NUREG/CR-6143
SAND93-2440
Vol. 4

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

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

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Sandia National Laboratories
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Sandia Corporation

Prepared for
U.S. Nuclear Regulatory Commission

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Manuscript Completed: April 1994
Date Published: July 1994

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Prepared for
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Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
NRC FIN L1923

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Abstract

An estimate of the contribution of internal flooding to the mean core damage frequency at the Grand Gulf Nuclear Station was calculated for Plant Operational State 5 during a refueling outage. Pursuant to this objective, flood zones and sources were identified and flood volumes were calculated. Equipment necessary for the maintenance of plant safety was identified and its vulnerability to flooding was determined. Event trees and fault trees were modified or developed as required, and PRA quantification was performed using the IRRAS code. The mean core damage frequency estimate for GGNS during POS 5 was found to be 2.3 E-8 per year.

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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

Acronyms

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

Executive Summary

ES.1 Introduction

As accident initiators, internal floods, like earthquakes and fires, have the potential to cause multiple equipment failures during a single event. Because such failures could present risks to the safe operation of a nuclear power plant, it is prudent to include internal floods among the possible accident initiators treated in a plant Probabilistic Risk Analysis (PRA).

Some internal flood PRAs have been performed for plants operating at full power. However, despite analyses which show that accident risk can be significant during shutdown, virtually no consideration has been given to internal floods when the plant is in such a state. As part of the BWR Low Power and Shutdown Accident Sequence Frequencies Project conducted for the U.S. Nuclear Regulatory Commission's Office of Nuclear Regulatory Research (NRC/RES), Sandia National Laboratories has undertaken a probabilistic study of flood-induced accident sequences for the Grand Gulf Nuclear Station (GGNS) in Plant Operational State 5 (POS 5).

ES.2 Objective

The objective of this study is to estimate the contributions of internal flooding to the total core damage frequency at GGNS for POS 5 during a refueling outage. For the purposes of this study, POS 5 was taken to mean that the plant was in cold shutdown (coolant temperature 200 °F or less) with the vessel head on. The work includes the consideration of recovery actions and uncertainty analysis.

ES.3 Analysis Approach

The analysis was performed in three phases:

- Phase 1: Work in this phase identified potential flood zones, flood sources within each zone, and equipment in each zone. Equipment whose failure could have safety implications for the plant, and the susceptibility of this equipment to failure due to a flood in its location were also determined. It also quantified the potential water inventory released from each source.

- Phase 2: Work in this phase developed flood scenarios, determined which of these might lead to core damage, and characterized flood initiating event frequencies. The number of scenarios was then reduced to a size more amenable to analysis. This was done by considering which scenarios would threaten safety-related equipment and, where appropriate, combining some scenarios into one.

- Phase 3: Work in this phase developed and/or adapted appropriate fault and event tree models, quantified operator actions and performed sequence frequency quantifications and uncertainty analyses.

The quantification phases followed the same approach used in the internal events analysis of the BWR Low Power and Shutdown Accident Frequencies Project. Several of the event trees from that work were applicable to the flooding analysis. In these cases, initiating event frequencies were modified to correspond to flood frequencies, system and component failures based on flood volume and location were included, and operator actions were modified as appropriate. For cases in which no analogous event trees from previous work were available, new trees were developed.

The Integrated Reliability and Risk Analysis System (IRRAS) was used to quantify frequencies for core damage accident sequences. Sequences having point estimate frequencies below 1.0 E-8 per year were considered to be non-contributors to the overall core damage frequency and were discarded.

Sequences surviving this analysis were examined in more detail during a "time window" analysis wherein each surviving sequence was partitioned into three distinct time window sequences. These sequences were then quantified based on the characteristics of the particular time window being examined. As before, any sequence having a core damage frequency estimate below 1.0E-8 was truncated. An uncertainty analysis was performed for any sequence surviving the time window screening analysis.

ES.4 Results

A single sequence survived through the time window analysis. The mean core damage frequency for this sequence is 2.3E-8 per year. The 5th and 95th percentiles are 8.2E-11 and 8.6E-6 per year respectively.

The initiating event for the surviving sequence is TAB39. This initiator represents a break in a Fire Water System pipe. The resulting flood from this initiator disables Divisions 1,2, and 3 Class 1E AC and DC power. Given the severity of this postulated accident sequence, no operator recovery was postulated. This initiating event is summarized in Table ES.1 below.

ES.5 Conclusions

The overall conclusion of this work is that internal floods do not pose a significant core damage threat to the Grand Gulf Nuclear Station for POS 5 during a refueling outage.

The core damage frequency of 2.3 E-8 per year due to internal flood events is approximately two orders of magnitude lower than the core damage frequency of 2.0E-6 per year for internal events excluding flood and fire (Volume 2, Part 1 of this report). Thus, internal flooding represents only a minor contribution to the total core damage frequency at GGNS during POS 5. This small contribution is due principally to the low frequency of fluid boundary component breaks that could result in a flood and to the large separation of systems that would be available to mitigate the effects of such an accident.

The two conservative assumptions affecting flow rates and flood volumes included in these analyses (i.e., fully guillotined catastrophic breaks and full hour undetected breaks) did not significantly impact the results of this study. For completeness, it should be noted that the assumed undetected break time for the single surviving sequence was 15 minutes. This time, while a departure from the one hour assumption , was sufficient to cause a loss of all Class 1E AC and DC power and probably represents a more realistic estimate of the undetected break time for POS 5 during a refueling outage.

Table ES.1
Core Damage Initiating Event Summary

Initiating Event	No. of Sequence/Cut Sets	Time Window	Mean Core Damage Frequency (/yr)	% of Total CD Frequency
TAB39	1/1	3	2.3 E-8	100

1.0 Introduction

1.1 Background

Internal floods are typically caused by rupture or leakage of fluid (water) boundary systems such as pipes, pumps, valves, tanks, and heat exchangers. These failures can either be randomly initiated or induced as a result of human errors. A number of internal flooding events have occurred at nuclear power plants in the United States. Each occurrence demonstrated a potential to cause multiple failures.

While full power flood analyses have been done for some U.S. nuclear power plants such as La Salle Nuclear Power Plant [1], Oconee Nuclear Power Station [2], and Surry Power Station [3], little has been done to analyze the risk due to internal flooding under low power and shutdown (LP&S) conditions. Low power and shutdown conditions correspond to the plant operational states that range from operation at less than 15% power down to and including refueling operations.

Previous estimates both in the United States and abroad indicate that Light Water Reactor (LWR) risk during shutdown can be substantial (i.e., about 1/3 of the risk experienced during power operation) [4].

With this risk level in mind, Sandia National Laboratories (SNL) was assigned the task of estimating the risk due to internal flooding at Grand Gulf Nuclear Station (GGNS) while the plant operates in Plant Operational State 5 (POS 5). For the purposes of these analyses, POS 5 was taken to mean that the plant was in cold shutdown (coolant temperature 200° F or less) with the vessel head on. A detailed description of POS 5 is given in Reference 5.

As discussed in Appendix F, many of the flood initiating events resulted in conditions which were sufficiently similar to the internal events discussed in [5] to allow the same event trees to be used for the flooding work. The initiating event (IE) of the Reference 5 event tree was replaced with the flood IE nomenclature (see Table 2.3) and the flood IE frequency was used. Appropriate changes in system availability/failures were included so as to reflect the flooding effects on system components. The behavioral effects of flood initiators on pertinent operator actions were also considered. Because none of the floods threatened the control room, effects of the flood *per se* were not considered in the determination of operator actions in the control room. In many cases, it is possible that the operator would be aware of a flood induced failure before he knew that it had been caused by a flood. Thus, operator actions in the control room were considered to be based only on systems and component failures and unavailabilities. However, the potential impact of the flooding on operator actions to be conducted outside the control room was examined to determine if any of the required actions would be affected by the flooding.

1.2 Objectives

The objective of this study is to estimate the contribution of internal flooding to the total core damage frequency at GGNS for POS 5 during a refueling outage. This required the development and quantification of appropriate flood propagation models and the performance of recovery and uncertainty analyses.

1.3 The Analysis Process

The process involved in performing a flood PRA consists of:

- identifying all areas of a nuclear power plant susceptible to internal flooding

- identifying and categorizing the major flood sources in these areas

- determining the flood capacity of each source

- developing flooding scenarios and determining their effect on vulnerable equipment, and

- quantifying these scenarios to estimate the core damage frequency due to internal flooding.

