exist and because of relevant feedback to the operators. Second check HEPs were: Med. = .2 Mean = .323	0.004 0.01	(5)	Second check HEPs are multiplied by the original HEP for each action.
3. Isolate letdown (RWCU)	Med. = 0.02 Mean = 0.032	Second check HEPs were: Med. = .2 Mean = .323	0.004 0.01	(5)	
4. Provide makeup with CRD or CDS.	Med. = 0.02 Mean = 0.032	Second check HEPs were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.013 0.036 Total Median HEP = 0.013 Total Mean HEP = 0.036	<u>(5)</u> (5)	The error factor associated with the dominant HEPs was assigned.

**Table 10.1.75.1
HEP 75 Calculation**

Human Action Event (1)	OPECC and (OPSRV and OPMSV following OPECC)
Event Tree(s) (2)	ES
Initiators (3)	S2-5, S2H-5, S3-5
Sequence Locator Files (4)	OPECC.S25, OPECC.S2H, OPECC.S35
Event Description (5)	OPECC in this case includes diagnosing the need to initiate ECCS water solid operation after initiating SPMU in the context of a small or small-small LOCA inside containment, and performing the relevant actions.
Event Context (6)	<p>OPECC (HEP 75) is the operator action to initiate ECCS water solid after providing a dump of SPMU (OPSPM succeeds) in the context of a small or small-small LOCA inside containment. The small LOCA is not immediately isolated. Reactor level is dropping and the ECCS pumps will initiate automatically at level 2. Since operators have initiated SPMU, it is assumed that they are aware of the small LOCA. Several alarms have sounded to indicate that level is dropping, including a level 3 alarm which will indicate a loss of SDC. With level dropping and a loss of SDC, EP-2 and the IDHR ONEP will direct the operators to start ECCS (if it hasn't already) and initiate ECCS water solid operation.</p> <p>OPSRV which the operator action to open at least 1 SRV is covered as part of OPECC in this case. Thus, if OPECC succeeds, it is assumed that the operators opened at least 1 SRV per the IDHR ONEP and OPSRV is set to succeed. OPMSV, which is the closing of any open MSIVs is assumed to take place during the 3 hours allowed for OPECC and OPSRV. Checking closed MSIVs is part of procedure for going ECCS water solid. Thus, OPMSV is set to succeed if OPECC succeeds.</p>
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.1.75.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for additional makeup and core cooling.	O	The operators have initiated SPMU so are apparently aware of a break. Low level 3 alarm, RHR pump trip alarm, and closure of MV 8 or 9. In addition, the crew is required to check the chart recorders (level, temperature, pressure) every 30 minutes and with the additional time available for OPECS, these checks should occur. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.1.75.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal with an unisolated small or small-small LOCA. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system.</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.1.75.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ca}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	180 minutes	0	180 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.75.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system per SOI (includes isolating letdown (RWCU) at some point).	CR	--	2 minutes (per Table 8-1, Step 5b)	<u>2 minutes</u> 9 min. Total	Initiation of ECCS system would require some realignment per SOI. These actions were assumed to be completely dependent. Isolation of RWCU is also included in this step. Letdown and makeup are still matched since CRD also continues to run and the operators are controlling level with LPCI or HPCS. Thus, isolation of RWCU is not immediately critical.

Table 10.1.75.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	180 minutes	9 minutes	Approx. 170 minutes	

Table 10.1.75.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 170 minutes diagnosis time was assigned.		Med. = 1.0E-5 Mean = 8.5E-5	The site interviews indicated that the operators have a clear understanding of the procedure and the requirements.

Table 10.1.75.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.75.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.75.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 1.0E-5 Mean = 8.5E-5	--	Med. Mean 1.0E-5 8.5E-5	(30)	-
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available. Med. = .2 Mean = .323	<u>0.004</u> <u>0.0104</u> 0.024 0.01 Total Median HEP = 0.004 Total Mean HEP = 0.01	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.1.76.1
HEP 76 Calculation

Human Action Event (1)	OPFLL (2)
Event Tree(s) (2)	FS
Initiators (3)	S2-5, S2H-5, S3-5
Sequence Locator Files (4)	OPFLL.S25, OPFLL.S2H, OPFLL8.S25, OPFLL8.S2H
Event Description (5)	OPFLL is the operator decision and action to inject into the vessel and flood containment following a small or small-small LOCA in POS 5.
Event Context (6)	For the OPFLL (2) calculation (HEP 76), a small or small-small LOCA inside containment has occurred. The operators initially fail to isolate letdown and provide additional makeup (OPLDM). The vessel would continue to drain and operators would get numerous alarms and indications. Alarms would occur at levels 4 and 3 and SDC cooling would isolate at level 3. In the relevant scenarios, the operators either realize the existence of the break and dump the SPMU in order to provide sufficient level for ECCS or the fail to initiate SPMU. Regardless, the initial level in the SP is low and insufficient water is available to complete ECCS water solid operation per the IDHR ONEP. That is, the water dumping into the drywell from the break would not reach a level high enough to connect with the SP. The operators must realize that the level in the SP will be inadequate. Operators are instructed by EP-2 to initiate SSWXT and (eventually) to flood containment.
Applicable Procedures (7)	EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.1.76.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A small or small-small LOCA has occurred and the ECCS systems are not available. Makeup is needed and SSWXT is available for vessel/containment flooding.	0	In addition to numerous alarms and indications of decreasing level which would already be present, reactor temperature (and in some cases pressure) will be increasing). SP low level alarms would occur.	

Table 10.1.76.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A small or small-small LOCA has occurred and the level in the SP is inadequate for ECCS. Makeup is needed and SSWXT is available for vessel/containment flooding.	One	Open two valves from the CR to initiate SSWXT for flooding	

Table 10.1.76.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{∞}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate flooding	38 minutes	0	38 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.76.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Examine EP-2 and RHR SOI	CR	--	2 minutes	2 minutes	
2. Initiate SSWXT per RHR SOI 04- 1-01-E12-1, step 6.10. Requires 2 valves to be opened.	CR	--	1 minutes (per Table 8-1, Step 5b)	<u>1 minute</u> 3 min. Total	

Table 10.1.76.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment	38 minutes	3 minutes	35 minutes	

Table 10.1.76.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment with SSWXT. The operators must realize the SP level is inadequate and that SSWXT can be used.	Per ASEP Table 8-3, the upper bound from Figure 8-1 for 35 minutes diagnosis time was assigned.		Med. = 7.0E-3 Mean = 0.019	The diagnosis in these sequences could be more difficult than in the large or intermediate LOCA case. Level is decreasing at a slower rate and the operators have to realize that the SP level will be too low for ECCS. Furthermore, in some of the sequences the operators have failed to attempt to initiate SPMU. Thus, the upper bound diagnosis value from Figure 8-1 of ASEP HRAP was used.

Table 10.1.76.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Flood the vessel/ containment.	N/A	Actions are specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.76.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_R <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Flood with SSWXT.	N/A ¹	Small LOCA	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.76.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{cz}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 7.0E-3 Mean = 0.019	--	Med. Mean 0.007 0.019	(10)	Since both HEPs made significant contributions to the total HEP, the largest error factor was assigned.
2. Initiate vessel/containment flooding with SSWXT.	Med. = 0.02 Mean = 0.032	Credit for a second check was given. Second check HEPs were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.011 0.03 - Total Median HEP = 0.011 Total Mean HEP = 0.03	<u>(5)</u> (10)	Second check HEPs are multiplied by the original HEP for each action.

Table 10.1.77.1
HEP 77 Calculation

Human Action Event (1)	OPDHR (4)
Event Tree(s) (2)	L, LA, LP,
Initiators (3)	TIOP5
Sequence Locator Files (4)	OPDHR.TIO
Event Description (5)	OPDHR is the operator action to control vessel level in order to avoid a "functional" loss of SDC caused by inadequate circulation between the core and the downcomer regions of the vessel. That is, even if SDC continues to operate, if vessel level becomes too low, a "disconnect" between the core and downcomer regions can occur. This will result in inadequate cooling of the core even though SDC continues to operate. The indications to the operators that the event is occurring can be subtle because temperature readings are apparently taken from the downcomer region, where the water being cooled by SDC is returned. Also, the vessel level would not be so low that any level alarms would sound. A loss of forced recirculation, or a loss of makeup (usually CRD) coupled with continued draindown, can lead to inadequate level. Only 10 minutes was allowed for the operator diagnosis and actions in OPDHR.
Event Context (6)	The important constants for the OPDHR (4) calculation (HEP 77) are that a mismatch between letdown and makeup has occurred (because of a decrease in letdown) which leads to a potential overpressurization of the vessel. In this scenario (TIOP5 initiator), the operators have responded to the problem by controlling makeup (LCMK succeeds). Later in the scenario, makeup (CRD) fails or doesn't fail. SDC(B) or ADHRS has continued to run. RWCU may be functioning (even if at a decreased rate), which could lead to a draindown of the vessel if CRD has failed. OPDHR calls for operators to control level either: 1) before the lowering of level leads to a disconnect between the core and the downcomer, which could result in a "functional" loss of SDC, or 2) before increasing level leads to overpressurization of the vessel. A loss of CRD would be alarmed, as would a level decrease to level 4. Similarly, levels 7 and 8 would also be alarmed if level was increasing. While operators may have only 10 min. to diagnose and respond to the problem, they successfully responded to the earlier mismatch between letdown and makeup (LCMK) and should be closely monitoring level. Thus, OPDHR in this context is somewhat different than in other transients. In spite of the fact that the existing conditions might not directly enter the operators into a procedure, they will be striving to keep water level at the appropriate place. In cases where CRD is lost, the operators will have to decide which system to use to provide the makeup (most likely an ECCS system unless SDC is from ADHRS, in which case CDS might be an option).
Applicable Procedures (7)	No specific procedures, but the Inadequate Decay Heat Removal ONEP (05-1-02-III-1) would be relevant, as would the relevant SOIs, e.g., RHR SOI (04-1-01-E12-1).

Table 10.1.77.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR caused by inadequate circulation between the core and the downcomer regions of the vessel. Level control (makeup) is needed.	- O	As noted in Table 77-1, the indications for this event may be subtle because vessel temperature readings could be misleading and no level alarms would sound. However, in all the sequences covered, CRD and/or forced recirculation is lost. These events will be alarmed and if the operators are knowledgeable regarding the potential problem, these indications should suffice. Moreover, the operators have been actively controlling level and will have had ample time to consider potential problems and relevant signals.	

Table 10.1.77.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A "functional" loss of SDC leads to IDHR. The operators need to diagnose the need and increase vessel level.	One	The operators need to increase RPV water level with any available injection system. CRD (if available), CDS, or an ECCS system are possible choices.	

Table 10.1.77.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{α}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	10 minutes	0	10 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.77.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
If available, increase flow with CRD. If CRD is not available and SDC is not being provided by SDC(B), use CDS. Otherwise, use an ECCS system. Note. With only 10 min. available for OPDHR, if CDS was asked and it failed, credit was not taken for both CDS and an ECCS system.	CR	--	2 minutes	2 minutes	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column. The actions involved in initiating a makeup system were assumed to be completely dependent. System initiation would be proceduralized.

Table 10.1.77.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	10 minutes	2 minutes	8 minutes	

Table 10.1.77.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to provide makeup	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 8 minutes diagnosis time was assigned.		Med. = 0.015 Mean = 0.04	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. The lower bound diagnosis value was judged appropriate in these scenarios because of the successes of the operators, the fact that they have been concerned with level, and the time available after the initiator to consider potential problems that could arise (given level control success in LCMK).

Table 10.1.77.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate an injection system to provide makeup.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Dynamic. Given that the operators would have determine which system to start on their own, the actions were assumed to be dynamic, per ASEP.	

Table 10.1.77.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate an injection system to provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.77.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^{op}	Independent Check/Correction HEP (HEP _c) (3) ^c	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.015 Mean = 0.04	—	Med. Mean 0.015 0.04	(10)	
2. Initiate an injection system to provide makeup and vessel level control.	Med. = 0.05 Mean = 0.081	Credit for a second check was not taken because of the time limitations.	<u>0.05</u> <u>0.081</u> 0.065 0.12 Total Median HEP = 0.065 Total Mean HEP = 0.12	<u>(5)</u> (10)	Since both HEPs contribute to the total HEP, the larger error factor was assigned.

Table 10.1.78.1
HEP 78 Calculation

Human Action Event (1)	OPECS (18)
Event Tree(s) (2)	EA
Initiators (3)	TIOP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSAD5.TIO, OPECSAD5.TLM, OPECSAD5.TRP
Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	<p>The important constants for the OPECS (18) calculation (HEP 78) is that the control room has failed to diagnose the loss of SDC (ADHR) in 37 minutes (OPSDC fails). That is, in 37 min. the control room has not diagnosed the loss of SDC or entered the IDHR ONEP. However, by requirements (every 30 min.) the reactor temperature (and/or pressure) chart recorder would very likely be checked (to reveal increases) in the 23 min. available for this event. In addition, if a boil-off had begun, a low level alarm (level 4) may occur. With the additional time and new indicators, it was assumed that the HEP computations for OPECS etc. would parallel those for similar events in which the need for an ECCS system must be diagnosed and the related actions carried-out without a successful OPSDC.</p> <p>In OPECS (18) (HEP 78), the operators must recognize the loss of ADHR and enter the IDHR ONEP. In some cases, prior to initiating ECCS water solid operation, the operators will need to isolate ADHR from the control room. The IDHR ONEP directs the operators to initiate ECCS water solid operation (LPCI, HPCS, or both are available, depending on context).</p>
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.1.78.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	In addition to numerous alarms and indications which would already be present, reactor temperature (and in some cases pressure) will be increasing). The crew is required to check the chart recorders every 30 minutes and with the additional time available for OPECS, these checks should occur. Furthermore, a low level alarm would also be likely to occur during this period. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.1.78.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<ol style="list-style-type: none"> 1. Isolate ADHR from the control room by closing 8 or 9 valve. 2. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	<p>Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. In some sequences, however, HPCS is the choice due to the initiator, e.g., T5A5H (loss of SSW).</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.1.78.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_s) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.78.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Isolate ADHR from the control room by closing 8 or 9 valve, if necessary.	CR	--	1 minute	0 minutes - if action necessary, assumed to be done in parallel with OPECS actions below	
3. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
4. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
5. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.1.78.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	23 minutes	8 minutes	15 minutes	

Table 10.1.78.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned.		Med. = 0.04 Mean = 0.106	For this event, the operators have failed to diagnose the loss of SDC in spite of several indications (OPSDC or OPDHR have failed). Given these previous failures, it was judged that the lower bound diagnosis value would not be appropriate even though the site interviews indicated that the operators have a clear understanding of the procedure and the requirements.

Table 10.1.78.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.78.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.78.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.04 Mean = 0.106	--	Med. Mean 0.04 0.106	(10)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations and because of failures or problems in closing MSIVs or opening 2 SRVs would have to be considered by operators in the same time period i.e., OPMSV and OP1SV.	<u>0.02</u> <u>0.032</u> 0.06 0.138 Total Median HEP = 0.06 Total Mean HEP = 0.138	<u>(5)</u> (10)	The error factor associated with the dominant HEP was assigned.

**Table 10.1.79.1
HEP 79 Calculation**

Human Action Event (1)	OPECS (19)
Event Tree(s) (2)	E, EA
Initiators (3)	TIOP5, E1T5H
Sequence Locator Files (4)	OPECSP.TIO, OPECSP.E1T
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (19) calculation (HEP 79) are that the operators have failed to successfully control letdown and makeup in response to situations that lead to an increase in level (LCMK fails), such as mismatch between makeup and letdown. Later in the scenario SDC isolates on high pressure. A pump trip alarm would occur and level 7 and 8 alarms would sound if they haven't already. Pressure would be increasing. Given the two hours preceding the need to do something and the numerous indicators present, it was assumed that the operators will have entered the IDHR ONEP prior to OPECS. They will need to stop makeup (CRD), start LPCI, and perform related OPECS actions for initiating ECCS water solid operation. OPMSV is set to 0 in this scenario because the vessel would not pressurize with the MSIVs open.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44), HPCS SOI (04-1-01-E22-1, Rev. 28).

Table 10.1.79.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	4 minutes	19 minutes	

Table 10.1.79.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 19 minutes diagnosis time was assigned.		Median = 0.001 (EF = 10) Mean = 0.0027	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. Moreover, given the numerous indications and the obvious need to stop makeup and provide some form of SDC, the lower bound value from ASEP was assigned.

Table 10.1.79.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for initiation of ECCS water solid operation.	O	Loss of systems were alarmed, several level and pressure alarms should sound, and the operators should accomplish periodic checks of temperature and pressure in the new time available. Reactor pressure and level will be rising. Given the amount of time preceding the need to respond and the numerous indicators, it was assumed that the IDHR ONEP has been entered.	

Table 10.1.79.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. Operators have entered the IDHR ONEP. They must diagnose the need to initiate ECCS water solid operation and stop makeup.	One	<ol style="list-style-type: none"> 1. Stop makeup (CRD). 2. Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) assumed to be the first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP.

Table 10.1.79.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.79.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Stop makeup (CRD)	CR	--	1 minute	1 minute	
2. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 2, 3, and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
4. Initiate ECCS system per SOIs	CR	--	1 minute	<u>1 minute</u> 4 minutes (approx.) Total time for all actions.	

Table 10.1.79.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.79.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.79.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to stop CRD, initiate ECCS water solid operation and determine relevant actions.	Med. = 0.001 Mean = 0.0027	--	Med. Mean 0.001 0.0027	(10)	Total HEPs are the sum of the individual HEPs from the diagnosis and actions.
2. Actions A. Stop makeup. B. Initiate ECCS water solid operation per procedure - open 2 SRVs - check closed MSIVs - initiate LPCI(C) or HPCS	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the numerous indications and that fact that operators would get immediate feedback if the failed to accomplish the actions, it was decided that for this case (even though limited time was available), credit for second checks would be appropriate. HEPs for failure to provide a second check were: Median = 0.2 Mean = 0.323	Med. Mean 0.004 0.01 Med. Mean <u>0.004</u> <u>0.01</u> 0.009 0.023 Total median HEP = 0.009 Total mean HEP = 0.023	(5) (5) (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEPs was assigned.

Table 10.1.80.1
HEP 80 Calculation

Human Action Event (1)	OP1SV (14)
Event Tree(s) (2)	E, EA
Initiators (3)	TIOP5, E1T5H
Sequence Locator Files (4)	OPECSP.TIO, OPECSP.E1T
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 79), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds and must occur in the same time period.
Event Context (6)	The important constants for the OP1SV (13) calculation (HEP 80) are that the operators have failed to successfully control letdown and makeup in response to situations that lead to an increase in level (LCMK fails), such as mismatch between makeup and letdown. Later in the scenario SDC isolates on high pressure. A pump trip alarm would occur and level 7 and 8 alarms would sound if they haven't already. Pressure would be increasing. Given the two hours preceding the need to do something and the numerous indicators present, it was assumed that the operators will have entered the IDHR ONEP prior to OPECS. They will need to stop makeup (CRD), start LPCI, and perform related OPECS actions for initiating ECCS water solid operation. OPMSV is set to 0 in this scenario because the vessel would not pressurize with the MSIVs open. The operators decide to initiate ECCS water solid operation. The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44), HPCS SOI (04-1-01-E22-1, Rev. 28).

Table 10.1.80.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Loss of systems were alarmed, several level and pressure alarms should sound, and the operators should accomplish periodic checks of temperature and pressure in the new time available. Reactor pressure and level will be rising. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.80.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs.	One	<ol style="list-style-type: none"> 1. Stop makeup (CRD). 2. Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs (one in this case) are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) assumed to be the first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP.

Table 10.1.80.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	<p>SEA Calculation C90-492-01-A16.</p> <p>Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 79 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, the fact that proceeding with 1 SRV is not explicitly indicated by procedure, the median diagnosis value from ASEP, Figure 8-1, rather than the lower bound value, was assigned.</p>

Table 10.1.80.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Stop makeup (CRD)	CR	--	1 minute	1 minute	
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR	--	5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
4. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
5. Initiate ECCS system per SOIs	CR	--	1 minute	<u>1 minute</u> 9 minutes (approx.) Total time for all actions.	

Table 10.1.80.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV.	23 minutes	9 minutes	14 minutes	

Table 10.1.80.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV and determine what the appropriate actions should be.	Per ASEP Table 8-3, the median value from Figure 8-1 for 14 minutes diagnosis time was assigned.		Median = 0.035 (EF = 10) Mean = 0.093	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option even though it is not explicitly called by procedure. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling. However, since the action is not a procedural action, the lower bound diagnosis value was not used.

Table 10.1.80.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.80.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.80.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^{op}	Independent Check/Correction HEP (HEP _c) (3) ^{cz}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.035 Mean = 0.093	—	Med. Mean 0.035 0.093	(10)	Total HEPs are the sum of the individual HEPs from the diagnosis and actions.
2. Actions A. Stop makeup. B. Initiate ECCS water solid operation per procedure, except that only 1 SRV is available. - open 2 SRVs - check closed MSIVs - initiate LPCI(C) or HPCS	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the numerous indications and that fact that operators would get immediate feedback if they failed to accomplish the actions, it was decided that for this case (even though limited time was available), credit for second checks would be appropriate. HEPs for failure to provide a second check were: Median = 0.2 Mean = 0.323	Med. Mean 0.004 0.01 Med. Mean <u>0.004</u> <u>0.01</u> 0.043 0.11 Total median HEP = 0.043 Total mean HEP = 0.11	(5) (5) (10)	Second check HEPs are multiplied by the original HEP for each action. Since both the diagnosis and action HEPs make significant contributions to the total HEP, the larger of the two EFs was assigned.

Table 10.1.81.1
HEP 81 Calculation

Human Action Event (1)	OPISA (1)
Event Tree(s) (2)	EA, EAP, EAX
Initiators (3)	All transients except those that logically entail being initially on RHR/SDC(B) for SDC, e.g. E1B5H, E2B5H, E1T5H, and E2T5H.
Sequence Locator Files (4)	All files beginning with OPECS in which operators were initially using ADHR for SDC, e.g., OPECSADH.TDB.
Event Description (5)	OPISA is the operator action to isolate ADHR for ECCS water solid operation.
Event Context (6)	OPISA had to be performed in the same time period as OPECS. It was determined that the operators would want to isolate the low pressure ADHR piping before proceeding with ECCS water solid operation. The SOI for initiating LPCI directs the operators to isolate ADHR when switching to RHR/SDC or LPCI. Thus, the OPISA operator actions were included in the calculations for OPECS where appropriate. In the relevant sequences, when OPECS succeeded, then OPISA was also set to succeed. OPISA is not asked when OPECS failed. Since detailed ASEP HRAP calculations were not required for HEP 81, Tables 10.1.81.2 through 10.1.81.9 were not included.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Note. Tables 10.1.81.2 through 10.1.81.9 were unnecessary for HEP 81 and therefore they were not included.

Table 10.1.81.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Isolate ADHR.	Med. = 0 Mean = 0	--	Med. = 0 Mean = 0		Operator action completely dependent on OPECS in the relevant sequences. If OPECS succeeds, the so does OPISA.

Table 10.1.82.1
HEP 82 Calculation

Human Action Event (1)	OPOMS
Event Tree(s) (2)	S, SP, SX
Initiators (3)	All
Sequence Locator Files (4)	OPOMS occurs in all files in which OPSTM is successful, e.g., OPSTMNFD.TIF.
Event Description (5)	OPOMS is the operator action to open MSIVs when steaming the vessel/containment.
Event Context (6)	OPOMS was asked in the "S" trees if the operators were unable to get an SRV open for steaming. The question was whether the operators would steam the vessel through the MSIVS. On the basis of site interviews with the operators, it was determined that the operators would not open MSIVs for steaming unless there was a vacuum in the condenser. Since it cannot be assumed that a vacuum would exist in the condenser during POS 5, OPOMS was always set to 1.0 (failure). Since detailed ASEP calculations were not required for HEP 82, Tables 10.1.82.2 through 10.1.82.9 were not included.
Applicable Procedures (7)	

Note. Tables 10.1.82.2 through 10.1.82.9 were unnecessary for HEP 82 and therefore were not included.

Table 10.1.82.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Open MSIVs for steaming.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table 10.1.83.1
HEP 83 Calculation

Human Action Event (1)	OPCNF
Event Tree(s) (2)	TRPT5
Initiators (3)	TRPT5
Sequence Locator Files (4)	OPCNF.TRP
Event Description (5)	OPCNF is the operator decision and action to depressurize during a HYDRO test following a loss of forced recirculation to avoid exceeding 70 degrees F during natural recirculation.
Event Context (6)	OPCNF (HEP 83) addresses the situation where forced recirculation is lost during HYDRO and decay heat removal is inadequate using CRD as makeup and RWCU as letdown. By depressurizing the operators can control heat removal. They can depressurize in any of several ways including stopping CRD and letting RWCU continue to run or opening an SRV. Some form of SDC will be needed and the operators have 8.7 hours to diagnose the need and align a normal means of SDC.
Applicable Procedures (7)	RHR SOI (04-1-01-E12-1), Inadequate Decay Heat Removal ONEP (05-83-02-III-1)

Table 10.1.83.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Forced recirculation is lost during a HYDRO test. Depressurization of the vessel and initiation of SDC is needed.	O	A loss of forced recirculation will be alarmed. Increases in temperature and pressure will be indicated.	

Table 10.1.83.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
The operators will need to depressurize and provide a normal means of SDC.	One	Depressurize and initiate an SDC system.	Depressurizing in this context would be obvious to the operators. Alignment of SDC is a frequently performed action during LP&S conditions. It is proceduralized.

Table 10.1.83.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Depressurize and initiate an SDC system.	8.7 hours	0	8.7 hours	SEA Calculation C90-492-083- A16

Table 10.1.83.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_l) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Depressurize and start SDC system.	Control Room	--	5 minutes	5 minutes	

Table 10.1.83.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_A) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Realize the need to initiate SDC.	8.7 hours	5 minutes	At least 8 hours	

Table 10.1.83.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to depressurize and initiate SDC.	Per ASEP HRAP Table 8-3, the upper bound value from ASEP HRAP Figure 8-1 for 8 hours diagnosis time was assigned.	N/A	Median = 0.001 Mean = 0.0027	The upper bound diagnosis value was used because the action is not proceduralized and the operators were not explicitly asked about it. In all likelihood, however, the decision would be obvious. Substantial time is available for the diagnosis.

Table 10.1.83.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA^P

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Depressurize and initiate SDC.	N/A	Training would cover this diagnosis and actions	No	Step-by-Step	

Table 10.1.83.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA^P

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Depressurize and initiate SDC.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage and several safety systems available.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.83.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose need to depressurize and align normal means of SDC.	Median = 0.001 Mean = 0.0027		Med. Mean 0.001 0.0027	(10)	
2. Depressurize and align normal means of SDC.	Median = 0.02 Mean = 0.032	Credit for a second check and third check was given. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	<u>0.0008</u> <u>0.0033</u> 0.0018 0.006 Total Median HEP = 0.0018 Total Mean HEP = 0.006	(5) (10)	Second check HEPs are multiplied by the original HEP for each action. Third check HEPs are multiplied by the result obtained from applying the second check. Since both HEPs made significant contributions to the total HEP, the larger of the two error factors was assigned.

**Table 10.1.85.1
HEP 85 Calculation**

Human Action Event (1)	LCMK (2)
Event Tree(s) (2)	L, LA, LP, LAP
Initiators (3)	T1-5, TLM5H, TIOP5, TRPT5, TORV5, TIOF5, TIHP5, E1V5H, E1T5H, E2C-5
Sequence Locator Files (4)	OPDHR&.LP&, OPDHRHYD.LP, OPDHRHYD.TLM, OPDHRHYR.TLM, OPDHRHYD.TIO, OPDHRHYR.TIO, OPDHRR.TRP, OPDHRHYD.TRP, OPDHRHYD.TRV, OPDHR.TIF, OPDHR.TIH, OPDHROP.TIH, OPDHRLAP.E1V, OPDHR.E1V, OPDHR.E1T, OPDHRLP.E1T, OPDHRHYD.E2C
Event Description (5)	LCMK is the operator action to recognize that makeup is greater than letdown and control makeup.
Event Context (6)	The important constants for the LCMK (2) calculation (HEP 85) is that letdown is isolated and therefore makeup (CDS or ECCS) needs to be controlled. The operators have diagnosed the need and have initiated makeup to avoid a loss of SDC created by a disconnect between the core and downcomer regions of the vessel (OPDHR succeeds). Overfill and overpressurization are of concern and the operators have 2.5 hours to realize that they need to control makeup. For HEP 85, makeup is with CDS or an ECCS system. Level can increase very rapidly with CDS or an ECCS system (4000+ GPM). It was assumed that if the operators attempted to provide makeup with one of these systems (OPDHR), they would not just walk away from it and allow overpressurization to occur. Thus, when CDS or ECCS systems were used in OPDHR, LCMK was assumed completely dependent on OPDHR. That is, if OPDHR succeeds with CDS or an ECCS system, it was assumed that the operators would not fail to control level and the HEP for LCMK was set to 0.0 (success), per ASEP Table 8-1, Step 12. Since detailed ASEP calculations were not required for HEP 85, Tables 10.1.85.2 through 10.1.85.9 were not included.
Applicable Procedures (7)	No specific procedures other than EP-2, RPV Control, Rev.19.

Note. Tables 10.1.85.2 through 10.1.85.9 were unnecessary for HEP 85 and therefore were not included.

Table 10.1.85.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)^{op}	Independent Check/Correction HEP (HEP_{ic}) (3)^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Control flow rate and vessel level using CDS or an ECCS system.	Med. = 0.0 Mean = 0.0	—	Med. Mean 0.0 0.0		ASEP Table 8-1, Step 12

Table 10.1.86.1
HEP 86 Calculation

Human Action Event (1)	OPSLP or OPHPC
Event Tree(s) (2)	TIOF5, TIHP5
Initiators (3)	TIOF5, TIHP5
Sequence Locator Files (4)	OPSLP.TIF, OPHPC.TIH
Event Description (5)	OPSLP and OPHPC are operator actions to recognize and stop an inadvertent actuation of LPCI or HPCS, respectively.
Event Context (6)	For OPSLP or OPHPC (HEP 86), the operators would get level 7 and 8 alarms within 1 minute of actuation. The operators have 7.7 minutes to stop the spurious actuation before SDC will auto-isolate on high pressure (overpressurization). HPCS should auto-isolate at level 8. If the auto-isolation fails and it is assumed that level 8 is reached within 1 minute, the operators would still have 6.7 minutes to stop the injection. -
Applicable Procedures (7)	The need to investigate an unexpected actuation of LPCI or HPCS would be obvious.

Table 10.1.86.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Spurious actuation of LPCI or HPCS. Injection needs to be stopped.	O	Pump starts would be indicated and alarmed. Level 7 and 8 would be reached within 1 minute and they would be alarmed. Pressure increases would be indicated.	

Table 10.1.86.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Spurious actuation of LPCI or HPCS. Injection needs to be stopped prior to overpressurization and isolation of SDC.	One	The operators need to stop the inadvertent actuation.	

Table 10.1.86.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Stop the inadvertent actuation of LPCI or HPCS.	7.7 minutes	0	7.7 minutes	SEA Calculation C90-492-01-A16

Table 10.1.86.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Turn off relevant systems at control room panel.	CR	--	1 minutes	1 minutes	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.

Table 10.1.86.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to recognize that the actuation was spurious and stop the injecting system.	7.7 minutes	1 minutes	Approx. 6.7 minutes	For the HPCS case, even if the operators expect the system to auto-isolate, they would still be likely to attend to an unexpected isolation immediately. Thus, time available is measured from the initial actuation for both OPSLP and OPHPC.

Table 10.1.86.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Recognize spurious actuation of LPCI and HPCS and determine need to stop injection.	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 6 minutes diagnosis time was assigned.		Med. = 0.04 Mean = 0.106	The need to turn off an inadvertent actuation would be obvious. Determining that the actuation was spurious may not be so obvious. Nevertheless, this type of event is well within operator's training and the lower bound diagnosis value was judged appropriate per ASEP HRA, Table 8-3.

Table 10.1.86.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Stopping a spurious actuation was assumed to be completely dependent on a correct diagnosis. That is, it was assumed that if the diagnosis succeeded, the operators would stop the injecting system.	N/A	Training would cover this type of action. Determining that the actuation was spurious could require some problem solving.	No	N/A	

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Table 10.1.86.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Stop injecting system.	N/A ¹	N/A	No ²	N/A	N/A	Stopping a spurious actuation was assumed to be completely dependent on a correct diagnosis. That is, it was assumed that if the diagnosis succeeded, the operators would stop the injecting system with a success probability of 1.0.

¹

At least moderately high stress was assumed for all events.

²For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.86.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Recognize inadvertent actuation of LPCI or HPCS and stop it.	Med. = 0.04 Mean = 0.106	N/A	Med. Mean 0.04 0.106	(10)	It was assumed that if the operators recognized a spurious actuation, they would not fail to turn off the injecting system. Thus, the failure probability for OPSLP and OPHPC was determined by the diagnosis HEP.

Table 10.1.87.1
HEP 87 Calculation

Human Action Event (1)	OPDHR (5)
Event Tree(s) (2)	L, LA, LP,
Initiators (3)	TIOP5, TLM5H, TRPT5, TORV5
Sequence Locator Files (4)	OPDHRHYR.TIO, OPDHRHYR.TLM, OPDHRHYR.TRP, OPDHRHYR.TRV
Event Description (5)	OPDHR is the operator action to control vessel level in order to avoid a "functional" loss of SDC caused by inadequate circulation between the core and the downcomer regions of the vessel. That is, even if SDC continues to operate, if vessel level becomes too low, a "disconnect" between the core and downcomer regions can occur. This will result in inadequate cooling of the core even though SDC continues to operate. The indications to the operators that the event is occurring can be subtle because temperature readings are apparently taken from the downcomer region, where the water being cooled by SDC is returned. Also, the vessel level would not be so low that any level alarms would sound. A loss of forced recirculation, or a loss of makeup (usually CRD) coupled with continued draindown, can lead to inadequate level. Only 10 minutes was allowed for the operator diagnosis and actions in OPDHR.
Event Context (6)	The important constants for the OPDHR (5) calculation (HEP 87) are that the operators are conducting a HYDRO test when the initiator occurs and regardless of what the initiator is, RWCU continues to run in recirculation mode. Thus, vessel cooling continues, level is relatively high, and letdown is relatively slow. Thus, operators have 115 minutes for OPDHR in this case. However, given the context, very little has happened that might lead the operators to be concerned about a potential disconnect between the core and the downcomer and a resulting functional loss of SDC. Since the IDHR ONEP will not yet have been entered, the operators will not be cued to be concerned about SDC. Thus, the cues for OPDHR in this case may be subtle. Operators need to diagnose the need for makeup.
Applicable Procedures (7)	No specific procedures, but the Inadequate Decay Heat Removal ONEP (05-1-02-III-1) would be relevant, as would the relevant SOIs, e.g., RHR SOI (04-1-01-E12-1).

Table 10.1.87.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR caused by inadequate circulation between the core and the downcomer regions of the vessel. Level control (makeup) is needed.	O	As noted in Table 10.1.87.1, the indications for this event may be subtle because vessel temperature readings could be misleading and no level alarms would sound. Moreover, SDC has not been lost, level is high, and letdown is relatively slow. Thus, the loss of level may be gradual and the indicators that would occur may be temporally separated. The operators will not have entered into the IDHR yet. Nevertheless, the initiators should cue the operators to be at least somewhat concerned with level and substantial time is available for the diagnosis.	

Table 10.1.87.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A "functional" loss of SDC leads to IDHR. The operators need to diagnose the need and increase vessel level.	One	The operators need to increase RPV water level with any available injection system. CRD (if available), CDS, or an ECCS system are possible choices.	

Table 10.1.87.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	115 minutes	0	115 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.87.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
If available, increase flow with CRD. If CRD is not available and SDC is not being provided by SDC(B), use CDS. Otherwise, use an ECCS system. Note. With only 10 min. available for OPDHR, if CDS was asked and it failed, credit was not taken for both CDS and an ECCS system.	CR	—	2 minutes	2 minutes	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column. The actions involved in initiating a makeup system were assumed to be completely dependent. System initiation would be proceduralized.

Table 10.1.87.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	115 minutes	2 minutes	Approx. 110 minutes	

Table 10.1.87.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to provide makeup	Per ASEP Table 8-3, the upper bound value from Figure 8-1 for 110 minutes diagnosis time was assigned.		Med. = 0.002 Mean = 0.005	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. The upper bound diagnosis value was judged appropriate in these scenarios because of the lack of procedures and the potential subtlety of the indicators.

Table 10.1.87.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate an injection system to provide makeup.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step-by-step Although inconsistent with the other OPDHR calculations, the substantial increase in the time available for diagnosis and response makes the step-by-step designation more appropriate. With the extra time, the EPs etc. can be used for guidance.	

Table 10.1.87.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate an injection system to provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.87.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.002 Mean = 0.005	--	Med. Mean 0.002 0.005	(10)	
2. Initiate an injection system to provide makeup and vessel level control.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the additional time with little else of concern. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.006 0.015 Total Median HEP = 0.006 Total Mean HEP = 0.015	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEPs was assigned.

Table 10.1.88.1
HEP 88 Calculation

Human Action Event (1)	OPECS (20)
Event Tree(s) (2)	E, EA, EP
Initiators (3)	TIOF5, TIHP5
Sequence Locator Files (4)	OPECS.TIF, OPECS.TIH
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (20) calculation (HEP 88) are that a spurious actuation of LPCI (TIOF5) or HPCS (TIHP5) has occurred. The operators would get level 7 and level 8 alarms within 1 min. of actuation. HPCS should auto-isolate on level 8, but the auto-isolation fails (HPCAO fails). Level would be increasing rapidly and operators would check systems likely to allow such level changes. Pump starts and valve openings would be indicated. OPSLP (or OPHPC) is operator action to detect and stop the inadvertent injection of LPCI (or HPCS) prior to overpressurization. OPSLP or OPHPC fails (less than 7 min. for diagnosis) in this scenario and the operating SDC system isolates on high pressure (135 psi). If a LOSP occurs, the diesel generators successfully start. Additional alarms would sound. Operators should enter IDHR ONEP and attempt to initiate ECCS water solid operation. MSIVs are closed.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.1.88.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	The operators would get level 7 and level 8 alarms within 1 min. of actuation. Level and pressure would be increasing rapidly and operators would check systems likely to allow such level changes. Pump starts and valve openings would be indicated. SDC would isolate on high pressure and pump trips would be alarmed. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.1.88.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation. Note: it was assumed that stopping the inadvertent actuation was completely dependent on diagnosing the problem. That is, if the operators detect the inadvertent actuation and the loss of SDC, they <u>will</u> stop the injection (complete dependence assumed).	One	Per IDHR ONEP (Step 5.1.3c) <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. LPCI is initiated from 04-1-01-E12-1, Step 5.4.2. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table 10.1.88.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.88.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent. Also, in the present scenario they have not yet diagnosed the inadvertent actuation.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.1.88.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	23 minutes	8 minutes	15 minutes	

Table 10.1.88.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid. Stopping the inadvertent actuation was assumed to succeed if the correct diagnosis was made.	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 15 minutes diagnosis time was assigned. (See comments in Column 5 of this table).		Med. = 0.003 Mean = 0.008	The site interviews indicated that the operators have a clear understanding of the procedure and the requirements. Moreover, with the extensive alarms and clear procedures, it was judged that the lower bound value would be appropriate (per ASEP) in this instance.

Table 10.1.88.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.88.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.88.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.003 Mean = 0.008	--	Med. Mean 0.003 0.008	(10)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations and the number of other concerns present in the control room.	<u>0.02</u> <u>0.032</u> 0.023 0.040 Total Median HEP = 0.023 Total Mean HEP = 0.04	<u>(5)</u> (5)	The error factor associated with the dominant HEP was assigned.

Table 10.1.89.1
HEP 89 Calculation

Human Action Event (1)	OPDSV
Event Tree(s) (2)	OVPR, OVPRP, HYHPA
Initiators (3)	Any initiator which could occur during a HYDRO test
Sequence Locator Files (4)	Not listed in any.
Event Description (5)	OPDSV is the operator action to depressurize in HYDRO by opening one SRV in relief mode.
Event Context (6)	OPDSV was always set to fail because no time was available for this event. (SEA Calculation C90-492-052-A16). Since detailed ASEP calculations were not required for HEP 89, Tables 10.1.89.2 through 10.1.89.9 were not included.
Applicable Procedures (7)	N/A

Note. Tables 10.1.89.2 through 10.1.89.9 were unnecessary for HEP 89 and therefore were not included.

Table 10.1.89.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{cc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
OPDSV is the operator action to depressurize in HYDRO by opening one SRV in relief mode.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		With no time for this event, it was always set to fail.

Table 10.1.90.1
HEP 90 Calculation

Human Action Event (1)	OPMSV (4)
Event Tree(s) (2)	F
Initiators (3)	TLM5H, E1T5H
Sequence Locator Files (4)	OPFLDHYD.TLM, OPFLDLER.TLM, OPFLDRM.TLM, OPFLDRMH.TLM, OPFLDLER.E1T, OPFLDRM.E1T
Event Description (5)	OPMSV is the operator action to close open MSIVs.
Event Context (6)	For the OPMSV (4) calculation (HEP 90), the operators have attempted to control level to ensure adequate decay heat removal (OPDHR has succeeded). Eventually, all ECCS systems have failed or are unavailable. Thus, the operators have attempted to do the correct actions, but the systems asked have failed or been unavailable. One option available to the operators to provide level and core cooling is to flood the vessel/containment. SSWXT or FW are systems that could (potentially) be used to flood. If vessel level is too low and not increasing, EP-2 calls out for alternate level control which will eventually lead the operators to initiate flooding. If the operators decide to flood (OPFLD succeeds), they should also ensure that no MSIVs are open. EP-2 instructs the operators to close any open MSIVs when RPV level is greater than - 167 inches. If the operators do initiate flooding with SSWXT and fail to close any open MSIVs, they will still have about 20 minutes before flooding down the steam lines occurs.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.1.90.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators are flooding the vessel/containment and need to close any open MSIVs to prevent flooding down steam lines.	O	Level will be rising and EP-2 instructs the operators to close open MSIVs when level exceeds - 167 inches. Operators have entered EP-2 and have decided to flood. Should get some high level alarms prior to reaching steam lines.	

Table 10.1.90.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators are flooding the vessel/containment to provide core cooling and need to close any open MSIVs to prevent flooding down steam lines.	One	Close open MSIVs from the control room	

Table 10.1.90.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ca}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Close any open MSIVs	20 minutes	0	20 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.90.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Close any open MSIVs. At the most, 18 MSIVs could be open.	CR	--	2 minutes	2 minutes	

Table 10.1.90.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Close open MSIVs	20 minutes	2 minutes	18 minutes	

Table 10.1.90.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Close any open MSIVs.	Per ASEP HRAP Table 8-3, the lower bound value from Figure 8-1 for 15 minutes diagnosis time was assigned.		Med. = 0.0015 Mean = 0.004	The operators have decided to flood and have probably entered EP-2, where they are instructed to close any open MSIVs when level exceeds -167 inches. Site interviews indicated that the operators would not want water running down the steam lines and that they would be likely to check the position of the MSIVs. Level alarms would indicate increasing level. Thus, per ASEP HRAP, Table 8-3, the lower bound value was judged appropriate.

Table 10.1.90.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Close any open MSIVs	N/A	Actions are specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.90.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Close MSIVs.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage and operators have been performing correctly.

¹ At least moderately high stress was assumed for all events

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.90.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.0015 Mean = 0.004	--	Med. Mean 0.0015 0.004	(10)	
2. Close any open MSIVs to prevent flooding down steam lines.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available and the fact that the operators would want to be sure the MSIVs were closed once they realized they were open. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004 0.01</u> 0.006 0.014 Total Median HEP = 0.006 Total Mean HEP = 0.01	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.1.94.1
HEP 94 Calculation

Human Action Event (1)	RESB and RESCS (2)
Event Tree(s) (2)	E1B5H, E1T5H, E1V5H
Initiators (3)	E1B5H, E1T5H, E1V5H
Sequence Locator Files (4)	RESB.E1B, RESC.E1T, RESC.E1V
Event Description (5)	RESB is the operator action to unisolate RHR/SDC loop B and RESCS is the operator action to unisolate the SDC common suction line.
Event Context (6)	HEP 94 applies to sequences where a LOSP also occurs, the diesel generator fails to start, and HPCS is unavailable. In these sequences, the operators must cross-tie the HPCS DG to train 2 and they must realize as part of OPSDC that SDC will auto-isolate on high pressure when the cross-tie is completed and power is restored. Thus, if OPSDC succeeds, the operators will not attempt to restore SDC because it will isolate again when power is restored to train 2. Since RESB and RESCS are only asked when OPSDC succeeds, they will not be accomplished and were therefore set to 1.0. Since detailed ASEP calculations were not required for HEP 94, Tables 10.1.94.2 through 10.1.94.9 were not included.
	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Note. Tables 10.1.94.2 through 10.1.94.9 were unnecessary for HEP 94 and therefore were not included.

Table 10.1.94.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Restore loss of SDC	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table 10.1.95.1
HEP 95 Calculation

Human Action Event (1)	OPMSV (5)
Event Tree(s) (2)	S, SP
Initiators (3)	T1-5, TLM5H
Sequence Locator Files (4)	OPSTMFD3.SP, OPSTMFD2.TLM, OPSTMNFD.TLM
Event Description (5)	OPMSV is the operator action to close open MSIVs.
Event Context (6)	<p>For the OPMSV (5) calculation (HEP 95), the operators have attempted to control level to ensure adequate decay heat removal (OPDHR has succeeded). Eventually, all ECCS systems have failed or are unavailable. Thus, the operators have attempted to do the correct actions, but the systems asked have failed or been unavailable. The operators then fail to decide to flood the vessel/containment in order to provide level and core cooling (OPFLD fails). Another option available is to steam the vessel (OPSTM). If the operators decide to steam the vessel, they will need to close any open MSIVs to prevent steaming down the steam lines, which could cause problems if there is not a vacuum in the condenser. While steaming is not indicated by procedure, EP-2 instructs the operators to close any open MSIVs when RPV level is greater than -167 inches. If the operators do decide to steam, they will have about 35 minutes to close the MSIVs before problems might occur. Site interviews with operators indicated that they are aware of the potential problems and would not want any SRVs open if steaming.</p>
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19)

Table 10.1.95.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T.) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators have decided to steam the vessel and need to close any open MSIVs to prevent steaming down steam lines.	O	EP-2 instructs the operators to close any open MSIVs when level exceeds -167 inches. Open MSIVs will be indicated and the operators will not want any open MSIVs if they decide to steam.	

Table 10.1.95.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators have decided steam the vessel and need to close any open MSIVs to steaming flooding down steam lines.	One	Close open MSIVs from the control room	

Table 10.1.95.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Close any open MSIVs	35 minutes	0	35 Minutes	SEA Calculation C95-492-01-A16

Table 10.1.95.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Close any open MSIVs. At the most, 18 MSIVs could be open.	CR	--	2 minutes	2 minutes	

Table 10.1.95.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Close open MSIVs	35 minutes	2 minutes	33 minutes	

Table 10.1.95.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Close any open MSIVs.	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 33 minutes diagnosis time was assigned.		Med. = 0.001 Mean = 0.0027	Site interviews indicated that the operators would not want water running down the steam lines and that they would be likely to check the position of the MSIVs once they begin to bring level up. Level alarms would indicate increasing level. Thus, even though steaming is not explicitly indicated by procedure, once the operators decide to steam, they would be likely to understand the need to close open MSIVs. Per ASEP HRAP, Table 8-3, the median value from ASEP HRAP, Figure 8-1 was judged appropriate.

Table 10.1.95.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Close any open MSIVs	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.95.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Close MSIVs.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage and operators have been performing correctly.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.95.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)^{op}	Independent Check/Correction HEP (HEP_{c2}) (3)^{c2}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.001 Mean = 0.0027	--	Med. Mean 0.001 0.0027	(10)	
2. Close any open MSIVs after deciding to steam the vessel.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available and the fact that the operators would want to be sure the MSIVs were closed once they realized they were open. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004 0.01</u> 0.005 0.0127 Total Median HEP = 0.005 Total Mean HEP = 0.01	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.1.96.1
HEP 96 Calculation

Human Action Event (1)	OPSTM (3)
Event Tree(s) (2)	S, SP, SNP
Initiators (3)	TIOF5, TIHP5
Sequence Locator Files (4)	OPSTM51.TIH, OPSTM51.TIF, OPSTM81.TIH, and OPSTM81.TIF.
Event Description (5)	OPSTM is the operator decision to initiate steaming of the core.
Event Context (6)	<p>OPSTM (3) (HEP 96) represents the operators decision to steam the vessel to provide core cooling when an overfill has occurred from an inadvertent actuation of HPCS or LPCI. In the relevant scenarios, SDC has isolated on high pressure, but the operators have failed to stop the overfill and have failed to initiate ECCS water solid operation in the time available (OPECS fails). While the operators have failed to follow procedure, several aspects of the scenarios suggest that the operators would open an SRV, which is all that would initially be required to steam. At this point in the sequences, the core would be full of water and pressure and temperature would have been increasing. As pressure increased, LPCI and HPCS would pump slower until the min-flow valve opened on low flow and then the water would be diverted to the SP. In order to steam the vessel, all the operators would have to do would be to open an SRV and stop the injecting system. At a later point, the previously injecting system could be used for makeup. In fact, if the operators opened an SRV and didn't stop injection, they would be initiating ECCS water solid operations. Thus, OPSTM represents the operators doing "something" in response to the problem. With the substantial indications about the presence of the overfill and the loss of SDC, it was judged that credit for "steaming" would be appropriate even though the operators had initially failed to follow procedure. Several systems may be used for steaming, e.g., CRD, CDS, SSWXT, and FW, and ECCS may still be available after the inadvertent actuation has been stopped.</p>
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-96-02-III-1)

Table 10.1.96.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Inadvertent actuation of LPCI or HPCS. The operators initially fail to stop the overfill and fail to initiate ECCS water operation when SDC auto-isolates. OPSTM asks whether the operators will consciously decide to steam the vessel (or at least open an SRV, which would functionally lead to water solid operation.)	O	Numerous indications regarding the inadvertent start of an ECCS system, the auto-isolation of SDC, and the increasing vessel pressure and temperature would be available. Given the increasing pressure, an obvious response would be to open an SRV.	BWRs basically operate by steaming. Thus, stopping the overfill and opening an SRV would not be an "unusual" response to the problem.

Table 10.1.96.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
The operators need to stop the inadvertently injecting system and open at least 1 SRV in order to steam the vessel.	One	<ol style="list-style-type: none"> 1. Open an SRV. 2. At least temporarily stop the inadvertently injecting system. 	Site interviews with operators indicated that steaming was a viable option when other means of SDC had failed. Operators appeared to be knowledgeable about the process and the necessary steps. However, the process is not described in the relevant procedures.

Table 10.1.96.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{∞}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Open at least 1 SRV and stop the injecting system.	23 minutes	0	23 minutes	SEA Calculation C90-492-096-A16

Table 10.1.96.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_l) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Open at least one SRV 2. Stop the injecting system. Note. If the operators decide to steam, it was assumed that the two actions would be completely dependent. That is, if they decide to steam and open an SRV, they will also attempt to stop the overfill. In any case, if they at least open an SRV, cooling will be provided because they will then be operating water solid.	Control Room	--	1 minute	1 minute	Per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for the critical action of opening an SRV. Time for stopping the system was not included simply because it is not absolutely necessary.

Table 10.1.96.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Consciously decide to steam the vessel.	23	Approx. 1 minute	Approx. 22 minutes	

Table 10.1.96.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to steam the vessel.	Per ASEP HRA Table 8-3, the median value from ASEP HRA Figure 8-1 for 22 minutes diagnosis time was assigned.	N/A	Median = 0.004 Mean = 0.0106	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and as likely to be used. However, since it is not proceduralized and apparently not covered specifically in training, it is not clear that all operators would consciously decide to steam. Nevertheless, in the particular sequences covered here, the operators really need only to recognize the need to open a SRV. Thus, it was judged that per ASEP HRA Table 8-3, the median diagnosis value was indicated.

Table 10.1.96.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Open at least 1 SRV and stop injecting system.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.96.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Open at least 1 SRV and stop injecting system. Initi ate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.96.10
Total HEP

Action (1)	Original Operator HEP (HEP_o) (2)^{op}	Independent Check/Correction HEP (HEP_c) (3)^{rc}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose need to steam vessel	Median = 0.004 Mean = 0.0106		Med. Mean 0.004 0.0106	(10)	
2. Open an SRV and stop injecting system.	Median = 0.02 Mean = 0.032	Credit for a second check on opening a SRV was given. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.008 0.0206 Total Median HEP = 0.008 Total Mean HEP = 0.021	<u>(5)</u> (10)	Second check HEPs are multiplied by the original HEP for each action. Since both HEPs contributed to the total HEP, the larger of the two error factors was assigned.