To identify all areas of a nuclear power plant susceptible to internal flooding, general arrangement diagrams of the plant were reviewed to determine the layout of the buildings containing critical components and the location of potential flood sources. The vulnerabilities of equipment to internal flooding in these locations were then determined.

Next, major flood sources in each location were identified using the plant's piping composite diagrams. The release capacity of each source and the potential flood propagation paths for each source rupture were determined. The effect of each source rupture on equipment in each location defined a scenario.

In the final stages of the analysis, the scenarios were quantified by adapting or developing suitable fault and event tree models to represent the component failures and the subsequent accident sequences. An accident sequence is defined as the sequence of events, both random and flood related, that could occur following a flood initiating event.

Recovery analyses were then performed to credit certain actions that could reduce the severity of the accidents [6].

Throughout the process, a number of conservative assumptions were made to simplify the analysis. These assumptions were then followed by more realistic qualitative and quantitative arguments.

1.4 Report Organization

This report is intended as a complement/companion to NUREG/CR-6143, Volume 2, Part 1 report [5]. As such, it draws upon the contents of that report. This report is organized into four sections and eight Appendices. Section 1.0 is the introductory chapter which discusses the background and scope of the report. Section 2.0 contains the methodology developed and utilized in the study. Section 3.0 contains the results. Section 4.0 contains a description and results of the plant damage state analysis. Section 5.0 contains conclusions. Appendix A contains schematics of the flood zones considered in the study. Appendix B contains a summary of the components in each flood zone. Appendix C contains a listing of the flood sources within each flood zone. Appendix D discusses an evaluation of human error probabilities for failing to close water tight doors, an evaluation of the probability of pipe failure during Emergency Core Cooling System (ECCS) flow tests, and a calculation of the volume of flow from the Suppression Pool given a fully guillotined pipe rupture. Appendix E contains the propagation scenarios developed in this study. Appendix F contains a discussion of flood events which were quantified. Appendix G discusses the Human Reliability Analysis (HRA) methodology used to characterize operator actions. Finally, Appendix H contains flood-specific event trees used in the analyses.

2.0 Methodology

The methodology used in this study was a hybrid of the methodology used in References 1, 2, and 4 and was performed in three phases. They are outlined as follows:

PHASE 1: LOCATION SCREENING ANALYSIS PHASE

This phase of the analysis identified potential flood locations or flood zones, determined flood sources within each flood zone, determined the potential inventory released from each source, identified equipment in each flood zone, and determined equipment vulnerabilities.

PHASE 2: FLOOD PROPAGATION SCENARIO DEVELOPMENT AND REDUCTION PHASE

This phase consisted of the development of flood scenarios, the determination of flood scenarios having the potential to cause core damage, the characterization of flood initiating event frequencies, and the reduction of flood scenarios to a size more amenable to analysis.

PHASE 3: QUANTIFICATION PHASE

This phase consisted of the development and/or adaptation of fault and event tree models to flood effects, the quantification of appropriate human actions, analysis of the scenarios, and the performance of recovery and uncertainty analyses.

2.1 Location Screening Analysis Phase

This section of the report describes the location and screening phase of the analysis. This phase included:

- identification of potential flood locations or flood zones
- determination of the flood sources within each flood zone
- determination of the potential volume of release from each source
- identification of the equipment in each flood zone
- determination of equipment flood vulnerabilities

2.1.1 Identification of Flood Zones

A flood event is defined as a flood, spray, or splash event arising from the rupture of a fluid boundary. Sprays affect components in the line of sight of the spray by direct impingement. Floods affect components through the accumulation of water [7]. A splash event results from water falling down through openings such as elevator shafts or stairwells.

Flood locations were determined by reviewing the general arrangement diagrams for each elevation of the plant and consulting with GGNS personnel on specific plant layouts.

Each flood zone was assumed to be 25% occupied by equipment that reduced the total floor area of that zone. In the initial stage of the flood analysis, the identification of "flood locations" or "flood zones" was of primary importance. During this process, the plant was divided into individual flood zones. Flood zones were defined as regions separated by walls, doors, or other flood barriers [7]. These flood zones either contained their own unique flood sources or were vulnerable to floods propagating from other zones.

A simplified schematic indicating each flood zone is provided in Appendix A. Flood zones were identified in the following buildings:

- Auxiliary Building
- Control Building
- Diesel Generator Building
- Fire Water Pump House
- Standby Service Water Basin
- Radwaste Building
- Water Treatment Building
- Turbine Building

Large areas such as the auxiliary building corridors or the turbine building were sub-divided into smaller flood zones at each elevation. This was done to better analyze the localized effects of flooding.

The auxiliary building corridor, at each elevation, was given a single name even though flooding effects were analyzed in four quadrants, namely, northeast, northwest, southeast, and southwest.

The turbine building was divided into six flood zones at each elevation.

Approximately 250 potential flood zones were identified. These flood zones were characterized by a numerical identifier or a number-literal combination. For example, the abbreviation "TB-93-1" was used to identify area 1 of the turbine building at the 93' elevation.

Effective areas for each of the flood zones identified were then calculated by reducing the approximated area of the zones by 25% to account for the space occupied by equipment in each location (see Appendix B). This was consistent with past flood analyses [1,2].

2.1.2 Determination of Flood Sources

Potential flood sources in a commercial nuclear power plant include water tanks, pools, valves, pumps, etc [5]. Flooding from these sources results from random failure of a fluid boundary or from human errors.

Due to the complex nature of the human induced floods, this report is limited to those floods which are randomly initiated. It is expected that the issue of human induced floods will be re-examined upon completion of ongoing NRC research to improve human reliability analysis for LP&S conditions.

Potential sources were identified in each location by reviewing the information on fluid system boundaries provided on the plant piping composite diagrams. The information included pipe sizes and the locations of pipe system components such as valves, pumps, heat exchangers, etc.

One flood source per system was considered for each flood zone. This flood source was the one whose rupture would lead to the largest fluid inventory release.

Flood sources were identified by the piping and instrumentation diagram designations of the pipe section in which a break might occur. In cases where two or more sizes of pipe are used in the same system, the larger of the pipes was used for the source designation. For example, a continuous run of Plant Service Water pipe might increase in diameter from a 24-inch section labelled 24 JBD-150 to a 30-inch section labelled 30 JBD-105. A rupture in either pipe section would be designated 30 JBD-105. Flood event frequencies were based on the total length of pipe and other fluid handling components in a given system within a given flood zone.

2.1.3 Determination of Potential Flood Volume From Each Source

For each flood zone identified in Appendix A, the pipe system with the largest potential release was selected as a potential flood source. The following assumptions were made in determining flood volume:

- Given a rupture in a fluid boundary, it was assumed that flow continued one hour before detection and isolation unless:
  - the inventory of the system was depleted
  - automatic or prompt manual isolation occurred
  - the pressure head driving the flow became insufficient or the pumps in the system failed due to a loss of NPSH
- All pipe breaks were considered to be fully guillotined (i.e., a complete circumferential break).
- Flow rates or system pressure for the system operating in POS 5 were used.
- Tank or heat exchanger ruptures were considered to be catastrophic (i.e., they instantaneously released their total inventory).

Inventory release rates for each system were determined from system flow diagrams and system descriptions and are recorded in Appendix C. The flow from any of the sources was limited by the volume of the source inventory. In cases for which flow stopped in less than one hour, total inventory is recorded.

Using a simple qualitative analysis and consulting with Grand Gulf personnel, one hour was assumed to be conservative in most cases because when the plant is operating in POS 5, there are many plant personnel performing different types of surveillance and maintenance functions twenty-four hours a day throughout the plant. In addition, there are numerous flood detection and alarm devices located throughout the plant. With these two factors in mind, it was thought to be unlikely that a flood would go undetected in critical

flood zones for over an hour.

2.1.4 Identification of Equipment in Flood Zones and Determination of Their Vulnerabilities

The release and propagation of water can degrade the operability of certain equipment depending on its flood vulnerability. Table 2.1 lists several components and their corresponding flood failure/degradation states. As seen in Table 2.1, some equipment, such as heat exchangers and tanks, would not be adversely aff water. However, others, such as motor-operate (MOVs), motor-driven pumps (MDPs), air-oper valves (AOVs), electrical equipment (e.g., switchgears), and diesel generators, can be disabled by effects such as an electrical short [8].

Using a computer listing of the components modeled in the GGNS BWR LP&S Study [5] and Table 2.1, all components vulnerable to internal flooding were identified. These components were then mapped to their individual flood zones that were identified in the location analysis by using the equipment location diagrams. The power sources for the flood vulnerable equipment were also determined from the plant equipment logic diagrams and one line electrical diagrams.

Finally, the depth to which water would have to accumulate to fail each piece of equipment was determined and recorded in Appendix B as the equipment critical height.

Table 2.1 Component Flood Vulnerabilities

Component	Submerged	Splash or Spray Effect
Motor Operated Valves	Fail as is	Fail as is
Air Operated Valves	Fail	Ok
Solenoid Operated Valves	Fail	Fail
Check/Manual Valves	Ok	Ok
Motor/Turbine Driven Pumps	Fail	Fail
Compressors	Fail	Fail
Fan Coolers	Fail	Fail
Diesel Generators	Fail	Fail
Electrical Equipment (excluding cables)	Fail	Fail
Instrumentation	Fail	Fail
Heat Exchangers	Ok	Ok
Tanks	Ok	Ok

Adapted from Reference 8.

2.2 Flood Propagation Scenario Development and Reduction Phase

Flood propagation scenarios were developed to represent flow pathways from one flood zone to another. These pathways include but are not limited to

- stairways
- floor penetrations
- elevator shafts
- open hatches
- non watertight doors
- floor space

In this section of the report the processes of flood scenario development and reduction are detailed. These include

- the development of flood scenarios
- the determination of flood scenarios having the potential to cause core damage
- the characterization of flood initiating event frequencies
- the reduction of flood scenarios

2.2.1 Development of Flood Scenarios

One of the first tasks in developing the flood scenarios was to perform a review of the plant layout to identify design features, such as the location of flood barriers and pathways, and differences in elevations between flood zones that tend to inhibit flood propagation.

The possibility of water propagating or backflowing to the ECCS rooms was a primary concern. A preliminary analysis showed that flooding of the ECCS rooms by backflow through the sump pump discharge piping was prevented by means of check valves on the discharge piping near the pump flange [9]. The auxiliary building drains were also found to run so that external leakage into the ECCS rooms could not occur.

A further analysis of flooding through drainage systems from other separated flood zones was not performed for this study. Such treatment is not normally considered in flooding analyses of nuclear power plants and to do so would introduce a level of complexity beyond the intent of the present work.

For the occurrence of a flood event in a given flood zone, all vulnerable equipment in the zone was assumed to fail if it was splashed or sprayed as the flood reached its critical height. An exception was made for flood zones where certain spray barriers prevented equipment failure.

The flood was propagated to other plant areas depending on the locations of flood barriers or flood pathways. The propagation was assumed to continue until the volume of water released from the source reached an equilibrium depth throughout the affected flood zones.

During the propagation, flood propagation barriers such as walls and curbs were assumed to maintain their structural integrity [8]. Floor penetrations were considered operable only if propagation through them to lower levels of the plant resulted in scenarios that were of equal or greater severity than the scenarios already developed at the lower plant level. An HRA was performed to determine the probability of watertight doors being left open (see Appendix D).

The equipment that failed as a result of a flood was determined by comparing the equipment critical height to the equilibrium water depth in each flood zone. This equilibrium depth was calculated by dividing the volume of water released in each scenario by the total area of the flood zones to which the water propagated. If the water accumulation depth was greater than or equal to the equipment critical height then the equipment was assumed to fail in the state defined in Table 2.1. It was also determined whether or not the system whose fluid boundary ruptured failed due to the loss of inventory.

2.2.2 Determination of Flood Scenarios Having the Potential to Cause Core Damage

Once the propagation scenarios were developed, a qualitative scenario reduction process was instituted to identify flood scenarios that could lead to core damage.

Flood scenarios that had the potential to cause core damage were designated flood initiating events.

For power operations, a flood initiating event is a flood related event that necessitates a trip or a controlled shutdown of the plant to prevent core damage. For non-power operating states, such as POS 5, a flood initiating event is defined as a flood related event that required an automatic or manual response to prevent core damage since the plant is already shutdown. This response would be necessary whenever the decay heat removal capacity of the reactor cooling systems or the water level in the reactor vessel was challenged. For example, during power operations, a flood in the High Pressure Core Spray (HPCS) pump room would result in an automatic plant trip. This would be a flood initiating event. However, during plant shutdown with the plant already tripped, a flood in the HPCS pump room would not lead to core damage unless the flood propagated from the confines of the HPCS room and compromised the decay heat removal capacity of the plant or challenged the reactor water level.

Using the above definition of a flood initiating event, the flood scenarios developed were reviewed to identify those that fit the above criteria. Because the probability of one initiator given another is so small, these initiators were not considered concurrently with any other initiator such as Loss of Offsite Power (LOSP). For the same reason, multiple flood initiators consisting of two or more floods occurring simultaneously were not analyzed.

For each flood zone, the flood sources in the zone, the propagation pathways, the equipment that failed, and the status of the scenario (i.e., whether or not the scenario was an initiating event) are recorded in Appendix E.

2.2.3 Characterization of Flood Initiating Event Frequency

For later use in the quantification phase of potential core damage sequences, flood frequencies for potential core damage scenarios were determined. These frequencies are recorded in Appendix E.

These frequencies were determined from industry wide data on pipes, valves, pumps, and heat exchanger leakage and rupture rates. In this analysis, only full guillotine breaks and complete fluid boundary system ruptures were considered.

2.2.3.1 Valve Rupture Frequencies

Using the information presented in WASH-1400 Appendix 3 [10], the mean valve leakage rate was estimated to be 2.7 E-8/hr (2.4E-4/yr) with a lognormal distribution and an error factor (EF) of 10. In the LaSalle PRA [1], a factor of 1/18 was recommended for use to account for leakage before rupture. Using the 1/18 factor and the estimated mean leakage rate of 2.4E-4/yr, a mean valve rupture rate of 1.3E-5/yr was calculated.

The EGG-SSRE-9639 report [11], published in 1991, recommended a valve rupture rate of 4E-10/hr (3.5E-6/yr) with a lognormal distribution EF of 30. The data on valve rupture rates contained in the report was the most current data, and was based on a comprehensive analysis of Licensee Event Report (LERs) and In-Plant Reliability Data (IPRD). An EF of 30 was chosen in the report based on engineering judgement and the belief that rupture frequency estimates were more uncertain than leakage frequency estimates.

For this analysis the valve rupture rate of 3.5E-6/yr with an EF=30 was used.

2.2.3.2 Pump Rupture Frequencies

One of the few sources containing information on pump leakage and rupture rates was Reference 11. This report gave the mean pump rupture rate as 1.2E-9/hr (1.1E-5/yr) with an EF of 30. The data contained in the report was the most current data on pump rupture rates and was based on IPRD data. Again, an EF of 30 was chosen in the report based on engineering judgement and the belief that rupture frequency estimates were more uncertain than leakage frequency estimates.

2.2.3.3 Pipe Rupture Frequencies

Using the information presented in WASH-1400 Appendix 3 [10], the mean pipe leakage rate was estimated as 8.5 E-10/hr per section with an EF=30. To estimate the pipe rupture rate from the pipe leakage rate, WASH-1400, Appendix 3 and

page 77, suggested the use of a severity fraction of 0.05. This fraction was defined as the ratio of ruptures to leakages. Using the 0.05 factor and assuming that a section of pipe was 20 ft long, the mean pipe rupture rate was estimated 3.7E-7/yr per 20 ft with a lognormal distribution having an EF of 30.

2.2.3.4 Heat Exchanger Rupture Frequencies

EGG SSRE-9639 [11], gave the mean shell rupture rate for heat exchanger as 4E-10/hr (3.5E-6/yr) with an EFof 30. Again, an EF of 30 was chosen in the report based on engineering judgement and the belief that rupture frequency estimates were more uncertain than leakage frequency estimates. The resulting fluid boundary system rupture frequencies used in the analysis are summarized in Table 2.2.

lumping together all flood scenarios in a given flood zone resulting from the same system's rupture that would cause exactly the same failures.

In the location analysis, large areas such as the auxiliary building corridors and the turbine building were sub-divided into smaller flood zones at each elevation. This was done to better analyze the localized effects of flooding. As a result, a single pipe (or loop of a system) running through a large area was divided into smaller sections according to the flood zones through which it passed. Floods resulting from ruptures in this divided system were then postulated in these locations and the flooding effects were analyzed separately. However, since these small zones and pipe sections came from a larger one, it was reasonable to lump them together whenever similar system ruptures resulted in the same scenario. The lumping (literally adding the frequencies) was accomplished using the flood scenarios and flood event frequencies tabulated in Table E.1 (Appendix E).