Table 10.1.99.1
HEP 99 Calculation

Human Action Event (1)	OPMSV (3)
Event Tree(s) (2)	SNP
Initiators (3)	T1-5, E1T5H
Sequence Locator Files (4)	OPSTMSNP.SNP, OPSTMSNP.E1T
Event Description (5)	OPMSV is the operator action to close open MSIVs.
Event Context (6)	For the OPMSV (3) calculation (HEP 99), a LOSP occurs and the diesels fail to start. HPCS is available, but the operators fail to initiate ECCS water solid operation with the only system they have available (OPECS fails). Since operators have failed to follow the IDHR ONEP, no reason to expect them to consciously decide to steam the vessel, which is a non-proceduralized action. In addition, there would not be anything in particular that would drive the operators to check and close any open MSIVs, at least at this point. Moreover, their failure to follow procedure may indicate an unawareness of the problem. Thus, OPMSV was set to one in these scenarios. Since detailed ASEP HRAP calculations were not required for HEP 99, Tables 10.1.99.2 through 10.1.99.9 were not included.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), HPCS SOI (04-1-01-E22-1).

Note. Tables 10.1.99.2 through 10.1.99.9 were unnecessary for HEP 99 and therefore they were not included.

Table 10.1.99.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Close any open MSIVs.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table 10.1.100.1
HEP 100 Calculation

Human Action Event (1)	OPSTH (2)
Event Tree(s) (2)	P, PP
Initiators (3)	TIHP5
Sequence Locator Files (4)	OPSTHSTM.TIH
Event Description (5)	OPSTH is the operator decision and action to initiate steaming of the core at high pressure.
Event Context (6)	<p>OPSTH (2) (HEP 100) represents the operator decision to steam the core at high pressure. In the sequence covered by HEP 100, an inadvertent actuation of HPCS has occurred. The auto-isolation of HPCS at level 8 fails and the operators initially fail to stop HPCS injection. SDC isolates on high pressure. The operators then fail to initiate ECCS water solid operation per procedure (OPECS fails). Failure of OPECS in this instance implies a failure to provide makeup with ECCS and go water solid. These activities are clearly called out by procedure. In many scenarios where OPECS fails, OPSTM (which is a non-proceduralized action) is also assumed to fail. However, in the inadvertent HPCS actuation scenario, OPSTM was not assumed to be completely dependent on OPECS. Thus, at this point in the scenario over 50 min. could have elapsed and the operators have not yet responded. With no SRVs open and SDC isolated, pressure and temperature will be increasing significantly. Either HPCS would begin to inject into the SP when pressure in the reactor reduced HPCS flow to the point that the min-flow valve would open or SRVs would open on their safety set points as pressure increased and some of the water would return to the SP. In this context, the operators do not really have to do anything to successfully steam or at least be in a rather unusual state of water solid operation. That is, running water through the SRVs when they open on pressure release. Thus, OPSTH is set to 0 (success) in this sequence. Since detailed ASEP calculations were not required for HEP 100, Tables 10.1.100.2 through 10.1.100.9 were not included.</p>
Applicable Procedures (7)	EP-2 (RPV Control), Inadequate Decay Heat Removal ONEP (05-100-02-III-1)

Note. Tables 10.1.100.2 through 10.1.100.9 were unnecessary for HEP 100 and therefore were not included.

Table 10.1.100.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Steam at high pressure.	Med. = 0.0 Mean = 0.0	-	Med. = 0.0 Mean = 0.0		

**Table 10.1.101.1
HEP 101 Calculation**

Human Action Event (1)	OPECS (5)
Event Tree(s) (2)	EX
Initiators (3)	T1-5, TIA5H
Sequence Locator Files (4)	OPCADH14.EAX, OPCSDC13.EX, OPCADH14.TIA, OPSDC13.TIA
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The most important constant for the OPECS (5) calculation (HEP 101) is that the control room has failed to diagnose the likelihood that SDC will isolate on high pressure when the HPCS diesel generator cross-tie is completed (OPSDC fails). A failure to make this diagnosis during the 37 minutes allowed for OPSDC is taken to mean that the operators are counting on restarting SDC and have not realized the need for some other form of SDC. Since much of OPECS must be accomplished in parallel with the cross-tie, if the operators do not comprehend the situation during the time available for OPSDC and they wait until the cross-tie is completed before realizing SDC will isolate, then insufficient time will be available to complete OPECS. Therefore, it was assumed that OPECS was completely dependent on OPSDC in the sense that if OPSDC failed, then OPECS would also fail. Thus, per ASEP Table 8-1, Step 12, HEP 101 (OPECS (5)) was set to 1.0. Since detailed ASEP calculations were not necessary for HEP 101, Tables 10.1.101.2 through 10.1.101.9 were not included.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Note. Tables 10.1.101.2 through 10.1.101.9 were unnecessary for HEP 101 and therefore were not included.

Table 10.1.101.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Initiating ECCS water solid operation, in the context of a cross-tie of the HPCS diesel generator and a <u>failure</u> of the operators to realize SDC will isolate on high pressure when the cross-tie is complete (OPSDC fails), was determined to be completely dependent on OPSDC. Since OPSDC fails, OPECS fails.	Med. = 1.0 Mean = 1.0	--	Med. Mean 1.0 1.0 --		ASEP Table 8-1, Step 12

Table 10.1.102.1
HEP 102 Calculation

Human Action Event (1)	OPECS (6)
Event Tree(s) (2)	HPSWA
Initiators (3)	T1-5, TAB5H, TIA5H
Sequence Locator Files (4)	OPECS&.HPA, OPECAD10.TAB, OPCADH26.TIA
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid with HPCS and performing the relevant actions.
Event Context (6)	The important constants for the HEP 102 calculation (OPECS (6)) are that a LOSP has occurred, the DV1-2 diesels fail to start and HPCS is available. SDC (ADHR for these scenarios) has failed due to the LOSP and all normal means of SDC are rendered unavailable. Per the IDHR ONEP, the operators are directed to initiate ECCS water solid operation. The operators would be aware that ADHR is lost with an LOSP and that without power, no normal means of SDC are available. In addition, the ADHR pump trip alarms would sound and the operators would be very likely to check temperature and pressure increases on the chart recorders in the 23 minutes allowed for OPECS. However, the operators would have to retrieve and read the IDHR ONEP and the HPCS SOI, isolate ADHR locally because power is not available (isolating ADHR is not explicitly directed by procedure in this context), align HPCS for injection per HPCS SOI 04-1-01-E22-1, and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), HPCS SOI (04-1-01-E22-1, Rev. 28), Loss of AC Power ONEP (05-1-02-I-4, Rev 21)

Table 10.1.102.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Operator knowledge regarding the effects of a LOSP and DG failures would be one indication . In addition, the ADHR pump trip would be alarmed and the operators should accomplish periodic checks of temperature and pressure in the time available. Reactor pressure and coolant temperature would be rising with no operating SDC systems.	

Table 10.1.102.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control and vessel cooling is needed, IDHR ONEP directs operators to initiate ECCS water solid operation (HPCS is the only system available).	One - the loss of power is the abnormal event. Loss of SDC is an artifact of the loss of power.	Isolate ADHR to prevent overpressurizing low pressure piping (not explicitly called by procedure). With DV1-2 failed, the isolation of the 8 or 9 valve will have to be done locally. Per HPCS SOI (Step 5.2) Manual startup of HPCS system Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context HPCS is the only available ECCS system	

Table 10.1.102.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T _a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T _s) (3)	Maximum Time Available to Perform the Identified Operator Activities (T _m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.102.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T _L) (3)	Performance Time (T _P) (4)	Total Action Time (T _A) (5)	Comments/ Source of Information (6)
1. Given the loss of power, the operators will need to realize the need and retrieve and read the IDHR ONEP and the HPCS SOI.	CR	--	5 minutes (Table 8-1, Step 5a)	5 minutes	See HEP 1 (OPSDC (1)), same table, for rationale regarding time.
2. Isolate ADHR (not explicitly proceduralized) Key is to close the 8 or 9 valve locally to prevent overpressurization of the low pressure piping	Outside the CR - the 8 valve is outside containment	--	15 minutes - travel and performance time. Estimates based on interviews with plant personnel.	15 minutes	
3. Check closed MSIVs	CR	--	1 minute (Table 8-1, Step 5b)	1 minute	Steps 3 and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Ensure 2 SRVs open	CR	--	1 minute (Table 8-1, Step 5b)	1 minute	
5. Align and initiate HPCS per HPCS SOI (step 5.2). HPCS is the only available injection system.	CR	--	1 minute (Table 8-1, Step 5b)	<u>1 minute</u> 23 minutes Total time for all actions.	The two critical steps required to start HPCS injection when the system is in standby were judged to be completely dependent.

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Table 10.1.102.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation (includes isolating ADHR).	23 minutes	23 minutes	0 minutes	

Table 10.1.102.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation. Diagnose need to isolate ADHR locally. Determine what the appropriate actions should be.	Since no time is available for the diagnosis, HEP 102 is equal to 1.0. Even if it was less conservatively assumed that the procedures would be quickly retrieved and read in this case, e.g., 2 minutes required rather than 5, the HEP would still be equal to 1.0.		Med. = 1.0 Mean = 1.0	

Table 10.1.102.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.					Since diagnosis value is equal to a failure probability of 1.0, the action HEPs are irrelevant.

Table 10.1.102.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid						Since diagnosis value is equal to a failure probability of 1.0, the action HEPs are irrelevant.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.102.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 1.0 Mean = 1.0	—	Med. Mean 1.0 1.0		
2. Initiate ECCS water solid per procedure.	Not calculated given diagnosis = 1.0		Total HEP = 1.0		

Table 10.1.103.1
HEP 103 Calculation

Human Action Event (1)	OPECS (21)
Event Tree(s) (2)	EA
Initiators (3)	E1V5H, TRPT5, E1D5H
Sequence Locator Files (4)	OPECSEAR.E1V, OPECSEAR.TRP, OPECSEAR.E1D
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (21) calculation (HEP 103) are that an isolation of the SDC common suction line has occurred. The operators recognized the loss of ADHR (OPSDC has succeeded), unisolated the SDC line (RESCS succeeds), and restored ADHR. At some point later, CRD fails and the operators attempt to control level with CDS (OPDHR succeeds), but CDS fails. RWCU has been isolated. Level control with ECCS (OPLEC in the R tree) fails because the time available was spent in OPDHR initiating CDS. With the loss in their ability to control level, inadequate decay heat removal will be a concern. The IDHR ONEP instructs the operators to initiate ECCS water solid operation. At this point in the scenario the operators have done everything correctly. Isolation of ADHR, alignment and injection with LPCI, and the related OPECS actions are accomplished from the control room.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.103.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems are alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. In keeping with the scenario, the operators have been interacting with the system and should be aware of the need for some form of SDC.	

Table 10.1.103.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators must enter the IDHR ONEP and diagnose the need to initiate ECCS water solid operation.	One	<p>A. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>B. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.103.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ca}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01- A16

Table 10.1.103.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read the IDHR ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but when the action is necessary, it was assumed to be done in parallel with alignment and start of LPCI (action 5 below) and the other OPECS actions.	0 minutes	Isolating ADHR and aligning LPCI (action 5 below) were judged to be an integrated set of actions and were assumed to be completely dependent. They are successive steps in a procedure specifically written to cover switching from ADRS to LPCI (RHR SOI (04-1-01-E12- 1, Step 6.6 or 6.8)
3. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 3 and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
5. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	3 minutes - includes time for isolating ADHR when required.	3 minutes 10 minutes (approx.) Total time for all actions.	

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Table 10.1.103.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	10 minutes	13 minutes	

Table 10.1.103.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine relevant actions.	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 13 minutes diagnosis time was assigned.		Median = 0.008 (EF = 10) Mean = 0.021	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. Moreover, the operators have done everything correctly up to this point and the necessary actions are all proceduralized. Thus, the lower bound value for the diagnosis was judged appropriate.

Table 10.1.103.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.103.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.103.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Med. = 0.008 Mean = 0.021	--	Med. Mean 0.008 0.021	(10)	
2. Actions A. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. B. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given that the operators have done everything correctly in this scenario, credit for second checks on the actions were given. HEPs for the control room failing to provide a second check were: Med. = 0.2 Mean = .323	Med. Mean 0.004 0.01 Med. Mean <u>0.004</u> <u>0.01</u> 0.016 0.042 Total median HEP = 0.16 Total mean HEP = 0.042	(5) (5) (10)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. Since both the diagnosis and actions HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.104.1
HEP 104 Calculation

Human Action Event (1)	OP1SV (16)
Event Tree(s) (2)	EA
Initiators (3)	E1V5H, TRPT5, E1D5H
Sequence Locator Files (4)	OPECSEAR.E1V, OPECSEAR.TRP, OPECSEAR.E1D
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decisions and actions as OPECS (HEP 103), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds and must occur in the same time period.
Event Context (6)	The important constants for the OP1SV (16) calculation (HEP 104) are that an isolation of the SDC common suction line has occurred. The operators recognized the loss of ADHR (OPSDC has succeeded), unisolated the SDC line (RESCS succeeds), and restored ADHR. At some point later, CRD fails and the operators attempt to control level with CDS (OPDHR succeeds), but CDS fails. RWCU has been isolated. Level control with ECCS (OPLEC in the R tree) fails because the time available was spent in OPDHR initiating CDS. With the loss in their ability to control level, inadequate decay heat removal will be a concern. The IDHR ONEP instructs the operators to initiate ECCS water solid operation. The operators must diagnose the need to initiate ECCS water solid operation with only 1 SRV available. The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.1.104.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Loss of systems are alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. In keeping with the scenario, the operators have been interacting with the system and should be aware of the need for some form of SDC. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.104.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
The operators must diagnose the need to initiate ECCS water solid operation, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	<p>A. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3) Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>B. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> Check closed MSIVs Ensure that two SRVs (1 in this case) are open Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.1.104.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ca}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	SEA Calculation C90-492-01-A16 Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 103 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, the fact that proceeding with 1 SRV is not explicitly indicated by procedure, the median diagnosis value from ASEP, Figure 8-1, rather than the lower bound value, was assigned.

Table 10.1.104.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read the IDHR ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but when the action is necessary, it was assumed to be done in parallel with alignment and start of LPCI (action 6 below) and the other OPECS actions.	0 minutes	Isolating ADHR and aligning LPCI (action 6 below) were judged to be an integrated set of actions and were assumed to be completely dependent. They are successive steps in a procedure specifically written to cover switching from ADRS to LPCI (RHR SOI (04-1-01-E12-1, Step 6.6 or 6.8)
3. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 3, 4 and 5 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR	--	5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
5. Ensure 1 SRVs open	CR	--	1 minute	1 minute	
6. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	3 minutes - includes time for isolating ADHR when required.	<u>3 minutes</u> 15 minutes (approx.) Total time for all actions.	

Table 10.1.104.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	23 minutes	15 minutes	8 minutes	

Table 10.1.104.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to proceed with ECCS water solid operation with only 1 SRV open.	Per ASEP Table 8-3, the median value from Figure 8-1 for 8 minutes diagnosis time was assigned.		Median = 0.105 (EF = 10) Mean = 0.279 Note. The median value for 8 min. is actually 0.15 (approximately). The error was (unfortunately) carried through.	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, the fact that only 1 SRV opened, the lower bound value for the diagnosis did not seem appropriate in this context. However, credit for second checks on the actions in the control room will still be given because of the success of the operators so far in the scenario.

Table 10.1.104.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.1.104.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.104.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Med. = 0.105 Mean = 0.279	--	Med. Mean 0.105 0.279	(10)	
2. Actions A. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. B. OPECS actions - proceed with one open SRV - check closed MSIVs - start LPCI(C)	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given that the operators have done everything correctly in this scenario, credit for second checks on the actions were given. HEPs for the control room failing to provide a second check were: Med. = 0.2 Mean = .323	Med. Mean 0.004 0.01 Med. Mean <u>0.004 0.01</u> 0.113 0.30 Total median HEP = 0.113 Total mean HEP = 0.30	(5) (5) (10)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. Since both the diagnosis and actions HEPs make significant contributions to the Total HEP in this case, the larger of the two EFs was assigned.

Table 10.1.105.1
HEP 105 Calculation

Human Action Event (1)	OP1SV (4)
Event Tree(s) (2)	EA, EAP
Initiators (3)	TAB5H, TDB5H, T5A5H, E1D5H, E2D5H
Sequence Locator Files (4)	OPECSADH.TAB, OPECSADH.TDB, OPECS3.T5A, OPECSADH.E1D, OPECSADP.E1D, OPECSADH.E2D
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 16), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds.
Event Context (6)	The important constants for the OP1SV (4) calculation (HEP 105) are that the operators have detected the loss of SDC (OPSDC succeeds), HPCS is the only available ECCS system, and ADHR may need to be isolated from the control room. Closing of the 8 or 9 valve from the control room is adequate to isolate ADHR. The operators have entered the ONEP for IDHR, they realize no normal means of SDC are available and they have decided to initiate ECCS water solid operation as directed by procedure (OPECS succeeds). The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1), Loss of AC Power ONEP (05-1-02-I-4, Rev 20)

Table 10.1.105.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Control room is aware that normal SDC unavailable or inadequate. Loss of systems were alarmed. ONEP for IDHR directs the control room to use ECCS to go water solid in this context. ONEP has been entered and the operators have decided to initiate ECCS water solid operation. Reactor coolant temperature will be rising. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.105.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	<p>1. Isolate ADHR from the control room (if necessary) by closing 8 or 9 valve.</p> <p>2. Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two (one in this case) SRVs are open - Increase RPV water level with any available injection system. In this context HPCS is the only available ECCS system. 	<p>Isolation of ADHR is not directed by procedure in this context. However, on the basis of interviews with operators, it was clear that they would be aware of the need to isolate the low pressure piping if necessary. In addition, during the site interviews, the operators clearly indicated that HPCS would be initiated. However, it is not <u>explicitly</u> called by the procedure.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.1.105.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 minutes	0	23 minutes	SEA Calculation C90-492-01-A16 Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds, it was decided that the HEP for OP1SV would be determined as if it were OPECS, except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. It was assumed that the operators would make several attempts to get the second SRV open and would discuss the problem among themselves before proceeding.

Table 10.1.105.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Isolate ADHR from the control room (in most cases this action would already be accomplished by the time the operators reached this point)	CR	--	1 minute	0 minutes - if action necessary, it was assumed to be done in parallel with OPECS actions listed below	Per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action inside the CR at a main panel.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
4. Ensure 1 SRV open	CR	--	1 minute	1 minute	
5. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b, see Column 6.	<u>1 minute</u> 8 min. Total action time	

Table 10.1.105.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	8 minutes	15 minutes	

Table 10.1.105.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the median value from Figure 8-1 for 15 minutes diagnosis time was assigned		Median = 0.03 Mean = 0.08 (EF=10)	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling. The median value from Figure 8-1 was selected because the isolation of ADHR and proceeding with 1 SRV is not explicitly called out by procedure in this context. Site interviews suggested that the operators would perform these actions.

Table 10.1.105.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions for initiating ECCS water solid operation are specified by the IDHR ONEP. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.105.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _{FF} < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	HPCS is available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.105.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.03 Mean = 0.08	--	Med. Mean 0.03 0.08	(10)	
2. Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available. Includes isolating ADHR if necessary.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations, additional concerns which might be facing the operators as a function of the specific initiators, and because failures or problems in closing MSIVs or opening 2 SRVs have to be considered by the operators in the same time period i.e., OPMSV and OP1SV.	<u>0.02</u> <u>0.032</u> 0.05 0.112 Total Median HEP = 0.05 Total Mean HEP = 0.112	<u>(5)</u> (10)	Since both HEPs contribute to the total HEP, the largest of the two EFs was assigned.

Table 10.1.106.1
HEP 106 Calculation

Human Action Event (1)	OP1SV (5)
Event Tree(s) (2)	E, EP
Initiators (3)	T1-5, TIA5H, TDB5H, T5A5H, T5D5H, E1B5H, E2B5H, E1T5H, E2T5H, E1V5H, E2V5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSSDC8.SDC, OPECSLP4.EP, OPCSEL32.TIA, OPECSLP8.TIA, OPECSDC6.TIA, OPECSDC10.TIA, OPECSL.TDB, OPECS4.T5A, OPECSLAP.T5D, OPECSLEP.T5D, OPECS10.T5D, OPECSDC0.E1B, OPECSDC6.E2B, OPECSDCF.E1T, OPECSDC5.E2T, OPECSADF.E1V, OPECSAD5.E2V, OPECSLHY.TLM, OPECSLP.TIF, OPECSLP.TIH, OPECSLP.TLM, OPECSLP.TRP
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 18), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds and must occur in the same time period.
Event Context (6)	The important constants for the OP1SV (5) calculation (HEP 106) is that the control room has initially failed to diagnose a loss of SDC (either OPDHR or OPSDC have failed, see HEP 18 for more details on the context of the failures). With the loss of SDC, the operators would need to enter the ONEP for IDHR. During the time allowed for OPECS and OP1SV, additional indications for the loss of SDC would occur. The ONEP directs the operators to initiate ECCS water solid operation. The operators decide to initiate ECCS water solid operation as directed by procedure (OPECS succeeds). The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20).

Table 10.1.106.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Control room is aware that normal SDC unavailable or inadequate. Loss of systems were alarmed. ONEP for IDHR directs the control room to use ECCS to go water solid in this context. ONEP has been entered and the operators have decided to initiate ECCS water solid operation. Reactor coolant temperature will be rising. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.106.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	Per IDHR ONEP (Step 5.1.3c) <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two (one in this case) SRVs are open - Increase RPV water level with any available injection system. In this context, LPCI(C) was assumed the system of choice. HPCS would also be available. 	Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. In some sequences, however, HPCS is the choice due to the initiator, e.g., T5A5H, (loss of SSW). LPCI is initiated from 04-1-01-E12-1, Step 5.4.2. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table 10.1.106.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ca}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min. —	SEA Calculation C90-492-01-A16. Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 18 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, given the earlier failures of the operators and the fact that proceeding with 1 SRV is not explicitly indicated by procedure, the median diagnosis value from ASEP, Figure 8-1, rather than the lower bound value, was assigned.

Table 10.1.106.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and Read ONEP for IDHR	CR		5 minutes, (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
4. Ensure 1 SRV open	CR	--	1 minute	1 minute	
5. Initiate ECCS system	CR	--	1 minute	<u>1 minute</u> 13 min. Total action time	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.

Table 10.1.106.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	13 minutes	10 minutes	

Table 10.1.106.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the median value from Figure 8-1 for 10 minutes diagnosis time was assigned		Median = 0.1 Mean = 0.27 (EF = 10)	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option even though it is not explicitly called by procedure. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling. However, for this event, the operators initially failed to diagnose the loss of SDC in spite of several indications (OPSDC or OPDHR have failed). Given these previous failures, it was judged that the lower bound diagnosis value would not be appropriate even though the site interviews indicated that the operators have a clear understanding of the procedure and the requirements.

Table 10.1.106.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Some form of SDC is clearly called for and indicated by procedure.

Table 10.1.106.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several safety systems are available and there is substantial time before core damage

¹

At least moderately high stress was assumed for all events.

²For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.106.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.1 Mean = 0.27	--	Med. Mean 0.1 0.27	(10)	
2. Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations, the additional concerns which might be facing operators as a function of the specific initiators and because failures or problems in closing MSIVs or attempting to get 2 SRVs open would have to be considered by operators in the same time period i.e., OPMSV and OP1SV.	<u>0.02</u> <u>0.032</u> 0.12 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	<u>(5)</u> (10)	The EF from the dominant HEP was assigned.

Table 10.1.107.1
HEP 107 Calculation

Human Action Event (1)	OPISV (11)					
Event Tree(s) (2)	E, EP					
Initiators (3)	J2-5					
Sequence Locator Files (4)	OPBCS.J25					
Event Description (5)	<p>OPISV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OPISV is the same decision and actions as OPECS (HEP 61), except that only 1 SRV, rather than the two specified by procedure, will open. OPISV is asked only in sequences where OPECS succeeds and must occur in the same time period.</p>					
Event Context (6)	<p>The important constants for the OPISV (11) calculation (HEP 107) are that a break in the SDC line has occurred outside containment. MV 8 or 9 auto-isolates on low level (level 3), which results in isolation of the break and SDC. If LOSP also occurs, the diesels start and load (DVI-2 succeeds). Level 3 alarms (RPV level below 11.4) will cause the operators to enter EP-2, which will direct them to restore level. The RHR pump trip alarms and closure of MV 8 or 9 will indicate a loss of SDC and the corresponding IDHR to the operators. The operators have entered the IDHR ONEP, which instructs them to initiate ECCS water solid operation. The operators decide to initiate ECCS water solid operation as directed by procedure (OPECS succeeds). The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OPISV is asked only in sequences where OPECS succeeds.</p>					
Applicable Procedures (7)	<p>Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20).</p>					

Table 10.1.107.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T.) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.107.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	Per IDHR ONEP (Step 5.1.3c) <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two (one in this case) SRVs are open - Increase RPV water level with any available injection system. In this context, LPCI(C) was assumed the system of choice. HPCS would also be available. 	Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. LPCI is initiated from 04-1-01-E12-1, Step 5.4.2. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table 10.1.107.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	SEA Calculation C90-492-01-A16. Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 61 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, proceeding with 1 SRV is not indicated by procedure.

Table 10.1.107.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and Read ONEP for IDHR	CR		5 minutes, (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
4. Ensure 1 SRV open	CR	--	1 minute	1 minute	
5. Initiate ECCS system	CR	--	1 minute	<u>1 minute</u> 13 min. Total action time	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.

Table 10.1.107.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	13 minutes	10 minutes	

Table 10.1.107.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the median value from Figure 8-1 for 10 minutes diagnosis time was assigned. (See comments in Column 5 of this table).		<p align="center">Median = 0.1</p> <p align="center">Mean = 0.27</p> <p align="center">(EF=10)</p>	<p>Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option even though it is not explicitly called by procedure. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.</p> <p>Given the concerns arising from the occurrence of the LOCA, the median diagnosis value from ASEP, Figure 8-1, rather than the lower bound, was judged appropriate.</p> <p>Note. Upon further review, given the indications present, the fact that the operators would have two different procedures guiding them, and the operators understanding of the situation based on the site interviews, it was judged that the lower bound value would have been more appropriate (per ASEP) in this instance. It was decided that where important, the resulting difference in HEP value would be considered during the recovery analysis.</p>

Table 10.1.107.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Some form of SDC is clearly called for and indicated by procedure.

Table 10.1.107.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several safety systems are available and there is substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.107.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.1 Mean = 0.27	--	Med. Mean 0.1 0.27	(10)	
2. Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the occurrence of a LOCA, and the time limitations.	<u>0.02</u> <u>0.032</u> 0.05 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	<u>(5)</u> (10)	The Error Factor from the dominant HEP was assigned.

Table 10.1.108.1
HEP 108 Calculation

Human Action Event (1)	OP1SV (13)
Event Tree(s) (2)	E, EP
Initiators (3)	TIOP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSAD5.TIO, OPECSAD5.TLM, OPECSAD5.TRP
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 78), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds and must occur in the same time period.
Event Context (6)	The important constants for the OP1SV (13) calculation (HEP 108) is that the control room has failed to diagnose the loss of SDC (ADHR) in 37 minutes (OPSDC fails). That is, in 37 min. the control room has not diagnosed the loss of SDC or entered the IDHR ONEP. However, by requirements (every 30 min.) the reactor temperature (and/or pressure) chart recorder would very likely be checked (to reveal increases) in the 23 min. available for this event. In addition, if a boil-off had begun, a low level alarm (level 4) may occur. The operators must recognize the loss of ADHR and enter the IDHR ONEP. In some cases, prior to initiating ECCS water solid operation, the operators will need to isolate ADHR from the control room. The operators decide to initiate ECCS water solid operation as directed by procedure (OPECS succeeds). The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20).

Table 10.1.108.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	O	Control room is aware that normal SDC unavailable or inadequate. Loss of systems were alarmed. ONEP for IDHR directs the control room to use ECCS to go water solid in this context. ONEP has been entered and the operators have decided to initiate ECCS water solid operation. Reactor coolant temperature will be rising. The control room gets feedback regarding the opening and closing of SRVs.	

Table 10.1.108.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	<p>1. Isolate ADHR from the control room by closing 8 or 9 valve.</p> <p>2. Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two (one in this case) SRVs are open - Increase RPV water level with any available injection system. In this context, LPCI(C) was assumed the system of choice. HPCS would also be available. 	<p>It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. In some sequences, however, HPCS is the choice due to the initiator, e.g., T5A5H, (loss of SSW).</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.1.108.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	<p>SEA Calculation C90-492-01-A16.</p> <p>Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 78 in this case), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, given the earlier failures of the operators and the fact that proceeding with 1 SRV is not explicitly indicated by procedure, the median diagnosis value from ASEP, Figure 8-1, rather than the lower bound value, was assigned.</p>

Table 10.1.108.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and Read ONEP for IDHR	CR		5 minutes, (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Isolate ADHR from the control room by closing 8 or 9 valve, if necessary.	CR	--	1 minute	0 minutes - if action necessary, assumed to be done in parallel with OPECS actions below	
3. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
4. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
5. Ensure 1 SRV open	CR	--	1 minute	1 minute	
6. Initiate ECCS system	CR	--	1 minute	<u>1 minute</u> 13 min. Total action time	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.

Table 10.1.108.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	13 minutes	10 minutes	

Table 10.1.108.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the median value from Figure 8-1 for 10 minutes diagnosis time was assigned		Median = 0.1 Mean = 0.27 (EF = 10)	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option even though it is not explicitly called by procedure. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling. However, for this event, the operators initially failed to diagnose the loss of SDC in spite of several indications (OPSDC failed). Given this previous failure, it was judged that the lower bound diagnosis value would not be appropriate even though the site interviews indicated that the operators have a clear understanding of the procedure and the requirements.

Table 10.1.108.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Some form of SDC is clearly called for and indicated by procedure.

Table 10.1.108.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_F < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several safety systems are available and there is substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.108.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^{op}	Independent Check/Correction HEP (HEP _c) (3) ^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.1 Mean = 0.27	--	Med. Mean 0.1 0.27	(10)	
2. Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations and the additional concerns which might be facing operators as a function of the specific initiators.	<u>0.02</u> <u>0.032</u> 0.05 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	<u>(5)</u> (10)	The EF from the dominant HEP was assigned.

Table 10.1.109.1
HEP 109 Calculation

Human Action Event (1)	OP1SV (15)
Event Tree(s) (2)	E, EA, EP
Initiators (3)	TIOF5, TIHP5
Sequence Locator Files (4)	OPECS.TIF, OPECS.TIH
Event Description (5)	OP1SV asks whether the operators will proceed with the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 88), except that only 1 SRV, rather than the two specified by procedure, will open. OP1SV is asked only in sequences where OPECS succeeds.
Event Context (6)	The important constants for the OP1SV (15) calculation (HEP 109) are that a spurious actuation of LPCI (TIOF5) or HPCS (TIHP5) has occurred. The operators would get level 7 and level 8 alarms within 1 min. of actuation. HPCS should auto-isolate on level 8, but the auto-isolation fails (HPCAO fails). Level would be increasing rapidly and operators would check systems likely to allow such level changes. Pump starts and valve openings would be indicated. OPSLP (or OPHPC) is operator action to detect and stop the inadvertent injection of LPCI (or HPCS) prior to overpressurization. OPSLP or OPHPC fails (less than 7 min. for diagnosis) in this scenario and the operating SDC system isolates on high pressure (135 psi). If a LOSP occurs, the diesel generators successfully start. Additional alarms would sound. Operators should enter IDHR ONEP and attempt to initiate ECCS water solid operation. MSIVs are closed. The IDHR ONEP directs the operators to open 2 SRVs when initiating ECCS water solid operation. The issue is whether the operators will initiate ECCS water solid operation if only 1 SRV can be opened. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20).

Table 10.1.109.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	0	The operators would get level 7 and level 8 alarms within 1 min. of actuation. Level and pressure would be increasing rapidly and operators would check systems likely to allow such level changes. Pump starts and valve openings would be indicated. SDC would isolate on high pressure and pump trips would be alarmed. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context. The control room gets feedback regarding the opening and closing of valves.	

Table 10.1.109.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available and level control is needed. The IDHR ONEP directs the operators to initiate ECCS water solid operation. Operators have decided to go water solid, but only 1 SRV is available. The question is whether they will proceed with the initiation of water solid operation if they cannot match the ONEPs demand for 2 SRVs	One	Per IDHR ONEP (Step 5.1.3c) 1. - Check closed MSIVs - Ensure that two (one in this case) SRVs are open - Increase RPV water level with any available injection system. In this context, LPCI was assumed to be the first choice, then HPCS.	It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. LPCI is initiated from 04-1-01-E12-1, Step 5.4.2. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table 10.1.109.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ca}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds.	23 min.	0 minutes	23 min.	SEA Calculation C90-492-01-A16. Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds, it was decided that the HEP for OP1SV would be determined as if it were OPECS (HEP 88), except for one difference. Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. However, proceeding with 1 SRV is not explicitly called out in the IDHR ONEP.

Table 10.1.109.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and Read ONEP for IDHR	CR		5 minutes, (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent. Also, in the present scenario they have not yet diagnosed the inadvertent actuation.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of proceduralized actions.
3. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
4. Ensure 1 SRV open	CR	--	1 minute	1 minute	
5. Initiate ECCS system	CR	--	1 minute	<u>1 minute</u> 13 min. Total action time	Note. Per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)

Table 10.1.109.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_A) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	23 minutes	13 minutes	10 minutes	

Table 10.1.109.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation with only 1 SRV open	Per Table 8-3, the median value from Figure 8-1 for 10 minutes diagnosis time was assigned		Median = 0.1 Mean = 0.27 (EF=10)	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.

Table 10.1.109.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation with 1 SRV available.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Some form of SDC is clearly called for.

Table 10.1.109.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems are available and there is substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.109.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.1 Mean = 0.27	—	Med. Mean 0.1 0.27	(10)	
2. Initiate ECCS water solid as directed by procedure, except that only 1 SRV is available.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations and the number of other concerns present in the control room.	<u>0.02</u> <u>0.032</u> 0.05 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	<u>(5)</u> (10)	The EF from the dominant HEP was assigned.

Table 10.1.110.1
HEP 110 Calculation

Human Action Event (1)	OPL1L, OPLIS, OPL2L
Event Tree(s) (2)	H1-5H
Initiators (3)	H1-5H
Sequence Locator Files (4)	OPL1L.H15
Event Description (5)	<p>OPL1L and OPLIS are the operator actions to isolate either a large or small diversion to the SP before level 3 is reached and before level drops to a point that makeup cannot restore level for SDC.</p> <p>OPL2L is a similar operator action except that the operators must isolate a large diversion after level 3 is reached, but the auto-isolation signals for SDC (the 8 and 9 valves) fails.</p>
Event Context (6)	<p>HEP 110 applies to OPL1L and OPLIS, and to OPL2L. For OPL1L and OPLIS, the operator must realize the need and isolate either a large or small diversion to the SP before level 3 is reached and before level drops to a point that makeup (CRD) cannot restore level for SDC.</p> <p>T-H calculations allowed 23 sec. for OPL1L (large diversion) and 3.8 min. for OPLIS (small diversion). Operators will receive an alarm at level 4 to indicate level is going down. However, it must assumed that at least some time will be required to determine that the rate level is dropping is significant. The operators must then diagnose where the diversion is located and how to stop it. That is, operators would have to scan the positions of many valves and determine where the diversion lies (which ones should be closed and which ones should be open) and how to respond. Realistically, the operators would probably isolate both letdown and SDC fairly soon since they are likely choices for the level loss. However, with a maximum of 3.8 min., insufficient time is available to assume much will be done. Thus, both OPL1L and OPLIS are assumed to fail (HEP = 1.0).</p> <p>OPL2L is similar except that the operators must isolate a large diversion after level 3 is reached and the auto-isolation signal for SDC (the 8 and 9 valves fails). While level 3 would be alarmed, operators would have to ID diversion and/or failure of 8 and 9 to close and ensure that they get closed. The 3.5 min. assumed to be available for this task was assumed to be insufficient and OPL2L was assumed to fail in this scenario. Since detailed ASEP calculations were not required for HEP 110, Tables 10.1.110.2 through 10.1.110.9 were not included.</p>
Applicable Procedures (7)	EP-2 (RPV Control)

Note. Tables 10.1.110.2 through 10.1.110.9 were unnecessary for HEP 110 and therefore they were not included.

Table 10.1.110.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Identify and isolate a diversion to the SP. Actions OPL1L, OPL1S, and OPL2L.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table 10.1.111.1
HEP 111 Calculation

Human Action Event (1)	LCHPC, LC-LP, (and OPHRP when preceded by a failed LCHPC)
Event Tree(s) (2)	RH1, RH2, RAH1, RAH2
Initiators (3)	H1-5H
Sequence Locator Files (4)	OPLCHPLP.H15
Event Description (5)	LCHPC and LC-LP are operator actions to control level after (in this case) the auto-initiation of HPCS or LPCI on low level in order to avoid overpressurization or overfill. OPHRP is the operator action to take manual control of HPCS after it auto-isolates on level 8 because the operators initially failed to control level after the auto-start of HPCS (LCHPC failed).
Event Context (6)	<p>For HEP 111, the initiator is a diversion through RHR/SDC to the SP. Vessel inventory decreases to level 3, but the auto-isolation of SDC fails. At level 2 HPCS auto-starts and if it fails LPCI will auto-start. LCHPC and LC-LP are the operator actions to control level for HPCS or LPCI, respectively, to avoid vessel overpressurization or overfill.</p> <p>If HPCS auto-starts and the operators fail to control level (LCHPC fails), HPCS should auto-isolate at level 8. If it does, OPRHP asks whether the operators will recognize the problem and take manual control of HPCS. However, at this point in the scenario, the operators have not done anything correctly and only approximately 3.8 min. are allowed for OPHRP. Thus, OPHRP is assumed to fail and the auto-start of LPCI is asked.</p>
Applicable Procedures (7)	EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1)

Table 10.1.111.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A diversion to the SP has occurred and an ECCS system has auto-started. The operators must realize the need to control level.	0	Several low level alarms would occur and the auto-start of the ECCS systems would be alarmed. Level and pressure would increase rapidly and additional alarms would occur.	

Table 10.1.111.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A diversion to the SP has occurred and an ECCS system has auto-started. The operators must realize the need to control level and do so.	One	Control level from the control panel.	

Table 10.1.111.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Control level after auto-start of HPCS or LPCI	7.7 minutes	0	7.7 minutes	SEA Calculation C90-492-01- A16

Table 10.1.111.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Control level to prevent overpressurizat ion or overfill after auto-start of HPCS or LPCI.	CR	—	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 1 min. Total	Controlling level would be more or less continuous process, but it was assumed that the initial steps to control level would require about 1 minute.

Table 10.1.111.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to control level in order to prevent overpressurization or overfill after an auto-start of HPCS or LPCI.	7.7 minutes	1 minute	6.6 minutes	Whether or not the operators would control level once they figured-out what was going on was not really in question. The operators know the injection rates and would want to control level. The limitation is the amount of time available.

Table 10.1.111.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to control level in order to prevent overpressurization or overfill after an auto-start of HPCS or LPCI.	Per ASEP HRA Table 8-3, the lower bound value from Figure 8-1 for 6.6 minutes diagnosis time was assigned.		Med. = 0.02 Mean = 0.05	Whether or not the operators would control level once they figured-out what was going on was not really in question. The operators know the injection rates and would want to control level. The limitation is the amount of time available. Thus, lower bound value for the diagnosis was assigned.

Table 10.1.111.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Control level.	N/A	The nature of the action is obvious.	No	N/A	The action was assumed to be an "immediate emergency action" per ASEP HRAP Table 8-5, Item 10. As soon as the operators realized HPCS or LPCI was injecting, they would be very likely to control level.

Table 10.1.111.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _F < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Control level.	N/A ¹	Even though the diversion could be large, an ECCS system is injecting.	No ²	N/A	N/A	The action was assumed to be an "immediate emergency action" per ASEP HRAP Table 8-5, Item 10. As soon as the operators realized HPCS or LPCI was injecting, they would be very likely to control level.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.111.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)^{op}	Independent Check/Correction HEP (HEP_{cz}) (3)^{cz}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Median = 0.02 Mean = 0.05	—	Med. Mean 0.02 0.05	(10)	
2. Control level to prevent overpressurization or overfill after auto-start of HPCS or LPCI.	Immediate emergency action. Median = 0.001 Mean = 0.001 Note. The mean HEP should have been 0.0026 rather than 0.001, which was the median. However, relative to the diagnosis HEP, the action HEP is negligible in either case.	N/A	<u>0.001</u> <u>0.001</u> 0.021 0.051 Total Median HEP = 0.021 Total Mean HEP = 0.051	<u>(10)</u> (10)	The error factors were the same for both HEPs.

Table 10.1.113.1
HEP 113 Calculation

Human Action Event (1)	ISO89	RH1, RH2, RAH1, RAH2	H1-5H	OP.LCHPLP.H15	ISO89 is the operator action to manually isolate SDC.	Event Description (5)	Event Context (6)	Applicable Procedures (7)
Event Tree(s) (2)	<p>For the sequences where the auto-isolation logic for SDC failed (RHRIL fails) rather than a hardware related failure of the valves to close (SDCIL), ISO89 is asked if HPCS or LPCI is started and successfully controlled. ISO89 is the operator action to manually isolate SDC (locally). This would be the natural thing to do and they would then be in position to initiate ECCS water solid operation. However, they are already in sort of a "backwards" mode of water solid operation in their present alignment (water into SP because of the diversion and back into the vessel through HPCS or LPCI) and could continue in this mode as long as they eventually provided makeup to the SP. It was assumed that if they decide to manually isolate SDC, they are essentially deciding to initiate ECCS water solid operation per the IDHR ONEP. Regardless of their choice, they will eventually proceed to an "EC" type tree where the same actions will be required for success.</p>							EP-2 (RPV Control, Rev. 19), Inadequate Decay Heat Removal ONEP (05-1-02-III-1)

Table 10.1.113.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A diversion to the SP has occurred. The auto-isolation logic for SDC fails and an ECCS system has auto-started. The question is whether the operators will decide to manually isolate SDC locally, when they are functionally in a "backwards" water solid situation.	0	Several low level alarms would occur and the auto-start of the ECCS systems would be alarmed. The failure of SDC to isolate would be alarmed and the operators would expect the SDC isolation on level 3.	

Table 10.1.113.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A diversion to the SP has occurred. The auto-isolation logic for SDC fails and an ECCS system has auto-started. The operators control level and are functionally in a sort of "backwards" water solid operation. The question is whether the operators will decide to manually isolate SDC locally and initiate ECCS water solid per procedure.	One	Manually isolate SDC.	

Table 10.1.113.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{∞}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Manually isolate SDC locally after logic for auto-isolation fails. At this point in the scenario, deciding to isolate SDC is essentially deciding to initiate ECCS water solid in the normal manner.	1 hour	0	1 hour	SEA Calculation C90-492-01-A16. This action must occur in the same time period as other operator actions in the EC tree. A total of 11 hours would be available, but to ensure adequate time for the actions in the EC tree and because the operators do not absolutely have to accomplish the action, 1 hour was conservatively assumed for making the decision to isolate SDC and initiate ECCS water solid in the normal fashion.

Table 10.1.113.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
Manually isolate SDC locally.	Outside the CR	--	15 minutes (Combined travel and action time)	<u>15 minute</u> 15 min. Total	Travel and performance time is based on discussions with plant personnel.

Table 10.1.113.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_t) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Manually isolate SDC locally after logic for auto-isolation fails. At this point in the scenario, deciding to isolate SDC is essentially deciding to initiate ECCS water solid in the normal manner per the IDHR ONEP.	1 hour	15 minutes	45 minutes	

Table 10.1.113.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Isolate SDC in order to initiate ECCS water solid operation in the normal way per the IDHR ONEP.	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 45 minutes diagnosis time was assigned.		Med. = $2.0E-4$ Mean = $1.7E-3$	While there are no explicit procedures which would instruct the operators to isolate SDC, an auto-isolation has failed. The operators have been successfully controlling level and would probably figure-out where the diversion was. While the operators were not interviewed on this action, they have been trained to follow the IDHR ONEP and the current alignment is somewhat odd. In any case, they can be successful regardless of their decision and will end up in an "EC" type tree in either case.

Table 10.1.113.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs, Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Locally isolate SDC.	N/A	Not explicitly covered by procedure, but the action is straightforward given the context.	No	Step-by-step	

Table 10.1.113.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Locally isolate SDC by closing 8 or 9 valve.	N/A ¹	Even though the diversion could be large, an ECCS system is injecting and cooling is being provided.	No ²	N/A	N/A	The action was assumed to be an "immediate emergency action" per ASEP HRAP Table 8-5, Item 10. As soon as the operators realized HPCS or LPCI was injecting, they would be very likely to control level.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.113.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Median = 2.0E-4 Mean = 1.7E-3	-	Med. Mean 2.0E-4 1.7E-3	(10)	
2. Isolate SDC locally by closing 8 or 9 valve.	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the time available. Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.0042 0.012 Total Median HEP = 0.0042 Total Mean HEP = 0.012	<u>(5)</u> (5)	The error factor from the dominant HEP was assigned.

Table 10.1.114.1
HEP 114 Calculation

Human Action Event (1)	OPECS (22)
Event Tree(s) (2)	E, EA
Initiators (3)	H1-5H
Sequence Locator Files (4)	OPECS.H15
Event Description (5)	OPECS in this case includes attempting to open 2 SRVs and checking closed any MSIVs for water solid operation. It is assumed that the diagnosis to initiate ECCS water solid operation was made in ISO89 (see HEP 113 and discussion below).
Event Context (6)	For the OPECS (22) calculation (HEP 114), a diversion to the SP via RHR/SDC has occurred. The operators initially fail (in 3 min.) to identify the diversion and isolate (OPL1S) it before level 3 is reached. Level 3 isolation signal fails (logic) for 8 and 9 valve, so the valves fail to close. An ECCS system auto-starts on low level and the operators successfully control level (LCHPC or LC-LP succeed). The operators then decide to manually isolate SDC (ISO89 succeeds). Given the manual isolation of SDC, the operators will be aware of the need for SDC and they will have entered the IDHR ONEP. In fact, since they were already in a "backwards" water solid operation mode (through RHR to SP and back into vessel through ECCS system), the decision to isolate SDC is assumed to indicate a decision to initiate the normal means of ECCS water solid operation. With ECCS already injecting, for OPECS the operators need only to open 2 SRVs and check closed the MSIVS. Even if only get 1SRV, operators unlikely to turn off ECCS given EP-2 instructs the operation of ECCS for makeup. Moreover, since diagnosis for water solid operation was assumed to be made in ISO89, there is ample time available to diagnose the need to proceed with 1 SRV. Thus, a somewhat lower value was obtained for OP1SV in these sequences than in some others (see HEP 115).
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19)

Table 10.1.114.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators have manually isolated SDC and decided to initiate ECCS water solid operation. They need to open 2 SRVs and check closed MSIVs per the IDHR ONEP.	O	The operators have decided to initiate ECCS water solid operation. The ONEP for IDHR directs the control room to open 2 SRVs and check closed any open MSIVs in initiating ECCS water solid operation.	

Table 10.1.114.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators have manually isolated SDC and decided to initiate ECCS water solid operation. They need to open 2 SRVs and check closed MSIVs per the IDHR ONEP. ECCS is already injecting and the operators are controlling level.	One	Per IDHR ONEP (Step 5.1.3c) <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - An ECCS system is already injecting, per EP-2. 	

Table 10.1.114.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{∞}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Operators have manually isolated SDC and decided to initiate ECCS water solid operation. They need to open 2 SRVs and check closed MSIVs per the IDHR ONEP. ECCS is already injecting and the operators are controlling level.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table 10.1.114.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for completing ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
2. Ensure 2 SRVs open	CR	--	1 minute	<u>1 minute</u> 2 minutes Total.	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.

Table 10.1.114.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The correct diagnosis has been made. The operators are simply following steps in a procedure.	23 minutes	2 minutes	21 minutes, but no time for diagnosis is needed.	

Table 10.1.114.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Complete actions for ECCS water solid operation per procedure. Diagnosis has already been made.	N/A		N/A	

Table 10.1.114.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Complete actions for ECCS water solid operation. Open SRVs and check closed MSIVs.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.114.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Complete actions for ECCS water solid operation. Open SRVs and check closed MSIVs.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.114.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{cz}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis assumed correctly accomplished in ISO89.	N/A	--	N/A	N/A	
2. Complete actions for ECCS water solid operation. Open SRVs and check closed MSIVs.	Med. = 0.02 Mean = 0.032	Credit for a second and third check were given. With no diagnosis required, ample time is available for recovery credit for failed actions. The HEPs for the second and third check were: Median = .2 Mean = .323	<u>0.0008</u> <u>0.003</u> 0.0008 0.003 Total Median HEP = 0.0008 Total Mean HEP = 0.003	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action and the third check HEP is multiplied by the result.

Table 10.1.115.1
HEP 115 Calculation

Human Action Event (1)	OP1SV (18)
Event Tree(s) (2)	E, EA
Initiators (3)	H1-5H
Sequence Locator Files (4)	OPECS.H15
Event Description (5)	OP1SV asks whether the operators will proceed with the actions necessary to complete the initiation of ECCS water solid operation when only 1 SRV can be opened and the IDHR ONEP calls for 2 SRVs to be opened. In essence, OP1SV is the same decision and actions as OPECS (HEP 114), except that only 1 SRV, rather than the two specified by procedure, will open. It is assumed that the diagnosis to initiate ECCS water solid operation was made in ISO89 (see HEP 113 and discussion below). OP1SV is asked only in sequences where OPECS succeeds and must occur in the same time period.
Event Context (6)	For the OP1SV (18) calculation (HEP 115), a diversion to the SP via RHR/SDC has occurred. The operators initially fail (in 3 min.) to identify the diversion and isolate (OPL1S) it before level 3 is reached. Level 3 isolation signal fails (logic) for 8 and 9 valve, so the valves fail to close. An ECCS system auto-starts on low level and the operators successfully control level (LCHPC or LC-LP succeed). The operators then decide to manually isolate SDC (ISO89 succeeds). Given the manual isolation of SDC, the operators will be aware of the need for SDC and they will have entered the IDHR ONEP. In fact, since they were already in a "backwards" water solid operation mode (through RHR to SP and back into vessel through ECCS system), the decision to isolate SDC is assumed to indicate a decision to initiate the normal means of ECCS water solid operation. With ECCS already injecting, for OPECS the operators need only to open 2 SRVs and check closed the MSIVS. Even if only get 1SRV, operators unlikely to turn off ECCS given EP-2 instructs the operation of ECCS for makeup. Moreover, since diagnosis for water solid operation was assumed to be made in ISO89, there is ample time available to diagnose the need to proceed with 1 SRV. Thus, a somewhat lower value was obtained for OP1SV in these sequences than in some others. OP1SV is asked only in sequences where OPECS succeeds.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19)

Table 10.1.115.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators have manually isolated SDC and decided to initiate ECCS water solid operation. They need to open 2 SRVs per procedure, but only opens, and check closed MSIVs per the IDHR ONEP.	O	The operators have decided to initiate ECCS water solid operation. The ONEP for IDHR directs the control room to open 2 SRVs and check closed any open MSIVs in initiating ECCS water solid operation. The control room gets feedback regarding the opening and closing of SRVs. No procedures explicitly instruct the operators to proceed with only 1 SRV available.	

Table 10.1.115.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators have manually isolated SDC and decided to initiate ECCS water solid operation. Per the IDHR ONEP, they need to open 2 SRVs and check closed MSIVs. ECCS is already injecting and the operators are controlling level. The issue is whether they will decide to proceed with ECCS water solid operation when only 1 SRV is available.	One	Per IDHR ONEP (Step 5.1.3c) <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two (one in this case) SRVs are open - An ECCS system is already injecting, per EP-2. 	

Table 10.1.115.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
<p>Complete initiation of ECCS water solid operation with only 1 SRV available. This task must occur in the same time frame allowed for OPECS. That is, it must occur in the same 23 minutes. Functionally, OP1SV is OPECS, except that only 1 SRV is available. OP1SV is asked only when OPECS succeeds. ECCS is already injecting and the operators are controlling level.</p>	23 minutes	0	23 Minutes	<p>SEA Calculation C90-492-01-A16</p> <p>Note. There is clearly a dependency between OPECS and OP1SV. Essentially they constitute the same action, but an additional diagnosis is involved in OP1SV. Since OP1SV is asked only when OPECS succeeds and must occur in the same time period, it was decided that the HEP for OP1SV would be determined similarly to OPECS (HEP 114 in this case), except that a diagnosis is required (proceeding with only one SRV). Five minutes less would be available for the diagnosis because of the time lost in responding to the failure to get two SRVs open. Operators would probably make several attempts to get one more SRV open and would discuss proceeding with 1 SRV among each other. The site interviews indicated the operators would be likely to proceed with water solid operations even though only 1 SRV was available. However, proceeding with 1 SRV is not indicated by procedure.</p>

Table 10.1.115.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Make several attempts to get the second SRV open and discuss proceeding with 1 SRV.	CR		5 minutes	5 minutes	Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for completing ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs (one in this case) are open.	CR	--	1 minute	<u>1 minute</u> 7 minutes Total.	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.

Table 10.1.115.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_A) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Decide to proceed with ECCS water solid operation with only 1 SRV available.	23 minutes	7 minutes	16 minutes	

Table 10.1.115.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Decide to proceed with ECCS water solid operation with only one SRV and complete actions for ECCS water solid operation per procedure.	Per Table 8-3, the lower bound value from Figure 8-1 for 16 minutes diagnosis time was assigned. (See comments in Column 5 of this table).		Med. = 0.002 Mean = 0.005 EF = 10	<p>Operators at GGNS indicated that proceeding with ECCS water solid operation with only one SRV would be a viable and likely option even though it is not explicitly called by procedure. The immediate objective is to get some form of decay heat removal operating and initiating water solid operation with 1 SRV would provide core cooling. Also, given that EP-2 directs the operators to start injection with ECCS, ECCS is already injecting, and the operators are controlling level, it becomes even more unlikely that the operators would stop ECCS just because cannot get 2 SRVs.</p> <p>Given the indications present, the fact that the operators would have two different procedures guiding them, and the operators understanding of the situation based on the site interviews, it was judged that the lower bound value was appropriate (per ASEP HRAP) in this instance.</p>

Table 10.1.115.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Complete actions for ECCS water solid operation. Proceed with 1 SRVs and check closed MSIVs.	N/A	Except for proceeding with 1 SRV, the actions are clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.115.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Complete actions for ECCS water solid operation. Proceed with 1 SRV and check closed MSIVs.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.115.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.002 Mean = 0.005	--	Med. Mean 0.002 0.005	(10)	
2. Complete actions for ECCS water solid operation. Proceed with one SRVs and check closed MSIVs.	Med. = 0.02 Mean = 0.032	Credit for a second check was given. Operators have the situation in hand and ample time is available for recovery credit for failed actions. The HEPs for the second check were: Median = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.006 0.015 Total Median HEP = 0.006 Total Mean HEP = 0.015	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action and the third check HEP is multiplied by the result. The error factor from the dominant HEP was assigned.

Table 10.1.116.1
HEP 116 Calculation

Recovery Action (1)	RA-CRD-1
Event Description (2)	RA-CRD-1 is the operator action to provide makeup with CRD for "steaming" the vessel.
Event Context (3)	For the RA-CRD-1 calculation (HEP 116), the operators have diagnosed the fact that they are by default "steaming" the vessel and have opened at least 1 SRV. With the SRVs open, the operators will now have approximately 1.6 hours to provide makeup to the vessel before boil-off to the top of the core occurs (2.6 hours minus 1 hour allowed for earlier operator actions which may or may not have succeeded (OPECS, OPFLD, OPSTM etc., see Table F.2.1). Except for diagnosing that they are steaming the vessel and that they have opened 1 SRV, no assumptions about prior operator actions were made. RA-CRD-1 is the operator action to diagnose the need for makeup, select CRD, restore IA if necessary, and initiate CRD (both pumps required). Other injection systems may be available, e.g., CDS, HPCS, but CRD is assumed to be the system of choice, since it is the usual makeup system during LP&S. In addition, since it may be necessary to restore IA before CRD can be used, the HEP for initiating CRD is more conservative than for the other systems. It was assumed that IA could be restored and CRD aligned for injection within 36 min., leaving 1 hr for the diagnosis. Restoration of IA (ATTH. 7 of EP-2) could be easily accomplished from the control room, unless it was necessary to jumper around an isolation signal, which might require a trip to the relay room. CRD can be initiated from the control room.
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19), EP-2 (Attachment 7, Defeating Auxiliary Building, Containment, and Drywell Instrument Air Isolation Interlocks, 05-S-01-EP2-2).

Table 10.1.116.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators need to provide makeup with CRD to successfully steam the vessel. They have already opened 1 SRV.	O	The operators have diagnosed that they are steaming the vessel by default and have opened 1 SRV. Temperature will increase to a point and level will gradually decrease. Given their correct diagnosis, they will be aware of the need to provide some form of makeup. EP-2 will indicate a need for level control. Isolation signals in the CR will indicate the need to unisolate IA if they plan to use CRD.	

Table 10.1.116.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators need to provide makeup with CRD to successfully steam the vessel. They have already opened 1 SRV. In some cases they may need to unisolate IA. While other injection systems may be available, CRD is assumed the system of choice.	One	<ul style="list-style-type: none"> - Unisolate IA if necessary - Initiate two pump CRD injection. 	

Table 10.1.116.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to initiate CRD to provide level for steaming.	96 minutes	0	96 Minutes	SEA Calculation C90-492-01-A16. Also see Table F.2.1.

Table 10.1.116.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Unisolate IA if necessary.	CR and in some cases the relay room	--	Estimated travel and performance time for overriding an IA isolation, including jumpering a bypass in the relay room was approximately 35 minutes.	35 minutes	Specific estimates regarding performance time were not obtained from the plant. The travel and performance time estimate was based on the PRA teams familiarity with the plant and the action and on general discussions with operators during the site interviews regarding jumpering relays etc. outside the CR.
2. Initiate two pump CRD injection.	CR	--	1 minute	<u>1 minute</u> 36 minutes Total.	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action in the CR.

Table 10.1.116.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to initiate CRD to provide level for steaming and unisolate IA if necessary.	96 minutes	Approx. 36 minutes	60 minutes	

Table 10.1.116.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to initiate CRD to provide level for steaming and unisolate IA if necessary.	Per ASEP HRAP Table 8-3, the median value from ASEP Figure 8-1 for 60 minutes diagnosis time was assigned.		Median = 1.0E-4 EF = 30 Mean = 9.0E-4	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. In the present context, the operators have decided to steam and have opened 1 SRV. Thus, even though steaming is not proceduralized, they will be likely to realize the need for makeup. EP-2 directs the need for level control even without the notion of steaming.

Table 10.1.116.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Unisolate IA and start CRD pumps for injection.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.116.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Unisolate IA and start CRD pumps for injection.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems may still be available.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.116.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to initiate CRD to provide level for steaming and unisolate IA if necessary.	Median = 1.0E-4 Mean = 9.0E-4	--	Med. Mean 1.0E-4 9.0E-4	(30)	
2. Override IA isolation	Med. = 0.02 Mean = 0.032	Credit for a second check was not given in this instance (see Column 6 for rationale).	0.02 0.032	(5)	This recovery HEP was assumed to be a "generic" value in the sense that previous operator performance (except for diagnosing that they were steaming and opening 1 SRV) was not taken into account. Moreover, it was assumed that other systems may still be available.
3. Initiate two pump CRD injection.	Med. = 0.02 Mean = 0.032		<u>0.02</u> <u>0.032</u> <u>0.04</u> <u>0.065</u> Total Median HEP = 0.04 Total Mean HEP = 0.065	<u>(5)</u> (5)	The error factor associated with the dominant HEPs was assigned.

Table 10.1.117.1
HEP 117 Calculation

Recovery Action (1)	RA-CRD-MOD1
Event Description (2)	RA-CRD-MOD1 is the operator action to provide makeup with CRD for "steaming" the vessel.
Event Context (3)	For the RA-CRD-MOD1 calculation (HEP 117), the operators have diagnosed the fact that they are by default "steaming" the vessel and have opened at least 1 SRV. With the SRVs open, the operators will now have approximately 1.6 hours to provide makeup to the vessel before boil-off to the top of the core occurs (2.6 hours minus 1 hour allowed for earlier operator actions (e.g., OPECS, OPFLD, OPSTM etc., see Table F.2.1). RA-CRD-MOD1 is the operator action to diagnose the need for makeup, select CRD, and initiate CRD (both pumps required). In calculating the HEP for this recovery action, it was assumed that IA would <u>not</u> have to be restored and that the operators had attempted to follow procedure in earlier parts of the relevant sequences (i.e., they had attempted ECCS water solid operation (OPECS succeeds)) and had been performing correctly. It was also assumed that CRD might be their last available injection system. CRD can be initiated from the control room.
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19), EP-2 (Attachment 7, Defeating Auxiliary Building, Containment, and Drywell Instrument Air Isolation Interlocks, 05-S-01-EP2-2).

Table 10.1.117.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators need to provide makeup with CRD to successfully steam the vessel. They have already opened 1 SRV.	O	The operators have diagnosed that they are steaming the vessel by default and have opened 1 SRV. Temperature will increase to a point and level will gradually decrease. Given their correct diagnosis, they will be aware of the need to provide some form of makeup. EP-2 will indicate a need for level control.	

Table 10.1.117.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators need to provide makeup with CRD to successfully steam the vessel. They have already opened 1 SRV.	One	Initiate two pump CRD injection.	

Table 10.1.117.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to initiate CRD to provide level for steaming.	96 minutes	0	96 Minutes	SEA Calculation C90-492-01-A16. Also see Table F.2.1.

Table 10.1.117.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Initiate two pump CRD injection.	CR	--	1 minute	<u>1 minute</u> 1 minutes Total.	Per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action in the CR.

Table 10.1.117.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to initiate CRD to provide level for steaming.	96 minutes	1 minutes	Approx. 95 minutes	

Table 10.1.117.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to initiate CRD to provide level for steaming the vessel.	Per ASEP HRA Table 8-3, the median value from ASEP Figure 8-1 for 96 minutes diagnosis time was assigned.		<p>Median = $1.0E-4$</p> <p>EF = 30</p> <p>Mean = $9.0E-4$</p> <p>Note. The diagnosis values for 60 minutes rather than 95 minutes were incorrectly used. However, the contribution of the diagnosis HEP to the overall HEP is negligible in either case.</p>	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. In the present context, the operators have decided to steam and have opened 1 SRV. Thus, even though steaming is not proceduralized, they will be likely to realize the need for makeup. EP-2 directs the need for level control even without the notion of steaming.

Table 10.1.117.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Initiate CRD pumps for injection.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.117.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate CRD pumps for injection.	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.117.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to initiate CRD to provide level for steaming the vessel.	Median = 1.0E-4 Mean = 9.0E-4	--	Med. Mean 1.0E-4 9.0E-4	(30)	
2. Initiate two pump CRD injection.	Med. = 0.02 Mean = 0.032	Credit for a second and third check were given. It was assumed that the operators have performed correctly to this point and that CRD may be their last line of defense. Ample time is available for recovery credit for any failed actions. The HEPs for the second and third check were: Median = .2 Mean = .323	<u>0.0008</u> <u>0.0033</u> <u>0.0009</u> <u>0.0042</u> Total Median HEP = 0.0009 Total Mean HEP = 0.0042	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned

Table 10.1.118.1
HEP 118 Calculation

Recovery Action (1)	RA-CRD-MOD2
Event Description (2)	RA-CRD-MOD2 is the operator action to provide makeup with CRD for "steaming" the vessel.
Event Context (3)	<p>For the RA-CRD-MOD2 calculation (HEP 118), the operators have diagnosed the fact that they are by default "steaming" the vessel and have opened at least 1 SRV. With the SRVs open, the operators will now have approximately 1.6 hours to provide makeup to the vessel before boil-off to the top of the core occurs (2.6 hours minus 1 hour allowed for earlier operator actions (OPECS, OPFLD, OPSTM etc., see Table F.2.1). RA-CRD-MOD2 is the operator action to diagnose the need for makeup, select CRD, restore IA if necessary, and initiate CRD (both pumps required). In calculating the HEP for this recovery action, it was assumed that the operators had attempted to follow procedure in earlier parts of the relevant sequences (i.e., they had attempted ECCS water solid operation (OPECS succeeds)) and had been performing correctly. It was also assumed that CRD might be their last available injection system.</p> <p>It was assumed that IA could be restored and CRD aligned for injection within 36 min., leaving 1 hour for the diagnosis. Restoration of IA (ATTH. 7 of EP-2) could be easily accomplished from the control room, unless it was necessary to jumper around an isolation signal, which might require a trip to the relay room. CRD can be initiated from the control room.</p>
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19), EP-2 (Attachment 7, Defeating Auxiliary Building, Containment, and Drywell Instrument Air Isolation Interlocks, 05-S-01-EP2-2).

Table 10.1.118.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators need to provide makeup with CRD to successfully steam the vessel. They have already opened 1 SRV.	O	The operators have diagnosed that they are steaming the vessel by default and have opened 1 SRV. Temperature will increase to a point and level will gradually decrease. Given their correct diagnosis, they will be aware of the need to provide some form of makeup. EP-2 will indicate a need for level control. Isolation signals in the CR will indicate the need to unisolate IA if they plan to use CRD.	

Table 10.1.118.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators need to provide makeup with CRD to successfully steam the vessel. They have already opened 1 SRV. In some cases they may need to unisolate IA. While other injection systems may be available, CRD is assumed the system of choice.	One	<ul style="list-style-type: none"> - Unisolate IA if necessary - Initiate two pump CRD injection. 	

Table 10.1.118.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to initiate CRD to provide level for steaming.	96 minutes	0	96 Minutes	SEA Calculation C90-492-01-A16. Also see Table F.2.1.

Table 10.1.118.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Unisolate IA if necessary.	CR and in some cases the relay room	--	Estimated travel and performance time for overriding an IA isolation, including jumpering a bypass in the relay room was approximately 35 minutes.	35 minutes	Specific estimates regarding performance time were not obtained from the plant. The travel and performance time estimate was based on the PRA teams familiarity with the plant and the action and on general discussions with operators during the site interviews regarding jumpering relays etc. outside the CR.
2. Initiate two pump CRD injection.	CR	--	1 minute	<u>1 minute</u> 36 minutes Total.	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action in the CR.

Table 10.1.118.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to initiate CRD to provide level for steaming and unisolate IA if necessary.	96 minutes	Approx. 36 minutes	60 minutes	

Table 10.1.118.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to initiate CRD to provide level for steaming and unisolate IA if necessary.	Per ASEP HRAP Table 8-3, the median value from ASEP Figure 8-1 for 60 minutes diagnosis time was assigned.		Median = 1.0E-4 EF = 30 Mean = 9.0E-4	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. In the present context, the operators have decided to steam and have opened 1 SRV. Thus, even though steaming is not proceduralized, they will be likely to realize the need for makeup. EP-2 directs the need for level control even without the notion of steaming.

Table 10.1.118.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Unisolate IA and start CRD pumps for injection.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.118.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Unisolate IA and start CRD pumps for injection.	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.118.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to initiate CRD to provide level for steaming and unisolate IA if necessary.	Median = 1.0E-4 Mean = 9.0E-4	--	Med. Mean 1.0E-4 9.0E-4	(30)	
2. Override IA isolation	Med. = 0.02 Mean = 0.032	Credit for a second and third checks on both actions were given. It was assumed that the operators have performed correctly to this point and that CRD may be their last line of defense. Ample time is available for recovery credit for any failed actions. The HEPs for the second and third check were: Median = .2 Mean = .323	0.0008 0.0033	(5)	Second check HEPs are multiplied by the original HEP for each action and the third check HEP is multiplied by the result.
3. Initiate two pump CRD injection.	Med. = 0.02 Mean = 0.032	Yes, see above.	0.0008 0.0033 0.0025 0.0075 Total Median HEP = 0.0025 Total Mean HEP = 0.0075	(5) (5)	The error factor associated with the dominant HEPs was assigned.

Table 10.1.119.1
HEP 119 Calculation

Recovery Action (1)	RA-OPICT-1 and RA-OPICT-3
Event Description (2)	RA-OPICT-1 and RA-OPICT-3 are operator actions to close containment if only the lower personnel lock is open (containment is open "low") and not the large equipment hatch.
Event Context (3)	<p>For RA-OPICT-1 and RA-OPICT-3, the operators have decided to either flood the vessel/containment or steam the vessel, respectively. In either case, they should want to prevent water from going to places it is not supposed go and they should want to prevent any possible release if the situation deteriorates. Therefore, if primary containment is open, they should diagnose the need to close it if possible. If only the lower personnel lock is open, it can be closed easily within 1 to 2 hours. While no procedures explicitly instruct the operators to close containment, the operators will be aware of the status of containment and should realize the need to close the lower personnel locks if they are open. Obviously, these actions will take place outside the control room.</p> <p>Note. If the environment in containment permitted it, they operators would also want to close the lower personnel lock into the drywell.</p>
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19)

Table 10.1.119.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators are successfully steaming or flooding the vessel/containment. They need to diagnose the need to close containment (if it is only open low) and carry-out the relevant actions.	O	The operators have initiated steaming or flooding. Procedures do not explicitly direct them to close containment. However, they are in shutdown and will be aware of the status of containment. Given the previous problems, the fact that normal means of SDC are unavailable, and that steam or water will begin to enter unacceptable areas (or have the potential to do so), the operators should be aware of the need to close containment.	Telephone conversations with plant personnel indicated that if it appeared that normal means of SDC might not be immediately restorable, then they would begin to close containment.

Table 10.1.119.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Close the lower personnel locks in containment.	One	Obstructions such as boards, hoses, cables etc. will have to be removed. The air lock doors will then need to be closed.	

Table 10.1.119.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ed}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to close the lower personnel lock into containment.	96 minutes	0	96 Minutes	SEA Calculation C90-492-01-A16. Also see Table F.2.1.

Table 10.1.119.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Remove obstructions from air lock area (boards, hoses, cable etc.)	Primary containment	--	--	See below	In telephone conversations with plant personnel, it was stated that the personnel lock could be closed easily within 1 to 2 hours. The outside estimate of 2 hours was assumed for determining the HEP.
2. Secure the air lock doors.	Primary Containment	--	--	2 hours Total to complete closing of the personnel lock.	

Table 10.1.119.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to close containment.	96 minutes	Approx. 2 hours	36 minutes	

Table 10.1.119.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to close the lower personnel lock in order to seal containment in the context of flooding or steaming.	Per ASEP HRAP Table 8-3, the upper bound value from ASEP Figure 8-1 for 36 minutes diagnosis time was assigned.		<p align="center">Median = 0.01</p> <p align="center">EF = 10</p> <p align="center">Mean = 0.027</p>	Interviews with operators indicated a good awareness of the need to close containment. However, exactly when the operators should begin to close containment in the present scenario is not explicitly indicated by procedure and the operators could delay the action on the assumption that normal SDC will be restored. Thus, the upper bound value from ASEP HRAP Figure 8-1 was assigned.

Table 10.1.119.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Remove obstructions and close the lower personnel hatch into containment.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.119.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_E < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Remove obstructions and close the lower personnel hatch into containment.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems may still be available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.119.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)^{op}	Independent Check/Correction HEP (HEP_{ic}) (3)^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to close containment in the context of steaming or flooding the vessel.	Median = 0.01 Mean = 0.027	--	Med. Mean 0.01 0.027	(10)	
2. Remove obstructions.	Median 0.02 Mean = 0.032	See below —	0.02 0.032	(5)	
3. Secure air locks.	Median 0.02 Mean = 0.032	Credit for a second check was not given for either action in this instance because of the limited time available and the location of the personnel lock.	<u>0.02</u> <u>0.032</u> 0.05 0.09 Total Median HEP = 0.05 Total Mean HEP = 0.09	<u>(5)</u> (10)	Since all HEPs made significant contributions to the total HEP, the larger error factor was assigned.

Table 10.1.120.1
HEP 120 Calculation

Recovery Action (1)	RA-OPICT-2
Event Description (2)	RA-OPICT-2 is the operator action to close containment if only the lower personnel lock is open (containment is open "low") and not the large equipment hatch.
Event Context (3)	<p>For RA-OPICT-2, the operators have initiated ECCS water solid operation. They would want to prevent any generated steam from leaving containment (particularly if SPC and CS had failed) and they would want to prevent any possible release if the situation deteriorated. Therefore, if primary containment is open, they should diagnose the need to close it if possible. If only the lower personnel lock is open, it can be closed easily within 1 to 2 hours. While no procedures explicitly instruct the operators to close containment, the operators will be aware of the status of containment and should realize the need to close the lower personnel locks if they are open. Obviously, these actions will take place outside the control room.</p> <p>Note. If the environment in containment permitted it, they operators would also want to close the lower personnel lock into the drywell.</p>
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19)

Table 10.1.120.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators have successfully initiated ECCS water solid operation. They need to diagnose the need to close containment (if it is only open low) and carry-out the relevant actions.	O	The operators have initiated water solid operation. Procedures do not explicitly direct them to close containment. However, they are in shutdown and will be aware of the status of containment. Given the previous problems, the fact that normal means of SDC are unavailable, and that steam could begin to enter unacceptable areas (or have the potential to do so), the operators should be aware of the need to close containment.	Telephone conversations with plant personnel indicated that if it appeared that normal means of SDC might not be immediately restorable, then they would begin to close containment.

Table 10.1.120.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Close the lower personnel locks in containment.	One	Obstructions such as boards, hoses, cables etc. will have to be removed. The air lock doors will then need to be closed.	

Table 10.1.120.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{α}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to close the lower personnel lock into containment.	6.4 hours	Under ECCS water solid conditions, operators indicated that if normal SDC had not been restored within an hour, they would be likely to be begin to consider the closing of containment. 1 hour	5.4 hours	SEA Calculation C90-492-01-A16.

Table 10.1.120.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Remove obstructions from air lock area (boards, hoses, cable etc.)	Primary containment	--	--	See below	In telephone conversations with plant personnel, it was stated that the containment personnel lock could be closed easily within 1 to 2 hours. The outside estimate of 2 hours was assumed for determining the HEP.
2. Secure the air lock doors.	Primary Containment	--	--	2 hours Total to complete closing of the personnel lock.	

Table 10.1.120.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to close containment.	5.4 hours	Approx. 2 hours	3.4 hours	

Table 10.1.120.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to close the lower personnel lock in order to seal containment in the context of a loss of normal SDC and the initiation of ECCS water solid operation.	Per ASEP HRAP Table 8-3, the upper bound value from ASEP Figure 8-1 for approximately 3.4 hours diagnosis time was assigned.		Median = 0.001 EF = 10 Mean = 0.0027	Interviews with operators indicated a good awareness of the need to close containment. However, exactly when the operators should begin to close containment in the present scenario is not explicitly indicated by procedure and the operators could delay the action on the assumption that normal SDC will be restored. Thus, the upper bound value from ASEP HRAP Figure 8-1 was assigned.

Table 10.1.120.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Remove obstructions and close the lower personnel hatch into containment.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.120.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _m < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Remove obstructions and close the lower personnel hatch into containment.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems may still be available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.120.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to close containment in the context of steaming or flooding the vessel.	Median = 0.001 Mean = 0.0027	--	Med. Mean 0.001 0.0027	(10)	
2. Remove obstructions.	Median 0.02 Mean = 0.032	See below	0.02 0.032	(5)	
3. Secure air locks.	Median 0.02 Mean = 0.032	Credit for a second check was not given for either action in this instance because of the limited time available and the location of the personnel lock.	<u>0.02</u> <u>0.032</u> 0.041 0.067 Total Median HEP = 0.041 Total Mean HEP = 0.067	<u>(5)</u> (5)	The error factor from the dominant HEP was assigned.

Table 10.1.121.1
HEP 121 Calculation

Recovery Action (1)	RA-SWXT-1
Event Description (2)	RA-SWXT-1 is the operator action to provide makeup with SSWXT for "steaming" the vessel.
Event Context (3)	For the RA-SWXT-1 calculation (HEP 121), the operators have diagnosed the fact that they are by default "steaming" the vessel and have opened at least 1 SRV. With the SRVs open, the operators will now have approximately 1.6 hours to provide makeup to the vessel before boil-off to the top of the core occurs (2.6 hours minus 1 hour allowed for earlier operator actions which may or may not have succeeded (OPECS, OPFLD, OPSTM etc., see Table F.2.1). Except for diagnosing that they are steaming the vessel and that they have opened 1 SRV, no assumptions about prior operator actions were made. RA-SWXT-1 is the operator action to diagnose the need for makeup, select SSWXT (FW is the only other system available), and initiate the system. Power was assumed to be available, so SSWXT can be initiated from the control room.
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.1.121.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators need to provide makeup with SSWXT to successfully steam the vessel. They have already opened 1 SRV.	O	The operators have diagnosed that they are steaming the vessel by default and have opened 1 SRV. Temperature will increase to a point and level will gradually decrease. Given their correct diagnosis, they will be aware of the need to provide some form of makeup. EP-2 will indicate a need for level control.	

Table 10.1.121.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators need to provide makeup with SSWXT to successfully steam the vessel. They have already opened 1 SRV.	One	Initiate injection with SSWXT per RHR SOI, Step 6.10.	

Table 10.1.121.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_w) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to initiate SSWXT to provide level for steaming.	96 minutes	0	96 Minutes	SEA Calculation C90-492-01-A16. Also see Table F.2.1.

Table 10.1.121.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Initiate vessel injection with SSWXT.	CR	--	1 minute	1 minute Total.	Per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action in the CR.

Table 10.1.121.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to initiate SSWXT to provide level for steaming.	96 minutes	1 minute	Approx. 95 minutes	

Table 10.1.121.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to initiate SSWXT to provide level for steaming.	Per ASEP HRAP Table 8-3, the median value from ASEP Figure 8-1 for 95 minutes diagnosis time was assigned.		Median = 1.0E-4 EF = 30 Mean = 9.0E-4	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. In the present context, the operators have decided to steam and have opened 1 SRV. Thus, even though steaming is not proceduralized, they will be likely to realize the need for makeup. EP-2 directs the need for level control even without the notion of steaming and SSWXT is one of the options.

Table 10.1.121.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Initiate injection with SSWXT.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.121.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _E < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate injection with SSWXT.	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.121.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to initiate SSWXT to provide level for steaming.	Median = 1.0E-4 Mean = 9.0E-4	--	Med. Mean 1.0E-4 9.0E-4	(30)	
2. Initiate SSWXT injection.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given in this instance (see Column 6 for rationale).	<u>0.02</u> <u>0.032</u> 0.02 0.032 Total Median HEP = 0.02 Total Mean HEP = 0.032	<u>(5)</u> (5)	This recovery HEP was assumed to be a "generic" value in the sense that previous operator performance (except for diagnosing that they were steaming and opening 1 SRV) was not taken into account. Moreover, it was assumed that another systems (FW) may still be available. The error factor associated with the dominant HEPs was assigned.

Table 10.1.122.1
HEP 122 Calculation

Recovery Action (1)	RA-SWXT-MOD1
Event Description (2)	RA-SWXT-MOD1 is the operator action to provide makeup with SSWXT for "steaming" the vessel.
Event Context (3)	For the RA-SWXT-MOD1 calculation (HEP 122), the operators have diagnosed the fact that they are by default "steaming" the vessel and have opened at least 1 SRV. With the SRVs open, the operators will now have approximately 1.6 hours to provide makeup to the vessel before boil-off to the top of the core occurs (2.6 hours minus 1 hour allowed for earlier operator actions in the sequence (OPECS, OPFLD, OPSTM etc., see Table F.2.1). In calculating the HEP for this recovery action, it was assumed that the operators had attempted to follow procedure in earlier parts of the relevant sequences (i.e., they had attempted ECCS water solid operation (OPECS succeeds)) and had been performing correctly. RA-SWXT-1 is the operator action to diagnose the need for makeup, select SSWXT, and initiate the system. Power was assumed to be available, so SSWXT can be initiated from the control room.
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.1.122.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators need to provide makeup with SSWXT to successfully steam the vessel. They have already opened 1 SRV.	O	The operators have diagnosed that they are steaming the vessel by default and have opened 1 SRV. Temperature will increase to a point and level will gradually decrease. Given their correct diagnosis, they will be aware of the need to provide some form of makeup. EP-2 will indicate a need for level control.	

Table 10.1.122.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators need to provide makeup with SSWXT to successfully steam the vessel. They have already opened 1 SRV.	One	Initiate injection with SSWXT per RHR SOI, Step 6.10.	

Table 10.1.122.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to initiate SSWXT to provide level for steaming.	96 minutes	0	96 Minutes	SEA Calculation C90-492-01-A16. Also see Table F.2.1.

Table 10.1.122.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Initiate vessel injection with SSWXT.	CR	--	1 minute	1 minute Total.	Per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action in the CR.

Table 10.1.122.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to initiate SSWXT to provide level for steaming.	96 minutes	1 minute	Approx. 95 minutes	

Table 10.1.122.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to initiate SSWXT to provide level for steaming.	Per ASEP HRAP Table 8-3, the median value from ASEP Figure 8-1 for 95 minutes diagnosis time was assigned.		Median = 1.0E-4 EF = 30 Mean = 9.0E-4	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. In the present context, the operators have decided to steam and have opened 1 SRV. Thus, even though steaming is not proceduralized, they will be likely to realize the need for makeup. EP-2 directs the need for level control even without the notion of steaming and SSWXT is one of the options.

Table 10.1.122.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Initiate injection with SSWXT.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.122.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate injection with SSWXT.	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.122.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to initiate SSWXT to provide level for steaming.	Median = 1.0E-4 Mean = 9.0E-4	--	Med. Mean 1.0E-4 9.0E-4	(30)	
2. Initiate SSWXT injection.	Med. = 0.02 Mean = 0.032	Credit for a second and third check were given. It was assumed that the operators have performed correctly to this point and that SSWXT may be their last line of defense (given the time required to align FW). Ample time is available for recovery credit for any failed actions. The HEPs for the second and third check were: Median = .2 Mean = .323	<u>0.0008</u> <u>0.0033</u> 0.0009 0.0042 Total Median HEP = 0.0009 Total Mean HEP = 0.0042	<u>(5)</u> (5)	Second check HEPs are multiplied by the original HEP for each action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned

Table 10.1.123.1
HEP 123 Calculation

Recovery Action (1)	RA-FWLVL-1
Event Description (2)	RA-FWLVL-1 is the operator action to align FW for RPV injection to "steam" the vessel.
Event Context (3)	For the RA-FWLVL-1 calculation (HEP 123), the operators have diagnosed the fact that they are by default "steaming" the vessel and have opened at least 1 SRV. With the SRVs open, the operators will now have approximately 1.6 hours to provide makeup to the vessel before boil-off to the top of the core occurs (2.6 hours minus 1 hour allowed for earlier operator actions (OPECS, OPFLD, OPSTM etc., see Table F.2.1). RA-FWLVL-1 is the operator action to diagnose the need for makeup, select FW (which is the only available system), and align and initiate FW for RPV injection (per Attachment 26 of EP-2). In calculating the HEP for this recovery action, it was assumed that the operators had attempted to follow procedure in earlier parts of the relevant sequences (i.e., they had attempted ECCS water solid operation (OPECS succeeds)) and had been performing correctly.
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19), EP-2 (Attachment 26, Injection into the RPV with Fire Protection Water System, 05-S-01-EP2-2).

Table 10.1.123.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators need to provide makeup with FW to successfully steam the vessel. They have already opened 1 SRV.	O	The operators have diagnosed that they are steaming the vessel by default and have opened 1 SRV. Temperature will increase to a point and level will gradually decrease. Given their correct diagnosis, they will be aware of the need to provide some form of makeup. EP-2 will indicate a need for level control and FW is the only available system. Attachment 26 of EP-2 describes how to align FW for RPV injection.	

Table 10.1.123.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators need to align and provide makeup with FW to successfully steam the vessel. They have already opened 1 SRV.	One	<p>Per EP-2, Attachment 26:</p> <ol style="list-style-type: none"> 1. As many as 10 different hose connections must be made in the Auxiliary Building for <u>complete</u> alignment of the FW system. However, a couple of connections would be adequate to begin injection and the others could follow (Step 2.1). 2. Open any one of 4 valves (Step 2.2.1). 3. Start the FW pumps and pressurize the hose (Step 2.2.2a,b). 4. Open the test connection valves (connected in Step 2.1) and check for flow (2.2.2c) 	

Table 10.1.123.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ω}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to initiate FW to provide level for steaming.	96 minutes	0	96 Minutes	SEA Calculation C90-492-01-A16. Also see Table F.2.1.

Table 10.1.123.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Align FW system for RPV injection (see Table 10.1.123.3 above for description of actions).	Aux. Building	—	60 to 70 minutes	60 to 70 minutes	The travel and performance time estimate was based on examination of the procedure (EP-2, Attachment 26) and discussions with plant personnel. At least some injection with FW could be easily completed within an hour.

Table 10.1.123.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to align and initiate FW to provide level for steaming.	96 minutes	Approx. 70 minutes	26 minutes	

Table 10.1.123.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to align and initiate FW to provide level for steaming.	Per ASEP HRAP Table 8-3, the median value from ASEP Figure 8-1 for 26 minutes diagnosis time was assigned.		Median = 0.003 EF = 10 Mean = 0.008	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. In the present context, the operators have decided to steam and have opened 1 SRV. Thus, even though steaming is not proceduralized, they will be likely to realize the need for makeup. EP-2 directs the need for level control even without the notion of steaming. FW the only system available and the operators are trained to use FW in similar situations and alignment is described in EP-2.

Table 10.1.123.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Align FW for RPV injection (see Table 10.1.123.3 above for description of actions.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.123.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Align FW for RPV injection.	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.123.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^{op}	Independent Check/Correction HEP (HEP _c) (3) ^{c2}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to align and initiate FW to provide level for steaming.	Median = 0.003 Mean = 0.008	--	Med. 0.003 Mean 0.008	(10)	
2. As many as 10 different hose connections must be made in the Auxiliary Building for <u>complete</u> alignment of the FW system. However, a couple of connections would be adequate to begin injection and the others could follow (Step 2.1).	Med. = 0.02 Mean = 0.032 --	Credit for a second check on all the actions were given. It was assumed that the operators have performed correctly to this point and that FW may be their last line of defense. Furthermore, more than one person would be involved in the activity and a failure on a single test connection would not be likely to fail the entire procedure. The HEPs for the second were: Median = .2 Mean = .323	0.004 0.0104	(5)	Second check HEPs are multiplied by the original HEP for each action.
3. Open any one of 4 valves (Step 2.2.1).	Med. = 0.02 Mean = 0.032	Yes, see above.	0.004 0.0104	(5)	
4. Start the FW pumps and pressurize the hose (Step 2.2.2a,b).	Med. = 0.02 Mean = 0.032	Yes, see above.	0.004 0.0104	(5)	
5. Open the test connection valves (connected in Step 2.1) and check for flow (2.2.2c)	Med. = 0.02 Mean = 0.032	Yes, see above.	<u>0.004 0.0104</u> 0.015 0.05 Total Median HEP = 0.015 Total Mean HEP = 0.05	<u>(5)</u> (5)	The error factor associated with the dominant HEPs was assigned.

Table 10.1.124.1
HEP 124 Calculation

Recovery Action (1)	RA-ECCS-CONTROL
Event Description (2)	RA-ECCS-CONTROL is the operator action to control level after the auto-initiation of LPCI on low level. The operators have been steaming the vessel at low pressure with MSIVs open and need to control the level increase in order to avoid flooding down the open main steam lines.
Event Context (3)	For HEP 124, the operators are steaming the vessel at low pressure with MSIVs open. The operators have watched vessel level decrease and are aware that normal means of SDC are unavailable. As level has dropped, the operators will have received several alarms. At level 1, LPCI will auto-start and additional alarms will sound. At low pressure, LPCI will increase level rapidly and the operators will have about 7 minutes to control level before the begin to flood down the steam lines through the open MSIVs. The question is whether the operators will diagnose the need and control level. As noted, several alarms and indications will be available and additional alarms will sound as level increases. It was assumed that if the operators diagnose the need to control level, the action would be an "immediate emergency action" per ASEP HRA. Given the indications available, the operators awareness of the injection rate of LPCI, and (on the basis of interviews) their desire not flood down the steam lines, the correct diagnosis should be straightforward.
Applicable Procedures (7)	EP-2 (RPV Control, Rev. 19)

Table 10.1.124.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
LPCI has auto-started. The operators must realize the need to control level to avoid flooding down open main steam lines.	0	Several low level alarms would occur and the auto-start of the LPCI system would be alarmed. As level increased rapidly, additional alarms would occur.	

Table 10.1.124.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
The operators are steaming the core at low level with MSIVs open. LPCI auto-starts on low level. The operators must realize the need to control level to avoid flooding down the open main steam lines.	One	Control level from the control panel.	

Table 10.1.124.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Control level after auto-start of LPCI	7.7 minutes	0	7.7 minutes	SEA Calculation C90-492-01- A16

Table 10.1.124.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Control level to prevent flooding down open main steam lines.	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 1 min. Total	Controlling level would be more or less continuous process, but it was assumed that the initial steps to control level would require about 1 minute.

Table 10.1.124.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to control level after auto-start of LPCI in order to prevent flooding down open main steam lines.	7.7 minutes	1 minute	Approx. 6.6 minutes	Whether or not the operators would control level once they figured-out what was going on was not really in question. The operators know the injection rates and would want to control level. The limitation is the amount of time available.

Table 10.1.124.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to control level after an auto-start of LPCI on low level.	Per ASEP HRAP Table 8-3, the lower bound value from Figure 8-1 for 6.6 minutes diagnosis time was assigned.		Med. = 0.02 Mean = 0.05	Whether or not the operators would control level once they figured-out what was going on was not really in question. The operators know the injection rates and would want to control level. The limitation is the amount of time available. Thus, lower bound value for the diagnosis was assigned.

Table 10.1.124.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Control level.	N/A	The nature of the action is obvious.	No	N/A	The action was assumed to be an "immediate emergency action" per ASEP HRAP Table 8-5, Item 10. As soon as the operators realized LPCI was injecting, they would be very likely to control level.

Table 10.1.124.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Control level.	N/A ¹	N/A	No ²	N/A	N/A	The action was assumed to be an "immediate emergency action" per ASEP HRAP Table 8-5, Item 10. As soon as the operators realized that LPCI was injecting, they would be very likely to control level.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.124.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{cc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Median = 0.02 Mean = 0.05	--	Med. Mean 0.02 0.05	(10)	
2. Control level after an auto-start of LPCI on low level to prevent flooding down open steam lines.	Immediate emergency action. Median = 0.001 Mean = 0.0027	N/A	<u>0.001</u> <u>0.0027</u> 0.021 0.053 Total Median HEP = 0.021 Total Mean HEP = 0.053	<u>(10)</u> (10)	The error factors were the same for both HEPs.

**Table 10.1.125.1
HEP 125 Calculation**

Recovery Action (1)	RA-DEPRESSURIZE
Event Description (2)	RA-DEPRESSURIZE is the operator action to depressurize the vessel in order to steam at low pressure.
Event Context (3)	For the RA-DEPRESSURIZE calculation (HEP 125), the operators have decided to steam the vessel at high pressure. However, CRD and HPCS are not available and the operators have watched vessel level decrease. Since several low pressure systems are available, the logical action would be to depressurize the vessel by opening 2 SRVs, and steam at low pressure. LPCI has auto-started at level 1 and as soon as the operators depressurize, LPCI will begin to inject automatically. It was assumed that the operators would (conservatively) have about 10 minutes for the diagnosis and action once level 1 is reached. With level becoming critical and low pressure systems available or already running (LPCI on level 1), the decision to depressurize would be obvious and indicated by EP-2. The result would be steaming at low pressure with the needed makeup.
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19)

Table 10.1.125.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators are steaming at high pressure, but neither CRD or HPCS is available for injection and level is critical. Operators need to open 2 SRVs to depressurize the vessel. LPCI will begin to inject.	O	Low level signals and auto-start of LPCI on low level. EP-2 will indicate a need for level control and depressurization in order to use low pressure systems for makeup.	

Table 10.1.125.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators are steaming at high pressure, but neither CRD or HPCS is available for injection and level is critical. Operators need to open 2 SRVs to depressurize the vessel. LPCI will begin to inject.	One	Open 2SRVs from the CR	

Table 10.1.125.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to depressurize the vessel to allow steaming at low pressure.	10 minutes	0	10 minutes	Assumed per instructions of PRA team leader.

Table 10.1.125.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Open 2 SRVs.	CR	--	1 minute	1 minute	Per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action in the CR.

Table 10.1.125.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_A) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to depressurize the vessel to allow steaming at low pressure.	10 minutes	1 minute	Approximately 9 minutes	

Table 10.1.125.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Operators are steaming at high pressure, but neither CRD or HPCS is available for injection and level is critical. Operators need to open 2 SRVs to depressurize the vessel. LPCI will begin to inject, since it auto-started on level 1.	Per ASEP HRAP Table 8-3, the lower bound value from ASEP Figure 8-1 for approximately 9 minutes diagnosis time was assigned.		Median = 0.01 EF = 10 Mean = 0.027	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. In the present context, the operators have low pressure systems available for injection and level is low. All high pressure systems are unavailable. With the multiple indications and the guidance in EP-2 regarding level control, deciding to depressurize should be obvious. Thus, the lower bound from ASEP HRAP Figure 8-1 was assigned.

Table 10.1.125.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Open 2 SRVs.	N/A	Actions are obvious. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.1.125.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Open 2 SRVs.	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.1.125.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^{op}	Independent Check/Correction HEP (HEP _c) (3) ^{c2}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to depressurize the vessel to allow steaming at low pressure.	Median = 0.01 Mean = 0.027	--	Med. Mean 0.01 0.027	(30)	
2. Open 2 SRVs	Med. = 0.02 Mean = 0.032	Credit for a second and third checks on the action were given. Even though time is limited, the operators will be very concerned at this point and will be attending to any problems once the decision is made. Feedback should be immediate. The HEPs for the second and third check were: Median = .2 Mean = .323	<u>0.0008</u> <u>0.0033</u> 0.01 0.03 Total Median HEP = 0.01 Total Mean HEP = 0.03	<u>(5)</u> (10)	Second check HEPs are multiplied by the original HEP for each action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEPs was assigned.

Table 10.1.126.1
HEP 126 Calculation

Recovery Action (1)	RA-HPCS-HW-1 and RA-CRD-HW-1
Event Description (2)	RA-HPCS-HW-1 and RA-CRD-HW-1 are not operator actions. Their failure probabilities represent the combined probabilities of being unavailable because the system is out for maintenance or because of a hardware failure.
Event Context (3)	The failure probabilities for RA-HPCS-HW-1 and RA-CRD-HW-1 were used during recovery if the systems has not been asked earlier, but were asked for recovery.
Applicable Procedures (4)	N/A

Note. Tables 10.1.126.2 through 10.1.126.9 were unnecessary for HEP 126 and therefore they were not included.

Table 10.1.126.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. RA-HPCS-HW-1 Hardware + unavailability for HPCS	Mean = 0.25	N/A	Mean = 0.25		
2. RA-CRD-HW-1 Hardware + unavailability for CRD	Mean = 0.003	N/A	Mean = 0.003		

TABLE 10.2.1
Pre-accident Human Actions and Their Mean HEPs

Primary Name	Mean Probability	Event Description
ADR-XHE-RE-XV410	3.00e-02	FAILURE TO RESTORE MANUAL VALVE XV410 OPEN
CRD-XHE-RE-X217B	8.00e-03	OPERATOR FAILS TO RESTORE XV217B FOLLOWING MAINTENANCE
CSS-MOV-RE-MV28A	8.00e-03	FAILURE TO RESTORE CSS TRAIN A INJECTION VALVE AFTER MAINTENANCE
CSS-MOV-RE-MV28B	8.00e-03	FAILURE TO RESTORE CSS TRAIN B INJECTION VALVE AFTER MAINTENANCE
ESF-CCF-MC-697/8	6.75e-05	COMMON MODE MISCALIBRATION OF RX PRESS SENSORS PS-N697/698
ESF-CCF-MC-CSTLV	6.75e-05	COMMON MODE MISCALIBRATION OF CST LEVEL INSTRUMENTS
ESF-CCF-MC-DPRES	6.75e-05	MISCALIBRATION OF DRYWELL PRESSURE SENSORS 94
ESF-CCF-MC-LTO91	2.70e-04	COMMON MODE MISCALIBRATION OF REACTOR LEVEL SENSORS/TRANSM.
ESF-CCF-MC-N674	2.70e-04	COMMON MODE MISCALIBRATION OF LEVEL LS-N674C/L
ESF-CCF-MC-N679	2.70e-04	COMMON MODE FAILURE OF REACTOR PRESSURE SWITCHES N679A/B/C/D
ESF-CCF-MC-N680	2.70e-04	COMMON MODE MISCALIBRATION OF LEVEL 3 SENSORS N680A/B/C/D
ESF-CCF-MC-N681	2.70e-04	COMMON MODE MISCALIBRATION OF LEVEL 1 LIS-N681-A/B/C/D
ESF-CCF-MC-PT662	2.70e-04	COMMON MODE MISCALIBRATION OF CONTAINMENT PRESSURE SENSORS
ESF-CCF-MC-PT694	2.70e-04	MISCALIBRATION OF DRYWELL PRESSURE SENSORS 694
ESF-CCF-MC-VSLVL	6.75e-05	COMMON MODE MISCALIBRATION OF REACTOR LEVEL SENSORS/TRANSM.
HCS-XHE-RE-HPCS	5.50e-04	FAILURE TO RESTORE HPCS AFTER MAINTENANCE
IAS-MDC-RE-COO1B	1.00e+00	FAILURE TO PROPERLY RESTORE STANDBY IA COMPR.AFTER MAINT.
IAS-XHE-MC-PS	1.00e+00	MISCALIBRATION OF PRESSOR SENSOR FOR STANDBY IA COMPRESSOR
LCI-MOV-RE-MV4A	8.00e-03	MV4A MOTOR-OPERATED VALVE PS-131 IS LEFT CLOSED DUE TO TEST
LCI-MOV-RE-MV4B	8.00e-03	PS-128 MOV MV4B LEFT CLOSED BECAUSE OF TESTING

TABLE 10.2.1
Pre-accident Human Actions and Their Mean HEPs (Continued)

Primary Name	Mean Probability	Event Description
LCI-MOV-RE-MV4C	8.00e-03	MV4C (PS-124) IS LEFT CLOSED AFTER TEST
LCI-XHE-RE-LCIC	5.50e-04	FAILURE TO RESTORE LPCI TRAIN C AFTER MAINTENANCE
RHR-XHE-RE-HXA	1.00e-04	FAILURE TO RESTORE RHR A HEAT EXCHANGER COMP. AFTER MAINTENANCE
RHR-XHE-RE-HXB	1.00e-04	FAILURE TO RESTORE RHR B HEAT EXCHANGER COMP. AFTER MAINTENANCE
RHR-XHE-RE-RHRA	9.00e-04	FAILURE TO RESTORE RHR TRAIN A AFTER MAINTENANCE
RHR-XHE-RE-RHRB	9.00e-04	FAILURE TO RESTORE RHR TRAIN B AFTER MAINTENANCE
SAS-MDC-RE-COO1B	1.00e+00	FAILURE OF THE OPERATOR TO RESTORE MDC COO1B AFTER MAINTENANCE
SPM-XHE-RE-M603A	8.00e-03	MODE SELECTOR SWITCH HS-M603A NOT IN AUTO
SPM-XHE-RE-M603B	8.00e-03	MODE SELECTOR SWITCH HS-M603B NOT IN AUTO
SSW-XHE-RE-SSWA	2.50e-04	FAILURE TO RESTORE SSW TRAIN A AFTER MAINTENANCE
SSW-XHE-RE-SSWB	2.50e-04	FAILURE TO RESTORE SSW TRAIN B AFTER MAINTENANCE
SSW-XHE-RE-SSWC	3.70e-04	FAILURE TO RESTORE SSW TRAIN C AFTER MAINTENANCE
SSW-XHE-RE-TAB1	1.00e-03	FAILURE TO RESTORE SSW TRAIN A AFTER MAINTENANCE (TAB 1)
SSW-XHE-RE-TAB2	1.80e-03	FAILURE TO RESTORE SSW TRAIN A AFTER MAINTENANCE (TAB 2)
SSW-XHE-RE-TAB3	1.50e-03	FAILURE TO RESTORE SSW TRAIN B AFTER MAINTENANCE (TAB 3)
SSW-XHE-RE-TAB4	1.80e-03	FAILURE TO RESTORE SSW TRAIN B AFTER MAINTENANCE (TAB 4)

Table 10.3.1
T5D5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLECHYD.T5D
LC-LP	HEP 23	OPLECRAP.T5D
LC-LP	HEP 23	OPLECRP.T5D
LCHPC	HEP 23	OPLECRAP.T5D
LCHPC	HEP 23	OPLECHYD.T5D
LCHPC	HEP 23	OPLECRP.T5D
LCMK	HEP 85	OPDHRHYD.T5D
OP1SV	HEP 7	OPECS9.T5D
OP1SV	HEP 7	OPECSRTE.T5D
OP1SV	HEP 11	OPECSHPR.T5D
OP1SV	HEP 38	OPECSLEA.T5D
OP1SV	HEP 38	OPECSL32.T5D
OP1SV	HEP 40	OPECS.T5D
OP1SV	HEP 40	OPECS21.T5D
OP1SV	HEP 47	OPECS22.T5D
OP1SV	HEP 51	OPECSHYD.T5D
OP1SV	HEP 106	OPECSLEP.T5D
OP1SV	HEP 106	OPECS10.T5D
OP1SV	HEP 106	OPECLAP.T5D
OPDHR	HEP 3	OPDHRP.T5D
OPDHR	HEP 35	OPDHR.T5D
OPDHR	HEP 58	OPDHRHYD.T5D
OPECS	HEP 6	OPECSRTE.T5D
OPECS	HEP 6	OPECS9.T5D
OPECS	HEP 10	OPECSHPR.T5D
OPECS	HEP 18	OPECSLEP.T5D
OPECS	HEP 18	OPECS10.T5D
OPECS	HEP 18	OPECLAP.T5D

Table 10.3.1
T5D5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPECS	HEP 37	OPECSLEA.T5D
OPECS	HEP 37	OPECSL32.T5D
OPECS	HEP 39	OPECS.T5D
OPECS	HEP 39	OPECS21.T5D
OPECS	HEP 46	OPECS22.T5D
OPECS	HEP 50	OPECSHYD.T5D
OPFLD	HEP 28	OPFLDE.T5D
OPFLD	HEP 28	OPFLD.T5D
OPHIS	HEP 8	OPECSRTE.T5D
OPHIS	HEP 8	OPECSLEA.T5D
OPHIS	HEP 8	OPECSL32.T5D
OPHIS	HEP 8	OPECSLEP.T5D
OPHIS	HEP 8	OPECS9.T5D
OPHIS	HEP 8	OPECS10.T5D
OPHIS	HEP 8	OPECS.T5D
OPHIS	HEP 8	OPECLAP.T5D
OPHIS	HEP 8	OPECSHYD.T5D
OPHIS	HEP 8	OPECS21.T5D
OPHIS	HEP 8	OPECS22.T5D
OPHIS	HEP 8	OPECSHPR.T5D
OPICT	HEP 71	OPICTLCL.T5D
OPICT	HEP 71	OPICTHYD.T5D
OPICT	HEP 71	OPICT.T5D
OPIS	HEP 41	OPSTHS35.T5D
OPIS	HEP 41	OPSTH.T5D
OPIS	HEP 41	OPSTHS29.T5D
OPIS	HEP 41	OPSTHP.T5D
OPIS	HEP 57	OPSTHSRV.T5D

Table 10.3.1
TSD5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPIS	HEP 57	OPSTHF.T5D
OPIS	HEP 57	OPSTHOF.T5D
OPIS	HEP 57	OPSTHFNC.T5D
OPIS	HEP 57	OPSTHCFF.T5D
OPISA	HEP 81	OPECS21.T5D
OPISA	HEP 81	OPECSLEA.T5D
OPISA	HEP 81	OPECS22.T5D
OPLEC	HEP 23	OPLECLLA.T5D
OPLEC	HEP 23	OPLECRAP.T5D
OPLEC	HEP 23	OPLECRP.T5D
OPLEC	HEP 23	OPLECHYD.T5D
OPMSV	HEP 9	OPECSHPR.T5D
OPMSV	HEP 9	OPECS9.T5D
OPMSV	HEP 9	OPECSHYD.T5D
OPMSV	HEP 9	OPECSLEA.T5D
OPMSV	HEP 9	OPECS.T5D
OPMSV	HEP 9	OPECSRTE.T5D
OPMSV	HEP 9	OPECLAP.T5D
OPMSV	HEP 9	OPECS10.T5D
OPMSV	HEP 9	OPECSLEP.T5D
OPMSV	HEP 9	OPECS22.T5D
OPMSV	HEP 9	OPECS21.T5D
OPMSV	HEP 9	OPECSL32.T5D
OPOMS	HEP 82	OPSTMSRV.T5D
OPOMS	HEP 82	OPSTMNFD.T5D
OPOMS	HEP 82	OPSTMNFS.T5D
OPOMS	HEP 82	OPSTMOF.T5D
OPOMS	HEP 82	OPSTMMKU.T5D