Table 2.2 Rupture Rates for Fluid Boundary Systems

Component	Mean Rupture Frequency	Distribution	Error Factor
Pipe	3.7E-7/yr (per 20 ft)	Lognormal	30
Valve	3.5E-6/yr	Lognormal	30
Pump (External)	1.1E-5/yr	Lognormal	30
Heat Exchanger (Shell)	3.5E-6/yr	Lognormal	30

2.2.3.5 Estimation of Initiating Event Frequencies

The frequency of a flood initiating event was determined by incorporating the information on the fluid boundary systems rupture rates in Table 2.2 with the information on the length of piping and the number of valves, pumps, and heat exchangers in the pipe segment of interest. The total frequency of rupture for each pipe section of interest was determined by summing the rupture rates of all the component (pipes, pumps, valves, heat exchangers etc.) in the section. These calculations were performed and the results recorded in Table E.1 of Appendix E for those scenarios that survived the screening described in Appendix E.

2.2.4 Flood Scenario Reduction

A flood scenario reduction process was applied to reduce the number of flood initiating events summarized in Table E.1 of Appendix E. The process involved flood a

The resulting lumped scenarios are discussed in Appendix F and summarized in Table 2.3. Lumping of different system ruptures causing the same failures was not done.

If these lumped scenarios appeared to be dominant after quantification, the localized effect of each scenario could be reanalyzed to determine the types of structural modifications that would reduce the core damage frequency contribution in each flood zone.

Virtually all of the flood initiating events led to equipment and system losses which, taken in combination, were directly analogous to one or more of

the non-flood initiating events described in Reference 5. As a result, the initiating event nomenclature of Table 2.3 follows that of analogous non-flood events. In order to distinguish them from non-flood events, the flood initiating events had an "F" (for flood) attached to the initiation label accompanied by the significant digits of the event frequency. Thus, a flood-initiating event having the same effect as a J2 event (a LOCA in a connected system) and having a frequency of 5.6 E-6 per year was designated J2F56. A detailed discussion of the initiating event nomenclature for each source/scenario is given in Appendix F. The source/scenario designation is the pipe run designation from GGNS piping and instrumentation diagrams.

2.3 Quantification Phase

In this section of the report, the process of flood scenario quantification is discussed. This process includes the development of fault and event tree models, the quantification of appropriate human actions, the performance of recovery to determine the initial set of sequences to be examined during the "time window" analysis, the time window analysis wherein less conservative assmptions regarding ECCS Train A unavailabilities and decay heat loads were used to re-quantify the surviving core damage sequences, and an uncertainty analysis for any sequence surviving the time window analysis.

2.3.1 Accident Sequence Quantification

The quantification phase of the analyses followed the same approach as that of Reference 5. Many of the event trees for flood initiating events corresponded directly to IEs for that reference and were used with only a modification of the initiating event name and its frequency. Others required minor revisions to fault trees. A few required completely new IE and level 2 transfer event trees (i.e., the first set of transfer event trees used to continue the development of the sequence logic). All initiating event trees used in these analyses are given in Appendix H of this report. That appendix also contains the few level 2 trees developed specifically for these flooding events. For details of other event trees used in these analyses beyond level 1 (i.e., the IE event tree), the reader is referred to Reference 5. Detailed descriptions of the flood initiating events are given in Appendix F.

2.3.2 Development of Fault Trees and Event Trees

Once the scenarios summarized in Table 2.3 were finalized, appropriate fault trees and event trees were adapted or developed to model the sequence of events that occur as a result of internal flooding.

The event tree models incorporated the flood initiating event and the mitigating events necessary to prevent core damage (including operator diagnosis and response, Appendix G). Human actions necessary to mitigate the event were integrated at appropriate points in the models. In most cases the human actions included in the analyses were the same as those used for the internal events analyses of POS 5 [5]. It was assumed that as long as the flooding did not threaten the operators, they would respond to specific losses (such as loss of Instrument Air) in the usual ways with the goal of preventing any undesirable consequences.

2.3.3 Performance of Recovery, Time Window, and Uncertainty Analyses.

2.3.3.1 Recovery 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. There are numerous potential actions that an operator can perform in recovering from an accident sequence. Though these options are dictated by plant procedures, the option operators choose will depend on what is available accounting for plant conditions, availability of personnel, etc. [6].

In the present analysis, credit was taken for the traditional recovery actions such as restoration of LOSP. The nature of the event trees and the associated HRA sometimes indicated the availability of other systems for accident mitigation not credited during the basic analysis. Recovery actions were considered at the cut set level rather than at the sequence level [6]. Thus, where appropriate, credit for such systems and actions was applied to the surviving cut sets during the recovery analysis. A probability of non-recovery was estimated

for each cut set. So called "heroic" recovery actions were not considered. A detailed explanation of the recovery related operator actions and their quantification can be found in Appendix G. Once an event was chosen for recovery, the location of the recovery was determined, and the time for the recovery action was estimated using HRA procedures.

2.3.3.2 Time Window Analysis

Once a reduced set of accident seqence cut sets were determined from the recovery analysis, a less conservative quantification analysis was performed. For each sequence cut set surviving the initial analysis, the following steps were performed. Firstly, each cut set was reproduced twice resulting in three cut sets for each original cut set. Secondly, the first cut set was modified so that it represented the accident sequence during the first time window (i.e., POS 5 from entry into POS 5 to 24 hours after shutdown). This process was repeated for the other two time windows (i.e., Time Window 2 - time greater than 24 hours after shutdown until the end of POS 5 on the way down and Time Window 3 - POS 5 on the way back up from a refueling outage). Thirdly, each time window cut set was then examined and modified to account for the actual unavailability of Train A ECCS equipment during the specific time window being examined. These "actual" unavailabilities were derived from Grand Gulf specific information. Fourthly, the time available for the operator actions included in the cut sets were reexamined based on the use of thermal-hydraulic calculations specific to each time window. The purpose of this reexamination was to determine whether the failure probability assigned to the human action would be affected by the new times from the thermal-hydraulic calculations. Fifthly, the cut sets were reexamined to identify additional operator recovery actions that might be applicable during the time window being examined. Finally, the cut sets resulting from the above described procedure were requantified. Any cut sets surviving this requantification represented the final core damage cut sets for the POS 5 analysis.

2.3.3.3 Uncertainty Analysis

Only parameter value uncertainties were addressed in this study. Uncertainty information for each initiating event, primary event, and recovery event represented in the final core damage accident sequence was obtained [6]. This information was then used to perform uncertainty calculations for the surviving accident sequence.

Table 2.3 Flood Frequencies for Potential Flood Scenarios.

Flood Zone	Scenario/Source	Initiating Event Nomenclature	Mean Rupture Event Frequency (per year)
3	24 GBB-62	E2DF24	2.4E-5
	12 HBC-519	E2DF57	5.7E-5
	12 HBC-522	TIAF16	1.6E-5
6	PSW-6	TIAF40	4.0E-5
	30 JBD-105 (NE)	TIAF93	9.3E-6
	SSWB-6	T5AF19	1.9E-5
	14 JBD-327 (SW)	T5DF81	8.1E-5
	14 JBD-327 (NW)	TIAF22	2.2E-5
	6" HBD-382 (NW)	TIAF86	8.6E-5
14	18 GBB-74	J2F48	4.8E-5
45	10 JBD-202 (NW)	E2DF92	9.2E-6
	10 JBD-202 (SW)	TIOPF65	6.5E-6
54	18 GBB-31	E2BF20	2.0E-5
56A	4 DBZ-1	RWC26A	2.6E-5
56B	4 DBZ-1	RWC26B	2.6E-5
56C	SDC (20 GBB-31)	J2F56	5.6E-6
65	10 JBD-253	TAB39	3.9E-6
97	SDC B	J2F91	9.1E-6
100	6" DBA-9	RWC74	7.4E-6
SSW B	24 HBC-79	T5AF19	1.9E-5
TB-93	TBCW-93-1-5	TIAF23	2.3E-5
	10 JBD-489	TIAF10	1.0E-4
	PSW-TB-93	TIAF11	1.1E-5
TB-133-4	8 JBD-136	TIAF21	2.1E-6
WTB-133	4 JBD-466	TIAF13	1.3E-5

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3.0 Results

3.1 Introduction

Of the 25 flood initiating events described in Appendix F and listed in Table 2.3, 15 did not survive the initial point estimate screening. That is, all sequence frequencies for 15 of the flood IEs fell below the cutoff value of 1.0 E-8 per year before a core damage state was encountered.