Table 10.3.1
T5D5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSDC	HEP 1	OPSDC.T5D
OPSDC	HEP 2	OPSDC.T5D
OPSDC	HEP 20	OPSDC.T5D
OPSOF	HEP 12	OPECSHPR.T5D
OPSOF	HEP 30	OPSOF.T5D
OPSPM	HEP 26	OPICT.T5D
OPSPM	HEP 26	OPICTHYD.T5D
OPSPM	HEP 26	OPICTLCL.T5D
OPSTH	HEP 42	OPSTHSRV.T5D
OPSTH	HEP 42	OPSTHS29.T5D
OPSTH	HEP 42	OPSTHS35.T5D
OPSTH	HEP 42	OPSTHOF.T5D
OPSTH	HEP 42	OPSTHCFF.T5D
OPSTH	HEP 42	OPSTHF.T5D
OPSTH	HEP 42	OPSTHFNC.T5D
OPSTH	HEP 42	OPSTH.T5D
OPSTH	HEP 55	OPSTHP.T5D
OPSTM	HEP 29	OPSTMMKU.T5D
OPSTM	HEP 29	OPSTMNFD.T5D
OPSTM	HEP 29	OPSTMNFS.T5D
OPSTM	HEP 29	OPSTMOF.T5D
OPSTM	HEP 29	OPSTMSRV.T5D
OPSTM	HEP 29	OPSTMHPR.T5D
OPSTM	HEP 41	OPSTE81.T5D
OPSTM	HEP 49	OPSTE51.T5D
OPSTM	HEP 49	OPSTE851.T5D
OPSTM	HEP 49	OPSTEP51.T5D
OPVNT	HEP 25	OPICT.T5D

Table 10.3.1
T5D5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPVNT	HEP 25	OPICTHYD.T5D
OPVNT	HEP 25	OPICTLCI.T5D
SDCUI	HEP 54	SDCUI.T5D
SPMKN	HEP 27	OPSTMHPR.T5D
SPMKP	HEP 27	OPICT.T5D
SPMKP	HEP 27	OPICTLCI.T5D
SPMKP	HEP 27	OPICTHYD.T5D
SPMUN	HEP 26	OPSTMHPR.T5D

Table 10.3.2
T5A5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 11	OPECSHPR.T5A
OP1SV	HEP 105	OPECS3.T5A
OP1SV	HEP 106	OPECS4.T5A
OPECS	HEP 10	OPECSHPR.T5A
OPECS	HEP 16	OPECS3.T5A
OPECS	HEP 18	OPECS4.T5A
OPFLD	HEP 33	OPFLD.T5A
OPHIS	HEP 8	OPECS3.T5A
OPHIS	HEP 8	OPECS4.T5A
OPHIS	HEP 8	OPECSHPR.T5A
OPICT	HEP 71	OPICT.T5A
OPIS	HEP 41	OPSTH.T5A
OPIS	HEP 57	OPSTHCFF.T5A
OPIS	HEP 57	OPSTHFNC.T5A
OPIS	HEP 57	OPSTHOF.T5A
OPIS	HEP 57	OPSTHSRV.T5A
OPMSV	HEP 9	OPECS3.T5A
OPMSV	HEP 9	OPECS4.T5A
OPMSV	HEP 9	OPECSHPR.T5A
OPOMS	HEP 82	OPSTMMKU.T5A
OPOMS	HEP 82	OPSTMNFD.T5A
OPOMS	HEP 82	OPSTMOFP.T5A
OPOMS	HEP 82	OPSTMSRV.T5A
OPSDC	HEP 1	OPSDC.T5A
OPSOF	HEP 12	OPECSHPR.T5A
OPSOF	HEP 30	OPSOF.T5A
OPSPM	HEP 26	OPICT.T5A
OPSTH	HEP 42	OPSTH.T5A

Table 10.3.2
T5A5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTH	HEP 42	OPSTHCFF.T5A
OPSTH	HEP 42	OPSTHFNC.T5A
OPSTH	HEP 42	OPSTHOF.T5A
OPSTH	HEP 42	OPSTHSRV.T5A
OPSTM	HEP 29	OPSTMMKU.T5A
OPSTM	HEP 29	OPSTMNFD.T5A
OPSTM	HEP 29	OPSTMOF.T5A
OPSTM	HEP 29	OPSTMSRV.T5A
OPSTM	HEP 49	OPSTE51.T5A
OPSTM	HEP 49	OPSTE52.T5A
OPVNT	HEP 25	OPICT.T5A
SPMKN	HEP 27	SPMUN.T5A
SPMKN	HEP 27	SPMUNECN.T5A
SPMKP	HEP 27	OPICT.T5A
SPMUN	HEP 26	SPMUN.T5A
SPMUN	HEP 26	SPMUNECN.T5A

Table 10.3.3
TDB5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LCHPC	HEP 23	OPLEC.TDB
OP1SV	HEP 5	OPFLDFR.TDB
OP1SV	HEP 7	OPECSHYD.TDB
OP1SV	HEP 7	OPECSSDC.TDB
OP1SV	HEP 11	OPECSDC9.TDB
OP1SV	HEP 105	OPECSADH.TDB
OP1SV	HEP 106	OPECSL.TDB
OPDHR	HEP 3	OPDHR.TDB
OPECS	HEP 6	OPECSHYD.TDB
OPECS	HEP 6	OPECSSDC.TDB
OPECS	HEP 10	OPECSDC9.TDB
OPECS	HEP 16	OPECSADH.TDB
OPECS	HEP 17	OPECADH5.TDB
OPECS	HEP 18	OPECSL.TDB
OPFLD	HEP 28	OPFLDF.TDB
OPFLD	HEP 28	OPFLDFR.TDB
OPFLD	HEP 28	OPFLDHYD.TDB
OPFLD	HEP 33	OPFLDADH.TDB
OPHIS	HEP 8	OPECSADH.TDB
OPHIS	HEP 8	OPECSDC9.TDB
OPHIS	HEP 8	OPECSHYD.TDB
OPHIS	HEP 8	OPECSL.TDB
OPHIS	HEP 8	OPECSSDC.TDB
OPICT	HEP 71	OPICT.TDB
OPICT	HEP 71	OPICTHYD.TDB
OPIS	HEP 41	OPSTH.TDB
OPIS	HEP 41	OPSTHYD.TDB
OPIS	HEP 57	OPSTHCFF.TDB

Table 10.3.3
TDB5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPIS	HEP 57	OPSTHFNC.TDB
OPIS	HEP 57	OPSTHL7R.TDB
OPIS	HEP 57	OPSTHOF.TDB
OPIS	HEP 57	OPSTHOF2.TDB
OPIS	HEP 57	OPSTHS2.TDB
OPIS	HEP 57	OPSTHSRV.TDB
OPISA	HEP 81	OPECSADH.TDB
OPLEC	HEP 23	OPLEC.TDB
OPMSV	HEP 9	OPECSADH.TDB
OPMSV	HEP 9	OPECSDC9.TDB
OPMSV	HEP 9	OPECSHYD.TDB
OPMSV	HEP 9	OPECSL.TDB
OPMSV	HEP 9	OPECSSDC.TDB
OPMSV	HEP 34	OPFLDFR.TDB
OPOMS	HEP 82	OPSTMFNV.TDB
OPOMS	HEP 82	OPSTMMKO.TDB
OPOMS	HEP 82	OPSTMNFD.TDB
OPOMS	HEP 82	OPSTMNFS.TDB
OPOMS	HEP 82	OPSTMOF.TDB
OPOMS	HEP 82	OPSTMOF3.TDB
OPOMS	HEP 82	OPSTMSRV.TDB
OPOMS	HEP 82	OPSTMYD.TDB
OPSOF	HEP 12	OPECSDC9.TDB
OPSOF	HEP 30	OPSOF.TDB
OPSPM	HEP 26	OPICT.TDB
OPSPM	HEP 26	OPICTHYD.TDB
OPSTH	HEP 42	OPSTH.TDB
OPSTH	HEP 42	OPSTHCFF.TDB

Table 10.3.3
TDB5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTH	HEP 42	OPSTHFNC.TDB
OPSTH	HEP 42	OPSTHL7R.TDB
OPSTH	HEP 42	OPSTHOF.TDB
OPSTH	HEP 42	OPSTHOF2.TDB
OPSTH	HEP 42	OPSTHS2.TDB
OPSTH	HEP 42	OPSTHSRV.TDB
OPSTH	HEP 42	OPSTHYD.TDB
OPSTM	HEP 29	OPSTMFNV.TDB
OPSTM	HEP 29	OPSTMMKO.TDB
OPSTM	HEP 29	OPSTMNFD.TDB
OPSTM	HEP 29	OPSTMNFS.TDB
OPSTM	HEP 29	OPSTMOF.TDB
OPSTM	HEP 29	OPSTMOF3.TDB
OPSTM	HEP 29	OPSTMSRV.TDB
OPSTM	HEP 29	OPSTMYD.TDB
OPSTM	HEP 49	OPSTE851.TDB
OPSTM	HEP 49	OPSTE85H.TDB
OPVNT	HEP 25	OPICT.TDB
OPVNT	HEP 25	OPICTHYD.TDB
RM-LT	HEP 56	OPDHR.TDB
SDCUI	HEP 48	SDCUI.TDB
SPMKN	HEP 27	SPMUNECN.TDB
SPMKP	HEP 27	OPICT.TDB
SPMKP	HEP 27	OPICTHYD.TDB
SPMUN	HEP 26	SPMUNECN.TDB

Table 10.3.4
TIA5H¹ HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLCR31.TIA
LCHPC	HEP 23	OPLCR31.TIA
LCMK	HEP 85	OPDHRHYD.TIA
OP1SV	HEP 5	OPFLD.TIA
OP1SV	HEP 5	OPFLD2.TIA
OP1SV	HEP 5	OPFLDHY2.TIA
OP1SV	HEP 7	OPCSDC12.TIA
OP1SV	HEP 7	OPECSDC5.TIA
OP1SV	HEP 7	OPECSDC9.TIA
OP1SV	HEP 7	OPECSHY2.TIA
OP1SV	HEP 11	OPCSDC11.TIA
OP1SV	HEP 15	OPCADH20.TIA
OP1SV	HEP 51	OPECSHYD.TIA
OP1SV	HEP 51	OPECSLEA.TIA
OP1SV	HEP 106	OPCSDC10.TIA
OP1SV	HEP 106	OPCSEL32.TIA
OP1SV	HEP 106	OPECSDC6.TIA
OP1SV	HEP 106	OPECSLP8.TIA
OPCMT	HEP 73	OPICTFC.TIA
OPDHR	HEP 3	OPDHR.TIA
OPDHR	HEP 58	OPDHRHYD.TIA
OPECS	HEP 6	OPCSDC12.TIA
OPECS	HEP 6	OPECSDC5.TIA
OPECS	HEP 6	OPECSDC9.TIA
OPECS	HEP 6	OPECSHY2.TIA
OPECS	HEP 10	OPCSDC11.TIA
OPECS	HEP 13	OPCADH21.TIA
OPECS	HEP 14	OPCADH20.TIA
OPECS	HEP 18	OPCSDC10.TIA

Table 10.3.4
TIA5H¹ HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPECS	HEP 18	OPCSEL32.TIA
OPECS	HEP 18	OPECSDC6.TIA
OPECS	HEP 18	OPECSLP8.TIA
OPECS	HEP 50	OPECSHYD.TIA
OPECS	HEP 50	OPECSLEA.TIA
OPECS	HEP 101	OPCADH14.TIA
OPECS	HEP 101	OPCSDC13.TIA
OPECS	HEP 102	OPCADH26.TIA
OPFLD	HEP 28	OPFLD.TIA
OPFLD	HEP 28	OPFLD2.TIA
OPFLD	HEP 28	OPFLDHY2.TIA
OPFLD	HEP 28	OPFLDP.TIA
OPHIS	HEP 8	OPCADH20.TIA
OPHIS	HEP 8	OPCSDC10.TIA
OPHIS	HEP 8	OPCSDC11.TIA
OPHIS	HEP 8	OPCSDC12.TIA
OPHIS	HEP 8	OPCSEL32.TIA
OPHIS	HEP 8	OPECSDC5.TIA
OPHIS	HEP 8	OPECSDC6.TIA
OPHIS	HEP 8	OPECSDC9.TIA
OPHIS	HEP 8	OPECSHY2.TIA
OPHIS	HEP 8	OPECSHYD.TIA
OPHIS	HEP 8	OPECSLEA.TIA
OPHIS	HEP 8	OPECSLP8.TIA
OPICT	HEP 71	OPICT.TIA
OPICT	HEP 71	OPICTEC2.TIA
OPICT	HEP 71	OPICTECP.TIA
OPICT	HEP 71	OPICTFC.TIA
OPICT	HEP 71	OPICTHYD.TIA

Table 10.3.4
TIA5H¹ HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPIS	HEP 41	OPSTH.TIA
OPIS	HEP 41	OPSTH2.TIA
OPIS	HEP 41	OPSTH3.TIA
OPIS	HEP 41	OPSTH4.TIA
OPIS	HEP 41	OPSTH5.TIA
OPIS	HEP 57	OPSTHCFF.TIA
OPIS	HEP 57	OPSTHFNC.TIA
OPIS	HEP 57	OPSTHOF.TIA
OPIS	HEP 57	OPSTHSRV.TIA
OPISA	HEP 81	OPCADH20.TIA
OPISA	HEP 81	OPECSLEA.TIA
OPLC	HEP 23	OPLCR31.TIA
OPMSV	HEP 9	OPCADH20.TIA
OPMSV	HEP 9	OPCSDC10.TIA
OPMSV	HEP 9	OPCSDC11.TIA
OPMSV	HEP 9	OPCSDC12.TIA
OPMSV	HEP 9	OPCSEL32.TIA
OPMSV	HEP 9	OPECSDC5.TIA
OPMSV	HEP 9	OPECSDC6.TIA
OPMSV	HEP 9	OPECSDC9.TIA
OPMSV	HEP 9	OPECSHY2.TIA
OPMSV	HEP 9	OPECSHYD.TIA
OPMSV	HEP 9	OPECSLEA.TIA
OPMSV	HEP 9	OPECSLP8.TIA
OPMSV	HEP 34	OPFLD.TIA
OPMSV	HEP 34	OPFLD2.TIA
OPMSV	HEP 82	OPSTMFD2.TIA
OPOMS	HEP 82	OPSTMFD3.TIA
OPOMS	HEP 82	OPSTMFS2.TIA

Table 10.3.4
TIA5H¹ HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPOMS	HEP 82	OPSTMMK2.TIA
OPOMS	HEP 82	OPSTMMKU.TIA
OPOMS	HEP 82	OPSTMNFS.TIA
OPOMS	HEP 82	OPSTMOF.TIA
OPOMS	HEP 82	OPSTMSRV.TIA
OPOMS	HEP 82	OPSTMSV2.TIA
OPOMS	HEP 82	OPSTMYD2.TIA
OPSDC	HEP 1	OPSDCSDC.TIA
OPSDC	HEP 2	OPSDCADH.TIA
OPSDC	HEP 20	OPXTIE.TIA
OPSOF	HEP 12	OPCSDC11.TIA
OPSOF	HEP 30	OPSOF.TIA
OPSOF	HEP 30	OPSOF2.TIA
OPSOF	HEP 30	OPSOF9.TIA
OPSPM	HEP 26	OPICT.TIA
OPSPM	HEP 26	OPICTEC2.TIA
OPSPM	HEP 26	OPICTECP.TIA
OPSPM	HEP 26	OPICTHYD.TIA
OPSTH	HEP 42	OPSTH.TIA
OPSTH	HEP 42	OPSTH2.TIA
OPSTH	HEP 42	OPSTH4.TIA
OPSTH	HEP 42	OPSTH5.TIA
OPSTH	HEP 42	OPSTHCFF.TIA
OPSTH	HEP 42	OPSTHFNC.TIA
OPSTH	HEP 42	OPSTHOF.TIA
OPSTH	HEP 42	OPSTHSRV.TIA
OPSTH	HEP 55	OPSTH3.TIA
OPSTM	HEP 29	OPSTMFD2.TIA
OPSTM	HEP 29	OPSTMFD3.TIA

Table 10.3.4
TIA5H¹ HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTM	HEP 29	OPSTMFS2.TIA
OPSTM	HEP 29	OPSTMMK2.TIA
OPSTM	HEP 29	OPSTMMKU.TIA
OPSTM	HEP 29	OPSTMNFS.TIA
OPSTM	HEP 29	OPSTMOF.TIA
OPSTM	HEP 29	OPSTMSRV.TIA
OPSTM	HEP 29	OPSTMSV2.TIA
OPSTM	HEP 29	OPSTMYD2.TIA
OPSTM	HEP 49	OPSTE51.TIA
OPSTM	HEP 49	OPSTE51P.TIA
OPSTM	HEP 49	OPSTE81.TIA
OPSTM	HEP 49	OPSTE812.TIA
OPSTM	HEP 49	OPSTMYD.TIA
OPVNT	HEP 25	OPICT.TIA
OPVNT	HEP 25	OPICTEC2.TIA
OPVNT	HEP 25	OPICTECP.TIA
OPVNT	HEP 25	OPICTFC.TIA
OPVNT	HEP 25	OPICTHYD.TIA
SDCUI	HEP 52	SDCUI.TIA
SPMKN	HEP 27	SPMUNECN.TIA
SPMKP	HEP 27	OPICT.TIA
SPMKP	HEP 27	OPICTEC2.TIA
SPMKP	HEP 27	OPICTECP.TIA
SPMKP	HEP 27	OPICTHYD.TIA
SPMUN	HEP 26	SPMUNECN.TIA
XTIEB	HEP 19	OPXTIE.TIA

¹The same operator actions and HEPs used for TIA5H were also used for T5B5H and T5C5H.

Table 10.3.5
TAB5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 7	OPECSHYD.TAB
OP1SV	HEP 7	OPECSSDC.TAB
OP1SV	HEP 11	OPECSDC4.TAB
OP1SV	HEP 11	OPECSDC9.TAB
OP1SV	HEP 105	OPECSADH.TAB
OPECS	HEP 6	OPECSHYD.TAB
OPECS	HEP 6	OPECSSDC.TAB
OPECS	HEP 10	OPECSDC4.TAB
OPECS	HEP 10	OPECSDC9.TAB
OPECS	HEP 16	OPECSADH.TAB
OPECS	HEP 17	OPECADH5.TAB
OPFLD	HEP 33	OPFLDF.TAB
OPHIS	HEP 8	OPECSADH.TAB
OPHIS	HEP 8	OPECSDC4.TAB
OPHIS	HEP 8	OPECSDC9.TAB
OPHIS	HEP 8	OPECSHYD.TAB
OPHIS	HEP 8	OPECSSDC.TAB
OPICT	HEP 71	OPICT.TAB
OPICT	HEP 71	OPICTHYD.TAB
OPIS	HEP 41	OPSTHSTM.TAB
OPIS	HEP 57	OPSTH.TAB
OPIS	HEP 57	OPSTHCFF.TAB
OPIS	HEP 57	OPSTHFNC.TAB
OPISA	HEP 81	OPECSADH.TAB
OPMSV	HEP 9	OPECSADH.TAB
OPMSV	HEP 9	OPECSDC4.TAB
OPMSV	HEP 9	OPECSDC9.TAB
OPMSV	HEP 9	OPECSHYD.TAB

Table 10.3.5
TAB5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPMSV	HEP 9	OPECSSDC.TAB
OPOMS	HEP 82	OPSTMFWF.TAB
OPOMS	HEP 82	OPSTMMKH.TAB
OPOMS	HEP 82	OPSTMMKO.TAB
OPOMS	HEP 82	OPSTMNFD.TAB
OPOMS	HEP 82	OPSTMSRV.TAB
OPSDC	HEP 1	OPSDC.TAB
OPSOF	HEP 12	OPECSDC4.TAB
OPSOF	HEP 12	OPECSDC9.TAB
OPSOF	HEP 30	OPSOF.TAB
OPSPM	HEP 26	OPICT.TAB
OPSPM	HEP 26	OPICTHYD.TAB
OPSTH	HEP 42	OPSTH.TAB
OPSTH	HEP 42	OPSTHCFF.TAB
OPSTH	HEP 42	OPSTHFNC.TAB
OPSTH	HEP 42	OPSTHSTM.TAB
OPSTM	HEP 29	OPSTMMKH.TAB
OPSTM	HEP 29	OPSTMMKO.TAB
OPSTM	HEP 29	OPSTMNFD.TAB
OPSTM	HEP 29	OPSTMSRV.TAB
OPSTM	HEP 49	OPSTE851.TAB
OPSTM	HEP 49	OPSTMFWF.TAB
OPVNT	HEP 25	OPICT.TAB
OPVNT	HEP 25	OPICTHYD.TAB
SDCUI	HEP 48	SDCUI.TAB
SPMKP	HEP 27	OPICT.TAB
SPMKP	HEP 27	OPICTHYD.TAB

Table 10.3.6
J2-5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 107	OPECS.J2
OPECS	HEP 61	OPECS.J2
OPHIS	HEP 8	OPECS.J2
OPICT	HEP 71	OPICTE.J2
OPICT	HEP 71	OPICTE2.J2
OPIS	HEP 57	OPSTHOSV.J2
OPIS	HEP 57	OPSTHST3.J2
OPIS	HEP 57	OPSTHST4.J2
OPMSV	HEP 9	OPECS.J2
OPOMS	HEP 82	OPOSTMSRV.J2
OPSOF	HEP 30	OPSTHOSV.J2
OPSPM	HEP 26	OPICTE.J2
OPSPM	HEP 26	OPICTE2.J2
OPSTH	HEP 42	OPSTH.J2
OPSTH	HEP 42	OPSTHOSV.J2
OPSTH	HEP 42	OPSTHST3.J2
OPSTH	HEP 42	OPSTHST4.J2
OPSTM	HEP 29	OPSTMSRV.J2
OPSTM	HEP 49	OPSTE51.J2
OPSTM	HEP 49	OPSTE512.J2
OPVNT	HEP 25	OPICTE.J2
OPVNT	HEP 25	OPICTE2.J2
SPMKP	HEP 27	OPICTE.J2
SPMKP	HEP 27	OPICTE2.J2

Table 10.3.7
E1B5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLERCP.E1B
LCHPC	HEP 23	OPLERCP.E1B
LCMK	HEP 4	OPDHR.E1B
LCMK	HEP 4	RM-LT.E1B
LCMK	HEP 85	OPDHR.E1B
LCMK	HEP 85	OPDHRP.E1B
OP1SV	HEP 7	OPECSRTE.E1B
OP1SV	HEP 7	OPECSSDC.E1B
OP1SV	HEP 11	OPECSHPR.E1B
OP1SV	HEP 51	OPECSL5.E1B
OP1SV	HEP 51	OPECSLPE.E1B
OP1SV	HEP 106	OPECSDCO.E1B
OPDHR	HEP 3	OPDHRP.E1B
OPDHR	HEP 35	OPDHR.E1B
OPECS	HEP 6	OPECSRTE.E1B
OPECS	HEP 6	OPECSSDC.E1B
OPECS	HEP 10	OPECSHPR.E1B
OPECS	HEP 18	OPECSDCO.E1B
OPECS	HEP 50	OPECSL5.E1B
OPECS	HEP 50	OPECSLPE.E1B
OPFLD	HEP 28	OPFLDE.E1B
OPFLD	HEP 33	OPFLD.E1B
OPHIS	HEP 8	OPECSDCO.E1B
OPHIS	HEP 8	OPECSHPR.E1B
OPHIS	HEP 8	OPECSL5.E1B
OPHIS	HEP 8	OPECSLPE.E1B
OPHIS	HEP 8	OPECSRTE.E1B
OPHIS	HEP 8	OPECSSDC.E1B

Table 10.3.7
E1B5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPICT	HEP 71	OPICT.E1B
OPICT	HEP 71	OPICT2.E1B
OPIS	HEP 41	OPSTH.E1B
OPIS	HEP 41	OPSTHSTM.E1B
OPIS	HEP 57	OPSTHF.E1B
OPIS	HEP 57	OPSTHFNC.E1B
OPIS	HEP 57	OPSTHOF.E1B
OPIS	HEP 57	OPSTHSRV.E1B
OPISA	HEP 81	OPECSLPE.E1B
OPLEC	HEP 23	OPLECLR.E1B
OPLEC	HEP 23	OPLECRP.E1B
OPMSV	HEP 9	OPECSDCO.E1B
OPMSV	HEP 9	OPECSHPR.E1B
OPMSV	HEP 9	OPECSL5.E1B
OPMSV	HEP 9	OPECSLPE.E1B
OPMSV	HEP 9	OPECSRTE.E1B
OPMSV	HEP 9	OPECSSDC.E1B
OPOMS	HEP 82	OPSTMMKU.E1B
OPOMS	HEP 82	OPSTMNFD.E1B
OPOMS	HEP 82	OPSTMNFS.E1B
OPOMS	HEP 82	OPSTMOF.E1B
OPOMS	HEP 82	OPSTMOF2.E1B
OPOMS	HEP 82	OPSTMSRV.E1B
OPSDC	HEP 1	RESB.E1B
OPSDC	HEP 20	RESB.E1B
OPSOF	HEP 12	OPECSHPR.E1B
OPSOF	HEP 30	OPSOF.E1B
OPSPM	HEP 26	OPICT.E1B

Table 10.3.7
E1B5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSPM	HEP 26	OPICT2.E1B
OPSTH	HEP 42	OPSTH.E1B
OPSTH	HEP 42	OPSTHF.E1B
OPSTH	HEP 42	OPSTHFNC.E1B
OPSTH	HEP 42	OPSTHOF.E1B
OPSTH	HEP 42	OPSTHSRV.E1B
OPSTH	HEP 42	OPSTHSTM.E1B
OPSTM	HEP 29	OPSTM MKU.E1B
OPSTM	HEP 29	OPSTMNFD.E1B
OPSTM	HEP 29	OPSTMNFS.E1B
OPSTM	HEP 29	OPSTM OF.E1B
OPSTM	HEP 29	OPSTM OF2.E1B
OPSTM	HEP 29	OPSTM SRV.E1B
OPSTM	HEP 49	OPSTE51.E1B
OPSTM	HEP 49	OPSTE512.E1B
OPVNT	HEP 25	OPICT.E1B
OPVNT	HEP 25	OPICT2.E1B
RESB	HEP 31	RESB.E1B
RESB	HEP 94	RESB.E1B
RM-LT	HEP 56	RM-LT.E1B
SPMKN	HEP 27	SPMUNECN.E1B
SPMKP	HEP 27	OPICT.E1B
SPMKP	HEP 27	OPICT2.E1B
SPMUN	HEP 26	SPMUNECN.E1B

Table 10.3.8
E2B5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 7	OPECSSDC.E2B
OP1SV	HEP 11	OPECSHPR.E2B
OP1SV	HEP 106	OPECSDC6.E2B
OPECS	HEP 6	OPECSSDC.E2B
OPECS	HEP 10	OPECSHPR.E2B
OPECS	HEP 18	OPECSDC6.E2B
OPFLD	HEP 33	OPFLD.E2B
OPHIS	HEP 8	OPECSDC6.E2B
OPHIS	HEP 8	OPECSHPR.E2B
OPHIS	HEP 8	OPECSSDC.E2B
OPICT	HEP 71	OPICT.E2B
OPIS	HEP 41	OPSTHSTM.E2B
OPIS	HEP 57	OPSTHF.E2B
OPIS	HEP 57	OPSTHFNC.E2B
OPIS	HEP 57	OPSTHOF.E2B
OPIS	HEP 57	OPSTHSRV.E2B
OPMSV	HEP 9	OPECSDC6.E2B
OPMSV	HEP 9	OPECSHPR.E2B
OPMSV	HEP 9	OPECSSDC.E2B
OPOMS	HEP 82	OPSTMMKU.E2B
OPOMS	HEP 82	OPSTMNFD.E2B
OPOMS	HEP 82	OPSTMOF.E2B
OPOMS	HEP 82	OPSTMSRV.E2B
OPSDC	HEP 1	OPSDC.E2B
OPSDC	HEP 20	OPSDC.E2B
OPSOF	HEP 12	OPECSHPR.E2B
OPSOF	HEP 30	OPSOF.E2B
OPSPM	HEP 26	OPICT.E2B

Table 10.3.8
E2B5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTH	HEP 42	OPSTHF.E2B
OPSTH	HEP 42	OPSTHFNC.E2B
OPSTH	HEP 42	OPSTHOF.E2B
OPSTH	HEP 42	OPSTHSRV.E2B
OPSTH	HEP 42	OPSTHSTM.E2B
OPSTM	HEP 29	OPSTMMKU.E2B
OPSTM	HEP 29	OPSTMNFD.E2B
OPSTM	HEP 29	OPSTMOF.E2B
OPSTM	HEP 29	OPSTMSRV.E2B
OPSTM	HEP 49	OPSTE51.E2B
OPVNT	HEP 25	OPICT.E2B
SPMKN	HEP 27	SPMUNECN.E2B
SPMKP	HEP 27	OPICT.E2B
SPMUN	HEP 26	SPMUNECN.E2B

Table 10.3.9
E1D5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLERAP.E1D
LCHPC	HEP 23	OPLERAP.E1D
LCMK	HEP 4	OPDHR.E1D
LCMK	HEP 85	OPDHR.E1D
LCMK	HEP 85	OPDHRP.E1D
OP1SV	HEP 7	OPECSRTE.E1D
OP1SV	HEP 40	OPECSALB.E1D
OP1SV	HEP 60	OPECSALA.E1D
OP1SV	HEP 104	OPECSEAR.E1D
OP1SV	HEP 105	OPECSADH.E1D
OP1SV	HEP 105	OPECSADP.E1D
OPDHR	HEP 3	OPDHRP.E1D
OPDHR	HEP 35	OPDHR.E1D
OPECS	HEP 6	OPECSRTE.E1D
OPECS	HEP 13	OPECSA12.E1D
OPECS	HEP 16	OPECSADH.E1D
OPECS	HEP 16	OPECSADP.E1D
OPECS	HEP 39	OPECSALB.E1D
OPECS	HEP 59	OPECSALA.E1D
OPECS	HEP 103	OPECSEAR.E1D
OPFLD	HEP 28	OPFLDE.E1D
OPFLD	HEP 28	OPFLDE2.E1D
OPHIS	HEP 8	OPECSADH.E1D
OPHIS	HEP 8	OPECSADP.E1D
OPHIS	HEP 8	OPECSALA.E1D
OPHIS	HEP 8	OPECSALB.E1D
OPHIS	HEP 8	OPECSEAR.E1D
OPHIS	HEP 8	OPECSRTE.E1D

Table 10.3.9
E1D5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPICT	HEP 71	OPICT.E1D
OPICT	HEP 71	OPICT2.E1D
OPIS	HEP 41	OPSTHSTM.E1D
OPIS	HEP 57	OPSTHF.E1D
OPIS	HEP 57	OPSTHFNC.E1D
OPISA	HEP 81	OPECSADH.E1D
OPISA	HEP 81	OPECSADP.E1D
OPISA	HEP 81	OPECSALA.E1D
OPISA	HEP 81	OPECSALB.E1D
OPISA	HEP 81	OPECSEAR.E1D
OPLEC	HEP 23	OPLECLR.E1D
OPLEC	HEP 23	OPLECRAP.E1D
OPMSV	HEP 9	OPECSADH.E1D
OPMSV	HEP 9	OPECSADP.E1D
OPMSV	HEP 9	OPECSALA.E1D
OPMSV	HEP 9	OPECSALB.E1D
OPMSV	HEP 9	OPECSEAR.E1D
OPMSV	HEP 9	OPECSRTE.E1D
OPOMS	HEP 82	OPSTMMKU.E1D
OPOMS	HEP 82	OPSTMNFS.E1D
OPSDC	HEP 2	RESAD.E1D
OPSDC	HEP 20	RESAD.E1D
OPSPM	HEP 26	OPICT.E1D
OPSPM	HEP 26	OPICT2.E1D
OPSTH	HEP 42	OPSTHF.E1D
OPSTH	HEP 42	OPSTHFNC.E1D
OPSTH	HEP 42	OPSTHSTM.E1D
OPSTM	HEP 29	OPSTMMKU.E1D

Table 10.3.9
E1D5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTM	HEP 29	OPSTMNFS.E1D
OPSTM	HEP 49	OPSTE81.E1D
OPSTM	HEP 49	OPSTE812.E1D
OPVNT	HEP 25	OPICT.E1D
OPVNT	HEP 25	OPICT2.E1D
RESAD	HEP 31	RESAD.E1D
SPMKP	HEP 27	OPICT.E1D
SPMKP	HEP 27	OPICT2.E1D

Table 10.3.10
E2D5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LCMK	HEP 85	OPDHR.E2D
LCMK	HEP 85	OPDHRP.E2D
OP1SV	HEP 7	OPECSRTE.E2D
OP1SV	HEP 40	OPECSALB.E2D
OP1SV	HEP 105	OPECSADH.E2D
OPDHR	HEP 3	OPDHRP.E2D
OPDHR	HEP 35	OPDHR.E2D
OPECS	HEP 6	OPECSRTE.E2D
OPECS	HEP 13	OPECSA07.E2D
OPECS	HEP 16	OPECSADH.E2D
OPECS	HEP 39	OPECSALB.E2D
OPFLD	HEP 28	OPFLDE.E2D
OPFLD	HEP 28	OPFLDE2.E2D
OPHIS	HEP 8	OPECSADH.E2D
OPHIS	HEP 8	OPECSALB.E2D
OPHIS	HEP 8	OPECSRTE.E2D
OPICT	HEP 71	OPICT.E2D
OPICT	HEP 71	OPICT2.E2D
OPIS	HEP 41	OPSTHSTM.E2D
OPISA	HEP 81	OPECSADH.E2D
OPISA	HEP 81	OPECSALB.E2D
OPLEC	HEP 23	OPLECLR.E2D
OPMKP	HEP 27	OPICT.E2D
OPMSV	HEP 9	OPECSADH.E2D
OPMSV	HEP 9	OPECSALB.E2D
OPMSV	HEP 9	OPECSRTE.E2D
OPOMS	HEP 82	OPSTMMKU.E2D
OPOMS	HEP 82	OPSTMNFS.E2D

Table 10.3.10
E2D5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSDC	HEP 2	OPSDCADH.E2D
OPSDC	HEP 20	OPSDCADH.E2D
OPSPM	HEP 26	OPICT.E2D
OPSPM	HEP 26	OPICT2.E2D
OPSTH	HEP 42	OPSTHSTM.E2D
OPSTM	HEP 29	OPSTMMKU.E2D
OPSTM	HEP 29	OPSTMNFS.E2D
OPSTM	HEP 49	OPSTE81.E2D
OPSTM	HEP 49	OPSTE812.E2D
OPVNT	HEP 25	OPICT.E2D
OPVNT	HEP 25	OPICT2.E2D
SPMKP	HEP 27	OPICT2.E2D

Table 10.3.11
A5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 63	OPECSISO.A5
OPECS	HEP 64	OPECSISO.A5
OPFLL	HEP 66	OPFLL.A5
OPHIS	HEP 8	OPECSISO.A5
OPICT	HEP 71	OPICTE.A5
OPOMS	HEP 82	OPSTMMKU.A5
OPSPM	HEP 26	OPICTE.A5
OPSPM	HEP 65	OPSPM.A5
OPSTH	HEP 42	OPSTH.A5
OPSTM	HEP 29	OPSTMMKU.A5
OPSTM	HEP 49	OPSTE51.A5
OPVNT	HEP 25	OPICTE.A5
SPMKP	HEP 27	OPICTE.A5

Table 10.3.12
S2H-5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 63	OPECSISO.S2H
OPCMT	HEP 73	OPICTF.S2H
OPECS	HEP 64	OPECSISO.S2H
OPFLL	HEP 76	OPFLL.S2H
OPFLL	HEP 76	OPFLL8.S2H
OPHIS	HEP 8	OPECSISO.S2H
OPICT	HEP 71	OPICTE.S2H
OPICT	HEP 71	OPICTES.S2H
OPICT	HEP 71	OPICTF.S2H
OPLDM	HEP 67	OPLDM.S2H
OPMSV	HEP 9	OPECSISO.S2H
OPSPM	HEP 26	OPICTE.S2H
OPSPM	HEP 70	OPSPM.S2H
OPSRV	HEP 68	OPFLL.S2H
OPSRV	HEP 68	OPFLL8.S2H
OPSTH	HEP 42	OPSTH.S2H
OPSTM	HEP 49	OPSTE51.S2H
OPVNT	HEP 25	OPICTE.S2H
OPVNT	HEP 25	OPICTES.S2H
OPVNT	HEP 25	OPICTF.S2H
SPMKP	HEP 27	OPICTE.S2H
SPMKP	HEP 27	OPICTES.S2H

Table 10.3.13
S3H-5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
ISSSL	HEP 74	OISSL.S3H
OPLDM	HEP 74	OISSL.S3H
OPSDC	HEP 1	OISSL.S3H
OPSDC	HEP 2	OISSL.S3H
OPSDC	HEP 20	OISSL.S3H
OPSPM	HEP 70	OPSPM.S3H

Table 10.3.14
A5HY HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPCMT	HEP 73	OPICTF.AHY
OPFLL	HEP 66	OPFLL.AHY
OPICT	HEP 71	OPICTF.AHY
OPSPM	HEP 65	OPSPM.AHY
OPVNT	HEP 25	OPICTF.AHY

Table 10.3.15
S1H-5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPCMT	HEP 73	OPICTF.S1H
OPFL	HEP 66	OPFLL.S1H
OPICT	HEP 71	OPICTF.S1H
OPSPM	HEP 65	OPSPM.S1H
OPSRV	HEP 68	OPFLL.S1H
OPVNT	HEP 25	OPICTF.S1H

Table 10.3.16
S2-5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 63	OPECSISO.S25
OPCMT	HEP 73	OPICTF.S25
OPECC	HEP 75	OPECC.S25
OPECS	HEP 64	OPECSISO.S25
OPFLL	HEP 76	OPFLL.S25
OPFLL	HEP 76	OPFLL8.S25
OPHIS	HEP 8	OPECSISO.S25
OPICT	HEP 71	OPICTE.S25
OPICT	HEP 71	OPICTES.S25
OPICT	HEP 71	OPICTF.S25
OPIS	HEP 57	OPSTH.S25
OPLDM	HEP 67	OPLDM.S25
OPMSV	HEP 9	OPECSISO.S25
OPMSV	HEP 69	OPFLL.S25
OPMSV	HEP 69	OPFLL8.S25
OPMSV	HEP 75	OPECC.S25
OPOMS	HEP 82	OPSTMMKU.S25
OPSPM	HEP 26	OPICTE.S25
OPSPM	HEP 70	OPSPM.S25
OPSRV	HEP 68	OPFLL.S25
OPSRV	HEP 68	OPFLL8.S25
OPSRV	HEP 75	OPECC.S25
OPSTH	HEP 42	OPSTH.S25
OPSTM	HEP 29	OPSTMMKU.S25
OPSTM	HEP 49	OPSTE51.S25
OPVNT	HEP 25	OPICTE.S25
OPVNT	HEP 25	OPICTES.S25
OPVNT	HEP 25	OPICTF.S25
SPMKP	HEP 27	OPICTE.S25
SPMKP	HEP 27	OPICTES.S25

Table 10.3.17
S3-5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
ISSSL	HEP 74	OISSL.S35
OPCMT	HEP 73	OPICTF.S35
OPECC	HEP 75	OPECC.S35
OPFLL	HEP 76	OPFLL.S35
OPICT	HEP 71	OPICTES.S35
OPICT	HEP 71	OPICTF.S35
OPLDM	HEP 74	OISSL.S35
OPMSV	HEP 69	OPFLL.S35
OPMSV	HEP 75	OPECC.S35
OPSDC	HEP 1	OISSL.S35
OPSDC	HEP 2	OISSL.S35
OPSDC	HEP 20	OISSL.S35
OPSPM	HEP 70	OPSPM.S35
OPSRV	HEP 68	OPFLL.S35
OPSRV	HEP 75	OPECC.S35
OPVNT	HEP 25	OPICTES.S35
OPVNT	HEP 25	OPICTF.S35
SPMKP	HEP 27	OPICTES.S35

Table 10.3.18
S1-5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 63	OPECSISO.S15
OPCMT	HEP 73	OPICTF.S15
OPECS	HEP 64	OPECSISO.S15
OPHIS	HEP 8	OPECSISO.S15
OPICT	HEP 71	OPICTE.S15
OPICT	HEP 71	OPICTF.S15
OPIS	HEP 57	OPSTH.S15
OPMSV	HEP 9	OPECSISO.S15
OPOMS	HEP 82	OPSTMMKU.S15
OPSPM	HEP 26	OPICTE.S15
OPSTH	HEP 42	OPSTH.S15
OPSTM	HEP 29	OPSTMMKU.S15
OPSTM	HEP 49	OPSTE51.S15
OPVNT	HEP 25	OPICTE.S15
OPVNT	HEP 25	OPICTF.S15
SPMKP	HEP 27	OPICTE.S15

Table 10.3.19
TIOP5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLECR.TIO
LCHPC	HEP 23	OPLECR.TIO
LCMK	HEP 4	LCMK.TIO
LCMK	HEP 4	RM-LT.TIO
LCMK	HEP 4	OPDHRHYD.TIO
LCMK	HEP 4	OPDHRHYR.TIO
LCMK	HEP 85	OPDHRHYD.TIO
LCMK	HEP 85	OPDHRHYR.TIO
OP1SV	HEP 7	OPECSADH.TIO
OP1SV	HEP 7	OPECSSDC.TIO
OP1SV	HEP 80	OPECS.P.TIO
OP1SV	HEP 108	OPECSAD5.TIO
OPDHR	HEP 58	OPDHRHYD.TIO
OPDHR	HEP 77	OPDHR.TIO
OPDHR	HEP 87	OPDHRHYR.TIO
OPECS	HEP 6	OPECSSDC.TIO
OPECS	HEP 6	OPECSADH.TIO
OPECS	HEP 78	OPECSAD5.TIO
OPECS	HEP 79	OPECS.P.TIO
OPFLD	HEP 28	OPFLDE.TIO
OPHIS	HEP 8	OPECSAD5.TIO
OPHIS	HEP 8	OPECSADH.TIO
OPHIS	HEP 8	OPECS.P.TIO
OPHIS	HEP 8	OPECSSDC.TIO
OPICT	HEP 71	OPICTE.TIO
OPICT	HEP 71	OPICTE2.TIO
OPISA	HEP 81	OPECSAD5.TIO
OPISA	HEP 81	OPECSADH.TIO

Table 10.3.19
TIOP5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPLEC	HEP 23	OPLECR.TIO
OPMSV	HEP 9	OPECSAD5.TIO
OPMSV	HEP 9	OPECSADH.TIO
OPMSV	HEP 9	OPECSSDC.TIO
OPOMS	HEP 82	OPSTMNFS.TIO
OPSDC	HEP 1	OPSDC.TIO
OPSDC	HEP 2	OPSDC.TIO
OPSDC	HEP 20	OPSDC.TIO
OPSPM	HEP 26	OPICTE.TIO
OPSPM	HEP 26	OPICTE2.TIO
OPSTM	HEP 29	OPSTMNFS.TIO
OPVNT	HEP 25	OPICTE.TIO
OPVNT	HEP 25	OPICTE2.TIO
RM-LT	HEP 56	RM-LT.TIO
RM-LT	HEP 56	OPDHRHYD.TIO
RM-LT	HEP 56	OPDHRHYR.TIO
SDCUI	HEP 52	SDCUI.TIO
SPMKP	HEP 27	OPICTE.TIO
SPMKP	HEP 27	OPICTE2.TIO

Table 10.3.20
E2C-5¹ HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LCMK	HEP 4	OPDHRHYD.E2C
LCMK	HEP 85	OPDHRHYD.E2C
OPDHR	HEP 58	OPDHRHYD.E2C
RM-LT	HEP 56	OPDHRHYD.E2C
SDCUI	HEP 52	SDCUI.E2C

¹The same operator actions and HEPs used for E2C-5 were also used for E1C-5.

Table 10.3.21
E2T5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 7	OPECSSDC.E2T
OP1SV	HEP 11	OPECSHPR.E2T
OP1SV	HEP 106	OPECSDC5.E2T
OPECS	HEP 6	OPECSSDC.E2T
OPECS	HEP 10	OPECSHPR.E2T
OPECS	HEP 18	OPECSDC5.E2T
OPFLD	HEP 28	OPFLDE.E2T
OPHIS	HEP 8	OPECSDC5.E2T
OPHIS	HEP 8	OPECSHPR.E2T
OPHIS	HEP 8	OPECSSDC.E2T
OPICT	HEP 71	OPICTE.E2T
OPICT	HEP 71	OPICTEP.E2T
OPMSV	HEP 9	OPECSDC5.E2T
OPMSV	HEP 9	OPECSHPR.E2T
OPMSV	HEP 9	OPECSSDC.E2T
OPOMS	HEP 82	OPSTMMKU.E2T
OPOMS	HEP 82	OPSTMNFD.E2T
OPOMS	HEP 82	OPSTMNFS.E2T
OPOMS	HEP 82	OPSTMOF.E2T
OPOMS	HEP 82	OPSTMSRV.E2T
OPSDC	HEP 1	OPSDC.E2T
OPSDC	HEP 20	OPSDC.E2T
OPSOF	HEP 30	OPSOF.E2T
OPSPM	HEP 26	OPICTE.E2T
OPSPM	HEP 26	OPICTEP.E2T
OPSTH	HEP 42	OPSTHSRV.E2T
OPSTH	HEP 42	OPSTHST2.E2T
OPSTH	HEP 42	OPSTHST3.E2T

Table 10.3.21
E2T5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTH	HEP 42	OPSTHST4.E2T
OPSTH	HEP 42	OPSTHSTM.E2T
OPSTM	HEP 29	OPSTM MKU.E2T
OPSTM	HEP 29	OPSTMNFD.E2T
OPSTM	HEP 29	OPSTMNFS.E2T
OPSTM	HEP 29	OPSTM OF.E2T
OPSTM	HEP 29	OPSTM SRV.E2T
OPSTM	HEP 49	OPSTE51.E2T
OPVNT	HEP 25	OPICTE.E2T
OPVNT	HEP 25	OPICTEP.E2T
SPMKP	HEP 27	OPICTE.E2T
SPMKP	HEP 27	OPICTEP.E2T

Table 10.3.22
E2V5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OP1SV	HEP 7	OPECSADH.E2V
OPECS	HEP 6	OPECSADH.E2V
OPFLD	HEP 28	OPFLDE.E2V
OPHIS	HEP 8	OPECSADH.E2V
OPICT	HEP 71	OPICTE.E2V
OPICT	HEP 71	OPICTEP.E2V
OPMSV	HEP 9	OPECSADH.E2V
OPOMS	HEP 82	OPSTMMKU.E2V
OPOMS	HEP 82	OPSTMNFD.E2V
OPOMS	HEP 82	OPSTMNFS.E2V
OPOMS	HEP 82	OPSTMOF.E2V
OPOMS	HEP 82	OPSTMSRV.E2V
OPSDC	HEP 2	OPSDC.E2V
OPSDC	HEP 20	OPSDC.E2V
OPSOF	HEP 30	OPSOF.E2V
OPSPM	HEP 26	OPICTE.E2V
OPSPM	HEP 26	OPICTEP.E2V
OPSTH	HEP 42	OPSTHSRV.E2V
OPSTH	HEP 42	OPSTHST3.E2V
OPSTH	HEP 42	OPSTHST4.E2V
OPSTH	HEP 42	OPSTHSTM.E2V
OPSTM	HEP 29	OPSTMMKU.E2V
OPSTM	HEP 29	OPSTMNFD.E2V
OPSTM	HEP 29	OPSTMNFS.E2V
OPSTM	HEP 29	OPSTMOF.E2V
OPSTM	HEP 29	OPSTMSRV.E2V
OPSTM	HEP 49	OPSTE51.E2V
OPVNT	HEP 25	OPICTE.E2V
OPVNT	HEP 25	OPICTEP.E2V
SPMKP	HEP 27	OPICTE.E2V
SPMKP	HEP 27	OPICTEP.E2V

Table 10.3.23
TLM5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLECHYD.TLM
LC-LP	HEP 23	OPLECRP.TLM
LCHPC	HEP 23	OPLECHYD.TLM
LCHPC	HEP 23	OPLECRP.TLM
LCMK	HEP 85	OPDHRHYD.TLM
LCMK	HEP 85	OPDHRHYR.TLM
OP1SV	HEP 5	OPFLDHYD.TLM
OP1SV	HEP 5	OPFLDLER.TLM
OP1SV	HEP 5	OPFLDRM.TLM
OP1SV	HEP 5	OPFLDRMH.TLM
OP1SV	HEP 7	OPECSADH.TLM
OP1SV	HEP 7	OPECSHYD.TLM
OP1SV	HEP 7	OPECSSDC.TLM
OP1SV	HEP 38	OPECSL.TLM
OP1SV	HEP 106	OPECSLHY.TLM
OP1SV	HEP 106	OPECSLP.TLM
OP1SV	HEP 108	OPECSAD5.TLM
OPDHR	HEP 3	OPDHR.TLM
OPDHR	HEP 58	OPDHRHYD.TLM
OPDHR	HEP 87	OPDHRHYR.TLM
OPEC	HEP 18	OPECSLHY.TLM
OPECS	HEP 6	OPECSADH.TLM
OPECS	HEP 6	OPECSHYD.TLM
OPECS	HEP 6	OPECSSDC.TLM
OPECS	HEP 18	OPECSLP.TLM
OPECS	HEP 37	OPECSL.TLM
OPECS	HEP 78	OPECSAD5.TLM
OPFLD	HEP 28	OPFLDE.TLM

Table 10.3.23
TLM5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPFLD	HEP 28	OPFLDHYD.TLM
OPFLD	HEP 28	OPFLDLER.TLM
OPFLD	HEP 28	OPFLDRM.TLM
OPFLD	HEP 28	OPFLDRMH.TLM
OPHIS	HEP 8	OPECSAD5.TLM
OPHIS	HEP 8	OPECSADH.TLM
OPHIS	HEP 8	OPECSHYD.TLM
OPHIS	HEP 8	OPECSL.TLM
OPHIS	HEP 8	OPECSLHY.TLM
OPHIS	HEP 8	OPECSLP.TLM
OPHIS	HEP 8	OPECSSDC.TLM
OPICT	HEP 71	OPICTE.TLM
OPICT	HEP 71	OPICTHYD.TLM
OPICT	HEP 71	OPICTLE.TLM
OPIS	HEP 41	OPSTHSTM.TLM
OPIS	HEP 57	OPSTHSRV.TLM
OPIS	HEP 57	OPSTHST2.TLM
OPIS	HEP 57	OPSTHST4.TLM
OPISA	HEP 81	OPECSAD5.TLM
OPLEC	HEP 23	OPLECHYD.TLM
OPLEC	HEP 23	OPLECRP.TLM
OPMSV	HEP 9	OPECSAD5.TLM
OPMSV	HEP 9	OPECSADH.TLM
OPMSV	HEP 9	OPECSHYD.TLM
OPMSV	HEP 9	OPECSL.TLM
OPMSV	HEP 9	OPECSLHY.TLM
OPMSV	HEP 9	OPECSLP.TLM
OPMSV	HEP 9	OPECSSDC.TLM

Table 10.3.23
TLM5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPMSV	HEP 90	OPFLDLER.TLM
OPMSV	HEP 90	OPFLDRM.TLM
OPMSV	HEP 90	OPFLDRMH.TLM
OPMSV	HEP 95	OPSTMFD2.TLM
OPMSV	HEP 95	OPSTMNFD.TLM
OPOMS	HEP 82	OPSTMFD2.TLM
OPOMS	HEP 82	OPSTMFS2.TLM
OPOMS	HEP 82	OPSTMKU2.TLM
OPOMS	HEP 82	OPSTMKUH.TLM
OPOMS	HEP 82	OPSTMMKU.TLM
OPOMS	HEP 82	OPSTMNFD.TLM
OPOMS	HEP 82	OPSTMNFS.TLM
OPOMS	HEP 82	OPSTMOF.TLM
OPOMS	HEP 82	OPSTMSRV.TLM
OPSDC	HEP 1	OPSDC.TLM
OPSDC	HEP 2	OPSDC.TLM
OPSDC	HEP 20	OPSDC.TLM
OPSOF	HEP 30	OPSOF.TLM
OPSPM	HEP 26	OPICTE.TLM
OPSPM	HEP 26	OPICTHYD.TLM
OPSPM	HEP 26	OPICTLE.TLM
OPSTH	HEP 42	OPSTHSRV.TLM
OPSTH	HEP 42	OPSTHST2.TLM
OPSTH	HEP 42	OPSTHST4.TLM
OPSTH	HEP 42	OPSTHSTM.TLM
OPSTM	HEP 29	OPSTMFD2.TLM
OPSTM	HEP 29	OPSTMFS2.TLM
OPSTM	HEP 29	OPSTMKU2.TLM

Table 10.3.23
TLM5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTM	HEP 29	OPSTMKU.H.TLM
OPSTM	HEP 29	OPSTMMKU.TLM
OPSTM	HEP 29	OPSTMNFD.TLM
OPSTM	HEP 29	OPSTMNFS.TLM
OPSTM	HEP 29	OPSTMOF.TLM
OPSTM	HEP 29	OPSTMSRV.TLM
OPSTM	HEP 49	OPSTE581.TLM
OPVNT	HEP 25	OPICTE.TLM
OPVNT	HEP 25	OPICTHYD.TLM
OPVNT	HEP 25	OPICTLE.TLM
RM-LT	HEP 56	OPDHRHYD.TLM
RM-LT	HEP 56	OPDHRHYR.TLM
SDCUI	HEP 52	SDCUI.TLM
SPMKP	HEP 27	OPICTE.TLM
SPMKP	HEP 27	OPICTHYD.TLM
SPMKP	HEP 27	OPICTLE.TLM

Table 10.3.24
E1T5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLCLR.E1T
LC-LP	HEP 23	OPLCRP.E1T
LCHPC	HEP 23	OPLCLR.E1T
LCHPC	HEP 23	OPLCRP.E1T
LCMK	HEP 4	OPDHR.E1T
LCMK	HEP 4	OPDHRLP.E1T
LCMK	HEP 85	OPDHR.E1T
LCMK	HEP 85	OPDHRLP.E1T
OP1SV	HEP 5	OPFLDLER.E1T
OP1SV	HEP 5	OPFLDRM.E1T
OP1SV	HEP 7	OPECSSDC.E1T
OP1SV	HEP 11	OPECSHPR.E1T
OP1SV	HEP 51	OPECSL5.E1T
OP1SV	HEP 51	OPECSLPE.E1T
OP1SV	HEP 80	OPECSP.E1T
OPDHR	HEP 3	OPDHRLP.E1T
OPDHR	HEP 35	OPDHR.E1T
OPECS	HEP 6	OPECSSDC.E1T
OPECS	HEP 10	OPECSHPR.E1T
OPECS	HEP 18	OPECSDCF.E1T
OPECS	HEP 50	OPECSL5.E1T
OPECS	HEP 50	OPECSLPE.E1T
OPECS	HEP 79	OPECSP.E1T
OPFLD	HEP 28	OPFLDE.E1T
OPFLD	HEP 28	OPFLDEP.E1T
OPFLD	HEP 28	OPFLDEP2.E1T
OPFLD	HEP 28	OPFLDLER.E1T
OPFLD	HEP 28	OPFLDRM.E1T
OPHIS	HEP 8	OPECSDCF.E1T

Table 10.3.24
E1T5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPHIS	HEP 8	OPECSHPR.E1T
OPHIS	HEP 8	OPECSL5.E1T
OPHIS	HEP 8	OPECSLPE.E1T
OPHIS	HEP 8	OPECSP.E1T
OPHIS	HEP 8	OPECSSDC.E1T
OPICT	HEP 71	OPICTE.E1T
OPICT	HEP 71	OPICTE2.E1T
OPICT	HEP 71	OPICTEP.E1T
OPICT	HEP 71	OPICTEP2.E1T
OPICT	HEP 71	OPICTLE.E1T
OPICT	HEP 71	SPMUNECN.E1T
OPIS	HEP 41	OPSTHL5N.E1T
OPIS	HEP 41	OPSTHSTM.E1T
OPIS	HEP 57	OPSTHL5.E1T
OPIS	HEP 57	OPSTHL6.E1T
OPIS	HEP 57	OPSTHSRV.E1T
OPIS	HEP 57	OPSTHSV2.E1T
OP1SV	HEP 106	OPECSDCF.E1T
OPLEC	HEP 23	OPLECLR.E1T
OPLEC	HEP 23	OPLECRP.E1T
OPMSV	HEP 9	OPECSDCF.E1T
OPMSV	HEP 9	OPECSHPR.E1T
OPMSV	HEP 9	OPECSL5.E1T
OPMSV	HEP 9	OPECSLPE.E1T
OPMSV	HEP 9	OPECSSDC.E1T
OPMSV	HEP 90	OPFLDLER.E1T
OPMSV	HEP 90	OPFLDRM.E1T
OPMSV	HEP 99	OPSTMSNP.E1T
OPOMS	HEP 82	OPSTMFD2.E1T

Table 10.3.24
E1T5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPOMS	HEP 82	OPSTMFD3.E1T
OPOMS	HEP 82	OPSTMFS2.E1T
OPOMS	HEP 82	OPSTMMK2.E1T
OPOMS	HEP 82	OPSTMMK3.E1T
OPOMS	HEP 82	OPSTMMKU.E1T
OPOMS	HEP 82	OPSTMOF.E1T
OPOMS	HEP 82	OPSTMOF2.E1T
OPOMS	HEP 82	OPSTMOF3.E1T
OPOMS	HEP 82	OPSTMSRV.E1T
OPOMS	HEP 82	OPSTMSV.E1T
OPSDC	HEP 1	RESC.E1T
OPSDC	HEP 20	RESC.E1T
OPSOF	HEP 30	OPSOF.E1T
OPSOF	HEP 30	OPSOF2.E1T
OPSPM	HEP 26	OPICTE.E1T
OPSPM	HEP 26	OPICTE2.E1T
OPSPM	HEP 26	OPICTEP.E1T
OPSPM	HEP 26	OPICTEP2.E1T
OPSPM	HEP 26	OPICTLE.E1T
OPSTH	HEP 42	OPSTHL4N.E1T
OPSTH	HEP 42	OPSTHL5.E1T
OPSTH	HEP 42	OPSTHL5N.E1T
OPSTH	HEP 42	OPSTHL6.E1T
OPSTH	HEP 42	OPSTHSRV.E1T
OPSTH	HEP 42	OPSTHSTM.E1T
OPSTH	HEP 42	OPSTHSV2.E1T
OPSTM	HEP 29	OPSTMFD2.E1T
OPSTM	HEP 29	OPSTMFD3.E1T
OPSTM	HEP 29	OPSTMFS2.E1T

Table 10.3.24
E1T5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTM	HEP 29	OPSTMMK2.E1T
OPSTM	HEP 29	OPSTMMK3.E1T
OPSTM	HEP 29	OPSTMMKU.E1T
OPSTM	HEP 29	OPSTMOF.E1T
OPSTM	HEP 29	OPSTMOF2.E1T
OPSTM	HEP 29	OPSTMOF3.E1T
OPSTM	HEP 29	OPSTMSRV.E1T
OPSTM	HEP 29	OPSTMSV.E1T
OPSTM	HEP 49	OPSTE51.E1T
OPSTM	HEP 49	OPSTE512.E1T
OPSTM	HEP 49	OPSTMSNP.E1T
OPVNT	HEP 25	OPICTE.E1T
OPVNT	HEP 25	OPICTE2.E1T
OPVNT	HEP 25	OPICTEP.E1T
OPVNT	HEP 25	OPICTEP2.E1T
OPVNT	HEP 25	OPICTLE.E1T
RESCS	HEP 31	RESC.E1T
RESCS	HEP 94	RESC.E1T
RM-LT	HEP 56	OPDHR.E1T
RM-LT	HEP 56	OPDHRLP.E1T
SPMKN	HEP 27	SPMUNECN.E1T
SPMKP	HEP 27	OPICTE.E1T
SPMKP	HEP 27	OPICTE2.E1T
SPMKP	HEP 27	OPICTEP.E1T
SPMKP	HEP 27	OPICTEP2.E1T
SPMKP	HEP 27	OPICTLE.E1T
SPMUN	HEP 26	SPMUNECN.E1T

Table 10.3.25
E1V5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLECLR.E1V
LCHPC	HEP 23	OPLECLR.E1V
LCMK	HEP 4	OPDHR.E1V
LCMK	HEP 4	OPDHRLAP.E1V
LCMK	HEP 85	OPDHR.E1V
LCMK	HEP 85	OPDHRLAP.E1V
OP1SV	HEP 7	OPECSAD2.E1V
OP1SV	HEP 7	OPECSADH.E1V
OP1SV	HEP 11	OPECSHPR.E1V
OP1SV	HEP 51	OPECSL5.E1V
OP1SV	HEP 51	OPECSLPE.E1V
OP1SV	HEP 60	OPECSALA.E1V
OP1SV	HEP 104	OPECSEAR.E1V
OP1SV	HEP 106	OPECSADF.E1V
OPDHR	HEP 3	OPDHRLAP.E1V
OPDHR	HEP 35	OPDHR.E1V
OPECS	HEP 6	OPECSAD2.E1V
OPECS	HEP 6	OPECSADH.E1V
OPECS	HEP 10	OPECSHPR.E1V
OPECS	HEP 18	OPECSADF.E1V
OPECS	HEP 50	OPECSL5.E1V
OPECS	HEP 50	OPECSLPE.E1V
OPECS	HEP 59	OPECSALA.E1V
OPECS	HEP 103	OPECSEAR.E1V
OPFLD	HEP 28	OPFLDE.E1V
OPHIS	HEP 8	OPECSAD2.E1V
OPHIS	HEP 8	OPECSADF.E1V
OPHIS	HEP 8	OPECSADH.E1V

Table 10.3.25
E1V5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPHIS	HEP 8	OPECSALA.E1V
OPHIS	HEP 8	OPECSEAR.E1V
OPHIS	HEP 8	OPECSHPR.E1V
OPHIS	HEP 8	OPECSL5.E1V
OPHIS	HEP 8	OPECSLPE.E1V
OPICT	HEP 71	OPICTE.E1V
OPICT	HEP 71	OPICTE2.E1V
OPICT	HEP 71	OPICTEP.E1V
OPICT	HEP 71	OPICTEP2.E1V
OPICT	HEP 71	OPICTLE.E1V
OPIS	HEP 41	OPSTHST2.E1V
OPIS	HEP 41	OPSTHSTM.E1V
OPIS	HEP 57	OPSTHL5.E1V
OPISA	HEP 81	OPECSAD2.E1V
OPISA	HEP 81	OPECSADH.E1V
OPISA	HEP 81	OPECSALA.E1V
OPISA	HEP 81	OPECSEAR.E1V
OPLEC	HEP 23	OPLECCLA.E1V
OPLEC	HEP 23	OPLECLR.E1V
OPMSV	HEP 9	OPECSAD2.E1V
OPMSV	HEP 9	OPECSADF.E1V
OPMSV	HEP 9	OPECSADH.E1V
OPMSV	HEP 9	OPECSALA.E1V
OPMSV	HEP 9	OPECSEAR.E1V
OPMSV	HEP 9	OPECSHPR.E1V
OPMSV	HEP 9	OPECSL5.E1V
OPMSV	HEP 9	OPECSLPE.E1V
OPOMS	HEP 82	OPSTMFD2.E1V

Table 10.3.25
E1V5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPOMS	HEP 82	OPSTMFS2.E1V
OPOMS	HEP 82	OPSTMMK2.E1V
OPOMS	HEP 82	OPSTMOF2.E1V
OPOMS	HEP 82	OPSTMSRV.E1V
OPSDC	HEP 2	RESC.E1V
OPSDC	HEP 20	RESC.E1V
OPSOF	HEP 30	OPSOF.E1V
OPSPM	HEP 26	OPICTE.E1V
OPSPM	HEP 26	OPICTE2.E1V
OPSPM	HEP 26	OPICTEP.E1V
OPSPM	HEP 26	OPICTEP2.E1V
OPSPM	HEP 26	OPICTLE.E1V
OPSTH	HEP 42	OPSTHL5.E1V
OPSTH	HEP 42	OPSTHSRV.E1V
OPSTH	HEP 42	OPSTHST2.E1V
OPSTH	HEP 42	OPSTHSTM.E1V
OPSTM	HEP 29	OPSTMFD2.E1V
OPSTM	HEP 29	OPSTMFS2.E1V
OPSTM	HEP 29	OPSTMMK2.E1V
OPSTM	HEP 29	OPSTMOF2.E1V
OPSTM	HEP 29	OPSTMSRV.E1V
OPSTM	HEP 49	OPSTE51.E1V
OPSTM	HEP 49	OPSTE512.E1V
OPVNT	HEP 25	OPICTE.E1V
OPVNT	HEP 25	OPICTE2.E1V
OPVNT	HEP 25	OPICTEP.E1V
OPVNT	HEP 25	OPICTEP2.E1V
OPVNT	HEP 25	OPICTLE.E1V

Table 10.3.25
E1V5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
RESCS	HEP 31	RESC.E1V
RESCS	HEP 94	RESC.E1V
RM-LT	HEP 56	OPDHR.E1V
RM-LT	HEP 56	OPDHRLAP.E1V
SPMKP	HEP 27	OPICTE.E1V
SPMKP	HEP 27	OPICTE2.E1V
SPMKP	HEP 27	OPICTEP.E1V
SPMKP	HEP 27	OPICTEP2.E1V
SPMKP	HEP 27	OPICTLE.E1V

Table 10.3.26
TIHP5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLECR.TIH
LC-LP	HEP 23	OPLECRP.TIH
LCHPC	HEP 23	OPLECR.TIH
LCHPC	HEP 23	OPLECRP.TIH
LCMK	HEP 4	OPDHR.TIH
LCMK	HEP 4	OPDHROP.TIH
LCMK	HEP 85	OPDHR.TIH
LCMK	HEP 85	OPDHROP.TIH
OP1SV	HEP 7	OPECSADH.TIH
OP1SV	HEP 7	OPECSSDC.TIH
OP1SV	HEP 38	OPECSL.TIH
OP1SV	HEP 106	OPECSLP.TIH
OP1SV	HEP 109	OPECS.TIH
OPCMT	HEP 73	OPICT2F.TIH
OPDHR	HEP 3	OPDHR.TIH
OPDHR	HEP 3	OPDHROP.TIH
OPECS	HEP 6	OPECSADH.TIH
OPECS	HEP 6	OPECSSDC.TIH
OPECS	HEP 18	OPECSLP.TIH
OPECS	HEP 37	OPECSL.TIH
OPECS	HEP 88	OPECS.TIH
OPFLD	HEP 28	OPFLDE.TIH
OPFLD	HEP 28	OPFLDE2.TIH
OPHIS	HEP 8	OPECS.TIH
OPHIS	HEP 8	OPECSADH.TIH
OPHIS	HEP 8	OPECSL.TIH
OPHIS	HEP 8	OPECSLP.TIH
OPHIS	HEP 8	OPECSSDC.TIH

Table 10.3.26
TIHP5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPHPC	HEP 86	OPHPC.TIH
OPICT	HEP 71	OPICT2F.TIH
OPICT	HEP 71	OPICTCAU.TIH
OPICT	HEP 71	OPICTE2.TIH
OPICT	HEP 71	OPICTE3.TIH
OPIS	HEP 41	OPSTHST3.TIH
OPIS	HEP 57	OPSTHST4.TIH
OPISA	HEP 81	OPECS.TIH
OPISA	HEP 81	OPECSADH.TIH
OPISA	HEP 81	OPECSL.TIH
OPLEC	HEP 23	OPLECR.TIH
OPLEC	HEP 23	OPLECRP.TIH
OPMSV	HEP 9	OPECSADH.TIH
OPMSV	HEP 9	OPECSL.TIH
OPMSV	HEP 9	OPECSLP.TIH
OPMSV	HEP 9	OPECSSDC.TIH
OPOMS	HEP 82	OPSTM51.TIH
OPOMS	HEP 82	OPSTM81.TIH
OPOMS	HEP 82	OPSTMFD2.TIH
OPOMS	HEP 82	OPSTMFS2.TIH
OPOMS	HEP 82	OPSTMFS4.TIH
OPOMS	HEP 82	OPSTMKU2.TIH
OPOMS	HEP 82	OPSTMOF.TIH
OPOMS	HEP 82	OPSTMSRV.TIH
OPSDC	HEP 1	OPSDC.TIH
OPSDC	HEP 2	OPSDC.TIH
OPSDC	HEP 20	OPSDC.TIH
OPSOF	HEP 30	OPSOF.TIH

Table 10.3.26
TIHP5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSPM	HEP 26	OPICTE2.TIH
OPSPM	HEP 26	OPICTE3.TIH
OPSTH	HEP 42	OPSTHST3.TIH
OPSTH	HEP 42	OPSTHST4.TIH
OPSTH	HEP 100	OPSTHSTM.TIH
OPSTM	HEP 29	OPSTMFD2.TIH
OPSTM	HEP 29	OPSTMFS2.TIH
OPSTM	HEP 29	OPSTMFS4.TIH
OPSTM	HEP 29	OPSTMKU2.TIH
OPSTM	HEP 29	OPSTMOF.TIH
OPSTM	HEP 29	OPSTMSRV.TIH
OPSTM	HEP 49	OPSTE513.TIH
OPSTM	HEP 96	OPSTM51.TIH
OPSTM	HEP 96	OPSTM81.TIH
OPVNT	HEP 25	OPICT2F.TIH
OPVNT	HEP 25	OPICTE2.TIH
OPVNT	HEP 25	OPICTE3.TIH
RM-LT	HEP 56	OPDHR.TIH
RM-LT	HEP 56	OPDHROP.TIH
SPMKP	HEP 27	OPICTE2.TIH
SPMKP	HEP 27	OPICTE3.TIH

Table 10.3.27
TIOF5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLECR.TIF
LC-LP	HEP 23	OPLECRP.TIF
LCHPC	HEP 23	OPLECR.TIF
LCHPC	HEP 23	OPLECRP.TIF
LCMK	HEP 85	OPDHR.TIF
OP1SV	HEP 7	OPECSADH.TIF
OP1SV	HEP 7	OPECSSDC.TIF
OP1SV	HEP 38	OPECSL.TIF
OP1SV	HEP 106	OPECSLP.TIF
OP1SV	HEP 109	OPECS.TIF
OPCMT	HEP 73	OPICT2F.TIF
OPCMT	HEP 73	OPICTF.TIF
OPDHR	HEP 3	OPDHR.TIF
OPECS	HEP 6	OPECSADH.TIF
OPECS	HEP 6	OPECSSDC.TIF
OPECS	HEP 18	OPECSLP.TIF
OPECS	HEP 37	OPECSL.TIF
OPECS	HEP 88	OPECS.TIF
OPFLD	HEP 28	OPFLDE.TIF
OPFLD	HEP 28	OPFLDE2.TIF
OPHIS	HEP 8	OPECS.TIF
OPHIS	HEP 8	OPECSADH.TIF
OPHIS	HEP 8	OPECSL.TIF
OPHIS	HEP 8	OPECSLP.TIF
OPHIS	HEP 8	OPECSSDC.TIF
OPICT	HEP 71	OPICT2F.TIF
OPICT	HEP 71	OPICTCAU.TIF
OPICT	HEP 71	OPICTE.TIF
OPICT	HEP 71	OPICTE2.TIF
OPICT	HEP 71	OPICTE3.TIF

Table 10.3.27
TIOF5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPICT	HEP 71	OPICTF.TIF
OPIS	HEP 41	OPSTHST2.TIF
OPIS	HEP 41	OPSTHST3.TIF
OPIS	HEP 57	OPSTHST4.TIF
OPISA	HEP 81	OPECS.TIF
OPISA	HEP 81	OPECSADH.TIF
OPISA	HEP 81	OPECSL.TIF
OPLEC	HEP 23	OPLECR.TIF
OPLEC	HEP 23	OPLECRP.TIF
OPMSV	HEP 9	OPECSADH.TIF
OPMSV	HEP 9	OPECSL.TIF
OPMSV	HEP 9	OPECSLP.TIF
OPMSV	HEP 9	OPECSSDC.TIF
OPOMS	HEP 82	OPSTM51.TIF
OPOMS	HEP 82	OPSTM81.TIF
OPOMS	HEP 82	OPSTMFD2.TIF
OPOMS	HEP 82	OPSTMFS2.TIF
OPOMS	HEP 82	OPSTMKU2.TIF
OPOMS	HEP 82	OPSTMMKU.TIF
OPOMS	HEP 82	OPSTMNFD.TIF
OPOMS	HEP 82	OPSTMNFS.TIF
OPOMS	HEP 82	OPSTMOPP.TIF
OPOMS	HEP 82	OPSTMSRV.TIF
OPOMS	HEP 82	OPSTMSV2.TIF
OPSDC	HEP 1	OPSDC.TIF
OPSDC	HEP 2	OPSDC.TIF
OPSDC	HEP 20	OPSDC.TIF
OPSLP	HEP 86	OPLSLP.TIF
OPSOF	HEP 30	OPSOF.TIF
OPSPM	HEP 26	OPICTE.TIF

Table 10.3.27
TIOF5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSPM	HEP 26	OPICTE2.TIF
OPSPM	HEP 26	OPICTE3.TIF
OPSTH	HEP 42	OPSTHSRV.TIF
OPSTH	HEP 42	OPSTHST2.TIF
OPSTH	HEP 42	OPSTHST3.TIF
OPSTH	HEP 42	OPSTHST4.TIF
OPSTH	HEP 42	OPSTHSTM.TIF
OPSTM	HEP 29	OPSTMFD2.TIF
OPSTM	HEP 29	OPSTMFS2.TIF
OPSTM	HEP 29	OPSTMKU2.TIF
OPSTM	HEP 29	OPSTMMKU.TIF
OPSTM	HEP 29	OPSTMNFD.TIF
OPSTM	HEP 29	OPSTMNFS.TIF
OPSTM	HEP 29	OPSTMOF.TIF
OPSTM	HEP 29	OPSTMSRV.TIF
OPSTM	HEP 29	OPSTMSV2.TIF
OPSTM	HEP 49	OPSTE512.TIF
OPSTM	HEP 49	OPSTE513.TIF
OPSTM	HEP 96	OPSTM51.TIF
OPSTM	HEP 96	OPSTM81.TIF
OPVNT	HEP 25	OPICT2F.TIF
OPVNT	HEP 25	OPICTE.TIF
OPVNT	HEP 25	OPICTE2.TIF
OPVNT	HEP 25	OPICTE3.TIF
OPVNT	HEP 25	OPICTF.TIF
RM-LT	HEP 56	OPDHR.TIF
SPMKP	HEP 27	OPICTE.TIF
SPMKP	HEP 27	OPICTE2.TIF
SPMKP	HEP 27	OPICTE3.TIF

Table 10.3.28
TORV5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLECLR.TRV
LCHPC	HEP 23	OPLECLR.TRV
LCMK	HEP 4	OPDHRHYR.TRV
LCMK	HEP 85	OPDHRHYD.TRV
LCMK	HEP 85	OPDHRHYR.TRV
OP1SV	HEP 7	OPECSHYD.TRV
OP1SV	HEP 7	OPECSTRTE.TRV
OP1SV	HEP 51	OPECSHY2.TRV
OPDHR	HEP 58	OPDHRHYD.TRV
OPDHR	HEP 87	OPDHRHYR.TRV
OPECS	HEP 6	OPECSHYD.TRV
OPECS	HEP 6	OPECSRTE.TRV
OPECS	HEP 50	OPECSHY2.TRV
OPFLD	HEP 28	OPFLDEHY.TRV
OPHIS	HEP 8	OPECSHY2.TRV
OPHIS	HEP 8	OPECSHYD.TRV
OPHIS	HEP 8	OPECSTRTE.TRV
OPICT	HEP 71	OPICTEHY.TRV
OPICT	HEP 71	OPICTHY2.TRV
OPLEC	HEP 23	OPLECLHY.TRV
OPLEC	HEP 23	OPLECLR.TRV
OPMSV	HEP 9	OPECSHY2.TRV
OPMSV	HEP 9	OPECSHYD.TRV
OPMSV	HEP 9	OPECSTRTE.TRV
OPOMS	HEP 82	OPSTMFS2.TRV
OPSPM	HEP 26	OPICTEHY.TRV
OPSPM	HEP 26	OPICTHY2.TRV
OPSTM	HEP 29	OPSTMFS2.TRV

Table 10.3.28
TORV5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPVNT	HEP 25	OPICTEHY.TRV
OPVNT	HEP 25	OPICTHY2.TRV
RM-LT	HEP 56	OPDHRHYD.TRV
RM-LT	HEP 56	OPDHRHYR.TRV
SDCUI	HEP 54	SDCUI.TRV
SPMKP	HEP 27	OPICTEHY.TRV
SPMKP	HEP 27	OPICTHY2.TRV

Table 10.3.29
T1-5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLECLAP.RAP
LC-LP	HEP 23	OPLECLP7.RP
LCHPC	HEP 23	OPLECLAP.RAP
LCHPC	HEP 23	OPLECLP7.RP
LCMK	HEP 4	OPDHR&.LP&
LCMK	HEP 4	OPDHRHYD.LP
LCMK	HEP 85	OPDHR&.LP&
LCMK	HEP 85	OPDHRHYD.LP
OP1SV	HEP 5	OPFLD.FP
OP1SV	HEP 5	OPFLDHY2.EP
OP1SV	HEP 7	OPCSDC12.EX
OP1SV	HEP 7	OPECS&.EP
OP1SV	HEP 7	OPECSHYD.EP
OP1SV	HEP 11	OPECS&.HPR
OP1SV	HEP 11	OPECSHYD.HPR
OP1SV	HEP 15	OPECSEQ8.EAP
OP1SV	HEP 51	OPECSHY2.EP
OP1SV	HEP 51	OPECSLAP.EAP
OP1SV	HEP 106	OPECSLP4.EP
OPDHR	HEP 3	OPDHR&.LP&
OPDHR	HEP 58	OPDHRHYD.LP
OPECS	HEP 6	OPCSDC12.EX
OPECS	HEP 6	OPECS&.EP
OPECS	HEP 6	OPECSHYD.EP
OPECS	HEP 10	OPECS&.HPR
OPECS	HEP 10	OPECSHYD.HPR
OPECS	HEP 13	OPECSEQ9.EAP
OPECS	HEP 14	OPECSEQ8.EAP

Table 10.3.29
T1-5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPECS	HEP 18	OPECSLP4.EP
OPECS	HEP 50	OPECSHY2.EP
OPECS	HEP 50	OPECSLAP.EAP
OPECS	HEP 101	OPCAD14.EAX
OPECS	HEP 101	OPECSDC13.EX
OPECS	HEP 102	OPECS&.HPA
OPFLD	HEP 28	OPFLD.FP
OPFLD	HEP 28	OPFLDADH.FP
OPFLD	HEP 28	OPFLDHY2.EP
OPFLD	HEP 28	OPFLDHYD.EP
OPFLD	HEP 33	OPFLD.FNP
OPHIS	HEP 8	OPCSDC12.EX
OPHIS	HEP 8	OPECS&.EP
OPHIS	HEP 8	OPECS&.HPR
OPHIS	HEP 8	OPECSEQ8.EAP
OPHIS	HEP 8	OPECSHY2.EP
OPHIS	HEP 8	OPECSHYD.EP
OPHIS	HEP 8	OPECSHYD.HPR
OPHIS	HEP 8	OPECSLAP.EAP
OPHIS	HEP 8	OPECSLP4.EP
OPICT	HEP 71	OPICT.ECP
OPICT	HEP 71	OPICT.ECX
OPICT	HEP 71	OPICTADH.ECP
OPICT	HEP 71	OPICTCAU.XX
OPICT	HEP 71	OPICTHY2.ECP
OPICT	HEP 71	OPICTHY2.ECP
OPICT	HEP 71	SPMUN2.ECN
OPIS	HEP 41	OPSTH.PP

Table 10.3.29
T1-5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPIS	HEP 41	OPSTH.PX
OPIS	HEP 41	OPSTHHYD.PP
OPIS	HEP 41	OPSTHL6N.PP
OPIS	HEP 41	OPSTHYD8.PP
OPIS	HEP 57	OPSTHL6S.PP
OPIS	HEP 57	OPSTHL7S.PP
OPIS	HEP 57	OPSTHLV6.PP
OPIS	HEP 57	OPSTHLV7.PP
OPIS	HEP 57	OPSTHLV8.PP
OPIS	HEP 57	OPSTHSRV.PP
OPISA	HEP 81	OPECSEQ8.EAP
OPISA	HEP 81	OPECSLAP.EAP
OPLEC	HEP 23	OPLECLAP.RAP
OPLEC	HEP 23	OPLECLP7.RP
OPMSV	HEP 9	OPCSDC12.EX
OPMSV	HEP 9	OPECS&.EP
OPMSV	HEP 9	OPECS&.HPR
OPMSV	HEP 9	OPECSEQ8.EAP
OPMSV	HEP 9	OPECSHY2.EP
OPMSV	HEP 9	OPECSHYD.EP
OPMSV	HEP 9	OPECSHYD.HPR
OPMSV	HEP 9	OPECSLAP.EAP
OPMSV	HEP 9	OPECSLP4.EP
OPMSV	HEP 9	OPSTM.SX
OPMSV	HEP 34	OPFLD.FP
OPMSV	HEP 95	OPSTMFD3.SP
OPMSV	HEP 99	OPSTMSNP.SNP
OPOMS	HEP 82	OPSTM.SP

Table 10.3.29
T1-5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPOMS	HEP 82	OPSTM.SX
OPOMS	HEP 82	OPSTMADH.SX
OPOMS	HEP 82	OPSTMFD2.SP
OPOMS	HEP 82	OPSTMFDE.SP
OPOMS	HEP 82	OPSTMFS2.SP
OPOMS	HEP 82	OPSTMFS3.SP
OPOMS	HEP 82	OPSTMMK3.SP
OPOMS	HEP 82	OPSTMMKO.SP
OPOMS	HEP 82	OPSTMMKO.SP2
OPOMS	HEP 82	OPSTMNFD.SP
OPOMS	HEP 82	OPSTMNFS.SP
OPOMS	HEP 82	OPSTMOF.OFP
OPOMS	HEP 82	OPSTMOF2.OFP
OPOMS	HEP 82	OPSTMOF3.OFP
OPSDC	HEP 1	OPSDC.SDC
OPSDC	HEP 2	OPSDC.ADH
OPSDC	HEP 20	OPXTIE.T1
OPSMV	HEP 9	OPSTMADH.SX
OPSOF	HEP 12	OPECS&.HPR
OPSOF	HEP 12	OPECSHYD.HPR
OPSOF	HEP 30	OPSOF.OFP
OPSPM	HEP 26	OPICT.ECP
OPSPM	HEP 26	OPICT.ECX
OPSPM	HEP 26	OPICTADH.ECP
OPSPM	HEP 26	OPICTHY2.ECP
OPSPM	HEP 26	OPICTHYD.ECP
OPSTH	HEP 42	OPSTH.PP
OPSTH	HEP 42	OPSTH.PX

Table 10.3.29
T1-5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTH	HEP 42	OPSTHHYD.PP
OPSTH	HEP 42	OPSTHL6N.PP
OPSTH	HEP 42	OPSTHL6S.PP
OPSTH	HEP 42	OPSTHL7S.PP
OPSTH	HEP 42	OPSTHLV6.PP
OPSTH	HEP 42	OPSTHLV7.PP
OPSTH	HEP 42	OPSTHLV8.PP
OPSTH	HEP 42	OPSTHSRV.PP
OPSTH	HEP 42	OPSTHYD8.PP
OPSTM	HEP 20	OPSTMFD2.SP
OPSTM	HEP 29	OPSTM.SNP
OPSTM	HEP 29	OPSTM.SP
OPSTM	HEP 29	OPSTM.SX
OPSTM	HEP 29	OPSTMADH.SX
OPSTM	HEP 29	OPSTMENP.SNP
OPSTM	HEP 29	OPSTMFD3.SP
OPSTM	HEP 29	OPSTMFNP.SNP
OPSTM	HEP 29	OPSTMFS2.SP
OPSTM	HEP 29	OPSTMFS3.SP
OPSTM	HEP 29	OPSTMHPR.ECN
OPSTM	HEP 29	OPSTM MK3.SP
OPSTM	HEP 29	OPSTM MKO.SP
OPSTM	HEP 29	OPSTM MKO.SP2
OPSTM	HEP 29	OPSTMNFD.SP
OPSTM	HEP 29	OPSTMNFS.SP
OPSTM	HEP 29	OPSTM OF.OFP
OPSTM	HEP 29	OPSTM OF2.OFP
OPSTM	HEP 29	OPSTM OF3.OFP

Table 10.3.29
T1-5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTM	HEP 49	OPSTE51H.EP
OPSTM	HEP 49	OPSTE5H.SP
OPSTM	HEP 49	OPSTE81.SP
OPSTM	HEP 49	OPSTMHYD.ECN
OPSTM	HEP 49	OPSTMSNP.SNP
OPVNT	HEP 25	OPICT.ECP
OPVNT	HEP 25	OPICT.ECX
OPVNT	HEP 25	OPICTADH.ECP
OPVNT	HEP 25	OPICTHY2.ECP
OPVNT	HEP 25	OPICTHYD.ECP
OPVNT	HEP 25	SPMUN2.ECN
SDCUI	HEP 52	SDCUI.ADP
SPMKN	HEP 27	OPSTM.SNP
SPMKN	HEP 27	SPMUN.ECN
SPMKN	HEP 27	SPMUN2.ECN
SPMKP	HEP 27	OPICT.ECP
SPMKP	HEP 27	OPICT.ECX
SPMKP	HEP 27	OPICTADH.ECP
SPMKP	HEP 27	OPICTHY2.ECP
SPMKP	HEP 27	OPICTHYD.ECP
SPMUN	HEP 26	OPSTM.SNP
SPMUN	HEP 26	SPMUN.ECN
SPMUN	HEP 26	SPMUN2.ECN
XTIEB	HEP 19	OPXTIE.T1

Table 10.3.30
H1-5H HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
ISO89	HEP 113	OPLCHPLP.H15
LC-LP	HEP 111	OPLCHPLP.H15
LCHPC	HEP 111	OPLCHPLP.H15
OP1SV	HEP 63	OPECSISO.H15
OP1SV	HEP 115	OPECS.H15
OPCMT	HEP 73	OPICTF2.H15
OPECS	HEP 64	OPECSISO.H15
OPECS	HEP 114	OPECS.H15
OPFLD	HEP 28	OPFLDE2.H15
OPHIS	HEP 8	OPECS.H15
OPHIS	HEP 8	OPECSISO.H15
OPICT	HEP 71	OPICT.H15
OPICT	HEP 71	OPICTCAU.H15
OPICT	HEP 71	OPICTE.H15
OPICT	HEP 71	OPICTF2.H15
OPICT	HEP 71	OPICTISO.H15
OPICT	HEP 71	OPICTNPE.H15
OPIS	HEP 57	OPSTHOSV.H15
OPIS	HEP 57	OPSTHSRV.H15
OPIS	HEP 57	OPSTHST2.H15
OPIS	HEP 57	OPSTHST3.H15
OPIS	HEP 57	OPSTHST4.H15
OPIS	HEP 57	OPSTHSTM.H15
OPL1L	HEP 110	OPL1L.H15
OPL1S	HEP 110	OPL1L.H15
OPL2L	HEP 110	OPL1L.H15
OPMSV	HEP 9	OPECS.H15
OPMSV	HEP 9	OPECSISO.H15

Table 10.3.30
H1-5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPOMS	HEP 82	OPSTMKU.H15
OPOMS	HEP 82	OPSTMMKU.H15
OPOMS	HEP 82	OPSTMNFD.H15
OPOMS	HEP 82	OPSTMNFS.H15
OPOMS	HEP 82	OPSTMOF.H15
OPOMS	HEP 82	OPSTMSRV.H15
OPRHP	HEP 111	OPLCHPLP.H15
OPSOF	HEP 30	OPSOF.H15
OPSPM	HEP 26	OPICT.H15
OPSPM	HEP 26	OPICTE.H15
OPSPM	HEP 26	OPICTISO.H15
OPSPM	HEP 26	OPICTNPE.H15
OPSTH	HEP 42	OPSTHOSV.H15
OPSTH	HEP 42	OPSTHSRV.H15
OPSTH	HEP 42	OPSTHST2.H15
OPSTH	HEP 42	OPSTHST3.H15
OPSTH	HEP 42	OPSTHST4.H15
OPSTH	HEP 42	OPSTHSTM.H15
OPSTM	HEP 29	OPSTMKU.H15
OPSTM	HEP 29	OPSTMMKU.H15
OPSTM	HEP 29	OPSTMNFD.H15
OPSTM	HEP 29	OPSTMNFS.H15
OPSTM	HEP 29	OPSTMOF.H15
OPSTM	HEP 29	OPSTMSRV.H15
OPSTM	HEP 49	OPSTE581.H15
OPVNT	HEP 25	OPICT.H15
OPVNT	HEP 25	OPICTE.H15
OPVNT	HEP 25	OPICTF2.H15

Table 10.3.30
H1-5H HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPVNT	HEP 25	OPICTISO.H15
OPVNT	HEP 25	OPICTNPE.H15
SPMKP	HEP 27	OPICT.H15
SPMKP	HEP 27	OPICTE.H15
SPMKP	HEP 27	OPICTISO.H15
SPMKP	HEP 27	OPICTNPE.H15

Table 10.3.31
TRPT5 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LC-LP	HEP 23	OPLECR.TRP
LC-LP	HEP 23	OPLECRA.TRP
LC-LP	HEP 23	OPLECRHY.TRP
LC-LP	HEP 23	OPLECRP.TRP
LCHPC	HEP 23	OPLECR.TRP
LCHPC	HEP 23	OPLECRA.TRP
LCHPC	HEP 23	OPLECRHY.TRP
LCHPC	HEP 23	OPLECRP.TRP
LCMK	HEP 4	OPDHR.TRP
LCMK	HEP 4	OPDHRHYD.TRP
LCMK	HEP 4	OPDHRHYR.TRP
LCMK	HEP 85	OPDHR.TRP
LCMK	HEP 85	OPDHRHYD.TRP
LCMK	HEP 85	OPDHRHYR.TRP
OP1SV	HEP 7	OPECSADH.TRP
OP1SV	HEP 7	OPECSHYD.TRP
OP1SV	HEP 7	OPECSRTE.TRP
OP1SV	HEP 7	OPECSSDC.TRP
OP1SV	HEP 11	OPECSHPR.TRP
OP1SV	HEP 38	OPECSL.TRP
OP1SV	HEP 51	OPECSHY2.TRP
OP1SV	HEP 51	OPECSL5.TRP
OP1SV	HEP 104	OPECSEAR.TRP
OP1SV	HEP 106	OPECSLP.TRP
OP1SV	HEP 108	OPECSAD5.TRP
OPCMT	HEP 73	OPICT2F.TRP
OPCMT	HEP 73	OPICTF3.TRP
OPDHR	HEP 3	OPDHR.TRP

Table 10.3.31
TRPT5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPDHR	HEP 58	OPDHRHYD.TRP
OPDHR	HEP 87	OPDHRHYR.TRP
OPECS	HEP 6	OPECSADH.TRP
OPECS	HEP 6	OPECSHYD.TRP
OPECS	HEP 6	OPECSRTE.TRP
OPECS	HEP 6	OPECSSDC.TRP
OPECS	HEP 10	OPECSHPR.TRP
OPECS	HEP 18	OPECSLP.TRP
OPECS	HEP 37	OPECSL.TRP
OPECS	HEP 50	OPECSHY2.TRP
OPECS	HEP 50	OPECSL5.TRP
OPECS	HEP 78	OPECSAD5.TRP
OPECS	HEP 103	OPECSEAR.TRP
OPFLD	HEP 28	OPFLDE.TRP
OPFLD	HEP 28	OPFLDE2.TRP
OPFLD	HEP 28	OPFLDE3.TRP
OPFLD	HEP 28	OPFLDEHY.TRP
OPHIS	HEP 8	OPECSAD5.TRP
OPHIS	HEP 8	OPECSADH.TRP
OPHIS	HEP 8	OPECSEAR.TRP
OPHIS	HEP 8	OPECSHPR.TRP
OPHIS	HEP 8	OPECSHY2.TRP
OPHIS	HEP 8	OPECSHYD.TRP
OPHIS	HEP 8	OPECSL.TRP
OPHIS	HEP 8	OPECSL5.TRP
OPHIS	HEP 8	OPECSLP.TRP
OPHIS	HEP 8	OPECSRTE.TRP
OPHIS	HEP 8	OPECSSDC.TRP

Table 10.3.31
TRPTS HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPICT	HEP 71	OPICT2F.TRP
OPICT	HEP 71	OPICTCAU.TRP
OPICT	HEP 71	OPICTE.TRP
OPICT	HEP 71	OPICTE3.TRP
OPICT	HEP 71	OPICTE4.TRP
OPICT	HEP 71	OPICTEHY.TRP
OPICT	HEP 71	OPICTEP.TRP
OPICT	HEP 71	OPICTF3.TRP
OPICT	HEP 71	SPMUN.TRP
OPIS	HEP 41	OPSTHST2.TRP
OPIS	HEP 41	OPSTHSTM.TRP
OPIS	HEP 57	OPSTHOSV.TRP
OPIS	HEP 57	OPSTHSRV.TRP
OPIS	HEP 57	OPSTHST2.TLM
OPIS	HEP 57	OPSTHST3.TRP
OPIS	HEP 57	OPSTHST5.TRP
OPISA	HEP 81	OPECSAD5.TRP
OPISA	HEP 81	OPECSADH.TRP
OPISA	HEP 81	OPECSEAR.TRP
OPISA	HEP 81	OPECSL.TRP
OPISA	HEP 81	OPECSL5.TRP
OPISA	HEP 81	OPECSLP.TRP
OPLEC	HEP 23	OPLECLHY.TRP
OPLEC	HEP 23	OPLECLLA.TRP
OPLEC	HEP 23	OPLECR.TRP
OPLEC	HEP 23	OPLECRA.TRP
OPLEC	HEP 23	OPLECRHY.TRP
OPLEC	HEP 23	OPLECRP.TRP

Table 10.3.31
TRPT5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPMSV	HEP 9	OPECSAD5.TRP
OPMSV	HEP 9	OPECSADH.TRP
OPMSV	HEP 9	OPECSEAR.TRP
OPMSV	HEP 9	OPECSHPR.TRP
OPMSV	HEP 9	OPECSHY2.TRP
OPMSV	HEP 9	OPECSHYD.TRP
OPMSV	HEP 9	OPECSL.TRP
OPMSV	HEP 9	OPECSL5.TRP
OPMSV	HEP 9	OPECSLP.TRP
OPMSV	HEP 9	OPECSRTE.TRP
OPMSV	HEP 9	OPECSSDC.TRP
OPNCF	HEP 83	OPNCF.TRP
OPOMS	HEP 82	OPSTMFD2.TRP
OPOMS	HEP 82	OPSTMFS2.TRP
OPOMS	HEP 82	OPSTMMK2.TRP
OPOMS	HEP 82	OPSTMMKU.TRP
OPOMS	HEP 82	OPSTMNFD.TRP
OPOMS	HEP 82	OPSTMNFS.TRP
OPOMS	HEP 82	OPSTMOF.TRP
OPOMS	HEP 82	OPSTMOF2.TRP
OPOMS	HEP 82	OPSTMSRV.TRP
OPSDC	HEP 1	OPSDC.TRP
OPSDC	HEP 2	OPSDC.TRP
OPSDC	HEP 20	OPSDC.TRP
OPSOF	HEP 30	OPSOF.TRP
OPSPM	HEP 26	OPICTE.TRP
OPSPM	HEP 26	OPICTE3.TRP
OPSPM	HEP 26	OPICTE4.TRP

Table 10.3.31
TRPT5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSPM	HEP 26	OPICTEHY.TRP
OPSPM	HEP 26	OPICTEP.TRP
OPSTH	HEP 42	OPSTHOSV.TRP
OPSTH	HEP 42	OPSTHSRV.TRP
OPSTH	HEP 42	OPSTHST2.TLM
OPSTH	HEP 42	OPSTHST2.TRP
OPSTH	HEP 42	OPSTHST3.TRP
OPSTH	HEP 42	OPSTHST5.TRP
OPSTH	HEP 42	OPSTHSTM.TRP
OPSTM	HEP 29	OPSTMFD2.TRP
OPSTM	HEP 29	OPSTMFS2.TRP
OPSTM	HEP 29	OPSTMMK2.TRP
OPSTM	HEP 29	OPSTMMKU.TRP
OPSTM	HEP 29	OPSTMNFD.TRP
OPSTM	HEP 29	OPSTMNFS.TRP
OPSTM	HEP 29	OPSTMOF.TRP
OPSTM	HEP 29	OPSTMOF2.TRP
OPSTM	HEP 29	OPSTMSRV.TRP
OPSTM	HEP 49	OPSTE51.TRP
OPSTM	HEP 49	OPSTE581.TRP
OPVNT	HEP 25	OPICT2F.TRP
OPVNT	HEP 25	OPICTE.TRP
OPVNT	HEP 25	OPICTE3.TRP
OPVNT	HEP 25	OPICTE4.TRP
OPVNT	HEP 25	OPICTEHY.TRP
OPVNT	HEP 25	OPICTEP.TRP
OPVNT	HEP 25	OPICTF3.TRP
OPVNT	HEP 25	SPMUN.TRP

Table 10.3.31
TRPT5 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
RM-LT	HEP 56	OPDHRHYD.TRP
RM-LT	HEP 56	OPDHRHYR.TRP
SDCUI	HEP 52	SDCUI.TRP
SPMKN	HEP 27	SPMUN.TRP
SPMKP	HEP 27	OPICTE.TRP
SPMKP	HEP 27	OPICTE3.TRP
SPMKP	HEP 27	OPICTE4.TRP
SPMKP	HEP 27	OPICTEHY.TRP
SPMKP	HEP 27	OPICTEP.TRP
SPMUN	HEP 26	SPMUN.TRP

Table 10.3.32
Post Accident Human Actions and Their Mean HEPs and Error Factors
Sorted by HEP Numbers

HEP NUMBER ¹	HUMAN ACTION ^{2,3}	HEP	ERROR FACTOR
1	OPSDC (1)	8.5E-4	30
2	OPSDC (2)	0.046	10
3	OPDRH (1)	0.48	10
4	LCMK (1)	0.011	5
5	OP1SV (17)	0.302	10
6	OPECS (1)	0.035	5
7	OP1SV (1)	0.112	10
8	OPHIS (1)	0 OR 1.0	--
9	OPMSV (1)	1.0	--
10	OPECS (2)	0.138	10
11	OP1SV (2)	0.302	10
12	OPSOF (1)	0.06	10
13	OPECS (3)	1.0	--
14	OPECS (7)	0.10	10
15	OP1SV (3)	0.44	10
16	OPECS (8)	0.059	10
17	OPECS (4)	1.0	10
18	OPECS (9)	0.138	10
19	XTIEB (1)	0.073	10
20	OPSDC (3)	0.6	--
23	OPLEC (1)	0 or 1.0	--
23	LCHPC (1)	0	--
23	LC-LP (1)	0	--
25	OPVNT (1)	0.011	5
26	OPSPM (1)	0.011	5
26	SPMUN (1)	0.011	5
27	SPMKP (1)	0.032	5
27	SPMKN (1)	0.032	5
28	OPFLD (1)	0.138	10

Table 10.3.32
Post Accident Human Actions and Their Mean HEPs and Error Factors
Sorted by HEP Numbers (Continued)

HEP NUMBER ¹	HUMAN ACTION ^{2,3}	HEP	ERROR FACTOR
29	OPSTM (1)	0.106	10
30	OPSOF (2)	0.05	10
31	RESB (1)	0.085	10
31	RESAD (1)	0.085	10
31	RESCS (1)	0.085	10
33	OPFLD (2)	1.0	--
34	OPMSV (2)	1.0	--
35	OPDHR (2)	0.70	--
37	OPECS (11)	0.40	10
38	OP1SV (6)	0.64	10
39	OPECS (12)	0.12	10
40	OP1SV (7)	0.31	10
41	OP1S (1)	1.0	--
42	OPSTH (1)	0.025	5
46	OPECS (13)	0.31	10
47	OP1SV (8)	0.57	10
48	SPCUI (3)	0.04	5
49	OPSTM (2)	1.0	--
50	OPECS (14)	0.059	10
51	OP1SV (9)	0.112	10
52	SDCUI (1)	3.5E-3	5
54	SDCUI (2)	6.8E-3	5
56	RM-LT (1)	3.6E-3	5
57	OP1S (2)	0.063	10
58	OPDHR (3)	0.108	10
59	OPECS (15)	0.45	10
60	OP1SV (10)	0.45	10
61	OPECS (16)	0.138	10
63	OP1SV (12)	0.08	10

Table 10.3.32
Post Accident Human Actions and Their Mean HEPs and Error Factors
Sorted by HEP Numbers (Continued)

HEP NUMBER ¹	HUMAN ACTION ^{2,3}	HEP	ERROR FACTOR
64	OPECS (17)	0.043	10
65	OPSPM (2)	1.0	--
66	OPFLL (1)	0.01	10
67	OPLDM (1)	1.0	--
68	OPSRV (1)	0.004	5
69	OPMSV (6)	0.011	5
70	OPSPM (3)	0.047	10
71	OPICT (1)	1.0	--
73	OPCMT (1)	N/A	--
73	OPSTL (1)	N/A	--
73	OPUNT (2)	N/A	--
74	ISSSL (1)	0.036	5
75	OPECC (1)	0.01	5
75	OPSRV (2)	0	--
75	OPMSV (6)	0	--
76	OPFLL (2)	0.03	10
77	OPDHR (4)	0.12	10
78	OPECS (18)	0.138	10
79	OPECS (19)	0.023	5
80	OP1SV (14)	0.11	10
81	OP1SA (1)	0	--
82	OPOMS (1)	1.0	--
83	OPCNF (1)	0.006	10
85	LCMK (2)	0	--
86	OPSLP (1)	0.106	10
87	OPDHR (5)	0.015	5
88	OPECS (20)	0.04	5
89	OPDSV (1)	1.0	--
90	OPMSV (4)	0.01	5

Table 10.3.32
Post Accident Human Actions and Their Mean HEPs and Error Factors
Sorted by HEP Numbers (Continued)

HEP NUMBER ¹	HUMAN ACTION ^{2,3}	HEP	ERROR FACTOR
94	RESB (2)	1.0	--
94	RESCS (2)	1.0	--
95	OPMSV (5)	0.01	5
96	OPSTM (3)	0.021	10
99	OPMSV (3)	1.0	--
100	OPSTH (2)	0	--
101	OPECS (5)	1.0	--
102	OPECS (6)	1.0	--
103	OPECS (21)	0.042	10
104	OP1SV (16)	0.30	10
105	OP1SV (4)	0.112	10
106	OP1SV (5)	0.302	10
107	OP1SV (11)	0.302	10
108	OP1SV (13)	0.302	10
109	OP1SV (15)	0.302	10
110	OPLIL (1)	1.0	--
110	OPLIS (1)	1.0	--
110	OPL2L (1)	1.0	--
111	LCHPC (2)	0.051	10
111	LC-LP (2)	0.051	10
111	OPHRP (1)	1.0	--
113	ISO89 (1)	0.012	5
114	OPECS (22)	0.003	5
115	OP1SV (18)	0.015	5

Footnotes:

¹Some HEP numbers are missing simply because not all numbers in the sequence were used.

²Multiple HEPs were determined for some operator actions. The occurrence number is presented in parentheses 0.

³Descriptions of the operator actions appear in the HEP calculation tables (Tables 10.1.1 through 10.1.115) and in Section 6.