The remaining 10 initiating events had core damage sequences with frequencies greater than or equal to the cut-off values before recovery actions were considered. Results from the analysis of these 10 events are presented here.

Section 3.2 contains brief IE descriptions for the 10 events and summary tables for each IE which identify core damage sequences and give the frequency and number of cut sets for each sequence before recovery, after recovery but before a cut set update, and after recovery and after a cut set update.

Of the 10 initiating events that survived the initial screening, three (including the T5AF19 initiator in two separate locations) were found to have sequences that survived the 1.0E-8 per year cut-off frequency after recovery. These sequences and their attendant cut sets were then examined during the Time Window Analysis. The results of this analysis are detailed in Section 3.3. The results of the uncertainty analysis for the sequence surviving the Time Window Analysis are contained in Section 3.4.

3.2 Accident Sequence Quantification

This section presents the results of the quantification of the accident sequences that survived the initial screening with a frequency of 1.0E-8 per year or greater. Results before and after recovery are presented for each initiating event in its own table.

3.2.1 TIAF16

This initiating event is a break in Plant Service Water (PSW) pipe 12 HBG-522 with the plant on ADHRS. The event results in the loss of instrument air. Results from the analysis of TIAF16 are given in Table 3.2.1.

3.2.2 TIAF40

This initiating event is a of break in any one of PSW pipes 24 JBD-150 (SE), 24 JBD-150 (SW) and 36 HBC-223 (NW). A break in any one of these lines results in the same failures which in turn lead to the loss of instrument air. Results from the analysis of TIAF40 are given in Table 3.2.2.

3.2.3 T5AF19 - (2 Initiating Events)

This initiating event is a break in either of two Standby Service Water (SSW) loop B pipes in flood zone 6, (20 HBC-79B NW or 20 HBC-79B NE) or pipe 24 HBC-79 in flood zone SSW B. The combined frequency for the breaks in zone 6 is 1.9 E-5 per year. This is also the frequency for the break in zone SSW B. Any of the breaks will result in a failure of PSW and the Component Cooling Water. Results from the analysis of the T5AF19 event corresponding to a break in either flood zone 6 (T5AF19 -A) or SSW B (T5AF19-B) are given in Table 3.2.3.

3.2.4 T5DF81

This initiating event is a break in CCW pipe 14 JBD-327 (SW). The subsequent flood will also fail Control Rod Drive (CRD) pumps A and B. Results from the analysis of T5DF81 are given in Table 3.2.4.

3.2.5 J2F48

This initiating event is a rupture in Shutdown Cooling (SDC) loop B pipe 18 GBB-74 during SDC-B operation. The initiator is essentially a LOCA with Suppression Pool Cooling loop B, LPCI loop B, and Containment Spray loop B failed. Results from the analysis of J2F48 are given in Table 3.2.5.

3.2.6 E2BF20

This initiating event is a break in SDC-B piping during SDC-B operations which also fails HPCS. Results form the E2BF20 analysis are given in Table 3.2.6.

3.2.7 J2F56

This initiating event is a break in the RHR common suction line 20 GBB-31. It is a LOCA in an operating RHR system. Results from the J2F56 analysis are given in Table 3.2.7.

3.2.8 TAB39

This initiating event is a break in Fire Water System (FWS) pipe 10 JBD-253 which results in the loss of Divisions A, B, and C power sources. The results of the analysis of TAB39 are given in Table 3.2.8.

3.2.9 J2F91

This initiating event is a break in SDC pipe 18 GBB-74 during SDC operations. The results of the analysis of J2F91 are given in Table 3.2.9.

3.2.10 Sequence Quantification Summary

Table 3.2.10 is a summary of sequences which survived recovery actions by initiating event. These sequences were then examined during the Time Window Analysis, and Table 3.2.11 summarizes the results from this analysis. Table 3.2.12 lists the core damage frequency by cut sets for the single surviving core damage sequence. For the Grand Gulf Nuclear Station the total point estimate for core damage frequency due to internal flooding of sequences greater than or equal to 1.0E-8 is 2.4 E-8 per year.

Table 3.2.1
Results from Quantification of TIAF16 Accident Sequence

	Before Recovery		After Recovery Before Cut Set Update		After Recovery After Cut Set Update	
Sequence	Frequency	No. Cut Sets	Frequency	No. Cut Sets	Frequency	No. Cut Sets
03-48-51-35-03	1.617E-8	1	0	0	0	0

Table 3.2.2
Results from Quantification of TIAF40 Accident Sequence

	Before Recovery		After Recovery Before Cut Set Update		After Recovery After Cut Set Update	
Sequence	Frequency	No. Cut Sets	Frequency	No. Cut Sets	Frequency	No.Cut Sets
03-32-51-35-03	2.374E-8	1	0	0	0	0
03-48-51-35-03	4.043E-8	1	0	0	0	0

Table 3.2.3
Results from Quantification of T5AF19 Accident Sequence

Sequence	Before Recovery		After Recovery Before Cut Set Update		After Recovery After Cut Set Update	
	Frequency	No.Cut Sets	Frequency	No.Cut Sets	Frequency	No.Cut Sets
03-04-21-05-A*	1.885E-7	1	0	0	0	0
03-04-21-35-03-A*	2.179E-8	1	2.179E-8	1	2.179E-8	1
03-09-21-05-A*	2.042E-7	1	1.000E-8	1	1.000E-8	1
03-09-21-35-03-A*	2.361E-8	1	2.361E-8	1	2.361E-8	1
03-51-35-03-A*	2.713E-8	1	0	0	0	0
03-04-21-05-B**	1.885E-7	1	0	0	0	0
03-04-21-35-03-B**	2.179E-8	1	2.179E-8	1	2.179E-8	1
03-09-21-05-B**	2.042E-7	1	1.000E-8	1	1.000E-8	1
03-09-21-35-03-B**	2.361E-8	1	2.361E-8	1	2.361E-8	1
03-51-35-03-B**	2.713E-8	1	0	0	0	0

* Break in flood zone 6
** Break in flood zone SSW B

Table 3.2.4
Results from Quantification of T5DF81 Accident Sequence

Sequence	Before Recovery		After Recovery Before Cut Set Update		After Recovery After Cut Set Update	
	Frequency	No.Cut Sets	Frequency	No.Cut Sets	Frequency	No.Cut Sets
03-32-51-35-03	2.032E-7	1	0	0	0	0
03-48-51-35-03	3.461E-7	1	0	0	0	0

Table 3.2.5
Results from Quantification of J2F48 Accident Sequence

Sequence	Before Recovery		After Recovery Before Cut Set Update		After Recovery After Cut Set Update	
	Frequency	No. Cut Sets	Frequency	No. Cut Sets	Frequency	No. Cut Sets
02-01-02-67	3.829E-8	1	0	0	0	0
02-01-07-67	4.149E-8	1	0	0	0	0
02-01-51-35-03	1.587E-8	1	0	0	0	0
02-01-51-35-01-19	1.314E-8	1	0	0	0	0

Table 3.2.6
Results from Quantification of E2BF20 Accident Sequence

Sequence	Before Recovery		After Recovery Before Cut Set Update		After Recovery After Cut Set Update	
	Frequency	No. Cut Sets	Frequency	No. Cut Sets	Frequency	No. Cut Sets
05-02-39	2.071E-8	1	0	0	0	0
05-02-67	1.864E-8	1	0	0	0	0
05-07-39	2.244E-8	1	0	0	0	0
05-07-37	2.019E-7	1	0	0	0	0
05-51-35-01-19	1.403E-8	1	0	0	0	0

Table 3.2.7
Results from Quantification of J2F56 Accident Sequence

Sequence	Before Recovery		After Recovery Before Cut Set Update		After Recovery After Cut Set Update	
	Frequency	No. Cut Sets	Frequency	No. Cut Sets	Frequency	No. Cut Sets
02-01-51-35-01	1.872E-8	1	0	0	0	0

Table 3.2.8
Results from Quantification of TAB39 Accident Sequence

Sequence	Before Recovery		After Recovery Before Cut Set Update		After Recovery After Cut Set Update	
	Frequency	No.Cut Sets	Frequency	No.Cut Sets	Frequency	No.Cut Sets
3	9.787E-8	1	9.787E-8	1	9.787E-8	1

Table 3.2.9
Results from Quantification of J2F91 Accident Sequence

Sequence	Before Recovery		After Recovery Before Cut Set Update		After Recovery After Cut Set Update	
	Frequency	No.Cut Sets	Frequency	No.Cut Sets	Frequency	No.Cut Sets
02-01-51-35-01	3.042E-8	1	0	0	0	0