Table 10.3.33
Post Accident Human Actions and Their Mean HEPs and Error Factors
Sorted by Human Action Identifiers

HEP NUMBER ¹	HUMAN ACTION ^{2,3}	HEP	ERROR FACTOR
113	ISO89 (1)	0.012	5
74	ISSSL (1)	0.036	5
23	LC-LP (1)	0	--
111	LC-LP (2)	0.051	10
23	LCHPC (1)	0	--
111	LCHPC (2)	0.051	10
4	LCMK (1)	0.011	5
85	LCMK (2)	0	--
73	OPCMT (1)	N/A	--
83	OPCNF (1)	0.006	10
35	OPDHR (2)	0.70	--
58	OPDHR (3)	0.108	10
77	OPDHR (4)	0.12	10
87	OPDHR (5)	0.015	5
3	OPDRH (1)	0.48	10
89	OPDSV (1)	1.0	--
75	OPECC (1)	0.01	5
6	OPECS (1)	0.035	5
10	OPECS (2)	0.138	10
13	OPECS (3)	1.0	--
14	OPECS (7)	0.10	10
16	OPECS (8)	0.059	10
17	OPECS (4)	1.0	10
18	OPECS (9)	0.138	10
37	OPECS (11)	0.40	10
39	OPECS (12)	0.12	10
46	OPECS (13)	0.31	10
50	OPECS (14)	0.059	10
59	OPECS (15)	0.45	10

Table 10.3.33
Post Accident Human Actions and Their Mean HEPs and Error Factors
Sorted by Human Action Identifiers (Continued)

HEP NUMBER ¹	HUMAN ACTION ^{2,3}	HEP	ERROR FACTOR
61	OPECS (16)	0.138	10
64	OPECS (17)	0.043	10
78	OPECS (18)	0.138	10
79	OPECS (19)	0.023	5
88	OPECS (20)	0.04	5
101	OPECS (5)	1.0	--
102	OPECS (6)	1.0	--
103	OPECS (21)	0.042	10
114	OPECS (22)	0.003	5
28	OPFLD (1)	0.138	10
33	OPFLD (2)	1.0	--
66	OPFLL (1)	0.01	10
76	OPFLL (2)	0.03	10
8	OPHIS (1)	0 OR 1.0	--
111	OPHRP (1)	1.0	--
71	OPICT (1)	1.0	--
41	OP1S (1)	1.0	--
57	OP1S (2)	0.063	10
81	OP1SA (1)	0	--
5	OP1SV (17)	0.302	10
7	OP1SV (1)	0.112	10
11	OP1SV (2)	0.302	10
15	OP1SV (3)	0.44	10
38	OP1SV (6)	0.64	10
40	OP1SV (7)	0.31	10
47	OP1SV (8)	0.57	10
51	OP1SV (9)	0.112	10
60	OP1SV (10)	0.45	10
63	OP1SV (12)	0.08	10

Table 10.3.33
Post Accident Human Actions and Their Mean HEPs and Error Factors
Sorted by Human Action Identifiers (Continued)

HEP NUMBER ¹	HUMAN ACTION ^{2,3}	HEP	ERROR FACTOR
80	OP1SV (14)	0.11	10
104	OP1SV (16)	0.30	10
105	OP1SV (4)	0.112	10
106	OP1SV (5)	0.302	10
107	OP1SV (11)	0.302	10
108	OP1SV (13)	0.302	10
109	OP1SV (15)	0.302	10
115	OP1SV (18)	0.015	5
110	OPL2L (1)	1.0	--
67	OPLDM (1)	1.0	--
23	OPLEC (1)	0 or 1.0	--
110	OPLIL (1)	1.0	--
110	OPLIS (1)	1.0	--
9	OPMSV (1)	1.0	--
34	OPMSV (2)	1.0	--
69	OPMSV (6)	0.011	5
75	OPMSV (6)	0	--
90	OPMSV (4)	0.01	5
95	OPMSV (5)	0.01	5
99	OPMSV (3)	1.0	--
82	OPOMS (1)	1.0	--
1	OPSDC (1)	8.5E-4	30
2	OPSDC (2)	0.046	10
20	OPSDC (3)	0.6	--
86	OPSLP (1)	0.106	10
12	OPSOF (1)	0.06	10
30	OPSOF (2)	0.05	10
26	OPSPM (1)	0.011	5
65	OPSPM (2)	1.0	--

Table 10.3.33
Post Accident Human Actions and Their Mean HEPs and Error Factors
Sorted by Human Action Identifiers (Continued)

HEP NUMBER ¹	HUMAN ACTION ^{2,3}	HEP	ERROR FACTOR
70	OPSPM (3)	0.047	10
68	OPSRV (1)	0.004	5
75	OPSRV (2)	0	--
42	OPSTH (1)	0.025	5
100	OPSTH (2)	0	--
73	OPSTL (1)	N/A	--
29	OPSTM (1)	0.106	10
49	OPSTM (2)	1.0	--
96	OPSTM (3)	0.021	10
73	OPUNT (2)	N/A	--
25	OPVNT (1)	0.011	5
31	RESAD (1)	0.085	10
31	RESB (1)	0.085	10
94	RESB (2)	1.0	--
31	RESCS (1)	0.085	10
94	RESCS (2)	1.0	--
56	RM-LT (1)	3.6E-3	5
52	SDCUI (1)	3.5E-3	5
54	SDCUI (2)	6.8E-3	5
48	SPCUI (3)	0.04	5
27	SPMKN (1)	0.032	5
27	SPMKP (1)	0.032	5
26	SPMUN (1)	0.011	5
19	XTIEB (1)	0.073	10

Footnotes:

¹Some HEP numbers are missing simply because not all numbers in the sequence were used.

²Multiple HEPs were determined for some operator actions. The occurrence number is presented in parentheses ().

³Descriptions of the operator actions appear in the HEP calculation tables (Tables 10.1.1 through 10.1.115) and in Section 6.

Table 10.4.1
Recovery Actions and Their Mean HEPS and Error Factors

HEP NUMBER	HUMAN ACTION ¹	HEP	ERROR FACTOR
116	RA-CRD-1	0.065	5
117	RA-CRD-MOD1	0.0042	5
118	RA-CRD-MOD2	0.0075	5
119	RA-OPICT-1	0.09	10
119	RA-OPICT-3	0.09	10
120	RA-OPICT-2	0.067	5
121	RA-SWXT-1	0.032	5
122	RA-SWXT-MOD1	0.0042	5
123	RA-FWLVL-2	0.05	5
124	RA-ECCS-CONTROL	0.053	10
125	RA-DEPRESSURIZE	0.03	10
126	RA-HPCS-HW-1	0.25	N/A
126	RA-CRD-HW-1	0.003	N/A

Footnotes:

¹Descriptions of the recovery actions appear in the HEP calculation tables (Tables 10.1.115 through 10.1.126).

Table 10.5.2R1.1
HEP 2R1 Calculation

Human Action Event (1)	OPSDC (2)
Event Tree(s) (2)	ADH, TIA5H, E1D5H, E2D5H, T5D5H, S3-5, S3-5H, E2V5H,
Initiators (3)	T1, TIA5H,, E1D5H, E2D5H, T5D5H, S3-5, S3-5H, E2V5H, TIOF5, TIHP5, TIOP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPSDC.ADH, OPSDCADH.TIA, RESAD.E1D, OPSDCADH.E2D, OPSDC.T5D, OISSL.S35, OISSL.S3H, OPSDC.E2V, OPSDC.TIF, OPSDC.TIH, OPSDC.TIO, OPSDC.TLM, OPSDC.TRP
Event Description (5)	OPSDC in this case includes the control room crew detecting the loss of the ADHRS, entering the Inadequate Decay Heat Removal ONEP, and initiating a standby source of SDC (RHR(B)) per SOI 04-1-01-E12-1.
Event Context (6)	SDC was being provided by ADHRS, one train of RHR/SDC is in standby.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), Residual Heat Removal SOI (04-1-01-E12-1)

Table 10.5.2R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A loss of ADHRS (operating mode of SDC)	0	In most cases, (pump trip, system/valve isolation, loss of heat sink, etc.) a loss of ADHRS will be alarmed. In addition, given certain initiators, operators are trained to know ADHRS will isolate or be rendered unavailable. Furthermore, ONEPS relevant to such events will usually note the loss of ADHRS; a loss of SDC will also be indicated by coolant temperature, flow, and discharge pressure changes. Operators are required by the plant to check reactor coolant temperatures every 30 minutes at the chart recorder.	During shutdown, SDC is a primary function and a major concern of the operators. Loss of SDC is covered during simulator training prior to each outage.

Table 10.5.2R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A loss of ADHRS occurs as a random event, spurious isolation, or as a result of the initiating event. OPSDC in this case includes detecting the loss of ADHRS, entering IDHR ONEP, and initiating a standby source of SDC (RHR(B)) per procedure.	One	<ol style="list-style-type: none"> 1. Enter ONEP for IDHR 2. Start standby RHR/SDC loop per SOI 04-1-01-E12-1 <ul style="list-style-type: none"> - Isolation of ADHRS includes opening breaker outside control room per Step 5.15.2d - RHR initiated from control room 	The RHR/SDC initiation procedure also directs operators to place LPCI (C) in standby (following completion of other actions). While it is assumed operators will follow procedures, the control room can initiate SDC (B) prior to these steps being completed. Placing LPCI (C) in standby was assumed to be completely dependent with initiating RHR/SDC(B).

Table 10.5.2R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate RHR/SDC (B)	55 minutes	0	55 Minutes	SNL MELCOR Calculation

Table 10.5.2R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for IDHR	CR		5 minutes (Table 8-1, Step 5A)	5 minutes	See HEP 1 (OPSDC (1)), Table 1-5 for rationale.
2. Initiate RHR/SDC (B) (includes isolation of ADHRS to prevent overpressurization of low pressure piping and placement of LPCI(C) in standby)					It was assumed that most (but not all) control room actions could occur in parallel with operator trip to open breaker (ASEP Table 8-1, Step 7).
- valve alignment and system initiation from control room	CR	--	5 minutes	5 minutes	Travel and performance time for opening breaker was established on the basis of discussions with plant personnel.
- open breaker outside CR as part of isolation of ADHRS	RHR (C) pump room, aux. bldg.	14 minutes	1 minute	<u>15 minutes</u> ≈ 25 minutes	

Table 10.5.2R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to align and initiate RHR/SDC (B)	55 minutes	25 minutes	30 minutes	

Table 10.5.2R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis HEP (4)	Comments/ Source of Information (5)
Diagnose loss of SDC and need for standby SDC	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 30 minutes diagnosis time was assigned	N/A	Median = 0.00015 Mean = 0.001	Loss of SDC would certainly be a "classic" event in the LPS environment and operators at GGNS receive substantial training on the event. Interviews with operators indicated a good awareness of the relevant indicators and a need to closely monitor the relevant indicators. Thus, the criteria listed in Table 8-3 for the lower bound were met.

Table 10.5.2R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs, Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Align & Initiate RHR/ SDC (B)	N/A	ONEPS clear and well-designed in regard to diagnosing and initiating standby SDC	No	Step-by-Step	Actions are clearly defined by procedure.

Table 10.5.2R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_E <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Align and initiate RHR/SDC (B)	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.2R1.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)^{op}	Independent Check/Correction HEP (HEP_{c2}) (3)^{c2}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Median = 0.00015 Mean = 0.001	--	Med. Mean 0.00015 0.001	(30)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions.
2. Align and initiate standby SDC (RHR/SDC(B)). The straightforward, conceptually integrated set of proceduralized actions (Steps 5.15.2 and 4.2.2.e) were assumed to be completely dependent. (See comments in Column 6 for additional information).	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the time available and the fact that the only critical action is to ensure that SDC (B) is started. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.004 0.01 Total Median HEP = 0.004 Total Mean HEP = 0.01	<u>(5)</u> 5	Opening of the breaker is a safety measure related to isolating ADHR and its failure or delay would not prevent successful start of SDC (B). Similarly, placing LPCI (C) in standby, which is subsequent to starting RHR/SDC(B) in the procedure, will not affect initiation or operation of SDC(B). Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.3R1.1
HEP 3R1 Calculation

Human Action Event (1)	OPDHR (1)
Event Tree(s) (2)	L, LA, LP, LAP
Initiators (3)	T1-5, TIA5H, TDB5H, T5D5H, E1B5H, E1D5H, E2D5H, E1T5H, E1V5H, TLM5H, TRPT5, TIHP5, TIOF5
Sequence Locator Files (4)	OPDHR&.LP&, OPDHR&.TIA, OPDHR.TDB, OPDHRP.T5D, OPDHRP.E1B, OPDHRP.E1D, OPDHRP.E2D, OPDHRLP.E1T, OPDHLAP.E1V, OPDHR.TLM, OPDHR.TRP, OPDHR.TIH, OPDHRP.TIH, OPDHR.TIF
Event Description (5)	OPDHR is the operator action to control vessel level in order to avoid a "functional" loss of SDC caused by inadequate circulation between the core and the downcomer regions of the vessel. That is, even if SDC continues to operate, if vessel level becomes too low, a "disconnect" between the core and downcomer regions can occur. This will result in inadequate cooling of the core even though SDC continues to operate. The indications to the operators that the event is occurring can be subtle because temperature readings are apparently taken from the downcomer region, where the water being cooled by SDC is returned. Also, the vessel level would not be so low that any level alarms would sound. A loss of forced recirculation, or a loss of makeup (usually CRD) coupled with continued draindown, can lead to inadequate level.
Event Context (6)	The important constants for the OPDHR (1) calculation (HEP 3) are that RWCU auto-isolates (an LOSP occurs or IA is lost) or the initiator was a loss of forced recirculation, a loss of (CRD) makeup, or an inadvertent overfill of the vessel that had been stopped. It was assumed that with only a loss of forced recirculation or a loss of makeup occurring, the resulting alarms would immediately lead the operators to isolation of RWCU (letdown). In the case of a recent overfill that was stopped, it was assumed that the operators would be attending to level and that any following loss of forced recirculation or makeup would also lead to an isolation of RWCU.
Applicable Procedures (7)	No specific procedures, but the Inadequate Decay Heat Removal ONEP (05-1-02-III-1) would be relevant, as would the relevant SOIs, e.g., RHR SOI (04-1-01-E12-1).

Table 10.5.3R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR caused by inadequate circulation between the core and the downcomer regions of the vessel. Level control (makeup) is needed.	O	As noted in Table 3-1, the indications for this event may be subtle because vessel temperature readings could be misleading and no level alarms would sound. However, in all the sequences covered, CRD and/or forced recirculation is lost. These events will be alarmed and if the operators are knowledgeable regarding the potential problem, these indications should suffice.	

Table 10.5.3R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A "functional" loss of SDC leads to IDHR. The operators need to diagnose the need and increase vessel level.	One	The operators need to increase RPV water level with any available injection system. CRD (if available), CDS, or an ECCS system are possible choices.	

Table 10.5.3R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	37 minutes	0	37 Minutes	SNL MELCOR Calculation

Table 10.5.3R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
If available, increase flow with CRD. If CRD is not available and SDC is not being provided by SDC(B), use CDS. Otherwise, use an ECCS system.	CR	--	2 minutes Since more than one system may need to be tried, 2 minutes, rather than 1 minute was assumed for conducting the activities.	2 minutes	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column. The actions involved in initiating a makeup system were assumed to be completely dependent. System initiation would be proceduralized.

Table 10.5.3R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	37 minutes	2 minutes	35 minutes	

Table 10.5.3R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to provide makeup	Per ASEP Table 8-3, the median value from Figure 8-1 for 35 minutes diagnosis time was assigned.		Med. = 0.0005 Mean = 0.004	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. However, with the potential for some subtlety in the indicators and the absence of any explicit procedures, the lower bound diagnosis value was not assumed appropriate.

Table 10.5.3R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate an injection system to provide makeup.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions. —	No	Step x step Even though the operators would have to determine which system to start on their own, the choices would be obvious and substantial time would be available.	

Table 10.5.3R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate an injection system to provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.3R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.0005 Mean = 0.004	--	Med. Mean 0.0005 0.004	(10)	
2. Initiate an injection system to provide makeup and vessel level control.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available and the importance of the actions given a correct diagnosis. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.005 0.014 Total Median HEP = 0.005 Total Mean HEP = 0.014	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.6R1.1
HEP 6R1 Calculation

Human Action Event (1)	OPECS (1)
Event Tree(s) (2)	E, EA, EP, EX
Initiators (3)	T1, TIA5H, TAB5H, TDB5H, T5D5H, E1B5H, E2B5H, E1D5H, E2D5H, TORV5, TRPT5, E1V5H, E2V5H, E1T5H, E2T5H, TIOF5, TIHP5, TLM5H, TIOP5
Sequence Locator Files (4)	OPECS&.EP, OPECSHY2.EP, OPECSHYD.EP, OPCSDDC12.EX, OPECSDDC5.TIA, OPECSDDC9.TIA, OPECSHY2.TIA OPECSSDC.TAB, OPECSHYD.TDB, OPECSSDC.TDB, OPECS9.T5D, OPECSRTE.T5D, OPECSSDC.E1B, OPECSRTE.E1B, OPECSSDC.E2B, OPECSRTE.E1D, OPECSRTE.E2D, OPECSRTE.TRV, OPECSHYD.TRV, OPECSHY2.TRV, OPECSRTE.TRP, OPECSHYD.TRP, OPECSHY2.TRP, OPECSL.TRP, OPECSL5.TRP, OPECSLP.TRP, OPECSSDC.TRP, OPECSAD5.TRP, OPECSADH.TRP, OPECSHPR.TRP, OPECSAD2.E1V, OPECSADH.E1V, OPECSL5.E1V, OPECSLPE.E1V, OPECSADF.E1V, OPECSALA.E1V, OPECSHPR.E1V, OPECSAD2.E2V, OPECSADH.E2V, OPECSSDC.E1T, OPECSDCF.E1T, OPECSHPR.E1T, OPECSLPE.E1T, OPECSL5.E1T, OPECSSDC.E2T, OPECSHPR.E2T, OPCSDDC5.E2T, OPECSADH.TIF, OPECSSDC.TIF, OPECSLP.TIF, OPECSL.TIF, OPECSADH.TIH, OPECSSDC.TIH, OPECSLP.TIH, OPECSL.TIH, OPECSADH.TIO, OPECSSDC.TIO, OPECSAD5.TIO, OPECSADH.TLM, OPECSSDC.TLM, OPECSAD5.TLM, OPECSL.TLM, OPECSLP.TLM, OPECSLHY.TLM, OPECSHYD.TLM
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (1) calculation (HEP 6) are that the control room has diagnosed the loss or inadequacy of SDC (e.g., OPSDC succeeds or OPDHR succeeds, but CDS fails), they have entered the ONEP for IDHR, they realize no normal means of SDC are available (RHR (A) assumed not available per refueling outage schedule), and they are aware of the need for level control. RWCU has been isolated. The ONEP directs the operators to go ECCS water solid (LPCI, HPCS, or both are available, depending on context).
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.5.6R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Control room is aware that normal SDC unavailable or inadequate. Loss of systems were alarmed. ONEP for IDHR directs the control room to use ECCS to go water solid in this context. ONEP has been entered. Reactor coolant temperature will be rising.	

Table 10.5.6R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control is needed, IDHR ONEP directs operators to go ECCS water solid.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ol style="list-style-type: none"> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system.</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.5.6R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	37 minutes	0	37 Minutes	SNL MELCOR Calculation

Table 10.5.6R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Check closed MSIVs	CR	--	1 minute	1 minute	The three critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of proceduralized actions.
2. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
3. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 3 min. Total	

Table 10.5.6R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	37 minutes	3 minutes	34 minutes	

Table 10.5.6R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per Table 8-3, the lower bound value from Figure 8-1 for 34 minutes diagnosis time was assigned		Med. = 5.0E-5 Mean = 4.2E-4	For this event, the ONEP has already been retrieved and, on the basis of interviews, operators have a clear understanding of the procedure and the requirements. Level control and core cooling is an obvious need in this context and would fall into the "classic" category, per ASEP.

Table 10.5.6R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.6R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.6R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 5.0E-5 Mean = 4.2E-4	—	Med. Mean 5.0E-5 4.2E-4	(30)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.004 0.01 Total Median HEP = 0.004 Total Mean HEP = 0.01	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.10R1.1
HEP 10R1 Calculation

Human Action Event (1)	OPECS (2)
Event Tree(s) (2)	E, HPSWR
Initiators (3)	T1-5, TIA5H, TAB5H, T5A5H, TDB5H, T5D5H, E1B5H, E2B5H, E1T5H, E1V5H, E2T5H, TRPT5
Sequence Description Files (4)	OPECS&.HPR, OPCSDC11.TIA, OPECSDC4.TAB, OPECSDC9.TAB, OPECSDC9.TDB, OPECSHPR.E1B, OPECSHPR.E2B, OPECSHPR.T5A, OPECSHPR.T5D, OPECSHYD.HPR, OPECSHPR.E1T, OPECSHPR.E1V, OPECSHPR.E2T, OPECSHPR.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (2) calculation (HEP 10) are that a LOSP has occurred and the Division 1 and 2 diesel generators have failed to start. The HPCS diesel is available. With the loss of both divisions of power, the operators would enter the ONEP for Loss of AC Power. Any operating SDC system (RHR/SDC or ADHRS) would fail and the operators would be aware of the need for some form of SDC. With the loss of SDC, the operators would need to enter the ONEP for IDHR. RWCU has been isolated. The ONEP directs the operators to initiate ECCS water solid operation. Only HPCS would be available.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20)

Table 10.5.10R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems would be alarmed. In the context of being in shutdown and the occurrence of a loss of AC power, operators would be aware of the need for some form of SDC. The ONEP for IDHR directs the control room to use ECCS to go water solid in this context. The operators will have to retrieve and enter the IDHR ONEP. Reactor coolant temperature will be rising.	

Table 10.5.10R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control is needed, IDHR ONEP directs operators to initiate ECCS water solid operation. HPCS is the only ECCS system available.	One--the loss of SDC is a result of the loss of power.	Per IDHR ONEP (Step 5.1.3c) 1. Check closed MSIVs. Ensure that two SRVs are open. Increase RPV water level with any available injection system. In this context HPCS is the only ECCS system available.	In the site interviews, the operators clearly indicated that HPCS would be initiated. However, it is not <u>explicitly</u> called by the procedure.

Table 10.5.10R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Max. Time Available to Perform Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	70 minutes	0	70 Minutes	SNL MELCOR Calculation

Table 10.5.10R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_t) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and Read ONEP for IDHR	CR		5 minutes (Table 8-1, Step 5a)	5 Minutes	See HEP 1 (OPSDC (1)), same table, for rationale.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The three critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of proceduralized actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 8 min. Total	

Table 10.5.10R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation	70 minutes	8 minutes	62 minutes	

Table 10.5.10R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per Table 8-3, the median value from Figure 8-1 for 62 minutes diagnosis time was assigned.		Median = 1.0E-4 Mean = 8.5E-4	The median value from Figure 8-1 (as opposed to the lower bound value) was selected because the amount of practice given the operators for a station blackout during LPS conditions was not clear. In addition, HPCS is not explicitly called in the procedure.

Table 10.5.10R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Clear procedures and HPCS is the only logical system available.

Table 10.5.10R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ² , the HPCS generator has started	N/A	Moderately High	HPCS is available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.10R1.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)^{op}	Independent Check/Correction HEP (HEP_{ic}) (3)^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 1.0E-4 Mean = 8.5E-4	--	Med. Mean 1.0E-4 8.5E-4	(30)	
2. Initiate ECCS water solid operation per procedure.	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.004 0.01 Total Median HEP = 0.004 Total Mean HEP = 0.01	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor from the dominant HEP was used.

Table 10.5.10R2.1
HEP 10R2 Calculation

Human Action Event (1)	OPECS (2)
Event Tree(s) (2)	E, HPSWR
Initiators (3)	T1-5, T1A5H, TAB5H, T5A5H, TDB5H, T5D5H, E1B5H, E2B5H, E1T5H, E1V5H, E2T5H, TRPT5
Sequence Description Files (4)	OPECS&.HPR, OPCSDC11.TIA, OPECSDC4.TAB, OPECSDC9.TAB, OPECSDC9.TDB, OPECSHPR.E1B, OPECSHPR.E2B, OPECSHPR.T5A, OPECSHPR.T5D, OPECSHYD.HPR, OPECSHPR.E1T, OPECSHPR.E1V, OPECSHPR.E2T, OPECSHPR.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (2) calculation (HEP 10) are that a LOSP has occurred and the Division 1 and 2 diesel generators have failed to start. The HPCS diesel is available. With the loss of both divisions of power, the operators would enter the ONEP for Loss of AC Power. Any operating SDC system (RHR/SDC or ADHRS) would fail and the operators would be aware of the need for some form of SDC. With the loss of SDC, the operators would need to enter the ONEP for IDHR. RWCU has been isolated. The ONEP directs the operators to initiate ECCS water solid operation. Only HPCS would be available.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20)

Table 10.5.10R2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems would be alarmed. In the context of being in shutdown and the occurrence of a loss of AC power, operators would be aware of the need for some form of SDC. The ONEP for IDHR directs the control room to use ECCS to go water solid in this context. The operators will have to retrieve and enter the IDHR ONEP. Reactor coolant temperature will be rising.	

Table 10.5.10R2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control is needed, IDHR ONEP directs operators to initiate ECCS water solid operation. HPCS is the only ECCS system available.	One--the loss of SDC is a result of the loss of power.	Per IDHR ONEP (Step 5.1.3c) <ol style="list-style-type: none"> 1. - Check closed MSIVs. - Ensure that two SRVs are open. - Increase RPV water level with any available injection system. In this context HPCS is the only ECCS system available. 	In the site interviews, the operators clearly indicated that HPCS would be initiated. However, it is not <u>explicitly</u> called by the procedure.

Table 10.5.10R2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Max. Time Available to Perform Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	110 minutes	0	110 Minutes	SNL MELCOR Calculation

Table 10.5.10R2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_t) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and Read ONEP for IDHR	CR		5 minutes (Table 8-1, Step 5a)	5 Minutes	See HEP 1 (OPSDC (1)), same table, for rationale.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The three critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of proceduralized actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 8 min. Total	

Table 10.5.10R2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation	110 minutes	8 minutes	102 minutes	

Table 10.5.10R2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per Table 8-3, the median value from Figure 8-1 for 102 minutes diagnosis time was assigned.		Med. = $7.0E-5$ Mean = $6.0E-4$	The median value from Figure 8-1 (as opposed to the lower bound value) was selected because the amount of practice given the operators for a station blackout during LPS conditions was not clear. In addition, HPCS is not explicitly called in the procedure.

Table 10.5.10R2.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	Clear procedures and HPCS is the only logical system available.

Table 10.5.10R2.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ² , the HPCS generator has started	N/A	Moderately High	HPCS is available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.10R2.10
Total HEP

Action (1)	Original Operator HEP (HEP_o) (2)^o	Independent Check/Correction HEP (HEP_c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 7.0E-5 Mean = 6.0E-4	--	Med. Mean 7.0E-5 6.0E-4	(30)	
2. Initiate ECCS water solid operation per procedure.	Median = 0.02 Mean = 0.032	Credit for a second and a third check on completing the action was given because of the time available for relevant feedback to occur, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	<u>0.0008</u> <u>0.003</u> <u>0.0009</u> <u>0.004</u> Total Median HEP = 0.0009 Total Mean HEP = 0.004	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for the action and the third check HEP is multiplied by the result. The error factor from the dominant HEP was used.

Table 10.5.13R1.1
HEP 13R1 Calculation

Human Action Event (1)	OPECS (3)
Event Tree(s) (2)	EA, EAP
Initiators (3)	T1-5, TIA5H, E1D5H, E2D5H
Sequence Locator Files (4)	OPECSEQ9.EAP, OPCADH21.TIA, OPECSA12.E1D, OPECSA07.E2D,
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (3) calculation (HEP 13) are that the control room has failed to diagnose the loss of SDC in 37 minutes, e.g., OPSDC fails). Thus, they have failed to enter the ONEP for IDHR. Since 37 minutes have elapsed, the operators would be very likely to check temperature and pressure on the chart recorders in the time allowed for OPECS and they may receive additional alarms. However, the operators would have to retrieve and read the IDHR ONEP and RHR SOI, perform a series of steps to isolate the ADHRS and align LPCI(C) or (B) for injection, per RHR SOI 04-1-01-E12-1, Step 6.6 or 6.8 ("Abnormal Operations"), and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.5.13R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period. Reactor pressure and coolant temperature will be rising.	

Table 10.5.13R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control and vessel cooling is needed, IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.5.13R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	55 minutes	0	55 Minutes	SNL MELCOR Calculation

Table 10.5.13R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/Source of Information (6)
1. Since OPSDC failed, operators still need to retrieve and read IDHR ONEP and RHR SOI	CR	—	5 minutes (Table 8-1, Step 5a)	5 minute	See HEP 1 (OPSDC (1)), same table, for rationale.
2. Secure ADHR, per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	—	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Check closed MSIVs	CR	—	1 minute	1 minute	Steps 3 and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Ensure 2 SRVs open	CR	—	1 minute	1 minute	
5. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	—	1 minute	<u>1 minute</u> 9 minutes Total time for all actions.	

Table 10.5.13R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_A) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	55 minutes	9 minutes	46 minutes	

Table 10.5.13R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the median value from Figure 8-1 for 46 minutes diagnosis time was assigned.		Med. = 2.0E-4 (EF = 30) Mean = 0.002	Given the failure of OPSDC, in conjunction with the need to perform "abnormal operations" from the RHR SOI, the lower bound was not judged to be appropriate.

Table 10.5.13R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step x Step	

Table 10.5.13R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	Since diagnosis value is equal to a failure probability of 1.0, the action HEPs are irrelevant.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.13R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 2.0E-4 Mean = 0.002	--	Med. Mean 2.0E-4 0.002	(30)	
2. Actions - Initiate ECCS water solid per procedure. 1. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. They constitute an integrated set of proceduralized actions. 2. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the time available, the importance of the actions, and the likelihood of relevant feedback regarding the success of the actions, credit for a second check was given for accomplishing those actions. Second check values for were: Median = 0.2 Mean = 0.323	0.004 0.01 Med. Mean <u>0.004</u> <u>0.01</u> 0.008 0.022 Total median HEP = 0.008 Total mean HEP = 0.022	(5) (5) (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for that action. The error factor associated with the dominant HEPs was assigned.

Table 10.5.13R2.1
HEP 13R2 Calculation

Human Action Event (1)	OPECS (3)
Event Tree(s) (2)	EA, EAP
Initiators (3)	T1-5, TIA5H, E1D5H, E2D5H
Sequence Locator Files (4)	OPECSEQ9.EAP, OPCADH21.TIA, OPECSA12.E1D, OPECSA07.E2D,
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (3) calculation (HEP 13) are that the control room has failed to diagnose the loss of SDC in 37 minutes, e.g., OPSDC fails). Thus, they have failed to enter the ONEP for IDHR. Since 37 minutes have elapsed, the operators would be very likely to check temperature and pressure on the chart recorders in the time allowed for OPECS and they may receive additional alarms. However, the operators would have to retrieve and read the IDHR ONEP and RHR SOI, perform a series of steps to isolate the ADHRS and align LPCI(C) or (B) for injection, per RHR SOI 04-1-01-E12-1, Step 6.6 or 6.8 ("Abnormal Operations"), and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.5.13R2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period. Reactor pressure and coolant temperature will be rising.	

Table 10.5.13R2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control and vessel cooling is needed, IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3)) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.5.13R2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ed}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	97 minutes	0	97 Minutes	SNL MELCOR Calculation

Table 10.5.13R2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/Source of Information (6)
1. Since OPSDC failed, operators still need to retrieve and read IDHR ONEP and RHR SOI	CR	--	5 minutes (Table 8-1, Step 5a)	5 minute	See HEP 1 (OPSDC (1)), same table, for rationale.
2. Secure ADHR, per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 3 and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
5. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	1 minute	<u>1 minute</u> 9 minutes Total time for all actions.	

Table 10.5.13R2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	97 minutes	9 minutes	88 minutes	

Table 10.5.13R2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the median value from Figure 8-1 for 88 minutes diagnosis time was assigned.		Med. = $8.0E-5$ Mean = 0.0007	Given the failure of OPSDC, in conjunction with the need to perform "abnormal operations" from the RHR SOI, the lower bound was not judged to be appropriate.

Table 10.5.13R2.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step x Step	

Table 10.5.13R2.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	Since diagnosis value is equal to a failure probability of 1.0, the action HEPs are irrelevant.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.13R2.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Med. = 8.0E-5 Mean = 0.0007	--	Med. Mean 8.0E-5 0.0007	(30)	
2. Actions - Initiate ECCS water solid per procedure. 1. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. They constitute an integrated set of proceduralized actions. 2. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Credit for a second and a third check on completing the actions was given because of the time available for relevant feedback to occur, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	0.0008 0.003 Med. Mean <u>0.0008</u> <u>0.003</u> 0.002 0.007 Total median HEP = 0.002 Total mean HEP = 0.007	(5) (5) (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for the action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEPs was assigned.

**Table 10.5.14R1.1
HEP 14R1 Calculation**

HRA

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Human Action Event (1)	OPECS (7)
Event Tree(s) (2)	EA, EAP
Initiators (3)	T1-5, TIA5H
Sequence Locator Files (4)	OPECSEQ8.EAP, OPCADH20.TIA
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (7) calculation (HEP 14) are that the control room has successfully diagnosed the loss of ADHR (OPSDC succeeds) and have attempted to start SDC(B). SDC(B) fails to start. In some sequences a LOSP occurs, but the diesels successfully start and load in all cases. With the success of OPSDC, the operators have entered the ONEP for IDHR. To initiate ECCS water solid operation, the operators must perform (or ensure that they have been performed during OPSDC) a series of steps to isolate ADHR and align LPCI(C) or (B) for injection (including a remote manual start of LPCI(C) or (B)), per RHR SOI 04-1-01-E12-1, Step 6.6 or 6.8 ("Abnormal Operations"), and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP. In aligning RHR/SDC(B) for SDC in this context, the procedures also instruct the operators to isolate ADHR and place LPCI(C) on standby. However, given the failure of SDC(B) to start, there is at least some probability that events may have precluded all steps being completed. Thus, it was conservatively assumed that the relevant actions would have to be carried-out in the time available for OPECS.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.5.14R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators are already aware of the loss of SDC. In addition, the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period. Reactor pressure and coolant temperature will be rising.	

Table 10.5.14R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control and vessel cooling is needed, IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3)) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.5.14R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	55 minutes	0	55 Minutes	SNL MELCOR calculation

Table 10.5.14R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
2. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 2 and 3 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
4. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	1 minute	<u>1 minute</u> 4 minutes Total time for all actions.	

Table 10.5.14R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	55 minutes	4 minutes	51 minutes	

Table 10.5.14R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 51 minutes diagnosis time was assigned.		Median = $1.0E-5$ (EF = 30) Mean = $8.5E-4$	For this event, the relevant ONEP has been retrieved and the operators have performed correctly to this point. On the basis of interviews, the operators have a clear understanding of the procedures and requirements. Level control and core cooling are obvious needs in this context and the event was judged to fall into the "classic" category per ASEP.

Table 10.5.14R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.5.14R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	While a LOSP occurs at some point in some sequences which use HEP 14, the diesels successfully start and load in all cases.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.14R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 1.0E-5 Mean = 8.5E-4	--	Med. Mean 1.0E-5 8.5E-4	(30)	
2. Actions - Initiate ECCS water solid per procedure. 1. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. They constitute an integrated set of proceduralized actions. 2. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the time available, the importance of the actions, and the likelihood of relevant feedback regarding the success of the actions, credit for a second check was given for accomplishing those actions. Second check values for were: Median = 0.2 Mean = 0.323	0.004 0.01 Med. Mean <u>0.004</u> <u>0.01</u> 0.008 0.02 Total median HEP = 0.008 Total mean HEP = 0.02	(5) (5) (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for that action. The error factor associated with the dominant HEPs was assigned.

Table 10.5.16R1.1
HEP 16R1 Calculation

Human Action Event (1)	OPECS (8)	EA, EAP							
Event Tree(s) (2)		EA, EAP							
Initiators (3)		TAB5H, TDB5H, T5A5H, EID5H, E2D5H.							
Sequence Description Files (4)		OPECSADH.TAB, OPECSADH.TDB, OPECS3.T5A, OPECSADH.EID, OPECSADP.EID, OPECSADH.E2D							
Event Description (5)		OPECS is this case includes diagnosing the need to initiate ECCS water solid operation and performing the needed actions.							
Event Context (6)		The important constants for the OPECS (8) calculation (HEP 16) are that the operators have detected the loss of SDC (OPSDC succeeds), HPCS is the only available ECCS system, and ADHR may need to be isolated from the control room. Closing of the 8 or 9 valve from the control room is adequate to isolate ADHR. With the loss of SDC, the operators would need to enter the ONEP for IDHR. The ONEP directs the operators to initiate ECCS water solid operation.							
Applicable Procedures (7)		Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), HPCS SOI (04-1-01-E22-1, Rev. 44), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20)							

Table 10.5.16R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	0	Loss of systems would be alarmed. In the context of being in shutdown the operators would be aware of the need for some form of SDC and have already detected the loss of normal SDC systems and entered the IDHR ONEP. The ONEP for IDHR directs the control room to use ECCS to go water solid in this context. Reactor coolant temperature will be rising.	

Table 10.5.16R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available. The IDHR ONEP directs operators to initiate ECCS water solid operation. HPCS is the only ECCS system available.	One--the loss of SDC is a result of the initiator.	<p>1. Isolate ADHR from the control room (if necessary) by closing 8 or 9 valve.</p> <p>2. Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs. - Ensure that two SRVs are open. - Increase RPV water level with any available injection system. In this context HPCS is the only ECCS system assumed available. 	Isolation of ADHR is not directed by procedure in this context. However, on the basis of interviews with operators, it was clear that they would be aware of the need to isolate the low pressure piping if necessary. In addition, during the site interviews, the operators clearly indicated that HPCS would be initiated. However, it is not <u>explicitly</u> called by the procedure.

Table 10.5.16R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	37 minutes	0	37 Minutes	SNL MELCOR Calculation

Table 10.5.16R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate ADHR from the control room (in most cases this action would already be accomplished by the time the operators reached this point)	CR	--	1 minute	0 minutes - if action necessary, it was assumed to be done in parallel with OPECS actions listed below	Per ASEP HRAP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
4. Initiate ECCS system (HPCS)	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 3 min. Total time for actions	

Table 10.5.16R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation	37 minutes	3 minutes	34 minutes	

Table 10.5.16R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per Table 8-3, the median value from Figure 8-1 for 34 minutes diagnosis time was assigned.		Median = 7.0E-4 Mean = 0.006	The median value from ASEP HRAP Figure 8-1 was selected because the isolation of ADHR and the use of HPCS is not explicitly called out by procedure in this context. Site interviews suggested that the operators would perform these actions.

Table 10.5.16R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements. Initiation of ECCS water solid operation is clearly indicated by the IDHR ONEP in this context.	No	Step-by-Step	

Table 10.5.16R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	HPCS is available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.16R1.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 7.0E-4 Mean = 0.006	—	Med. Mean 7.0E-4 0.006	(10)	
2. Initiate ECCS water solid operation per procedure (includes isolating ADHR if necessary).	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.005 0.016 Total Median HEP = 0.005 Total Mean HEP = 0.016	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.16R2.1
HEP 16R2 Calculation

Human Action Event (1)	OPECS (8)
Event Tree(s) (2)	EA, EAP
Initiators (3)	TAB5H, TDB5H, T5A5H, E1D5H, E2D5H.
Sequence Description Files (4)	OPECSADH.TAB, OPECSADH.TDB, OPECS3.T5A, OPECSADH.E1D, OPECSADP.E1D, OPECSADH.E2D
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the needed actions.
Event Context (6)	The important constants for the OPECS (8) calculation (HEP 16) are that the operators have detected the loss of SDC (OPSDC succeeds), HPCS is the only available ECCS system, and ADHR may need to be isolated from the control room. Closing of the 8 or 9 valve from the control room is adequate to isolate ADHR. With the loss of SDC, the operators would need to enter the ONEP for IDHR. The ONEP directs the operators to initiate ECCS water solid operation.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), HPCS SOI (04-1-01-E22-1, Rev. 44), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20)

Table 10.5.16R2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	Loss of systems would be alarmed. In the context of being in shutdown the operators would be aware of the need for some form of SDC and have already detected the loss of normal SDC systems and entered the IDHR ONEP. The ONEP for IDHR directs the control room to use ECCS to go water solid in this context. Reactor coolant temperature will be rising.	

Table 10.5.16R2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available. The IDHR ONEP directs operators to initiate ECCS water solid operation. HPCS is the only ECCS system available.	One--the loss of SDC is a result of the initiator.	<p>1. Isolate ADHR from the control room (if necessary) by closing 8 or 9 valve.</p> <p>2. Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs. - Ensure that two SRVs are open. - Increase RPV water level with any available injection system. In this context HPCS is the only ECCS system assumed available. 	Isolation of ADHR is not directed by procedure in this context. However, on the basis of interviews with operators, it was clear that they would be aware of the need to isolate the low pressure piping if necessary. In addition, during the site interviews, the operators clearly indicated that HPCS would be initiated. However, it is not <u>explicitly</u> called by the procedure.

Table 10.5.16R2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	55 minutes	0	55 Minutes	SNL MELCOR Calculation

Table 10.5.16R2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate ADHR from the control room (in most cases this action would already be accomplished by the time the operators reached this point)	CR	--	1 minute	0 minutes - if action necessary, it was assumed to be done in parallel with OPECS actions listed below	Per ASEP HRAP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
4. Initiate ECCS system (HPCS)	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 3 min. Total time for actions	

Table 10.5.16R2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation	55 minutes	3 minutes	52 minutes	

Table 10.5.16R2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per Table 8-3, the median value from Figure 8-1 for 52 minutes diagnosis time was assigned.		Median = 1.5E-4 Mean = 0.0013	The median value from ASEP HRAP Figure 8-1 was selected because the isolation of ADHR and the use of HPCS is not explicitly called out by procedure in this context. Site interviews suggested that the operators would perform these actions.

Table 10.5.16R2.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements. Initiation of ECCS water solid operation is clearly indicated by the IDHR ONEP in this context.	No	Step-by-Step	

Table 10.5.16R2.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	HPCS is available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.16R2.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 1.5E-4 Mean = 0.0013	--	Med. Mean 1.5E-4 0.0013	(30)	
2. Initiate ECCS water solid operation per procedure (includes isolating ADHR if necessary).	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.004 0.011 Total Median HEP = 0.004 Total Mean HEP = 0.011	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.16R3.1
HEP 16R3 Calculation

Human Action Event (1)	OPECS (8)
Event Tree(s) (2)	EA, EAP
Initiators (3)	TAB5H, TDB5H, T5A5H, E1D5H, E2D5H.
Sequence Description Files (4)	OPECSADH.TAB, OPECSADH.TDB, OPECS3.T5A, OPECSADH.E1D, OPECSADP.E1D, OPECSADH.E2D
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the needed actions.
Event Context (6)	The important constants for the OPECS (8) calculation (HEP 16) are that the operators have detected the loss of SDC (OPSDC succeeds), HPCS is the only available ECCS system, and ADHR may need to be isolated from the control room. Closing of the 8 or 9 valve from the control room is adequate to isolate ADHR. With the loss of SDC, the operators would need to enter the ONEP for IDHR. The ONEP directs the operators to initiate ECCS water solid operation.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), HPCS SOI (04-1-01-E22-1, Rev. 44), Loss of AC Power ONEP (05-1-02-I-4, Rev. 20)

Table 10.5.16R3.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	Loss of systems would be alarmed. In the context of being in shutdown the operators would be aware of the need for some form of SDC and have already detected the loss of normal SDC systems and entered the IDHR ONEP. The ONEP for IDHR directs the control room to use ECCS to go water solid in this context. Reactor coolant temperature will be rising.	

Table 10.5.16R3.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC is available. The IDHR ONEP directs operators to initiate ECCS water solid operation. HPCS is the only ECCS system available.	One--the loss of SDC is a result of the initiator.	<p>1. Isolate ADHR from the control room (if necessary) by closing 8 or 9 valve.</p> <p>2. Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs. - Ensure that two SRVs are open. - Increase RPV water level with any available injection system. In this context HPCS is the only ECCS system assumed available. 	Isolation of ADHR is not directed by procedure in this context. However, on the basis of interviews with operators, it was clear that they would be aware of the need to isolate the low pressure piping if necessary. In addition, during the site interviews, the operators clearly indicated that HPCS would be initiated. However, it is not <u>explicitly</u> called by the procedure.

Table 10.5.16R3.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	110 minutes	0	110 Minutes	SNL MELCOR Calculation

Table 10.5.16R3.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate ADHR from the control room (in most cases this action would already be accomplished by the time the operators reached this point)	CR	--	1 minute	0 minutes - if action necessary, it was assumed to be done in parallel with OPECS actions listed below	Per ASEP HRAP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
4. Initiate ECCS system (HPCS)	CR	--	1 minute (per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action)	<u>1 minute</u> 3 min. Total time for actions	

Table 10.5.16R3.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	110 minutes	3 minutes	107 minutes	

Table 10.5.16R3.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per Table 8-3, the median value from Figure 8-1 for 107 minutes diagnosis time was assigned.		Median = 7.0E-5 Mean = 6.0E-4	The median value from ASEP HRAP Figure 8-1 was selected because the isolation of ADHR and the use of HPCS is not explicitly called out by procedure in this context. Site interviews suggested that the operators would perform these actions.

Table 10.5.16R3.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements. Initiation of ECCS water solid operation is clearly indicated by the IDHR ONEP in this context.	No	Step-by-Step	

Table 10.5.16R3.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	HPCS is available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.16R3.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 7.0E-5 Mean = 6.0E-4	--	Med. Mean 7.0E-5 6.0E-4	(30)	
2. Initiate ECCS water solid operation per procedure (includes isolating ADHR if necessary).	Median = 0.02 Mean = 0.032	Credit for a second and a third check on completing the action was given because of the time available for relevant feedback to occur, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	<u>0.0008</u> <u>0.003</u> <u>0.0009</u> <u>0.004</u> Total Median HEP = 0.0009 Total Mean HEP = 0.004	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for the action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned.

Table 10.5.18R1.1
HEP 18R1 Calculation

Human Action Event (1)	OPECS (9)
Event Tree(s) (2)	E, EP
Initiators (3)	T1-5, TIA5H, TDB5H, T5A5H, T5D5H, E1B5H, E2B5H, E1T5H, E2T5H, E1V5H, E2V5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSSDC8.SDC, OPECSLP4.EP, OPCSEL32.TIA, OPECSLP8.TIA, OPECSDC6.TIA, OPECSDC10.TIA, OPECSL.TDB, OPECS4.T5A, OPECLAP.T5D, OPECSLEP.T5D, OPECS10.T5D, OPECSDC0.E1B, OPECSDC6.E2B, OPECSDCF.E1T, OPECSDC5.E2T, OPECSADF.E1V, OPECSAD5.E2V, OPECSLHY.TLM, OPECSLP.TIF, OPECSLP.TIH, OPECSLP.TLM, OPECSLP.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constant for the OPECS (9) calculation (HEP 18) is that the control room has failed to diagnose the loss of SDC. The failure to recognize the loss of SDC can occur in either of two contexts. The first context is that SDC(B) continues to run and the operators fail to recognize the need to provide level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to a loss of CRD and/or RWCU and/or forced recirculation. RWCU has auto-isolated in these sequences. The second context is that SDC(B) fails and the operators initially fail to recognize the loss of SDC (OPSDC fails). Regardless, in both cases the E or EP tree is entered with the operators apparently unaware of the need for SDC. In OPECS (9) (HEP 18), the operators must recognize the loss of SDC and enter the IDHR ONEP. In either scenario, additional indicators would be present during the time allowed for OPECS. The IDHR ONEP directs the operators to initiate ECCS water solid operation (LPCI, HPCS, or both are available, depending on context).
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.5.18R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	In addition to numerous alarms and indications which would already be present, reactor temperature (and in some cases pressure) will be increasing). The crew is required to check the chart recorders every 30 minutes and with the additional time available for OPECS, these checks should occur. Furthermore, a low level alarm would also be likely to occur during this period. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.5.18R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	Per IDHR ONEP (Step 5.1.3c) <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. In some sequences, however, HPCS is the choice due to the initiator, e.g., T5A5H (loss of SSW). LPCI is initiated from 04-1-01-E12-1, Step 5.4.2. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table 10.5.18R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{od}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	37 minutes	0	37 Minutes	SNL MELCOR Calculation

Table 10.5.18R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8- 1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.5.18R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	37 minutes	8 minutes	29 minutes	

Table 10.5.18R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the median value from Figure 8-1 for 29 minutes diagnosis time was assigned.		Med. = 0.0015 Mean = 0.004	For this event, the operators have failed to diagnose the loss of SDC in spite of several indications (OPSDC or OPDHR have failed). Given these previous failures, it was judged that the lower bound diagnosis value would not be appropriate even though the site interviews indicated that the operators have a clear understanding of the procedure and the requirements.

Table 10.5.18R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.18R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _E < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.18R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{cz}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.0015 Mean = 0.004	--	Med. Mean 0.0015 0.004	(10)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.006 0.014 Total Median HEP = 0.006 Total Mean HEP = 0.014	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.18R1.1
HEP 18R1 Calculation

Human Action Event (1)	OPECS (9)
Event Tree(s) (2)	E, EP
Initiators (3)	T1-5, TIA5H, TDB5H, T5A5H, T5D5H, E1B5H, E2B5H, E1T5H, E2T5H, E1V5H, E2V5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSSDC8.SDC, OPECSLP4.EP, OPCSEL32.TIA, OPECSLP8.TIA, OPECSSDC6.TIA, OPECSSDC10.TIA, OPECSL.TDB, OPECS4.T5A, OPECLAP.T5D, OPECSLEP.T5D, OPECS10.T5D, OPECSSDC0.E1B, OPECSSDC6.E2B, OPECSSDCF.E1T, OPECSSDC5.E2T, OPECSADF.E1V, OPECSAD5.E2V, OPECSLHY.TLM, OPECSLP.TIF, OPECSLP.TIH, OPECSLP.TLM, OPECSLP.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constant for the OPECS (9) calculation (HEP 18) is that the control room has failed to diagnose the loss of SDC. The failure to recognize the loss of SDC can occur in either of two contexts. The first context is that SDC(B) continues to run and the operators fail to recognize the need to provide level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to a loss of CRD and/or RWCU and/or forced recirculation. RWCU has auto-isolated in these sequences. The second context is that SDC(B) fails and the operators initially fail to recognize the loss of SDC (OPSDC fails). Regardless, in both cases the E or EP tree is entered with the operators apparently unaware of the need for SDC. In OPECS (9) (HEP 18), the operators must recognize the loss of SDC and enter the IDHR ONEP. In either scenario, additional indicators would be present during the time allowed for OPECS. The IDHR ONEP directs the operators to initiate ECCS water solid operation (LPCI, HPCS, or both are available, depending on context).
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.5.18R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	In addition to numerous alarms and indications which would already be present, reactor temperature (and in some cases pressure) will be increasing). The crew is required to check the chart recorders every 30 minutes and with the additional time available for OPECS, these checks should occur. Furthermore, a low level alarm would also be likely to occur during this period. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.5.18R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. In some sequences, however, HPCS is the choice due to the initiator, e.g., T5A5H (loss of SSW).</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.5.18R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	37 minutes	0	37 Minutes	SNL MELCOR Calculation

Table 10.5.18R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.5.18R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	37 minutes	8 minutes	29 minutes	

Table 10.5.18R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the median value from Figure 8-1 for 29 minutes diagnosis time was assigned.		Med. = 0.0015 Mean = 0.004	For this event, the operators have failed to diagnose the loss of SDC in spite of several indications (OPSDC or OPDHR have failed). Given these previous failures, it was judged that the lower bound diagnosis value would not be appropriate even though the site interviews indicated that the operators have a clear understanding of the procedure and the requirements.

Table 10.5.18R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.18R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _m < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.18R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^{op}	Independent Check/Correction HEP (HEP _c) (3) ¹²	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.0015 Mean = 0.004	--	Med. Mean 0.0015 0.004	(10)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.006 0.014 Total Median HEP = 0.006 Total Mean HEP = 0.014	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.18R3.1
HEP 18R3 Calculation

Human Action Event (1)	OPECS (9)
Event Tree(s) (2)	E, EP
Initiators (3)	T1-5, TIA5H, TDB5H, T5A5H, T5D5H, E1B5H, E2B5H, E1T5H, E2T5H, E1V5H, E2V5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSSDC8.SDC, OPECSLP4.EP, OPCSEL32.TIA, OPECSLP8.TIA, OPECSDC6.TIA, OPECSDC10.TIA, OPECSL.TDB, OPECS4.T5A, OPECLAP.T5D, OPECSLEP.T5D, OPECS10.T5D, OPECSDC0.E1B, OPECSDC6.E2B, OPECSDCF.E1T, OPECSDC5.E2T, OPECSADF.E1V, OPECSAD5.E2V, OPECSLHY.TLM, OPECSLP.TIF, OPECSLP.TIH, OPECSLP.TLM, OPECSLP.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constant for the OPECS (9) calculation (HEP 18) is that the control room has failed to diagnose the loss of SDC. The failure to recognize the loss of SDC can occur in either of two contexts. The first context is that SDC(B) continues to run and the operators fail to recognize the need to provide level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to a loss of CRD and/or RWCU and/or forced recirculation. RWCU has auto-isolated in these sequences. The second context is that SDC(B) fails and the operators initially fail to recognize the loss of SDC (OPSDC fails). Regardless, in both cases the E or EP tree is entered with the operators apparently unaware of the need for SDC. In OPECS (9) (HEP 18), the operators must recognize the loss of SDC and enter the IDHR ONEP. In either scenario, additional indicators would be present during the time allowed for OPECS. The IDHR ONEP directs the operators to initiate ECCS water solid operation (LPCI, HPCS, or both are available, depending on context).
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.5.18R3.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	In addition to numerous alarms and indications which would already be present, reactor temperature (and in some cases pressure) will be increasing). The crew is required to check the chart recorders every 30 minutes and with the additional time available for OPECS, these checks should occur. Furthermore, a low level alarm would also be likely to occur during this period. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.5.18R3.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system. In some sequences, however, HPCS is the choice due to the initiator, e.g., T5A5H (loss of SSW).</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.5.18R3.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	110 minutes	0	110 Minutes	SNL MELCOR Calculation

Table 10.5.18R3.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8- 1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.5.18R3.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	110 minutes	8 minutes	102 minutes	

Table 10.5.18R3.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the median value from Figure 8-1 for 102 minutes diagnosis time was assigned.		Med. = 7.0E-5 Mean = 6.0E-4	For this event, the operators have failed to diagnose the loss of SDC in spite of several indications (OPSDC or OPDHR have failed). Given these previous failures, it was judged that the lower bound diagnosis value would not be appropriate even though the site interviews indicated that the operators have a clear understanding of the procedure and the requirements.

Table 10.5.18R3.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.18R3.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.18R3.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 7.0E-5 Mean = 6.0E-4	--	Med. Mean 7.0E-5 6.0E-4	(30)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	Credit for a second and a third check on completing the action was given because of the time available for relevant feedback to occur, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	<u>0.0008</u> <u>0.003</u> 0.0009 0.004 Total Median HEP = 0.0009 Total Mean HEP = 0.004	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for the action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned.

Table 10.5.28R1.1
HEP 28R1 Calculation

Human Action Event (1)	OPFLD (1)
Event Tree(s) (2)	F, FP
Initiators (3)	All transients
Sequence Locator Files (4)	All files beginning with OPFLD, e.g., OPFLDE.E1T
Event Description (5)	OPFLD is the operator decision and action to flood the vessel/containment in order to provide some form of SDC.
Event Context (6)	For the OPFLD (1) calculation (HEP 28), OPECS or OPDHR have succeeded, but all ECCS systems have failed or are unavailable. Thus, the operators have attempted to do the correct actions, but the systems asked have failed or been unavailable. One option available to the operators to provide level and core cooling is to flood the vessel/containment. SSWXT or FW are systems that could (potentially) be used to flood. If vessel level is too low and not increasing, EP-2 calls out for alternate level control which will eventually lead the operators to initiate flooding.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.5.28R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
ECCS systems are not available and core cooling and makeup are needed. The question is whether will flood with SSWXT or FW.	O	In addition to numerous alarms and indications which would already be present, reactor temperature (and in some cases pressure) will be increasing). The crew has been attempting to respond to existing problems and will be aware of the need to provide core cooling in some way. Low level alarms would likely to occur during this period.	

Table 10.5.28R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators are attempting to respond to IDHR, but no ECCS systems are available. OPFLD asks whether the operators will attempt to flood with SSWXT or FW.	One	<ul style="list-style-type: none"> - Check closed MSIVs - Ensure that some SRVs are open - Align and initiate SSWXT for flooding 	It was assumed the SSWXT would be the operators first choice for flooding and credit was not taken for both SSWXT and FW in the sequences covered by this HEP.

Table 10.5.28R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate flooding	37 minutes	0	37 Minutes	SNL MELCOR Calculation

Table 10.5.28R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read EP-2 and apply to LP&S context.	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and study EP-2 is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LP&S and with the idea that some "generalization" of EP-2 to the LP&S context would be required.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for flooding were judged to be an integrated set of actions.
3. Ensure some SRVs are open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate SSWXT per RHR SOI 04-1-01-E12-1, step 6.10. Requires 2 valves to be opened.	CR	--	1 minutes (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.5.28R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment	37 minutes	8 minutes	29 minutes	

Table 10.5.28R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment.	Per ASEP Table 8-3, the median value from Figure 8-1 for 29 minutes diagnosis time was assigned.		Med. = 0.0015 Mean = 0.004	Flooding in response to IDHR during LP&S is not explicitly called out by procedure. However, it is at least indirectly indicated in EP-2 and the site interviews indicated that the operators have a clear understanding of the needed response and the necessary actions. Thus, per ASEP HRAP, Table 8-3, the median diagnosis value would be appropriate.

Table 10.5.28R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks -(4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Flood containment.	N/A	Actions are specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.28R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _m < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Flood with SSWXT.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.28R1.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.0015 Mean = 0.004	--	Med. Mean 0.0015 0.004	(10)	
2. Initiate flooding with SSWXT.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.006 0.014 Total Median HEP = 0.006 Total Mean HEP = 0.014	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.28R2.1
HEP 28R2 Calculation

Human Action Event (1)	OPFLD (1)
Event Tree(s) (2)	F, FP
Initiators (3)	All transients
Sequence Locator Files (4)	All files beginning with OPFLD, e.g., OPFLDE.E1T
Event Description (5)	OPFLD is the operator decision and action to flood the vessel/containment in order to provide some form of SDC.
Event Context (6)	For the OPFLD (1) calculation (HEP 28), OPECS or OPDHR have succeeded, but all ECCS systems have failed or are unavailable. Thus, the operators have attempted to do the correct actions, but the systems asked have failed or been unavailable. One option available to the operators to provide level and core cooling is to flood the vessel/containment. SSWXT or FW are systems that could (potentially) be used to flood. If vessel level is too low and not increasing, EP-2 calls out for alternate level control which will eventually lead the operators to initiate flooding.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.5.28R2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
ECCS systems are not available and core cooling and makeup are needed. The question is whether will flood with SSWXT or FW.	O	In addition to numerous alarms and indications which would already be present, reactor temperature (and in some cases pressure) will be increasing). The crew has been attempting to respond to existing problems and will be aware of the need to provide core cooling in some way. Low level alarms would likely to occur during this period.	

Table 10.5.28R2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators are attempting to respond to IDHR, but no ECCS systems are available. OPFLD asks whether the operators will attempt to flood with SSWXT or FW.	One	<ul style="list-style-type: none"> - Check closed MSIVs - Ensure that some SRVs are open - Align and initiate SSWXT for flooding 	It was assumed the SSWXT would be the operators first choice for flooding and credit was not taken for both SSWXT and FW in the sequences covered by this HEP.

Table 10.5.28R2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate flooding	55 minutes	0	55 Minutes	SNL MELCOR Calculation

Table 10.5.28R2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read EP-2 and apply to LP&S context.	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and study EP-2 is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LP&S and with the idea that some "generalization" of EP-2 to the LP&S context would be required.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for flooding were judged to be an integrated set of actions.
3. Ensure some SRVs are open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate SSWXT per RHR SOI 04-1-01-E12-1, step 6.10. Requires 2 valves to be opened.	CR	--	1 minutes (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.5.28R2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment	55 minutes	8 minutes	47 minutes	.

Table 10.5.28R2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment.	Per ASEP Table 8-3, the median value from Figure 8-1 for 47 minutes diagnosis time was assigned.		Med. = 0.0002 Mean = 0.0017	Flooding in response to IDHR during LP&S is not explicitly called out by procedure. However, it is at least indirectly indicated in EP-2 and the site interviews indicated that the operators have a clear understanding of the needed response and the necessary actions. Thus, per ASEP HRAP, Table 8-3, the median diagnosis value would be appropriate.

Table 10.5.28R2.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Flood containment.	N/A	Actions are specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.28R2.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_E <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Flood with SSWXT.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.28R2.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.0002 Mean = 0.0017	--	Med. Mean 0.0002 0.0017	(10)	
2. Initiate flooding with SSWXT.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.004 0.012 Total Median HEP = 0.004 Total Mean HEP = 0.012	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.29R1.1
HEP 29R1 Calculation

Human Action Event (1)	OPSTM (1)
Event Tree(s) (2)	S, SP, SNP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	All files beginning with OPSTM, e.g., OPSTMFD3.SP, with the exception of OPSTMHYD.ECN, OPSTMSNP.SNP, OPSTMSNP.E1T, OPSTM51.TIH, OPSTM51.TIF, OPSTM81.TIH, and OPSTM81.TIF.
Event Description (5)	OPSTM is the operator decision to initiate steaming of the core.
Event Context (6)	OPSTM (1) (HEP 29) applies in numerous sequences. It represents the operators decision to steam the vessel to provide core cooling when other actions they have taken have been unsuccessful. For example, in many sequences they have attempted to initiate ECCS water solid operation (OPECS succeeds), but the systems have failed. The critical aspect of HEP 29 is that the operators have demonstrated an awareness of the problem. While steaming of the vessel is a non-proceduralized action, the operators will essentially be steaming the core by default at this point. They will need to ensure 1 SRV is opened and eventually they will need to provide some form of makeup, which they have already been attempting to accomplish. Several systems may be used for steaming, e.g., CRD, CDS, SSWXT, and FW.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-29-02-III-1)

Table 10.5.29R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
The operators have attempted to respond to IDHR. For any of several reasons, their attempts have failed, e.g., ECCS fails. OPSTM asks whether or not the operators will consciously decide to steam the vessel. The operators need to ensure that 1 SRV is open.	O	Operators have been attempting to respond to IDHR. Thus they are aware that vessel temperature is going up. They are in fact steaming by default and need only open 1 SRV. There are no particular indicators that specify steaming.	<p>BWRs basically operate by steaming. Thus, it is not an "unusual" response to the problem.</p> <p>Note. Even if the operators have decided not to go water solid with only 1 SRV available (OP1SV fails in E tree), they may still decide to steam with 1 SRV. If they initially fail to get 1 SRV open, it was assumed they could still decide to attempt steaming.</p>

Table 10.5.29R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Previous attempts to provide SDC have failed. The operators may decide to steam the vessel.	One	Check open 1 SRV	Complete dependence was assumed between the control room consciously deciding to steam the vessel and checking open 1 SRV. In most of the sequences in which this HEP is applied, the SRV is already open. Thus, steaming is occurring by default. Interviews with operators indicated that they would not open MSIVs for steaming unless they had a vacuum in the condenser. Cannot assume a vacuum exists in the condenser during POS 5. Therefore, deciding to steam was assumed to entail ensuring that 1 SRV was open.

Table 10.5.29R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
A decision to steam is all that is asked in this event.	37 minutes	0	37 minutes	SNL MELCOR Calculation

Table 10.5.29R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_l) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
No action required. Checking open 1 SRV was assumed to part of the decision to steam. In most cases the necessary SRV is already open.	Control Room	--	--	--	Initiation of a makeup system is not immediately required. Eventually makeup is required and system success is asked later in the tree.

Table 10.5.29R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Consciously decide to steam the vessel.	37	0 minutes	37 minutes	

Table 10.5.29R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to steam the vessel.	Per ASEP HRAP Table 8-3, the upper bound value from ASEP Figure 8-1 for 37 minutes diagnosis time was assigned.	N/A	Median = 0.007 Mean = 0.019	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. However, since it is not proceduralized and apparently not covered specifically in training, it is not clear that all operators would consciously decide to steam. Thus, without additional information, per ASEP HRAP Table 8-3, the upper bound diagnosis value was indicated.

Table 10.5.29R1.8
Post-Diagnosis Action-Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs, Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

¹ Actions assumed completely dependent with diagnosis (see Table 10.1.29.3 for rationale).

Table 10.5.29R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_R <2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

¹ Actions assumed completely dependent with diagnosis (see Table 10.1.29R1.3 for rationale).

Table 10.5.29R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Decide to steam the vessel.	Diagnosis and Actions: Median = 0.007 Mean = 0.019	N/A	Median = 0.007 Mean = 0.019	10	

Table 10.5.29R2.1
HEP 29R2 Calculation

Human Action Event (1)	OPSTM (1)
Event Tree(s) (2)	S, SP, SNP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	All files beginning with OPSTM, e.g., OPSTMFD3.SP, with the exception of OPSTMHYD.ECN, OPSTMSNP.SNP, OPSTMSNP.E1T, OPSTM51.TIH, OPSTM51.TIF, OPSTM81.TIH, and OPSTM81.TIF.
Event Description (5)	OPSTM is the operator decision to initiate steaming of the core.
Event Context (6)	OPSTM (1) (HEP 29) applies in numerous sequences. It represents the operators decision to steam the vessel to provide core cooling when other actions they have taken have been unsuccessful. For example, in many sequences they have attempted to initiate ECCS water solid operation (OPECS succeeds), but the systems have failed. The critical aspect of HEP 29 is that the operators have demonstrated an awareness of the problem. While steaming of the vessel is a non-proceduralized action, the operators will essentially be steaming the core by default at this point. They will need to ensure 1 SRV is opened and eventually they will need to provide some form of makeup, which they have already been attempting to accomplish. Several systems may be used for steaming, e.g., CRD, CDS, SSWXT, and FW.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-29-02-III-1)

Table 10.5.29R2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
The operators have attempted to respond to IDHR. For any of several reasons, their attempts have failed, e.g., ECCS fails. OPSTM asks whether or not the operators will consciously decide to steam the vessel. The operators need to ensure that 1 SRV is open.	O	Operators have been attempting to respond to IDHR. Thus they are aware that vessel temperature is going up. They are in fact steaming by default and need only open 1 SRV. There are no particular indicators that specify steaming.	<p>BWRs basically operate by steaming. Thus, it is not an "unusual" response to the problem.</p> <p>Note. Even if the operators have decided not to go water solid with only 1 SRV available (OP1SV fails in E tree), they may still decide to steam with 1 SRV. If they initially fail to get 1 SRV open, it was assumed they could still decide to attempt steaming.</p>

Table 10.5.29R2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Previous attempts to provide SDC have failed. The operators may decide to steam the vessel.	One	Check open 1 SRV	Complete dependence was assumed between the control room consciously deciding to steam the vessel and checking open 1 SRV. In most of the sequences in which this HEP is applied, the SRV is already open. Thus, steaming is occurring by default. Interviews with operators indicated that they would not open MSIVs for steaming unless they had a vacuum in the condenser. Cannot assume a vacuum exists in the condenser during POS 5. Therefore, deciding to steam was assumed to entail ensuring that 1 SRV was open.

Table 10.5.29R2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
A decision to steam is all that is asked in this event.	55 minutes	0	55 minutes	SNL MELCOR Calculation

Table 10.5.29R2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_t) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
No action required. Checking open 1 SRV was assumed to part of the decision to steam. In most cases the necessary SRV is already open.	Control Room	--	--	--	Initiation of a makeup system is not immediately required. Eventually makeup is required and system success is asked later in the tree.

Table 10.5.29R2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Consciously decide to steam the vessel.	55	0 minutes	55 minutes	

Table 10.5.29R2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to steam the vessel.	Per ASEP HRAP Table 8-3, the upper bound value from ASEP Figure 8-1 for 55 minutes diagnosis time was assigned.	N/A	Median = 0.003 Mean = 0.008	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. However, since it is not proceduralized and apparently not covered specifically in training, it is not clear that all operators would consciously decide to steam. Thus, without additional information, per ASEP HRAP Table 8-3, the upper bound diagnosis value was indicated.

Table 10.5.29R2.8
Post-Diagnosis Action-Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs, Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

¹ Actions assumed completely dependent with diagnosis (see Table 10.1.29.3 for rationale).

Table 10.5.29R2.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

¹ Actions assumed completely dependent with diagnosis (see Table 10.1.29R2.3 for rationale).

Table 10.5.29R2.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Decide to steam the vessel.	Diagnosis and Actions: Median = 0.003 Mean = 0.008	N/A	Median = 0.003 Mean = 0.008	10	

Table 10.5.35R1.1
HEP 35R1 Calculation

Human Action Event (1)	OPDHR (2)
Event Tree(s) (2)	L, LA
Initiators (3)	T5D5H, E1B5H, E1D5H, E2D5H, E1T5H, E1V5H
Sequence Locator Files (4)	OPDHR.TDB, OPDHR.T5D, OPDHR.E1B, OPDHR.E1D, OPDHR.E2D, OPDHR.E1T, OPDHR.E1V
Event Description (5)	OPDHR is the operator action to control vessel level in order to avoid a "functional" loss of SDC caused by inadequate circulation between the core and the downcomer regions of the vessel. That is, even if SDC continues to operate, if vessel level becomes too low, a "disconnect" between the core and downcomer regions can occur. This will result in inadequate cooling of the core even though SDC continues to operate. The indications to the operators that the event is occurring can be subtle because temperature readings are apparently taken from the downcomer region, where the water being cooled by SDC is returned. Also, the vessel level would not be so low that any level alarms would sound. A loss of forced recirculation, or a loss of makeup (usually CRD) coupled with continued draindown, can lead to inadequate level.
Event Context (6)	The important constants for the OPDHR (2) calculation (HEP 35) are that RWCU has not been isolated by a LOSP or loss of IA. Moreover, any losses of forced recirculation or CRD or RWCU are either artifacts of the initiator (e.g., a loss of CCW) or are unrelated to the initiator and occur as random events.
Applicable Procedures (7)	No specific procedures, but the Loss of CCW ONEP (05-1-02-V-1, Rev. 11) and the Inadequate Decay Heat Removal ONEP (05-1-02-III-1) would be relevant, as would the relevant SOIs, e.g., RHR SOI (04-1-01-E12-1).

Table 10.5.35R1.2
Sequence Timing and Indications

(1) Event/Occurrence (of most interest)	(2) Time (T) Operator Alerted	(3) Annunciator/Indication	(4) Comments/ Source of Information
IDHR caused by inadequate circulation between the core and the downcomer regions of the vessel. Level control (makeup) is needed.	0	As noted in Table 10.5.35R1.1, the indications for this event may be subtle because vessel temperature readings could be misleading and no level alarms would sound. However, in all the sequences covered, CRD and/or forced recirculation is lost. These events will be alarmed and if the operators are knowledgeable regarding the potential problem, these indications should suffice.	

Table 10.5.35R1.3
Potential Operator Action

(1) Description of Event	(2) Number of Abnormal Events	(3) Activities (Tasks) Required to Perform Action and Procedures	(4) Comments/ Source of Information
A "functional" loss of SDC leads to IDHR. The operators need to diagnose the need and increase vessel level.	One	The operators need to increase RPV water level with any available injection system. CRD (if available), CDS, or an ECCS system are possible choices.	

Table 10.5.35R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ω}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to increase level to avoid inadequate core cooling.	37 minutes	0	37 Minutes	SNL MELCOR Calculation

Table 10.5.35R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate RWCU, and in some sequences the operators may need to stop CRD, forced recirculation, and RWCU.	CR	--	2 minutes	2 minutes	Note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
2. If available, increase flow with CRD. If CRD is not available and SDC is not being provided by SDC(B), use CDS. Otherwise, use an ECCS system.	CR	--	2 minutes Since more than one system may need to be tried, 2 minutes, rather than 1 minute was assumed for conducting the activities.	2 minutes	The actions involved in initiating a makeup system were assumed to be completely dependent. System initiation would be proceduralized.

Table 10.5.35R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_A) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
The operators need to diagnose the need to isolate RWCU and increase level to avoid inadequate core cooling.	37 minutes	4 minutes	33 minutes	

Table 10.5.35R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to isolate RWCU and provide makeup.	Per ASEP Table 8-3, the median value from Figure 8-1 for 33 minutes diagnosis time was assigned.		Med. = $9.0E-4$ Mean = 0.008	The site interviews indicated that the operators are aware of the problem of concern and have a clear understanding of the requirements. However, with the potential subtlety of the indicators, the absence of any explicit procedures, and the time limitations, the lower bound diagnosis value was not assumed appropriate.

Table 10.5.35R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Isolate RWCU and initiate an injection system to provide makeup.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions.	No	Step x Step Even though the operators would have to determine which system to start on their own, the choices for injection would be obvious and substantial time would be available.	

Table 10.5.35R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate an injection system to provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.35R1.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 9.0E-4 Mean = 0.008	--	Med. Mean 9.0E-4 0.008	(30)	
2. Isolate RWCU and in some sequences stop CRD and forced recirculation.	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available and the importance of the actions given a correct diagnosis. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01	(5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action.
3. Initiate an injection system to provide makeup and vessel level control.	Med. = 0.02 Mean = 0.032	Same as above	<u>0.004</u> <u>0.01</u> 0.009 0.028 Total Median HEP = 0.009 Total Mean HEP = 0.028	<u>(5)</u> (5)	The error factor associated with the dominant HEPs was assigned.

Table 10.5.37R1.1
HEP 37R1 Calculation

Human Action Event (1)	OPECS (11)
Event Tree(s) (2)	E, EA
Initiators (3)	T5D5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSL32.T5D, OPECSLEA.T5D, OPECSL.TIF, OPECSL.TIH, OPECSL.TLM, OPECSL.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (11) calculation (HEP 37) are that SDC(B) or ADHR has continued to run and forced recirculation and/or CRD and/or RWCU are lost. RWCU must be manually isolated from the control room to stop draindown, i.e., no auto-isolation. The operators initially fail to diagnose the need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. With SDC continuing to operate, the operators failing to diagnose the functional loss of SDC and the need for level control during the time for OPDHR, RWCU (letdown) needing to be isolated, and ADHR needing to be isolated in some sequences, OPECS is somewhat more demanding in these scenarios than in some others.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.5.37R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period as level decreases as a result of RWCU (letdown) not being isolated. Reactor pressure and coolant temperature will be rising. However, the coolant temperature of the core may not be apparent since the sensors sample the water in the recirculation areas which are being cooled by SDC in this scenario.	

Table 10.5.37R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Due to the "functional" loss of SDC, operators must enter the IDHR ONEP and diagnose the need to initiate ECCS water solid operation.	One	<p>A. Realize the need and isolate RWCU to stop letdown.</p> <p>B. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>C. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.5.37R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	37 minutes	0	37 Minutes	SNL MELCOR Calculation

Table 10.5.37R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read the IDHR ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent. In addition, in the present case the functional loss of SDC may be subtle and the needed response is not explicitly indicated in the IDHR ONEP. Thus, some "interpretation" will be required.
2. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but when the action is necessary, it was assumed to be done in parallel with alignment and start of LPCI (action 6 below) and the other OPECS actions.	0 minutes	Isolating ADHR and aligning LPCI (action 6 below) were judged to be an integrated set of actions and were assumed to be completely dependent. They are successive steps in a procedure specifically written to cover switching from ADRS to LPCI (RHR SOI (04-1-01-E12-1, Step 6.6 or 6.8)
4. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 4 and 5 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
5. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
6. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	3 minutes - includes time for isolating ADHR when required.	<u>3 minutes</u> 11 minutes (approx.) Total time for all actions.	

Table 10.5.37R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	37 minutes	11 minutes	26 minutes	

Table 10.5.37R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation in context of a "functional" loss of SDC and determine what the appropriate actions should be.	Per ASEP HRA Table 8-3, the median value from Figure 8-1 for 26 minutes diagnosis time was assigned.		Median = 0.003 (EF = 10) Mean = 0.008	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the failure of OPDHR, the need to diagnose the need to isolate RWCU and the potential subtlety of the "functional" loss of SDC without explicit procedures, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.5.37R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements. However, see comments in Column 6 of this table.	No	Dynamic and Step X Step See comments.	Isolating RWCU in this context was assumed to be dynamic per ASEP HRAP Table 8-1, Step 10, Items, a,b,c. The other actions were assumed to be step x step, since with careful reading of the available procedures (allowed by the time available), the appropriate steps are indicated.

Table 10.5.37R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.37R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.003 Mean = 0.008	--	Med. Mean 0.003 0.008	(10)	
2. Actions 1. Isolate RWCU (letdown). 2. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. 3. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.05 Mean = 0.081 Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the time available, the importance of the actions, and a correct diagnosis, credit for second checks on the actions supposed to be carried out were given. Second check HEPs were assumed to be step x step. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	Med. Mean 0.01 0.026 Med. Mean 0.004 0.01 Med. Mean <u>0.004</u> <u>0.01</u> 0.021 0.054 Total median HEP = 0.021 Total mean HEP = 0.054	(5) (5) (5) (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.37R2.1
HEP 37R2 Calculation

Human Action Event (1)	OPECS (11)
Event Tree(s) (2)	E, EA
Initiators (3)	T5D5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSL32.T5D, OPECSLEA.T5D, OPECSL.TIF, OPECSL.TIH, OPECSL.TLM, OPECSL.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (11) calculation (HEP 37) are that SDC(B) or ADHR has continued to run and forced recirculation and/or CRD and/or RWCU are lost. RWCU must be manually isolated from the control room to stop draindown, i.e., no auto-isolation. The operators initially fail to diagnose the need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. With SDC continuing to operate, the operators failing to diagnose the functional loss of SDC and the need for level control during the time for OPDHR, RWCU (letdown) needing to be isolated, and ADHR needing to be isolated in some sequences, OPECS is somewhat more demanding in these scenarios than in some others.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.5.37R2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period as level decreases as a result of RWCU (letdown) not being isolated. Reactor pressure and coolant temperature will be rising. However, the coolant temperature of the core may not be apparent since the sensors sample the water in the recirculation areas which are being cooled by SDC in this scenario.	

Table 10.5.37R2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Due to the "functional" loss of SDC, operators must enter the IDHR ONEP and diagnose the need to initiate ECCS water solid operation.	One	<p>A. Realize the need and isolate RWCU to stop letdown.</p> <p>B. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3)) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>C. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.5.37R2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	55 minutes	0	55 Minutes	SNL MELCOR Calculation

Table 10.5.37R2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal.	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read the IDHR ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent. In addition, in the present case the functional loss of SDC may be subtle and the needed response is not explicitly indicated in the IDHR ONEP. Thus, some "interpretation" will be required.
2. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but when the action is necessary, it was assumed to be done in parallel with alignment and start of LPCI (action 6 below) and the other OPECS actions.	0 minutes	Isolating ADHR and aligning LPCI (action 6 below) were judged to be an integrated set of actions and were assumed to be completely dependent. They are successive steps in a procedure specifically written to cover switching from ADRS to LPCI (RHR SOI (04-1-01-E12-1, Step 6.6 or 6.8)
4. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 4 and 5 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
5. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
6. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	3 minutes - includes time for isolating ADHR when required.	<u>3 minutes</u> 11 minutes (approx.) Total time for all actions.	

Table 10.5.37R2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	55 minutes	11 minutes	44 minutes	

Table 10.5.37R2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation in context of a "functional" loss of SDC and determine what the appropriate actions should be.	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 44 minutes diagnosis time was assigned.		Median = 0.0002 (EF = 30) Mean = 0.0017	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the failure of OPDHR, the need to diagnose the need to isolate RWCU and the potential subtlety of the "functional" loss of SDC without explicit procedures, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.5.37R2.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements. However, see comments in Column 6 of this table.	No	Dynamic and Step X Step See comments.	Isolating RWCU in this context was assumed to be dynamic per ASEP HRA Table 8-1, Step 10, Items, a,b,c. The other actions were assumed to be step x step, since with careful reading of the available procedures (allowed by the time available), the appropriate steps are indicated.

Table 10.5.37R2.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRA

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.37R2.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^{op}	Independent Check/Correction HEP (HEP _c) (3) ^c	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.0002 Mean = 0.0017	--	Med. Mean 0.0002 0.0017	(30)	
2. Actions 1. Isolate RWCU (letdown). 2. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. 3. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.05 Mean = 0.081 Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Given the time available, the importance of the actions, and a correct diagnosis, credit for second checks on the actions supposed to be carried out were given. Second check HEPs were assumed to be step x step. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	Med. Mean 0.01 0.026 Med. Mean 0.004 0.01 Med. Mean <u>0.004</u> <u>0.01</u> 0.018 0.048 Total median HEP = 0.018 Total mean HEP = 0.048	(5) (5) (5) (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.37R3.1
HEP 37R3 Calculation

Human Action Event (1)	OPECS (11)
Event Tree(s) (2)	E, EA
Initiators (3)	T5D5H, TIOF5, TIHP5, TLM5H, TRPT5
Sequence Locator Files (4)	OPECSL32.T5D, OPECSLEA.T5D, OPECSL.TIF, OPECSL.TIH, OPECSL.TLM, OPECSL.TRP
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (11) calculation (HEP 37) are that SDC(B) or ADHR has continued to run and forced recirculation and/or CRD and/or RWCU are lost. RWCU must be manually isolated from the control room to stop draindown, i.e., no auto-isolation. The operators initially fail to diagnose the need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. With SDC continuing to operate, the operators failing to diagnose the functional loss of SDC and the need for level control during the time for OPDHR, RWCU (letdown) needing to be isolated, and ADHR needing to be isolated in some sequences, OPECS is somewhat more demanding in these scenarios than in some others.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44)

Table 10.5.37R3.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. A level 3 alarm may also occur in this time period as level decreases as a result of RWCU (letdown) not being isolated. Reactor pressure and coolant temperature will be rising. However, the coolant temperature of the core may not be apparent since the sensors sample the water in the recirculation areas which are being cooled by SDC in this scenario.	

Table 10.5.37R3.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Due to the "functional" loss of SDC, operators must enter the IDHR ONEP and diagnose the need to initiate ECCS water solid operation.	One	<p>A. Realize the need and isolate RWCU to stop letdown.</p> <p>B. Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B</p> <ol style="list-style-type: none"> 1. Secure ADHRS (step 6.6.2.a (1-3) or step 6.8.2.a (1-3) 2. Align and start RHR C or B in LPCI mode (steps 6.6.2.b, (1-5) and 6.6.2.c,d,e,f or steps 6.8.2.b, (1-5) and 6.8.2.c,d,e,f) <p>C. Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) or (B) was assumed first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP. In addition, the procedures for initiation of LPCI instruct the operators to secure ADHRS, the HPCS procedures do not.

Table 10.5.37R3.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	110 minutes	0	110 Minutes	SNL MELCOR Calculation

Table 10.5.37R3.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read the IDHR ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent. In addition, in the present case the functional loss of SDC may be subtle and the needed response is not explicitly indicated in the IDHR ONEP. Thus, some "interpretation" will be required.
2. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
3. Ensure that ADHR is secured per RHR SOI procedure (step 6.6.1 or 6.8.1)	CR	--	1 - 3 minutes, but when the action is necessary, it was assumed to be done in parallel with alignment and start of LPCI (action 6 below) and the other OPECS actions.	0 minutes	Isolating ADHR and aligning LPCI (action 6 below) were judged to be an integrated set of actions and were assumed to be completely dependent. They are successive steps in a procedure specifically written to cover switching from ADRS to LPCI (RHR SOI (04-1-01-E12-1, Step 6.6 or 6.8)
4. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 4 and 5 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
5. Ensure 2 SRVs open	CR	--	1 minute	1 minute	
6. Align and initiate LPCI (C) or (B) per RHR SOI (step 6.6.2 or 6.8.2)	CR	--	3 minutes - includes time for isolating ADHR when required.	<u>3 minutes</u> 11 minutes (approx.) Total time for all actions.	

Table 10.5.37R3.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	110 minutes	11 minutes	99 minutes	

Table 10.5.37R3.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation in context of a "functional" loss of SDC and determine what the appropriate actions should be.	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 99 minutes diagnosis time was assigned.		Med. = $7.0E-5$ Mean = $6.0E-4$	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the failure of OPDHR, the need to diagnose the need to isolate RWCU and the potential subtlety of the "functional" loss of SDC without explicit procedures, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.5.37R3.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements. However, see comments in Column 6 of this table.	No	Dynamic and Step X Step See comments.	Isolating RWCU in this context was assumed to be dynamic per ASEP HRAP Table 8-1, Step 10, Items, a,b,c. The other actions were assumed to be step x step, since with careful reading of the available procedures (allowed by the time available), the appropriate steps are indicated.

Table 10.5.37R3.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.37R3.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{ic2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 0.0002 Mean = 0.0017	--	Med. Mean 7.0E-5 6.0E-4	(30)	
2. Actions 1. Isolate RWCU (letdown). 2. Isolating ADHR and aligning LPCI(C) for injection were assumed to be completely dependent. 3. OPECS actions - open 2 SRVs - check closed MSIVs - start LPCI(C)	Median = 0.05 Mean = 0.081 Median = 0.02 Mean = 0.032 Median = 0.02 Mean = 0.032	Credit for a second and a third check on completing the action was given because of the time available for relevant feedback to occur, the existence of relevant procedures, and the importance of the actions. Second and third check HEPs were assumed to be step x step. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	Med. Mean 0.002 0.009 Med. Mean 0.0008 0.003 Med. Mean <u>0.0008</u> <u>0.003</u> 0.004 0.016 Total median HEP = 0.004 Total mean HEP = 0.016	(5) (5) (5) (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for the action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned.

Table 10.5.42R1.1
HEP 42R1 Calculation

Human Action Event (1)	OPSTH (1)
Event Tree(s) (2)	P, PP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	All files beginning with OPSTH, e.g., OPSTHSRV.E1B
Event Description (5)	OPSTH is the operator decision and action to initiate steaming of the core at high pressure.
Event Context (6)	OPSTH (1) (HEP 42) represents the operator decision to steam the core at high pressure. OPSTH is asked in sequences where the operators have either failed to attempt to steam at low pressure (OPSTM fails) or attempted to steam at low pressure but could not get an SRV open in the relief mode. With the vessel "bottled-up," the operators can decide to steam at high pressure with 1 SRV on its safety set point. Steaming at high pressure would delay the core uncovering until SDC could be restored. The operators would have up to 4 hours to make the decision to steam at high pressure and provide makeup with CRD or HPCS. In cases where IA has isolated and CRD is the only available choice, the operators would have to restore IA.
Applicable Procedures (7)	EP-2 (RPV Control), Inadequate Decay Heat Removal ONEP (05-42-02-III-1)

Table 10.5.42R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Normal means of SDC are gone and a means of preventing the core from uncovering is needed. The operators failed to steam at low pressure and with no SRVs open, the operators will begin to steam at high pressure by default. They have 4 hours to provide makeup.	0	Low level 3 alarms will sound and temperature and pressure will begin to increase. SDC is gone and should be alarmed. SRVs will open on their safety set points eventually. Emergency Procedures, e.g. EP-2, indicate the need for level control. By providing makeup, the operators will have a substantial amount of time for restoring SDC.	BWRs basically operate by steaming and operators at GGNS indicated that steaming at high pressure would be a viable option that would provide time for determining and alleviating existing problems.

Table 10.5.42R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Normal SDC is gone and the operators have failed to steam at low pressure. By providing makeup they will steam the vessel at high pressure.	One	<ol style="list-style-type: none"> 1. In some cases letdown will have to be isolated. 2. Start a high pressure injection system (CRD or HPCS). In some cases, IA may have to be restored to be able to use CRD. 	Site interviews with operators indicated that steaming at high pressure would be a viable option when other means of SDC had failed. Operators appeared to be knowledgeable about the process and the necessary actions. However, the process is not explicitly described in the relevant procedures.

Table 10.5.42R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate steaming at high pressure.	6 hours	0	6 hours	SNL MELCOR Calculation

Table 10.5.42R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_l) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate letdown (if necessary).	CR or locally	--	Conservatively, 1 hour	1 hour	Performance time estimates includes any necessary travel time. Given the time available for OPSTH, time is not really an issue.
2. Initiate CRD or HPCS per SOI. If IA has isolated, restoration will be required if CRD is to be used	CR or possibly outside CR if IA must be restored.	--	Conservatively, 1 hour	1 hour	Restoring IA (if necessary) and starting CRD were assumed to be completely dependent.

Table 10.5.42R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Steam the vessel at high pressure.	6 hours	2 hours	4 hours	

Table 10.5.42R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to steam the vessel at high pressure.	Per ASEP HRAP Table 8-3, the upper bound value from ASEP HRAP Figure 8-1 for 4 hours diagnosis time was assigned.	N/A	Median = 0.001 Mean = 0.003	Interviews with operators indicated a good awareness of the notion of steaming the vessel at high pressure. However, since it is not proceduralized and apparently not covered specifically in training, it is not clear that all operators would decide to steam at high pressure. Nevertheless, in the particular sequences covered here, the operators are basically steaming at high pressure by default and need only provide makeup and isolate letdown. which would seem to be obvious. However, with no explicit procedures or training, per ASEP HRAP Table 8-3, the upper bound diagnosis value was assigned.

Table 10.5.42R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Start high pressure injection system and isolate letdown if necessary.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.42R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Start high pressure injection system and isolate letdown if necessary.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.42R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Decide to steam vessel at high pressure.	Median = 0.001 Mean = 0.003		Med. Mean 0.001 0.003	(10)	
2. Isolate letdown if necessary.	Median = 0.02 Mean = 0.032	Credit for a second check and a third check were given because of the time available and the obvious feedback from a failure to provide increasing level. HEPs for failure to provide a second and a third check and were: Med. = .2 Mean = .323	0.0008 0.003	(5)	Second check HEPs are multiplied by the original HEP for each action. Third check HEPs are multiplied by the result obtained from applying the second check.
3. Initiate high pressure injection system (CRD or HPCS). Includes unisolating IA if necessary.	Median = 0.02 Mean = 0.032	Credit for a second check and a third check were given because of the time available and the obvious feedback from a failure to provide increasing level. HEPs for failure to provide a second and a third check and were: Med. = .2 Mean = .323	<u>0.0008</u> <u>0.003</u> 0.0026 0.009 Total Median HEP = 0.0026 Total Mean HEP = 0.009	<u>(5)</u> (10)	Since both the diagnosis and action HEPs made significant contributions to the total HEP, the larger of the two EFs was assigned.

Table 10.5.42R2.1
HEP 42R2 Calculation

Human Action Event (1)	OPSTH (1)
Event Tree(s) (2)	P, PP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	All files beginning with OPSTH, e.g., OPSTHSRV.E1B
Event Description (5)	OPSTH is the operator decision and action to initiate steaming of the core at high pressure.
Event Context (6)	OPSTH (1) (HEP 42) represents the operator decision to steam the core at high pressure. OPSTH is asked in sequences where the operators have either failed to attempt to steam at low pressure (OPSTM fails) or attempted to steam at low pressure but could not get an SRV open in the relief mode. With the vessel "bottled-up," the operators can decide to steam at high pressure with 1 SRV on its safety set point. Steaming at high pressure would delay the core uncovering until SDC could be restored. The operators would have up to 2.75 hours to make the decision to steam at high pressure and provide makeup with CRD or HPCS. In cases where IA has isolated and CRD is the only available choice, the operators would have to restore IA.
Applicable Procedures (7)	EP-2 (RPV Control), Inadequate Decay Heat Removal ONEP (05-42-02-III-1)

Table 10.5.42R2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Normal means of SDC are gone and a means of preventing the core from uncovering is needed. The operators failed to steam at low pressure and with no SRVs open, the operators will begin to steam at high pressure by default. They have 4 hours to provide makeup.	O	Low level 3 alarms will sound and temperature and pressure will begin to increase. SDC is gone and should be alarmed. SRVs will open on their safety set points eventually. Emergency Procedures, e.g. EP-2, indicate the need for level control. By providing makeup, the operators will have a substantial amount of time for restoring SDC.	BWRs basically operate by steaming and operators at GGNS indicated that steaming at high pressure would be a viable option that would provide time for determining and alleviating existing problems.

Table 10.5.42R2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Normal SDC is gone and the operators have failed to steam at low pressure. By providing makeup they will steam the vessel at high pressure.	One	<ol style="list-style-type: none"> 1. In some cases letdown will have to be isolated. 2. Start a high pressure injection system (CRD or HPCS). In some cases, IA may have to be restored to be able to use CRD. 	Site interviews with operators indicated that steaming at high pressure would be a viable option when other means of SDC had failed. Operators appeared to be knowledgeable about the process and the necessary actions. However, the process is not explicitly described in the relevant procedures.

Table 10.5.42R2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate steaming at high pressure.	6 hours	0	6 hours	SNL MELCOR Calculation

Table 10.5.42R2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_t) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate letdown (if necessary).	CR or locally	--	15 minutes (time for a local (outside the CR) isolation was assumed	15 minutes	The time estimate for this action (HEP 42R2) is different than that used for HEP 42 and HEP 42R1. Given that less time is available for HEP 42R2 than in the other cases, a more realistic estimate of the time to perform the action was appropriate.
2. Initiate CRD or HPCS per SOI. If IA has isolated, restoration will be required if CRD is to be used	CR or possibly outside CR if IA must be restored.	--	Conservatively, 1 hour	1 hour Total action time is approx. 75 minutes	Restoring IA (if necessary) and starting CRD were assumed to be completely dependent.

Table 10.5.42R2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Steam the vessel at high pressure.	165 minutes	75 minutes	90 minutes	

Table 10.5.42R2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to steam the vessel at high pressure.	Per ASEP HRAP Table 8-3, the upper bound value from ASEP HRAP Figure 8-1 for 90 minutes diagnosis time was assigned.	N/A	Median = 0.002 Mean = 0.005	Interviews with operators indicated a good awareness of the notion of steaming the vessel at high pressure. However, since it is not proceduralized and apparently not covered specifically in training, it is not clear that all operators would decide to steam at high pressure. Nevertheless, in the particular sequences covered here, the operators are basically steaming at high pressure by default and need only provide makeup and isolate letdown. which would seem to be obvious. However, with no explicit procedures or training, per ASEP HRAP Table 8-3, the upper bound diagnosis value was assigned.

Table 10.5.42R2.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Start high pressure injection system and isolate letdown if necessary.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.42R2.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _P < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Start high pressure injection system and isolate letdown if necessary.	N/A ¹	N/A	No ²	N/A	Moderately High	Substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.42R2.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Decide to steam vessel at high pressure.	Median = 0.002 Mean = 0.005		Med. Mean 0.002 0.005	(10)	
2. Isolate letdown if necessary.	Median = 0.02 Mean = 0.032	Credit for a second check and a third check were given because of the time available, and the obvious feedback from a failure to provide increasing level. Given all that has happened in order to get to this point, the operators are likely to be attending to level. HEPs for failure to provide a second and a third check and were: Med. = .2 Mean = .323	0.0008 0.003	(5)	Second check HEPs are multiplied by the original HEP for each action. Third check HEPs are multiplied by the result obtained from applying the second check.
3. Initiate high pressure injection system (CRD or HPCS). Includes unisolating IA if necessary.	Median = 0.02 Mean = 0.032	Same as above	<u>0.0008</u> <u>0.003</u> 0.0036 0.009 Total Median HEP = 0.0036 Total Mean HEP = 0.011	<u>(5)</u> (10)	Since both the diagnosis and action HEPs made significant contributions to the total HEP, the larger of the two EFs was assigned.

Table 10.5.49R1.1
HEP 49R1 Calculation

Human Action Event (1)	OPSTM (2)
Event Tree(s) (2)	S, SP, SNP
Initiators (3)	All transients and LOCAS
Sequence Locator Files (4)	All files beginning with OPSTE, e.g., OPSTE51.E2B and files OPSTMHYD.ECN, OPSTMSNP.SNP, and OPSTMSNP.E1T.
Event Description (5)	OPSTM is the operator decision to initiate steaming of the core at low pressure.
-	<p>OPSTM (2) (HEP 49) applies in numerous sequences. It represents the operators decision to steam the vessel to provide core cooling when they have initially failed to perform actions that are clearly indicated by the IDHR procedure. For example, in many sequences, the initiation of ECCS water solid operation would be indicated by the context and by the IDHR ONEP, but the operators have failed to attempt this action (OPECS fails). Since OPSTM is not a proceduralized action, it was originally decided that if the operators had failed to follow procedure and therefore may not be aware of the problem, then credit could not be taken for deciding to steam the vessel in the time available (23 minutes). For this "time window" revision, however, substantially more time would be available (approximately 2 to 4.5 hours). Given the additional time available, the awareness of the steaming option demonstrated by the operators during plant interviews, and the fact that the operators can accomplish steaming at low pressure (OPSTM) by simply opening an SRV (and at some point realizing the need for vessel makeup), credit for deciding to steam was taken for this revision. Several systems may be used for steaming, e.g., LPCI(A), LPCS, CDS, SSWXT, and FW.</p>
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1)

Table 10.5.49R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
The operators have initially failed to respond (per procedure) to a state of inadequate decay heat removal. OPSTM asks whether or not the operators will consciously decide to steam the vessel. The operators need to ensure that 1 SRV is open and at some point provide some form of makeup.	O	The loss of SDC systems would be alarmed. Vessel temperature and pressure would be increasing and vessel level would begin to decrease, leading to additional alarms.	<p>BWRs basically operate by steaming. Thus, it is not an "unusual" response to the problem.</p> <p>In addition, with the time available, there would many opportunities for the operators to realize the need for makeup, which is obviously one of their primary concerns.</p>

Table 10.5.49R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
SDC has been lost and the operators did not respond during the time allowed for OPECS (23 minutes). 2 to 4.5 hours is now available for the operators to realize the need to cool the vessel in some way. To steam, they need only ensure that an SRV is open and at some point provide makeup. Thus, they do not even need to realize SDC is gone, but that makeup is needed with some additional cooling.	One	Check open 1 SRV	Complete dependence was assumed between the control room consciously deciding to steam the vessel and checking open 1 SRV. In most of the sequences in which this HEP is applied, the SRV is already open. Thus, steaming is occurring by default. Interviews with operators indicated that they would not open MSIVs for steaming unless they had a vacuum in the condenser. Cannot assume a vacuum exists in the condenser during POS 5. Therefore, deciding to steam was assumed to entail ensuring that 1 SRV was open.

Table 10.5.49R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
A decision to steam is all that is asked in this event.	At least 110 minutes	0	At least 110 minutes	SNL MELCOR Calculation

Table 10.5.49R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_l) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
No action required. Checking open 1 SRV was assumed to part of the decision to steam. In most cases the necessary SRV is already open.	Control Room	--	--	--	Initiation of a makeup system is not immediately required. Eventually makeup is required and system success is asked later in the tree.

Table 10.5.49R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Consciously decide to steam the vessel.	110 minutes	0 minutes	110 minutes	

Table 10.5.49R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Diagnosis (4)	Comments/ Source of Information (5)
Decide to steam the vessel.	Per ASEP HRA Table 8-3, the upper bound value from ASEP Figure 8-1 for 110 minutes diagnosis time was assigned.	N/A	Median = 0.002 Mean = 0.005	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. However, since it is not proceduralized and apparently not covered specifically in training, it is not clear that all operators would consciously decide to steam. Thus, without additional information, per ASEP HRA Table 8-3, the upper bound diagnosis value was indicated.

Table 10.5.49R1.8
Post-Diagnosis Action-Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs, Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

Actions assumed completely dependent with diagnosis (see Table 10.5.49R1.3 for rationale).

Table 10.5.49R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	N/A ¹	

Actions assumed completely dependent with diagnosis (see Table 10.5.49R1.3 for rationale).

Table 10.5.49R1.10
Total HEP

Action (1)	Original Operator HEP (HEP₁) (2)^{op}	Independent Check/Correction HEP (HEP₂) (3)^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
Decide to steam the vessel.	Diagnosis and Actions: Median = 0.002 Mean = 0.005	N/A	Median = 0.002 Mean = 0.005	10	

Table 10.5.50R1.1
HEP 50R1 Calculation

Human Action Event (1)	OPECS (14)
Event Tree(s) (2)	E, EA, EP, EAP
Initiators (3)	T1-5, TIA5H, E1B5H, T5D5H, TRPT5, TPRV5, E1T5H, E1V5H
Sequence Locator Files (4)	OPECSLAP.EAP, OPECSHY2.EP, OPECSHYD.TIA, OPECSLEA.TIA, OPECSL5.E1B, OPECSLPE.E1D, OPECSHYD.T5D, OPECSHY2.TRP, OPECSL5.TRP, OPECSHY2.TRV, OPECSLPE.E1T, OPECSLPE.E1V, OPECSL5.E1T, OPECSL5.E1V
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (14) calculation (HEP 50) are that the operators have recognized a loss of SDC (OPSDC or SDCUI succeeds) in the context of the initiator and have successfully started SDC(B). In some cases the operators have restored an inadvertent isolation of SDC(B) (RESB succeeds). The operators then initially fail to diagnose (in 10 min.) a need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. Regardless, in all the relevant sequences, the operators have been actively engaged in responding to the occurring problems. ADHR has been isolated and RWCU has auto-isolated. The operators must diagnose the need to initiate ECCS water solid operation with LPCI (C) or HPCS.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44), HPCS SOI (04-1-01-E22-1, Rev. 28).

Table 10.5.50R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for initiation of ECCS water solid operation.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. Reactor pressure and coolant temperature will be rising. The IDHR ONEP has been entered due to the initial loss of SDC and operators should be monitoring and considering the need for core cooling.	

Table 10.5.50R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. Operators have entered the IDHR ONEP. They must diagnose the need to initiate ECCS water solid operation.	One	<p>Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) assumed to be the first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP.

Table 10.5.50R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	55 minutes	0	55 Minutes	SNL MELCOR Calculation

Table 10.5.50R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 1, 2, and 3 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
4. Initiate ECCS system per SOIs	CR	--	1 minute	<u>1 minute</u> 3 minutes (approx.) Total time for all actions.	Note. ADHR is isolated by procedure in attempting to align SDC(B) in OPSDC.

Table 10.5.50R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	55 minutes	3 minutes	52 minutes	

Table 10.5.50R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the median value from Figure 8-1 for 52 minutes diagnosis time was assigned.		Median = $1.5E-4$ (EF = 30) Mean = 0.0013	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the operators failure to initially diagnose the need for level control (OPDHR fails) and the fact that the "functional" loss of SDC in this case could be subtle in regards to detection, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.5.50R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.5.50R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _{PE} < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.50R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 1.5E-4 Mean = 0.0013	--	Med. Mean 1.5E-4 0.0013	(30)	Total HEPs are the sum of the individual HEPs from the diagnosis and actions.
2. Actions Initiate ECCS water solid operation per procedure - open 2 SRVs - check closed MSIVs - initiate LPCI(C) or HPCS	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	Med. Mean <u>0.004</u> <u>0.01</u> 0.0042 0.011 Total median HEP = 0.004 Total mean HEP = 0.011	(5) (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.50R2.1
HEP 50R2 Calculation

Human Action Event (1)	OPECS (14)
Event Tree(s) (2)	E, EA, EP, EAP
Initiators (3)	T1-5, TIA5H, E1B5H, T5D5H, TRPT5, TPRV5, E1T5H, E1V5H
Sequence Locator Files (4)	OPECSLAP.EAP, OPECSHY2.EP, OPECSHYD.TIA, OPECSLEA.TIA, OPECSL5.E1B, OPECSLPE.E1D, OPECSHYD.T5D, OPECSHY2.TRP, OPECSL5.TRP, OPECSHY2.TRV, OPECSLPE.E1T, OPECSLPE.E1V, OPECSL5.E1T, OPECSL5.E1V
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (14) calculation (HEP 50) are that the operators have recognized a loss of SDC (OPSDC or SDCUI succeeds) in the context of the initiator and have successfully started SDC(B). In some cases the operators have restored an inadvertent isolation of SDC(B) (RESB succeeds). The operators then initially fail to diagnose a need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. Regardless, in all the relevant sequences, the operators have been actively engaged in responding to the occurring problems. ADHR has been isolated and RWCU has auto-isolated. The operators must diagnose the need to initiate ECCS water solid operation with LPCI (C) or HPCS.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44), HPCS SOI (04-1-01-E22-1, Rev. 28).

Table 10.5.50R2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for initiation of ECCS water solid operation.	O	Loss of systems were alarmed and the operators should - accomplish periodic checks of temperature and pressure in the new time available. Reactor pressure and coolant temperature will be rising. The IDHR ONEP has been entered due to the initial loss of SDC and operators should be monitoring and considering the need for core cooling.	

Table 10.5.50R2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. Operators have entered the IDHR ONEP. They must diagnose the need to initiate ECCS water solid operation.	One	Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) assumed to be the first choice if available, then HPCS.	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP.

Table 10.5.50R2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	110 minutes	0	110 Minutes	SNL MELCOR Calculation

Table 10.5.50R2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 1, 2, and 3 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
4. Initiate ECCS system per SOIs	CR	--	1 minute	<u>1 minute</u> 3 minutes (approx.) Total time for all actions.	Note. ADHR is isolated by procedure in attempting to align SDC(B) in OPSDC.

Table 10.5.50R2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	110 minutes	3 minutes	107 minutes	

Table 10.5.50R2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the median value from Figure 8-1 for 107 minutes diagnosis time was assigned.		Med. = $7.0E-5$ Mean = $6.0E-4$	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the operators failure to initially diagnose the need for level control (OPDHR fails) and the fact that the "functional" loss of SDC in this case could be subtle in regards to detection, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.5.50R2.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.5.50R2.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.50R2.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{c2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Med. = 7.0E-5 Mean = 6.0E-4	--	Med. Mean 7.0E-5 6.0E-4	(30)	Total HEPs are the sum of the individual HEPs from the diagnosis and actions.
2. Actions Initiate ECCS water solid operation per procedure - open 2 SRVs - check closed MSIVs - initiate LPCI(C) or HPCS	Median = 0.02 Mean = 0.032	Credit for a second and a third check on completing the action was given because of the time available for relevant feedback to occur, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	Med. Mean <u>0.0008</u> <u>0.003</u> 0.0009 0.004 Total Median HEP = 0.0009 Total Mean HEP = 0.004	(5) (5)	Second check HEPs are multiplied by the original HEP for the action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned.