Table 3.2.10
Post-Recovery Sequence Quantification Summary

Initiating Event	Sequence	Frequency (per yr)	% Frequency	No. Cut Sets
T5AF19	03-04-21-35-03-A* 03-09-21-05-A* 03-09-21-35-03-A*	2.179E-8 1.000E-8 2.361E-8	10.4 4.8 11.3	1 1 1
T5AF19	03-04-21-35-03-B** 03-09-21-05-B** 03-09-21-35-03-B**	2.179E-8 1.000E-8 2.361E-8	10.4 4.8 11.3	1 1 1
TAB39	03	9.787E-8	46.9	1
	TOTAL	2.087E-7	100%	7

*Break in flood zone 6
**Break in flood zone SSW B

Table 3.2.11
Core Damage Frequency Contribution for Sequence Surviving Time Window Analysis

Initiating Event	Sequence	Frequency (per year)
TAB39	3-W2	2.403 E-8
TOTAL		2.403 E-8

Table 3.2.12
Cut Set Core Damage Frequency Contributions

Initiating Event	Cut Set	Cut Set Frequency (per year)
TAB39	NOACDC, POS5, /ISSDC-W2, /RLOSP, /PRESS-W2, RA-NO-REC, WD-2	2.403E-8

3.3 Sequence Description and Cut Set Information for Surviving Scenario

This section provides discussion of the sequence and its attendant cut set which survived the Time Window Analysis with a frequency greater than or equal to 1.0 E-8 per year.

3.3.1 TAB39 Sequence 3-W2 Description

The logic for sequence 3-W2 is: TAB39*POS5*WD-2*/RLOSP*/PRESS-W2*/ISSDC-W2*NOACDC.

The sequence is initiated by a break in a Fire Water System (FWS) pipe which results in the subsequent loss of Division A, B and C power sources due to the resulting flood (TAB39). The break occurs while the plant is in Operational State 5 (POS5) during Time Window 2 (WD-2). Offsite power is available (/RLOSP) and the plant is under non-Hydro conditions (/PRESS-W2) with decay heat removal provided by the RHR system operating in the SDC mode (/ISSDC-W2). All three divisions of Class 1E AC and DC power are lost (NOACDC). Given the severity of the flood induced loss of equipment, no credit is given for operator recovery actions.

3.3.2 TAB39 Sequence 3-W2 Cut Set Information

Table 3.3.1 provides the sequence frequency (the Mincut Upper Bound) and the single cut set for the sequence. Table 3.3.2 lists the probabilities of the basic events used in the sequence quantification.

3.4 Uncertainty Analysis

An uncertainty analysis was performed on the one surviving sequence having a frequency greater than or equal to 1.0 E-08 per year. The analysis was performed using Latin Hypercube Sampling with 1000 samples for the surviving cut set.

The results of the uncertainty analysis for the surviving sequence is given in two tables. Table 3.4.1 describes the uncertainty results and also contains the point estimate frequency for comparison with the mean value calculated in the uncertainty analysis. Table 3.4.2 contains the results of a basic event importance analysis for the sequence.

In the importance analysis table, the probability of failure column contains the basic event point estimate failure probability used in the sequence screening. The Uncertainty Importance Measure is an indication of the effect on the sequence frequency if the basic event frequency were to be known with absolute certainty.

The Risk Reduction Difference is the amount by which a given sequence frequency would be reduced if the failure probability for a given basic event were to be reduced to zero. Since the surviving flood sequence had only a single cut set, setting any basic event failure probability to zero reduces the risk to zero. Thus, the Risk Reduction Difference is equal to the point estimate sequence frequency.

The Risk Increase Difference is the amount by which the sequence point estimate frequency would increase if the point estimate failure probability of a basic event were to be set to unity. For basic events whose failure probability was initially 1.0, there is no Risk Increase Difference.

Table 3.3.1 TAB39 Sequence 3-W2

```
                 SEQUENCE CUT SETS (QUANTIFICATION) REPORT
        Family   : FLOOD-TW            Sequence    : 3-W2
        Analysis : RANDOM              Event Tree  : TAB39
        Case     : ALTERNATE           Init. Event : TAB39
                     Mincut Upper Bound :  2.403E-008
```

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	100.0	100.0	2.4E-008	/ISSDC-W2, NOACDC, POS5, /PRESS-W2, RA-NO-REC, /RLOSP, WD-2

Table 3.3.2 Basic Event Probabilities for Sequence 3-W2

```
                 SEQUENCE CUT SETS (QUANTIFICATION) REPORT
        Family   : FLOOD-TW            Sequence    : 3-W2
        Analysis : RANDOM              Event Tree  : TAB39
        Case     : ALTERNATE           Init. Event : TAB39
                     Mincut Upper Bound :  2.403E-008

                  (Basic Event Probabilities Summary)
```

Basic Event	Probability	Basic Event	Probability
TAB39	3.900E-006	ISSDC-W2	6.200E-002
NOACDC	1.000E+000	POS5	3.100E-002
PRESS-W2	+0.000E+000	RA-NO-REC	1.000E+000
RLOSP	4.000E-004	WD-2	2.120E-001

Table 3.4.1 Sequence 3-W2 Uncertainty Results

SEQUENCE UNCERTAINTY VALUES REPORT

Family : FLOOD-TW   Case: CURRENT   Analysis: RANDOM

Seq. No.	Event Tree Sequence Name	Mean Median	MinCut Stand. Dev.	5th Perc. 95th Perc.	Minimum Maximum	Seed Size
1	TAB39	2.275E-008	2.403E-008	8.219E-011	+0.000E+000	12345
	3-W2	2.803E-009	1.033E-007	8.606E-008	2.341E-006	1000

Table 3.4.2 Sequence 3-W2 Importance Measures

SEQUENCE IMPORTANCE MEASURES REPORT

Family : FLOOD-TW Sequence : 3-W2
Analysis : RANDOM Event Tree : TAB39
Case : ALTERNATE Init. Event : TAB39

(Sorted by Uncertainty Importance Measure)

Event Name	Num. of Occ.	Probability of Failure	Uncertainty Importance Measure	Risk Reduction Difference	Risk Increase Difference
TAB39	1	3.900E-006	1.274E-002	2.403E-008	6.162E-003
WD-2	1	2.120E-001	1.133E-007	2.403E-008	8.932E-008
NOACDC	1	1.000E+000	2.403E-008	2.403E-008	+0.000E+000
RA-NO-REC	1	1.000E+000	2.403E-008	2.403E-008	+0.000E+000
POS5	1	3.100E-002	4.475E-009	2.403E-008	7.512E-007
RLOSP	1	4.000E-004	-4.666E-012	-9.616E-012	-2.403E-008
PRESS-W2	1	+0.000E+000	-2.403E-008	+0.000E+000	-2.403E-008
ISSDC-W2	1	6.200E-002	-3.586E-008	-1.588E-009	-2.403E-008

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4.0 Plant Damage State Analysis

This section of the report summarizes the plant damage state (PDS) analysis.

4.1 Analysis Methodology

4.1.1 Purpose

Plant damage states form the interface between the accident frequency analysis (i.e., Level 1 analysis) and the accident progression analysis (i.e., Level 2 analysis) and as such define the initial and boundary conditions for the Level 2 analysis. In the Level 1 analysis the sequence of events that will lead to core damage are identified. The minimum set of events that will result in core damage is called a cut set. In the plant damage state analysis, cut sets with similar characteristics that are important to the progression of the accident following core damage are grouped together; each group constitutes a PDS.

4.1.2 Approach

A four step approach was used to develop the PDSs. In the first step, general features of the accidents that will define the initial and boundary condition for the Level 2 analysis are identified. These general features define the configuration of the plant at the start of core damage and the status of systems than can be used to mitigate the accident. In the second step, specific systems and plant features are identified that address each of these general features. Each specific features is called a *characteristic*; the possible configurations of each system or characteristic are called an *attribute*. More than one characteristic may be used to define a general feature. For example, the following four systems (i.e., characteristics) could be used to define the general feature that addresses the status of core cooling : HPCS, LPCI, SSW crosstie, and CDS. That is, HPCS is one of four characteristics that defines the status of core cooling. The possible configurations of the HPCS system, or attributes, during the accident are: (A) HPCS available but not being used, (B) HPCS not available and not recoverable, and (C) HPCS not available but recoverable with the recovery of offsite power. In this example, the HPCS characteristic has three attributes. The list of characteristics and their associated attributes define the possible plant/system configuration for a particular accident. This is displayed as a string of alphanumeric characters. The first position corresponds to the first characteristic, the second position corresponds to the second characteristic and so on. The alphanumeric character assigned to each position is the attribute for the appropriate characteristic. In the third step, the cut sets are reviewed and the appropriate attributes for each characteristic are assigned to each cut set. Since the list of characteristics generally describes the accident in less detail than the cut set, groups of cut sets will have the same string of letters. A unique string of letters is called an End State (ES). (ESs are similar to PDSs except that they define the accident in more detail than the PDS.). While the number of ESs can be significantly less than the number of cut sets, typically there are still too many ESs to analyze individually in the Level 2 analysis. Therefore, in the fourth and final step, the many ESs are combined into a manageable number of PDSs. This step is possible because within the resolution of the Level 2 analysis many of the ESs will result in similar accident progressions and releases of radioactive material. To form the PDSs, ES characteristics are combined such that only the information that is needed to define the initial and boundary conditions for the Level 2 analysis are defined by the PDS. For example, the individual ESs may indicate the availability of many different coolant injection systems (e.g., LPCI, SSW cross-tie, and CDS). However, if LPCI is recoverable and the vessel is at low pressure then the status of the other systems is not important for the model used in the Level 2 analysis. Thus, assuming the other characteristics of the ESs are the same, all those ESs with LPCI recoverable would be combined regardless of the status of SSW cross-tie and CDS. Through this process the majority of the ESs can be combined into a dozen or so PDSs, however, the actual number of PDSs developed will depend on the diversity of the accident sequences and the resolution desired for the Level 2 analysis.

The general features of the accident that were used in this study to develop the PDSs are: the status of electric power, the status of core cooling, the status of containment heat removal, status of reactor pressure vessel integrity, the status of containment integrity, and accident timing characteristics. Each of these general accident features is discussed below.

Status of Electric Power: There are systems and components that can influence the progression of the accident following core damage but that were not modelled in the Level 1 analyses. Many of these systems depend primarily on electric power. Thus, in many cases this feature of the accident can be used to determine which systems can be used to mitigate the accident. For example, offsite ac power is required to close the containment. Similarly, in POS 5 emergency ac power is required to operate the hydrogen ignition system.

Status of Core Cooling: This feature is used to identify systems that can be used to restore core coolant during the core damage process. Restoration of core cooling offers the potential to arrest the core damage process and prevent vessel failure. Preventing vessel failure can substantially reduce the consequences of the accident.

Status of Containment Heat Removal: This feature addresses the status of systems that can be used to remove decay heat from the containment such as containment sprays and the suppression pool cooling systems. In cases where the containment is closed, the energy released to the containment atmosphere during core damage will pressurize the containment. These systems are used to attenuate this pressurization and thereby reduce the load on the containment structure. Containment heat removal is generally necessary to prevent containment failure. Containment sprays are also useful in that they remove aerosols from the containment atmosphere and thereby reduce any potential release of radioactive material. Since the suppression pool is an integral part of containment heat removal, this feature also addresses the status of the suppression pool at the time of core damage (i.e., amount of water in the pool and the temperature of the pool) and is used to identify situations where its performance may be impaired. The suppression pool is used as a heat sink for the reactor, supplies water to ECCS, and is an effective device for removing radioactive material released from the vessel.

Status of Reactor Pressure Vessel: This feature defines the integrity of the reactor pressure vessel and the pressure in the vessel at the time of core damage. The integrity of the vessel is important because it will determine the path by which steam and radioactive material will escape from the vessel. If the vessel integrity is maintained, the releases will pass from the vessel to the suppression pool via the SRV tailpipes. As mentioned previously, the suppression pool is an effective device for mitigating the release. For a LOCA, the vessel releases will enter the drywell. For an interfacing systems LOCA, the release will bypass the containment altogether and enter auxiliary building. If the vessel head vent is open a portion of the release will enter the drywell while the remaining portion will enter the suppression pool via the SRV tailpipes. When the vessel integrity is maintained, the pressure in the vessel will affect the timing of the accident, the amount of radioactive material released during core damage, and the pressure in the containment following vessel failure. The vessel pressure will also determine which systems can be used to provide makeup (i.e., high pressure systems or low pressure systems).

Status of Containment Integrity: This feature defines the integrity of the containment boundary at the time of core damage. The integrity of the containment boundary is one of the most important factors that will determine the severity of the accident. For severe core damage accidents in which the containment boundary remains intact, the offsite consequences are generally small. On the other hand, when the containment boundary is not maintained the consequences can be quite severe. Since in POS 5 the containment equipment hatch and personnel locks can be open, it is important to know the status of these penetrations at the time of core damage. This feature also addresses the status of the containment vent system which can be used to relieve pressure in the containment when containment heat removal systems are not available or inadequate. Opening the containment vent, however, will allow radioactive material in the containment atmosphere to enter the environment.

Accident Timing Characteristics: This feature defines the amount of time that elapses between the occurrence of the initiating event and the onset of core damage. This amount of time will directly affect the amount of decay heat that is present at the onset of core damage which will in turn affect the timing of key events following the onset of core damage (e.g., vessel failure and containment failure). The speed with which the accident proceeds can affect the amount of time that is available to restore core cooling and will also affect the relative timing between when the release of radioactive material occurs and when the public begins to evacuate. This last item can have a major impact of the magnitude of early health effects.

The PDS characteristics and attributes that define the PDSs are provided in Table 4.1.

Table 4.1 Plant Damage State Characteristics and Attributes

Characteristic	Attribute	Description
		STATUS OF ELECTRICAL POWER
1		**Status of Electrical Power**
	A	Offsite power (OSP) available
	B	OSP not available - but recoverable
	C	OSP not available - not recoverable, delayed failure of core cooling
	D	OSP not available - not recoverable, prompt failure of core cooling
	E	OSP available - Emergency AC and DC power not available and not recoverable
		STATUS OF CORE COOLING
2		**Status of Core Coolant Injection**
	A	Core injection is not available and cannot be recovered
	B	LPCI and/or SSW crosstie are unavailable due to operator error
	C	LPCI and/or SSW crosstie are unavailable but recoverable with recovery of OSP
		STATUS OF CONTAINMENT HEAT REMOVAL
3		**Status of Containment Sprays and Suppression Pool Cooling**
	A	CS/SPC is not available and cannot be recovered
	B	CS/SPC is not available but can be recovered with recovery of OSP
	C	CS/SPC is available
4		**Status of Suppression Pool Level**
	A	Water at "Low Level" or "Drained Level"
	B	Suppression pool level is at the ECCS suction strainers
5		**Status of Suppression Pool Temperature**
	A	Suppression Pool is sub-cooled
	B	Suppression Pool is saturated

Table 4.1 Plant Damage State Characteristics and Attributes (Continued)

Characteristic	Attribute	Description
		STATUS OF REACTOR VESSEL INTEGRITY
6		**Status of RPV Head Vent**
	A	Head vent is open during the accident
	B	Operators close the head vent prior to core damage
7		**Status of RPV Pressure and Integrity**
	A	Primary system is at system pressure
	B	Primary system is at low pressure (> 400 psia)
	C	Primary system is at low pressure; RPV is breached by a LOCA inside containment
	D	Primary system is at low pressure; RPV is breached by a LOCA in SDC system
	E	Primary system is at low pressure; RPV is breached by open MSIVs
		STATUS OF CONTAINMENT INTEGRITY
8		**Status of Containment Lower Personnel Lock**
	A	Containment lower personnel lock is open
	B	Containment status is unknown
9		**Status of Containment Vent System**
	A	CVS is unavailable and cannot be recovered
	B	CVS is unavailable but can be recovered with recovery of OSP
	C	CVS is available but has not been used because is has not been needed
		TIMING CHARACTERISTICS
10		**Time to Core Damage**
	A	Core damage occurs in 2 hour
	B	Core damage occurs in 2.35 hours
	C	Core damage occurs in 3.5 hours
	D	Core damage occurs in 5.5 hours
	E	Core damage occurs in 6.75 hours

Table 4.1 Plant Damage State Characteristics and Attributes (Continued)

Characteristic	Attribute	Description
10		**Time to Core Damage (Continued)**
	F	Core damage occurs in 7 hours
	G	Core damage occurs in 9.75 hours
	H	Core damage occurs in 12 hours
11		**Time Windows**
	A	Time Window 1: Ranges from 14 to 24 hours after shutdown
	B	Time Window 2: Ranges from 24 to 94 hours after shutdown
	C	Time Window 3: Ranges from 40 to 50.4 days after shutdown

4.2 Plant Damage State Description and Analysis Results

4.2.1 Description of Plant Damage State

A brief description of the PDS is presented in this section. The alpha-numeric identifiers for the one PDS is presented in Table 4.2. The definitions for these identifiers were given in Table 4.1.