Table 10.5.50R3.1
HEP 50R3 Calculation

Human Action Event (1)	OPECS (14)
Event Tree(s) (2)	E, EA, EP, EAP
Initiators (3)	T1-5, TIA5H, E1B5H, T5D5H, TRPT5, TPRV5, E1T5H, E1V5H
Sequence Locator Files (4)	OPECSLAP.EAP, OPECSHY2.EP, OPECSHYD.TIA, OPECSLEA.TIA, OPECSL5.E1B, OPECSLPE.E1D, OPECSHYD.T5D, OPECSHY2.TRP, OPECSL5.TRP, OPECSHY2.TRV, OPECSLPE.E1T, OPECSLPE.E1V, OPECSL5.E1T, OPECSL5.E1V
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (14) calculation (HEP 50) are that the operators have recognized a loss of SDC (OPSDC or SDCUI succeeds) in the context of the initiator and have successfully started SDC(B). In some cases the operators have restored an inadvertent isolation of SDC(B) (RESB succeeds). The operators then initially fail to diagnose (in 10 min.) a need for level control to avoid a functional loss of SDC caused by inadequate circulation between the core and the downcomer regions of the RPV (OPDHR fails). The inadequate circulation is due to the loss of CRD and/or RWCU and/or forced recirculation. Regardless, in all the relevant sequences, the operators have been actively engaged in responding to the occurring problems. ADHR has been isolated and RWCU has auto-isolated. The operators must diagnose the need to initiate ECCS water solid operation with LPCI (C) or HPCS.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), RHR SOI (04-1-01-E12-1, Rev. 44), HPCS SOI (04-1-01-E22-1, Rev. 28).

Table 10.5.50R3.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for initiation of ECCS water solid operation.	O	Loss of systems were alarmed and the operators should accomplish periodic checks of temperature and pressure in the new time available. Reactor pressure and coolant temperature will be rising. The IDHR ONEP has been entered due to the initial loss of SDC and operators should be monitoring and considering the need for core cooling.	

Table 10.5.50R3.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. Operators have entered the IDHR ONEP. They must diagnose the need to initiate ECCS water solid operation.	One	Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. In this context LPCI (C) assumed to be the first choice if available, then HPCS. 	It was assumed that at least initially, a low pressure injection system would be preferable to high pressure system and LPCI is referred to in IDHR ONEP.

Table 10.5.50R3.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	41 minutes	0	41 Minutes	SNL MELCOR Calculation

Table 10.5.50R3.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Check closed MSIVs	CR	--	1 minute	1 minute	Steps 1, 2, and 3 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that travel and manipulation (performance) times in the control room were determined using ASEP Table 8-1, Step 5b, and are grouped under the performance time column.
4. Initiate ECCS system per SOIs	CR	--	1 minute	<u>1 minute</u> 3 minutes (approx.) Total time for all actions.	Note. ADHR is isolated by procedure in attempting to align SDC(B) in OPSDC.

Table 10.5.50R3.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation.	41 minutes	3 minutes	38 minutes	

Table 10.5.50R3.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation and determine what the appropriate actions should be.	Per ASEP Table 8-3, the median value from Figure 8-1 for 38 minutes diagnosis time was assigned.		Median = $7.0E-4$ (EF = 30) Mean = 0.006	On the basis of the site interviews, it appeared that the operators had a clear understanding of this situation and recognized the requirements. However, given the operators failure to initially diagnose the need for level control (OPDHR fails) and the fact that the "functional" loss of SDC in this case could be subtle in regards to detection, the lower bound value for the diagnosis did not seem appropriate in this context.

Table 10.5.50R3.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	The site interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-step	

Table 10.5.50R3.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.50R3.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis Diagnose need to initiate ECCS water solid operation and determine relevant actions	Median = 7.0E-4 Mean = 0.006	--	Med. Mean 7.0E-4 0.006	(30)	Total HEPs are the sum of the individual HEPs from the diagnosis and actions.
2. Actions Initiate ECCS water solid operation per procedure - open 2 SRVs - check closed MSIVs - initiate LPCI(C) or HPCS	Median = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	Med. Mean <u>0.004</u> <u>0.01</u> 0.005 0.016 Total median HEP = 0.005 Total mean HEP = 0.016	(5) (5)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.61R1.1
HEP 61R1 Calculation

Human Action Event (1)	OPECS (16)
Event Tree(s) (2)	E, EP
Initiators (3)	J2-5
Sequence Locator Files (4)	OPECS.J25
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	The important constants for the OPECS (16) calculation (HEP 61) are that a break in the SDC line has occurred outside containment. MV 8 or 9 auto-isolates on low level (level 3), which results in isolation of the break and SDC. If LOSP also occurs, the diesels start and load (DV1-2 succeeds). Level 3 alarms (RPV level below 11.4) will cause the operators to enter EP-2, which will direct them to restore level. The RHR pump trip alarms and closure of MV 8 or 9 will indicate a loss of SDC and the corresponding IDHR to the operators. The operators will then enter the IDHR ONEP, which will instruct them to initiate ECCS water solid operation.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.5.61R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	Low level 3 alarm, RHR pump trip alarm, and closure of MV 8 or 9. In addition, the crew is required to check the chart recorders (level, temperature, pressure) every 30 minutes and with the additional time available for OPECS, these checks should occur. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.5.61R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>Where SDC(B) has failed, RHR(B) assumed unavailable. It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system.</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.5.61R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{α}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	55 minutes	0	55 Minutes	SNL MELCOR Calculation

Table 10.5.61R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8- 1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system	CR	--	1 minute (per Table 8-1, Step 5b)	<u>1 minute</u> 8 min. Total	

Table 10.5.61R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	55 minutes	8 minutes	47 minutes	

Table 10.5.61R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 47 minutes diagnosis time was assigned. (See comments in Column 5 of this table).		Med. = 1.0E-5 Mean = 8.5E-5	The site interviews indicated that the operators have a clear understanding of the procedure and the requirements. Given the fact that the operators would have two different procedures guiding them, and the operators understanding of the situation based on the site interviews, it was judged that the lower bound value for the diagnosis would be appropriate (per ASEP) in this instance.

Table 10.5.61R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.61R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _{sub} < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.61R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{rc}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 1.0E-5 Mean = 8.5E-5	--	Med. Mean 1.0E-5 8.5E-5	(30)	
2. Initiate ECCS water solid per procedure. --	Med. = 0.02 Mean = 0.032	Credit for a second check was given because of the time available, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.004 0.01 Total Median HEP = 0.004 Total Mean HEP = 0.01	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.64R1.1
HEP 64R1 Calculation

Human Action Event (1)	OPECS (17)
Event Tree(s) (2)	E, EA, EP
Initiators (3)	A5, S1-5, S2-5, S2H-5, H1-5H
Sequence Locator Files (4)	OPECSISO.A5, OPECSISO.S15, OPECSISO.S2-5, OPECSISO.S2H-5, OPECSISO.H15
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	For the OPECS (17) calculation (HEP 64), either 1) a break in the feedwater line has occurred outside containment and check valves isolate the break or 2) a diversion to the SP through RHR/SDC occurs. In either case, level 3 is reached (the feedwater lines are below level 3), MV 8 or 9 auto-isolates on low level, and the SDC pumps trip. Thus, SDC(B) or ADHR are lost. Level 3 alarms (RPV level below 11.4) will cause the operators to enter EP-2, which will direct them to restore level. The RHR pump trip alarms and closure of MV 8 or 9 will indicate a loss of SDC and the corresponding IDHR to the operators. The operators will then enter the IDHR ONEP, which will instruct them to initiate ECCS water solid operation. LPCI(C) or (B) and HPCS are potentially available.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.5.64R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	Low-level 3 alarm, RHR pump trip alarm, and closure of MV 8 or 9. In addition, the crew is required to check the chart recorders (level, temperature, pressure) every 30 minutes and with the additional time available for OPECS, these checks should occur. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.5.64R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system.</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.5.64R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	37 minutes	0	37 Minutes	SNL MELCOR Calculation

Table 10.5.64R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system per SOI (includes isolating letdown (RWCU) at some point in non- LOSP sequences, see Column 6, this Table)	CR	--	2 minutes (per Table 8-1, Step 5b)	<u>2 minutes</u> 9 min. Total	Initiation of ECCS system would require some realignment per SOI. These actions were assumed to be completely dependent. Isolation of RWCU is also included in this step. Even though RWCU continues to run in the non-LOSP sequences, letdown and makeup are still matched since CRD also continues to run. Thus, no hurry on isolation of RWCU. RWCU auto-isolates in the LOSP sequences.

Table 10.5.64R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	37 minutes	9 minutes	28 minutes	

Table 10.5.64R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 28 minutes diagnosis time was assigned. (See comments in Column 5 of this table).		Med. = 0.0002 Mean = 0.0017	The site interviews indicated that the operators have a clear understanding of the procedure and the requirements. Moreover, given the numerous and clear indicators present and the fact that the operators would have two different procedures guiding them, it was judged that the lower bound value would be appropriate (per ASEP) in this instance.

Table 10.5.64R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.64R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.64R1.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{ic}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.0002 Mean = 0.0017	--	Med. Mean 0.0002 0.0017	(10)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	With the break isolated and given the amount of time available, credit for a second check was given. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.0042 0.012 Total Median HEP = 0.0042 Total Mean HEP = 0.012	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.64R2.1
HEP 64R2 Calculation

Human Action Event (1)	OPECS (17)
Event Tree(s) (2)	E, EA, EP
Initiators (3)	A5, S1-5, S2-5, S2H-5, H1-5H
Sequence Locator Files (4)	OPECSISO.A5, OPECSISO.S15, OPECSISO.S2-5, OPECSISO.S2H-5, OPECSISO.H15
Event Description (5)	OPECS in this case includes diagnosing the need to initiate ECCS water solid operation and performing the relevant actions.
Event Context (6)	For the OPECS (17) calculation (HEP 64), either 1) a break in the feedwater line has occurred outside containment and check valves isolate the break or 2) a diversion to the SP through RHR/SDC occurs. In either case, level 3 is reached (the feedwater lines are below level 3), MV 8 or 9 auto-isolates on low level, and the SDC pumps trip. Thus, SDC(B) or ADHR are lost. Level 3 alarms (RPV level below 11.4) will cause the operators to enter EP-2, which will direct them to restore level. The RHR pump trip alarms and closure of MV 8 or 9 will indicate a loss of SDC and the corresponding IDHR to the operators. The operators will then enter the IDHR ONEP, which will instruct them to initiate ECCS water solid operation. LPCI(C) or (B) and HPCS are potentially available.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1), EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1), HPCS SOI (04-1-01-E22-1).

Table 10.5.64R2.2
-Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T.) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and core cooling.	O	Low level 3 alarm, RHR pump trip alarm, and closure of MV 8 or 9. In addition, the crew is required to check the chart recorders (level, temperature, pressure) every 30 minutes and with the additional time available for OPECS, these checks should occur. The ONEP for IDHR directs the control room to initiate ECCS to water solid operation in this context.	

Table 10.5.64R2.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Inadequate decay heat removal. The IDHR ONEP directs operators to initiate ECCS water solid operation.	One	<p>Per IDHR ONEP (Step 5.1.3c)</p> <ul style="list-style-type: none"> - Check closed MSIVs - Ensure that two SRVs are open - Increase RPV water level with any available injection system. In this context LPCI (C) was assumed first choice if available, then HPCS. 	<p>It was also assumed that at least initially, a low pressure injection system would be preferable to high pressure system.</p> <p>LPCI is initiated from 04-1-01-E12-1, Step 5.4.2.</p> <p>HPCS is initiated from 04-1-01-E22-1, Step 5.2.</p>

Table 10.5.64R2.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ca}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	110 minutes	0	110 Minutes	SNL MELCOR Calculation

Table 10.5.64R2.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Retrieve and read ONEP for Inadequate Decay Heat Removal	CR	--	5 minutes (ASEP Table 8-1, Step 5a)	5 minutes	5 minutes to retrieve and read ONEP is a conservative assumption given the training the operators receive. However, the delay seemed consistent with the "diversity of activities" ongoing during LPS, which might delay control room response to some extent.
2. Check closed MSIVs	CR	--	1 minute	1 minute	The critical actions for initiating ECCS water solid operation were assumed to be completely dependent. They were judged to be an integrated set of actions.
3. Ensure 2 SRVs open	CR	--	1 minute	1 minute	Also note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action.
4. Initiate ECCS system per SOI (includes isolating letdown (RWCU) at some point in non- LOSP sequences, see Column 6, this Table)	CR	--	2 minutes (per Table 8-1, Step 5b)	<u>2 minutes</u> 9 min. Total	Initiation of ECCS system would require some realignment per SOI. These actions were assumed to be completely dependent. Isolation of RWCU is also included in this step. Even though RWCU continues to run in the non-LOSP sequences, letdown and makeup are still matched since CRD also continues to run. Thus, no hurry on isolation of RWCU. RWCU auto-isolates in the LOSP sequences.

Table 10.5.64R2.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	110 minutes	9 minutes	101 minutes	

Table 10.5.64R2.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to go ECCS water solid	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 101 minutes diagnosis time was assigned. (See comments in Column 5 of this table).		Med. = 2.0E-5 Mean = 1.7E-4	The site interviews indicated that the operators have a clear understanding of the procedure and the requirements. Moreover, given the numerous and clear indicators present and the fact that the operators would have two different procedures guiding them, it was judged that the lower bound value would be appropriate (per ASEP) in this instance.

Table 10.5.64R2.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.64R2.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T ₀ < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.64R2.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP ₂) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 2.0E-5 Mean = 1.7E-4	--	Med. Mean 2.0E-5 1.7E-4	(30)	
2. Initiate ECCS water solid per procedure.	Med. = 0.02 Mean = 0.032	With the break isolated, the substantial time available for relevant feedback to occur, the existence of relevant procedures, and the importance of the actions. Credit for a second and a third check on completing the actions were given. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	<u>0.0008</u> <u>0.003</u> <u>0.0008</u> <u>0.003</u> Total Median HEP = 0.0008 Total Mean HEP = 0.003	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for the action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned.

Table 10.5.66R1.1
HEP 66R1 Calculation

Human Action Event (1)	OPFLL (1)
Event Tree(s) (2)	FAM, FS,
Initiators (3)	A5, ASHY, S1-5, S1H-5
Sequence Locator Files (4)	OPFLL.A5, OPFLL.AHY, OPFLL.S15, OPFLL.S1H
Event Description (5)	OPFLL is the operator decision and action to inject into the vessel and flood containment following a LOCA in POS 5.
Event Context (6)	For the OPFLL (1) calculation (HEP 66), a large or intermediate LOCA inside containment has occurred. The crew is initially on RHR/SDC(B) or ADHRS for SDC. Since the most likely break inside containment would be in the recirculation line, level 2 would be reached and ECCS would auto-actuate in less than a minute from the break. It was calculated that the operators would be unable to initiate SPMU prior to a too low SP water level (see HEP 65), resulting in the loss of ECCS. With reactor level dropping to 2/3 core height and low SP level signals, EP-2 instructs the operators to use any of several systems for injection/containment flooding and in this context, SSWXT is the only option modeled (FW inadequate). With 60 minutes available prior to core damage, it is likely operators would determine the need for vessel/containment flooding with SSWXT.
Applicable Procedures (7)	EP-2 (RPV Control, Rev. 19), RHR SOI (04-1-01-E12-1, Step 6.10)

Table 10.5.66R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A large or intermediate LOCA has occurred and the ECCS systems are not available. Makeup is needed and SSWXT is available for vessel/containment flooding.	0	In addition to numerous alarms and indications of decreasing level which would already be present, reactor temperature (and in some cases pressure) will be increasing). SP low level alarms would occur.	

Table 10.5.66R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
A large or intermediate LOCA has occurred and the ECCS systems are not available. Makeup is needed and SSWXT is available for vessel/containment flooding.	One	Open two valves from the CR to initiate SSWXT for flooding	SSWXT must be used. FW inadequate and too long to align.

Table 10.5.66R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ω}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate flooding	60 minutes	0	60 Minutes	SNL MELCOR Calculation

Table 10.5.66R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Examine EP-2 and RHR SOI	CR	--	2 minutes	2 minutes	
2. Initiate SSWXT per RHR SOI 04- 1-01-E12-1, step 6.10. Requires 2 valves to be opened.	CR	--	1 minutes (per Table 8-1, Step 5b)	<u>1 minute</u> 3 min. Total	

Table 10.5.66R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment	60 minutes	3 minutes	57 minutes	

Table 10.5.66R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to flood vessel/containment with SSWXT.	Per ASEP Table 8-3, the median value from Figure 8-1 for 57 minutes diagnosis time was assigned.		Med. = 1.0E-4 Mean = 8.5E-4	While a LOCA is certainly a "well recognized classic event" and the site interviews indicated that the operators have a clear understanding of the needed response and the necessary actions, the lower bound value for the diagnosis was not used because of the likely high stress levels and the fact that some selection of the relevant parts of EP-2 would be required because they are in shutdown. Thus, the median diagnosis value from Figure 8-1 of ASEP HRAP was used.

Table 10.5.66R1.8
- Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Flood the vessel/ containment.	N/A	Actions are specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.66R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _E < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Flood with SSWXT.	N/A ¹	No	No ²	N/A	Extremely High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.66R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{r2}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 7.0E-4 Mean = 1.9E-3	--	Med. Mean 1.0E-4 8.5E-4	(30)	
2. Initiate vessel/containment flooding with SSWXT.	Med. = 0.05 Mean = 0.081 (values reflect extremely high stress)	Credit for second and third checks were given. See comments in Column 6. Second and third checks for the straightforward and critical actions assessed were assumed to be step by step, the HEPs were: Med. = .2 Mean = .323	<u>0.002</u> <u>0.008</u> 0.0024 0.009 Total Median HEP = 0.002 Total Mean HEP = 0.009	<u>(5)</u> (5)	Given that the core could be partially uncovered and SSWXT may be all they have to prevent core damage. Credit for second and third checks is appropriate. Second check HEPs are multiplied by the original HEP for each action and third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned.

Table 10.5.67R1.1
HEP 67R1 Calculation

Human Action Event (1)	OPLDM
Event Tree(s) (2)	S2-5, S2H-5
Initiators (3)	S2-5, S2H-5
Sequence Locator Files (4)	OPLDM.S25, OPLDM.S2H
Event Description (5)	OPLDM is the operator action in response to a small LOCA (that cannot be isolated) to isolate letdown and increase makeup with CDS to match flow out the break. Action must be accomplished before SDC isolates on level 3. CRD is inadequate.
Event Context (6) —	The context for OPLDM is a small LOCA that is not isolated. The operators need to isolate letdown and increase flow with any available system before level 3 is reached and SDC is isolated. CRD alone is inadequate because the flow may not match break and in any case more makeup will be needed to provide adequate (natural) recirculation. Thus, makeup and SDC are needed. Operators will receive a level 4 alarm that will indicate that level is dropping and that a leak may be present. The level 4 alarm will also indicate the need to isolate letdown and provide additional make-up. Operators are aware that SDC will isolate at level 3.
Applicable Procedures (7)	EP-2 (RPV Control, Rev. 19)

Table 10.5.67R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Unisolated small LOCA. Operators need to isolate letdown and provide makeup to match flow out the break.	O	Operators will receive a level 4 alarm that will indicate that level is dropping and that a leak may be present. The level 4 alarm will also indicate the need to isolate letdown and provide additional make-up. Operators are aware that SDC will isolate at level 3.	

Table 10.5.67R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Unisolated small LOCA. Operators need to isolate letdown and provide makeup to match flow out the break until something can be done to isolate the break.	One	<ul style="list-style-type: none"> - Isolate letdown (RWCU). - Increase RPV water level with any available system. 	

Table 10.5.67R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_a) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Isolate letdown and provide makeup to match flow out the break.	56 minutes	0	56 Minutes	SNL MELCOR Calculation

Table 10.5.67R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Isolate letdown (RWCU)	CR	--	1 minute	1 minute	
2. Provide makeup (match flow out the break) with CDS or any available system.	CR	--	1 minute	<u>1 minute</u> 2 min. Total	

Table 10.5.67R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to isolate letdown and match the flow out the break.	56 minutes	2 minutes	Approx. 54 minutes	

Table 10.5.67R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to isolate letdown and match the flow out the break.	Per ASEP HRA Table 8-3, the median value from Figure 8-1 for 54 minutes diagnosis time was assigned.		Med. = 0.0002 Mean = 0.0017	Given the available procedures and the training the operators receive for LOCAs, at least the median diagnosis value was appropriate.

Table 10.5.67R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Isolate letdown and provide makeup.	N/A	Actions specified by procedure. EOPs clearly indicate the need for makeup if level is dropping.	No	Step-by-Step	

Table 10.5.67R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _R < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Isolate letdown and provide makeup.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems available and substantial time before core damage

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.67R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2)	Independent Check/Correction HEP (HEP _c) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Med. = 0.0002 Mean = 0.0017	--	Med. Mean 0.0002 0.0017	(30)	
2. Isolate letdown (RWCU)	Med. = 0.02 Mean = 0.032	Credit for a second and a third check on completing the action was given because of the time available for relevant feedback to occur, the existence of relevant procedures, and the importance of the actions. HEPs for failure to provide a second and a third check were: Med. = .2 Mean = .323	0.0008 0.003	(5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for the action and the third check HEP is multiplied by the result.
3. Provide makeup with CDS or any available injection system.	Med. = 0.02 Mean = 0.032	Same as above.	<u>0.0008</u> <u>0.003</u> 0.0018 0.008 Total Median HEP = 0.0018 Total Mean HEP = 0.008	<u>(5)</u> (30)	Since all of the HEPs made significant contributions to the total HEP, the largest error factor was assigned.

Table 10.5.102R1.1
HEP 102R1 Calculation

Human Action Event (1)	OPECS (6)
Event Tree(s) (2)	HPSWA
Initiators (3)	T1-5, TAB5H, TIA5H
Sequence Locator Files (4)	OPECS&.HPA, OPECAD10.TAB, OPCADH26.TIA
Event Description (5)	OPECS in this case includes diagnosing the need to go ECCS water solid with HPCS and performing the relevant actions.
Event Context (6)	The important constants for the HEP 102 calculation (OPECS (6)) are that a LOSP has occurred, the DV1-2 diesels fail to start and HPCS is available. SDC (ADHR for these scenarios) has failed due to the LOSP and all normal means of SDC are rendered unavailable. Per the IDHR ONEP, the operators are directed to initiate ECCS water solid operation. The operators would be aware that ADHR is lost with an LOSP and that without power, no normal means of SDC are available. In addition, the ADHR pump trip alarms would sound and the operators would be very likely to check temperature and pressure increases on the chart recorders in the 55 minutes allowed for OPECS. However, the operators would have to retrieve and read the IDHR ONEP and the HPCS SOI, isolate ADHR locally because power is not available (isolating ADHR is not explicitly directed by procedure in this context), align HPCS for injection per HPCS SOI 04-1-01-E22-1, and perform the related actions for initiating ECCS water solid operation per the IDHR ONEP.
Applicable Procedures (7)	Inadequate Decay Heat Removal ONEP (05-1-02-III-1, Rev. 15), HPCS SOI (04-1-01-E22-1, Rev. 28), Loss of AC Power ONEP (05-1-02-I-4, Rev 21)

Table 10.5.102R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
IDHR. Need for level control and cooling.	O	Operator knowledge regarding the effects of a LOSP and DG failures would be one indication . In addition, the ADHR pump trip would be alarmed and the operators should accomplish periodic checks of temperature and pressure in the time available. Reactor pressure and coolant temperature would be rising with no operating SDC systems.	

Table 10.5.102R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
No normal means of SDC, level control and vessel cooling is needed, IDHR ONEP directs operators to initiate ECCS water solid operation (HPCS is the only system available).	One - the loss of power is the abnormal event. Loss of SDC is an artifact of the loss of power.	<p>Isolate ADHR to prevent overpressurizing low pressure piping (not explicitly called by procedure). With DV1-2 failed, the isolation of the 8 or 9 valve will have to be done locally.</p> <p>Per HPCS SOI (Step 5.2) Manual startup of HPCS system Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation</p> <ol style="list-style-type: none"> 1. Check closed MSIVs 2. Ensure that two SRVs are open 3. Increase RPV water level with any available injection system. <p>In this context HPCS is the only available ECCS system</p>	While isolating ADHR is not explicitly called out in the HPCS procedure, it is indicated in the RHR procedure when going from ADHR to RHR/SDC. Operators understand the need to isolate ADHR.

Table 10.5.102R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Initiate ECCS water solid operation.	55 minutes	0	55 Minutes	SNL MELCOR Calculation

Table 10.5.102R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
1. Given the loss of power, the operators will need to realize the need and retrieve and read the IDHR ONEP and the HPCS SOI.	CR	--	5 minutes (Table 8-1, Step 5a)	5 minutes	See HEP 1 (OPSDC (1)), same table, for rationale regarding time.
2. Isolate ADHR (not explicitly proceduralized) Key is to close the 8 or 9 valve locally to prevent overpressurization of the low pressure piping	Outside the CR - the 8 valve is outside containment	--	15 minutes - travel and performance time. Estimates based on interviews with plant personnel.	15 minutes	
3. Check closed MSIVs	CR	--	1 minute (Table 8-1, Step 5b)	1 minute	Steps 3 and 4 are critical actions for initiating ECCS water solid operation. They were judged to be an integrated set of proceduralized actions and were assumed to be completely dependent.
4. Ensure 2 SRVs open	CR	--	1 minute (Table 8-1, Step 5b)	1 minute	
5. Align and initiate HPCS per HPCS SOI (step 5.2). HPCS is the only available injection system.	CR	--	1 minute (Table 8-1, Step 5b)	<u>1 minute</u> 23 minutes Total time for all actions.	The two critical steps required to start HPCS injection when the system is in standby were judged to be completely dependent.

Table 10.5.102R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation (includes isolating ADHR).	55 minutes	23 minutes	32 minutes	

Table 10.5.102R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to initiate ECCS water solid operation. Diagnose need to isolate ADHR locally. Determine what the appropriate actions should be.	Per Table 8-3, the median value from Figure 8-1 for 32 minutes diagnosis time was assigned.		Med. = 0.001 Mean = 0.003	The median value from ASEP HRAP Figure 8-1 was selected because the isolation of ADHR and the use of HPCS is not explicitly called out by procedure in this context. Site interviews suggested that the operators would perform these actions.

Table 10.5.102R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Initiate ECCS water solid operation	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements. Initiation of ECCS water solid operation is clearly indicated by the IDHR ONEP in this context.	No	Step x Step	

Table 10.5.102R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Initiate ECCS water solid	N/A ¹	No	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.102R1.10
Total HEP

Action (1)	Original Operator HEP (HEP _{op}) (2)	Independent Check/Correction HEP (HEP _{cz}) (3)	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose	Med. = 0.001 Mean = 0.003	--	Med. Mean 0.001 0.003	(10)	
2. Isolate ADHR locally.	Median = 0.02 Mean = .032	Credit for a second check was given because of the time available and because of the importance of the actions. In this context, once a correct diagnosis was made, operators would be likely to monitor the relevant feedback to ensure the appropriate response. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01	(5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action.
3. Initiate ECCS water solid operation with HPCS. - open 2 SRVs - check closed MSIVs - start HPCS per HPCS SOI (step 5.2)	Median = 0.02 Mean = .032	Same as above	<u>0.004</u> <u>0.01</u> 0.009 0.023 Total Median HEP = 0.009 Total Mean HEP = 0.023	<u>(5)</u> 5	The error factor associated with the dominant HEPs was assigned.

Table 10.5.119R1.1
HEP 119R1 Calculation

Recovery Action (1)	RA-OPICT-1 and RA-OPICT-3
Event Description (2)	RA-OPICT-1 and RA-OPICT-3 are operator actions to close containment if only the lower personnel lock is open (containment is open "low") and not the large equipment hatch.
Event Context (3)	<p>For RA-OPICT-1 and RA-OPICT-3, the operators have decided to either flood the vessel/containment or steam the vessel, respectively. In either case, they should want to prevent water from going to places it is not supposed go and they should want to prevent any possible release if the situation deteriorates. Therefore, if primary containment is open, they should diagnose the need to close it if possible. If only the lower personnel lock is open, it can be closed within 1 hour. While no procedures explicitly instruct the operators to close containment, the operators will be aware of the status of containment and should realize the need to close the lower personnel locks if they are open. Obviously, these actions will take place outside the control room.</p> <p>Note. If the environment in containment permitted it, they operators would also want to close the lower personnel lock into the drywell.</p>
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19)

Table 10.5.119R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Operators are successfully steaming or flooding the vessel/containment. They need to diagnose the need to close containment (if it is only open low) and carry-out the relevant actions.	O	The operators have initiated steaming or flooding. Procedures do not explicitly direct them to close containment. However, they are in shutdown and will be aware of the status of containment. Given the previous problems, the fact that normal means of SDC are unavailable, and that steam or water will begin to enter unacceptable areas (or have the potential to do so), the operators should be aware of the need to close containment.	Telephone conversations with plant personnel indicated that if it appeared that normal means of SDC might not be immediately restorable, then they would begin to close containment.

Table 10.5.119R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Close the lower personnel locks in containment.	One	Obstructions such as boards, hoses, cables etc. will have to be removed. The air lock doors will then need to be closed.	

Table 10.5.119R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to close the lower personnel lock into containment.	159 minutes	0	159 Minutes	SNL MELCOR Calculation

Table 10.5.119R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Remove obstructions from air lock area (boards, hoses, cable etc.)	Primary containment	--	--	See below	In telephone conversations with plant personnel, it was stated that the personnel lock could be closed easily within 1 hour. Given the explained requirements to close the lock, the one hour estimate seemed reasonable.
2. Secure the air lock doors.	Primary Containment	--	--	1 hour Total to complete closing of the personnel lock.	

Table 10.5.119R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to close containment.	159 minutes	Approx. 1 hour	99 minutes	

Table 10.5.119R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to close the lower personnel lock in order to seal containment in the context of flooding or steaming.	Per ASEP HRAP Table 8-3, the upper bound value from ASEP Figure 8-1 for 99 minutes diagnosis time was assigned.		Median = 0.002 EF = 10 Mean = 0.005	Interviews with operators indicated a good awareness of the need to close containment. However, exactly when the operators should begin to close containment in the present scenario is not explicitly indicated by procedure and the operators could delay the action on the assumption that normal SDC will be restored. Thus, the upper bound value from ASEP HRAP Figure 8-1 was assigned.

Table 10.5.119R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Remove obstructions and close the lower personnel hatch into containment.	N/A	Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.119R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Remove obstructions and close the lower personnel hatch into containment.	N/A ¹	N/A	No ²	N/A	Moderately High	Several systems may still be available and there is substantial time before core damage.

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.119R1.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)^{op}	Independent Check/Correction HEP (HEP_{ic}) (3)^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to close containment in the context of steaming or flooding the vessel.	Median = 0.002 Mean = 0.005	--	Med. Mean 0.002 0.005	(10)	
2. Remove obstructions.	Median 0.02 Mean = 0.032	See below	0.004 0.01	(5)	
3. Secure air locks.	Median 0.02 Mean = 0.032	Credit for a second check was given because of the substantial time available and the likely feedback from failures in performing either task. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	<u>0.004</u> <u>0.01</u> 0.01 0.025 Total Median HEP = 0.01 Total Mean HEP = 0.025	<u>(5)</u> (5)	Note. Total HEPs are the sum of the individual HEPs from the diagnosis and actions. Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table 10.5.123R1.1
HEP 123R1 Calculation

Recovery Action (1)	RA-FWLVL-3
Event Description (2)	RA-FWLVL-3 is the operator action to align FW for RPV injection, ensure 2 SRVs are open to "steam" the vessel, and follow load shedding procedures to minimize battery depletion time (station blackout conditions).
Event Context (3)	For the RA-FWLVL-3 calculation (HEP 123R1), a station blackout has occurred and HPCS has failed. The operators are directed by procedure to align the Fire Water System. They have to ensure SRVs are open and follow load shedding procedures to minimize battery depletion time (station blackout procedures). the operators will now have approximately 2 hours to diagnose the need and carry-out the actions.
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19), EP-2 (Attachment 26, Injection into the RPV with Fire Protection Water System, 05-S-01-EP2-2), Loss of AC Power (05-1-02-1-4).

Table 10.5.123R1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
FW is the only system available to provide makeup. Operators need to provide makeup with FW to successfully steam the vessel. They need to open 2 SRVs, and follow load shedding procedures.	O	Staion blackout and the loss of HPCS will be clearly indicated. Numerous indications will be available and procedures are clear. Attachment 26 of EP-2 describes how to align FW for RPV injection.	

Table 10.5.123R1.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Operators need to align and provide makeup with FW to successfully steam the vessel. They need to open 2 SRVs.	One	<p>A. Align Firewater Per EP-2, Attachment 26:</p> <ol style="list-style-type: none"> 1. As many as 10 different hose connections must be made in the Auxiliary Building for <u>complete</u> alignment of the FW system. However, a couple of connections would be adequate to begin injection and the others could follow (Step 2.1). 2. Open any one of 4 valves (Step 2.2.1). 3. Start the FW pumps and pressurize the hose (Step 2.2.2a,b). 4. Open the test connection valves (connected in Step 2.1) and check for flow (2.2.2c) <p>B. Open 2 SRVs</p> <p>C. Follow load shedding procedures</p>	

Table 10.5.123R1.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{act}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to initiate FW to provide level for steaming.	120 minutes	0	120 Minutes	SNL MELCOR calculation

Table 10.5.123R1.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_p) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Align FW system for RPV injection (see Table 10.5.123R1.3 above for description of actions).	Aux. Building	--	60 to 70 minutes	60 to 70 minutes	The travel and performance time estimate was based on examination of the procedure (EP-2, Attachment 26) and discussions with plant personnel. At least some injection with FW could be easily completed within an hour. It was assumed the the other actions could proceed in parallel with aligning FW.

Table 10.5.123R1.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need to align and initiate FW to provide level for steaming.	120 minutes	Approx. 70 minutes	50 minutes	

Table 10.5.123R1.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose the need to align and initiate FW to provide level for steaming.	Per ASEP HRAP Table 8-3, the median value from ASEP Figure 8-1 for 50 minutes diagnosis time was assigned.		Median = 0.0002 EF = 30 Mean = 0.0017	Interviews with operators indicated a good awareness of the notion of steaming the vessel. In fact, several operators indicated it would be preferable to flooding the vessel and more likely to be used. EP-2 directs the need for level control even without the notion of steaming. FW the only system available and the operators are trained to use FW in similar situations and alignment is described in EP-2.

Table 10.5.123R1.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Align FW for RPV injection (see Table 10.5.123R1. 3 above for description of actions.	N/A	Actions clearly specified by procedure. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.123R1.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T _F < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Align FW for RPV injection.	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.123R1.10
Total HEP

Action (1)	Original Operator HEP (HEP ₁) (2) ^{op}	Independent Check/Correction HEP (HEP ₂) (3) ^{rc}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to align and initiate FW to provide level for steaming.	Median = 0.0002 Mean = 0.0017	--	Med. Mean 0.0002 0.0017	(30)	
2. As many as 10 different hose connections must be made in the Auxiliary Building for <u>complete</u> alignment of the FW system. However, a couple of connections would be adequate to begin injection and the others could follow (Step 2.1).	Med. = 0.02 Mean = 0.032	Credit for a second check on all the actions were given. It was assumed that the operators have performed correctly to this point and that FW may be their last line of defense. Furthermore, more than one person would be involved in the activity and a failure on a single test connection would not be likely to fail the entire procedure. The HEPs for the second were: Median = .2 Mean = .323	0.004 0.01	(5)	Second check HEPs are multiplied by the original HEP for each action.
3. Open any one of 4 valves (Step 2.2.1).	Med. = 0.02 Mean = 0.032	Yes, see above.	0.004 0.01	(5)	
4. Start the FW pumps and pressurize the hose (Step 2.2.2a,b).	Med. = 0.02 Mean = 0.032	Yes, see above.	0.004 0.01	(5)	
5. Open the test connection valves (connected in Step 2.1) and check for flow (2.2.2c)	Med. = 0.02 Mean = 0.032	Yes, see above.	0.004 0.01	(5)	
6. Ensure 2 SRVs are open.	Med. = 0.02 Mean = 0.032	Yes, see above	0.004 0.01	(5)	
7. Follow load shedding procedures	Med. = 0.02 Mean = 0.032	Yes, see above	0.004 0.01 0.024 0.062 Total Median HEP = 0.024 Total Mean HEP = 0.062	(5) (5)	The error factor associated with the dominant HEPs was assigned.

Table 10.5.127.1
HEP 127 Calculation

Recovery Action (1)	RA-HPCS-SPMU-1
Event Description (2)	RA-HPCS-SPMU-1 is the operator action to stop injection into the vessel with HPCS (which is taking suction from the CST), provide a dump of the SPMU, realign HPCS suction to the SP, and start HPCS.
Event Context (3)	<p>For the RA-HPCS-SPMU-1 calculation (HEP 127), the operators have realized that a large LOCA has occurred. HPCS is the only ECCS system available. HPCS is injecting to maintain level and the operators have prevented the automatic switchover of HPCS suction from the CST to the suppression pool (SP). However, the CST level is low and the operators have 23 minutes to realize the situation and stop the HPCS pumps to prevent pump damage. The SP level is also low and before the operators can switch HPCS suction to the SP, they need to initiate a dump of SPMU. Because of the low decay heat levels during Time Window 3 (approx. 40 days after shutdown), once the operators stop the HPCS pumps, they will have approximately 5.5 hours to dump SPMU, realign HPCS suction to the SP, and restart the HPCS pumps. Given that the operators have recognized the LOCA and have taken the steps necessary to prevent the automatic switchover of HPCS suction from the CST to the suppression pool (SP), they will very likely be monitoring water levels in both the CST and the SP. Given the low levels in both the CST and the SP, the need to dump SPMU and realign HPCS to the SP should be apparent and is indicated in the emergency procedures (EP-2 and EP-3). The operators must override an isolation of SPMU before they can dump it and the override requires a trip out of the control room to close the appropriate breaker(s). Thus, the operators must first realize the need to stop the HPCS pumps to prevent damage before they attempt to dump SPMU and realign HPCS.</p>
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19), EP-3 (Containment Control), SPMU SOI(04-1-01-E30-1).

Table 10.5.127.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Large LOCA (40 days after shutdown). Two responses are of interest.			
1. HPCS is taking suction from CST and CST level is low. Operators need to stop HPCS pumps to prevent damage due to low suction head.	0	The operators have recognized the LOCA and have taken the steps necessary to prevent the automatic switchover of HPCS suction from the CST to the suppression pool (SP). Given a LOCA, the operators will very likely be monitoring water levels in both the CST and the SP. CST and SP levels will be alarmed and indicated. Operators are aware of the potential problems arising from low suction head. HPCS is the only ECCS system available.	—
2. Once the HPCS pumps are stopped, the operators need to dump SPMU and realign HPCS suction to the SP	0	In the context of a LOCA, given that the operators realize the CST is low and that the HPCS should be stopped, they will realize that additional makeup will be needed. They have 5.5 hours to diagnose the need and carry-out the actions necessary to dump SPMU, realign HPCS suction to the SP, and restart HPCS.	

Table 10.5.127.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
Large LOCA (40 days after shutdown). Makeup has been provided by HPCS taking suction from the CST. CST level is now low. HPCS is the only available ECCS system.	One	<ol style="list-style-type: none"> 1. Stop the HPCS pumps from the CR. 2. Dump SPMU from the CR. (must first defeat SPMU isolation by closing relevant breakers outside the CR) 3. Realign HPCS suction from CST to SP 4. Restart HPCS pumps from the CR 	Section 5.2 of the SPMU SOI describes the steps necessary to unisolate SPMU. Relevant breakers should be red tagged.

Table 10.5.127.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
1. Diagnose the need to stop the HPCS pumps to prevent damage from low suction head	23 minutes	0	23 minutes	SNL MELCOR Calculation
2. Diagnose the need to dump SPMU and realign HPCS suction to SP.	5.5 hours	0	5.5 hours	SNL MELCOR Calculation

Table 10.5.127.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_A) (5)	Comments/ Source of Information (6)
1. Stop the HPCS pumps from the CR.	CR	--	1 minute	Total time for stopping HPCS = 1 minute	Note that per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action in the CR.
2. Dump SPMU from the CR. (must first defeat SPMU isolation by closing relevant breakers outside the CR).			Estimated travel and performance time for overriding an SPMU isolation was approximately 15 minutes.	15 minutes	Travel and performance times to override SPMU isolation and initiate dump was based on discussions with plant personnel.
3. Realign HPCS suction from CST to SP.			15 minutes (conservative estimate)	15 minutes	
4. Restart HPCS pumps from the CR.	CR	--	1 minute	<u>1 minute</u> 31 minutes Given the time available, an additional hour was allowed for accomplishing the tasks. Total Time for dumping SPMU and realigning HPCS to provide injection was assumed to be 90 minutes.	

Table 10.5.127.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_t) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
1. Diagnose the need to stop the HPCS pumps to prevent damage from low suction head	23 minutes	1 minute	22 minutes	
2. Diagnose the need to dump SPMU and realign HPCS suction to SP.	5.5 hours	Conservatively, 90 minutes	Approx. 4 hours	

Table 10.5.127.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
1. Diagnose the need to stop the HPCS pumps to prevent damage from low suction head	Per ASEP HRAP Table 8-3, the median value from ASEP Figure 8-1 for 22 minutes diagnosis time was assigned.		Median = 0.005 EF = 10 Mean = 0.013	Given that the operators are aware of the LOCA, have intentionally had HPCS taking suction from the CST, and no other ECCS systems are available, at least the median diagnosis model seemed appropriate.
2. Diagnose the need to dump SPMU and realign HPCS suction to SP.	Per ASEP HRAP Table 8-3, the median value from ASEP Figure 8-1 for 4 hours diagnosis time was assigned.		Median = 4.0E-5 EF = 30 Mean = 3.0E-4	Conversations with plant personnel indicated that the operators would be aware of the problem of concern and have a clear understanding of the requirements. The procedures are clear.

Table 10.5.127.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Stopping HPCS, dumping SPMU, and realigning HPCS	N/A	Actions clearly specified by procedure.	No	Step-by-Step	

Table 10.5.127.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After IE (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Stopping HPCS, dumping SPMU, and realigning HPCS	N/A ¹	Recirculation has not been reestablished, but given the extremely low decay heat levels, the amount of time available, and the fact the situation is under control, extremely high stress levels were not assumed.	Maybe, but HPCS is working and the (long-term) situation is under control. Lots of time is available.	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.127.10
Total HEP

Action (1)	Original Operator HEP (HEP _o) (2) ^a	Independent Check/Correction HEP (HEP _i) (3) ^{a2}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to stop the HPCS pumps to prevent damage from low suction head	Median = 0.005 Mean = 0.013		Med. 0.005 Mean 0.013	(10)	
2. Diagnose the need to dump SPMU and realign HPCS suction to SP.	Median = 4.0E-5 Mean = 3.0E-4	--	Med. 4.0E-5 Mean 3.0E-4	(30)	
3. Stop the HPCS pumps from the CR.	Med. = 0.02 Mean = 0.032	Credit for a second check on successfully stopping HPCS was given. The HEPs for the second check were: Median = .2 Mean = .323	0.004 0.01	(5)	
4. Dump SPMU from the CR. (must first defeat SPMU isolation by closing relevant breakers outside the CR).	Med. = 0.02 Mean = 0.032	Credit for second and third checks on this action was given. Given the time available and the relevant feedback, credit for checks was reasonable. The HEPs for the second and third check were: Median = .2 Mean = .323	0.0008 0.0033	(5)	Second check HEPs are multiplied by the original HEP for each action and the third check HEP is multiplied by the result.
5. Realign HPCS suction from CST to SP.	Med. = 0.02 Mean = 0.032	Same as directly above	0.0008 0.0033	(5)	
6. Restart HPCS pumps from the CR.	Med. = 0.02 Mean = 0.032	Same as directly above	<u>0.0008 0.0033</u> 0.011 0.033 Total Median HEP = 0.011 Total Mean HEP = 0.033	<u>(5)</u> (10)	The error factor associated with the larger of the dominant HEPs was assigned.

Table 10.5.128.1
HEP 128 Calculation

Recovery Action (1)	ACP-XHE-MAN
Event Description (2)	ACP-XHE-MAN is the operator action to manually start the diesel generators after a auto-start has failed.
Event Context (3)	For the ACP-XHE-MAN calculation (HEP 128), a LOSP has occurred and the auto-start function for the diesel generators has failed. The operators must initiate a manual start from the CR.
Applicable Procedures (4)	Loss of AC Power (05-1-02-I-4)

Table 10.5.128.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
LOSP and diesel generator (DG) auto-start failure	O	The LOSP would be clearly indicated, as would the failure of the diesels to start. The operators would be focused on the need for the diesels and would attend very closely to whether or not they started (as would other plant personnel.	

Table 10.5.128.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
LOSP and diesel generator (DG) auto-start failure	Two	Attempt to start diesels from the CR	

Table 10.5.128.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ad}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to manually start the diesels.	5.5 hours	0	5.5 hours	SNL MELCOR Calculation

Table 10.5.128.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Start diesels from the CR.	CR	--	1 minute	1 minute	Per ASEP Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each action in the CR.

Table 10.5.128.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Diagnose the need and carry-out the actions required to start the diesels.	5.5 hours	1 minute	Approximately 5 hours	

Table 10.5.128.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to start diesels in context of a LOSP with a failure of the diesel auto-start.	Per ASEP HRAP Table 8-2, the median value for approximately 5 hours diagnosis time for a second abnormal event was assigned.		Median = 5.0E-5 EF = 30 Mean = 0.0004	This is a "classic" event and operators receive substantial training for responding to it. Actions are covered by procedure.

Table 10.5.128.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments/ Source of Information (6)
Manually start diesels	N/A	Actions are obvious. Interviews indicated that the operators were knowledgeable about the need for the actions and requirements.	No	Step-by-Step	

Table 10.5.128.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Start diesels.	N/A ¹	N/A	No ²	N/A	Moderately High	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.128.10
Total HEP

Action (1)	Original Operator HEP (HEP ₁) (2) ^{op}	Independent Check/Correction HEP (HEP ₂) (3) ^{r2}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnose the need to start the diesels.	Median = 5.0E-5 Mean = 0.0004	--	Med. Mean 5.0E-5 0.0004	(30)	
2. Manually start diesels from the CR	Med. = 0.02 Mean = 0.032	Credit for a second and third checks on the action were given. Feedback should be immediate and clear. A significant amount of time is available. The HEPs for the second and third checks were: Median = .2 Mean = .323	<u>0.0008 0.003</u> <u>0.0009 0.003</u> Total Median HEP = 0.0009 Total Mean HEP = 0.003	<u>(5)</u> <u>(5)</u>	Second check HEPs are multiplied by the original HEP for each action and the third check HEP is multiplied by the result. The error factor associated with the dominant HEP was assigned.

Table 10.5.129.1
HEP 129 Calculation

Recovery Event (1)	RA-ISO89
Event Description (2)	RA-ISO89 is the operator action to manually isolate SDC.
Event Context (3)	<p>For HEP 129, the initiator is a LOSP in which no AC power is available. At least initially, all diesels are unavailable or are lost. The operators successfully align FW to provide injection and two SRVs are open. For any of several reasons, the operators need to isolate the low pressure piping. i.e., close the SDC 8 or 9 valves. Reasons include:</p> <ol style="list-style-type: none">1. If power is restored, HPCS may auto-start which could over-pressurize the low pressure piping.2. If power is not restored in several hours, the batteries (DC power) may deplete, resulting in the closure of the SRVs and a loss of FW. If the low pressure piping is protected, substantial time would be available before core damage would occur. That is, by "bottling-up" the vessel, core damage would be delayed. Emergency lighting would be available for local closing of the valve(s).
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19), Inadequate Decay Heat Removal ONEP (05-1-02-III-1)

Table 10.5.129.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
A LOSP has occurred and the diesels are initially unavailable or are lost. FW is injecting. The question is whether the operators will decide to manually isolate SDC locally.	0	The failure of SDC to isolate would be alarmed and (as noted in Table 10.5.129.1 above), there are important reasons why the operators would want to close the 8 or 9 valve.	

Table 10.5.129.3
Potential Operator Action

Description of Event (1)	Number of Abnormal Events (2)	Activities (Tasks) Required to Perform Action and Procedures (3)	Comments/ Source of Information (4)
The question is whether the operators will decide to manually isolate SDC locally to protect the low pressure piping and ultimately the vessel.	One (events not necessarily occurring closely in time and at least 10 hours is available to respond)	Manually isolate SDC.	

Table 10.5.129.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{cd}) (2)	Time at Which Operator is Alerted that Symptom has Occurred (T_o) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Manually isolate SDC locally.	12 hours	2 hours (FW successfully operating allows the operators to attend to other concerns)	10 hours	SNL MELCOR Calculation

Table 10.5.129.5
Operator Action Performance Time

Activities (1)	Location (2)	Travel Time (T_L) (3)	Performance Time (T_P) (4)	Total Action Time (T_a) (5)	Comments/ Source of Information (6)
Manually isolate SDC locally.	Outside the CR	--	1 hour was conservatively assumed because only emergency lighting would be available. (1 hour travel and action time)	1 hour Total	Travel and performance time is based on analyst judgment.

Table 10.5.129.6
Diagnosis Time for Operator Action

Action (1)	Maximum Time Available (T_m) (2)	Total Action Time (T_a) (3)	Time Available to Diagnosis (T_d) (4)	Comments/ Source of Information (5)
Manually isolate SDC locally after auto-isolation fails due to LOSP.	10 hours	1 hour	9 hours	

Table 10.5.129.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
A LOSP has occurred and the diesels are initially unavailable or are lost. FW is injecting. The question is whether the operators will decide to manually isolate SDC locally, in order to protect the low pressure piping.	Per ASEP HRAP Table 8-3, the median value from Figure 8-1 for 9 hours diagnosis time was assigned.		Med. = $7.0E-4$ Mean = 0.006	While there are no <u>explicit</u> procedures which would instruct the operators to isolate SDC, an auto-isolation has failed. The operators have successfully responded to the situation and have a significant amount of time to address the need to isolate the low pressure piping. Site interviews indicated the operators have a good awareness of the need to protect the low pressure piping.

Table 10.5.129.8
Post-Diagnosis Action Type Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	Safety Systems Failed (2)	EOPs, Training, Use EOPs, Well Designed EOPs (3)	Individual Operator Must Perform Concurrent Tasks (4)	Dynamic or Step-by-Step (5)	Comments Source of Information (6)
Locally isolate SDC.	N/A	Not explicitly covered by procedure, but the action would be clearly warranted given the context.	No	Step-by-step	

Table 10.5.129.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T < 2h After 1E (2)	Recirc. Phase in Large LOCA (3)	More Than Two Safety Systems Fail (4)	Operator Familiar W/Sequence (5)	Stress Level (6)	Comments/ Source of Information (7)
Locally isolate SDC by closing 8 or 9 valve.	N/A ¹	No	No ²	N/A	Moderately high	

¹ At least moderately high stress was assumed for all events.

² For the LPS environment (usually long-term sequences) a failure of more than two safety systems did not necessarily lead to an assumption of extremely high stress. Each human action event was examined as a function of the context.

Table 10.5.129.10
Total HEP

Action (1)	Original Operator HEP (HEP ₁) (2) ^{op}	Independent Check/Correction HEP (HEP ₂) (3) ^{ic}	Total HEP (4)	EF (5)	Comments/ Source of Information (6)
1. Diagnosis	Median = 7.0E-4 Mean = 0.006	--	Med. Mean 7.0E-4 0.006	(10)	
2. Isolate SDC locally by closing 8 or 9 valve.	Median = 0.02 Mean = 0.032	Credit for a second check was not given because the CR may not receive any direct feedback and because ensuring that the task was accomplished may not be their highest priority.	<u>0.02</u> <u>0.032</u> 0.021 0.038 Total Median HEP = 0.021 Total Mean HEP = 0.038	<u>(5)</u> (5)	The error factor from the dominant HEP was assigned.

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Analysis of Core Damage Frequency from Internal Events for
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This document contains the accident sequence analysis of internally initiated events for Grand Gulf, Unit 1 as it operates in the Low Power and Shutdown Plant Operational State 5 during a refueling outage. The report documents the methodology used during the analysis, describes the results from the application of the methodology, and compares the results with the results from two full power analyses performed on Grand Gulf.

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