Table 4.2
Plant Damage State Description

Plant Damage State	Alpha-numeric Description
PDS-P2-1	E-A-AAA-AD-BA-DB

The accident leading to this PDS is initiated by a break in a Fire Water System main header. The resulting flood disables Divisions A, B and C ac and dc power sources. Offsite power is available but cannot be routed through these divisions for emergency applications. Upon loss of power, circulation ceases, shutdown cooling is lost, and pressure in the reactor vessel rises. Due to the rising pressure and loss of the three divisions of power, coolant-injection is impossible. The pipe break makes fire water unavailable.

The SRVs cannot be opened manually and the rising pressure causes a break in the low pressure SDC piping and subsequent draining of the vessel. Core damage is estimated to occur approximately 5.5 hours after accident initiation.

The containment can be either open or closed and containment cooling systems are lost for the duration of the accident. The loss of ac power leads to the loss of the hydrogen ignition system.

4.2.2 Plant Damage State Results

The PDS along with its alpha-numeric identifier, frequency and contribution to the core damage frequency are presented in Table 4.3. The definitions for the alpha-numeric identifiers were provided in Table 4.1.

Table 4.3 Plant Damage State Results

Plant Damage States	Alpha-numeric Description	Descriptive Statistics: Core Damage Frequency (1/yr)				Fractional Contribution[1]	# of Cut Sets
		5%	50%	95%	Mean	FCM-CDF	
PDS-F1-2	E-A-AAA-AD-BA-BD	8.219E-11	2.803E-09	8.606E-08	2.275E-08	1.0	1
				Total	2.275E-08	1.0	1

Note 1: FCM-CDF = Fractional contribution to mean core damage frequency

5.0 Conclusions

5.1 General Conclusions

The primary purpose of the analysis of internal flooding events during POS 5 was to develop an estimate of the core damage frequency at the Grand Gulf Nuclear Station due to floods resulting from breaches in fluid system boundaries. The mean core damage frequency estimate was determined to be 2.3E-8 per year. This frequency is approximately two orders of magnitude lower than the 2.0E-6 per year mean core damage frequency estimate for internal events excluding fire and flood [5]. Thus, internal flooding represents a minor contribution to the total core damage frequency at GGNS during POS 5. The low frequency is due principally to two factors: (1) the frequency for large breaks in fluid system boundaries is quite low compared to other failures that might lead to initiating events. (2) Even though several systems are shut down during POS 5, those that remain available are sufficiently separated that, with one possible exception discussed below, a single flood event will not threaten all of them simultaneously.

It must also be kept in mind that several of the assumptions made in these analyses are conservative. Perhaps the most conservative is that flow from a break would continue unabated for one hour. For all sequences other than the single surviving Time Window 2 sequence this assumption did not significantly impact the analysis. Given the high level of around-the-clock maintenance and refurbishing activity at GGNS during a refueling outage POS 5, this assumption was reexamined for the surviving sequence. The final unabated flow out the break was assumed to continue for 15 minutes. This time, in conjunction with the assumed flow rate, was sufficient to cause failure of all ac and dc Class 1E divisions of power. Thus, reduction of the unabated flow time did not alter the consequences of the potential accident sequence.

The assumption of a fully guillotined catastrophic failure is also conservative. Again, this assumption did not significantly affect the final results.

5.2 Specific Conclusions

The only potential core damage sequence having a frequency greater than or equal to 1.0E-8 is initiated by the TAB39 initiator. The sequence has only one cut set leading to core damage.

This sequence is the single surviving sequence of the TAB39 initiator. This initiating event is a break in the Fire Water System piping in the Division B switchgear area on the 111 foot level of the Control Building (Figure A-8). The flood propagates to all areas of this level disabling Division A, B and C Class 1E ac and dc power. While it was assumed that this loss of power negated any mitigative or recovery actions, it is possible that non ECCS equipment might be used. However, given the nature of the accident and the insignificant contribution to the total internal core damage frequency, no recovery potential was assigned to any such actions by the analysts. Again, due to the very small contribution of flood induced core damage accidents, this should not be construed as an important source of potential core damage frequency.

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6.0 References

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Appendix A

Flood Zone Location and Identifier

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Contents

Figures

Appendix A - Flood Zone Location and Identifier

This appendix contains figures depicting the flood zones used in this analysis. The figures provide a brief description of the major systems/components in the flood zones.

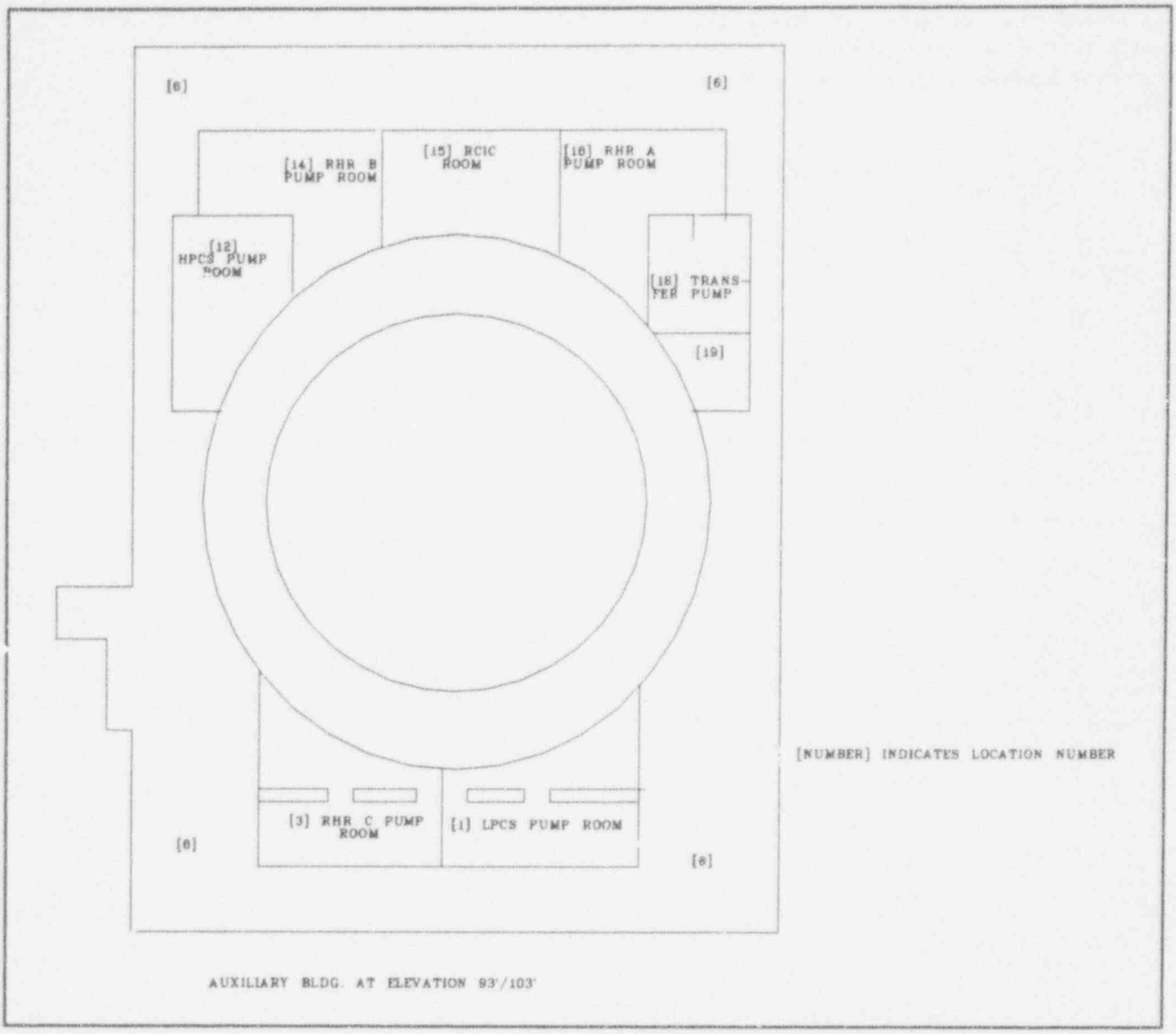

Figure A-1. Aux. Building, 93 ft Level

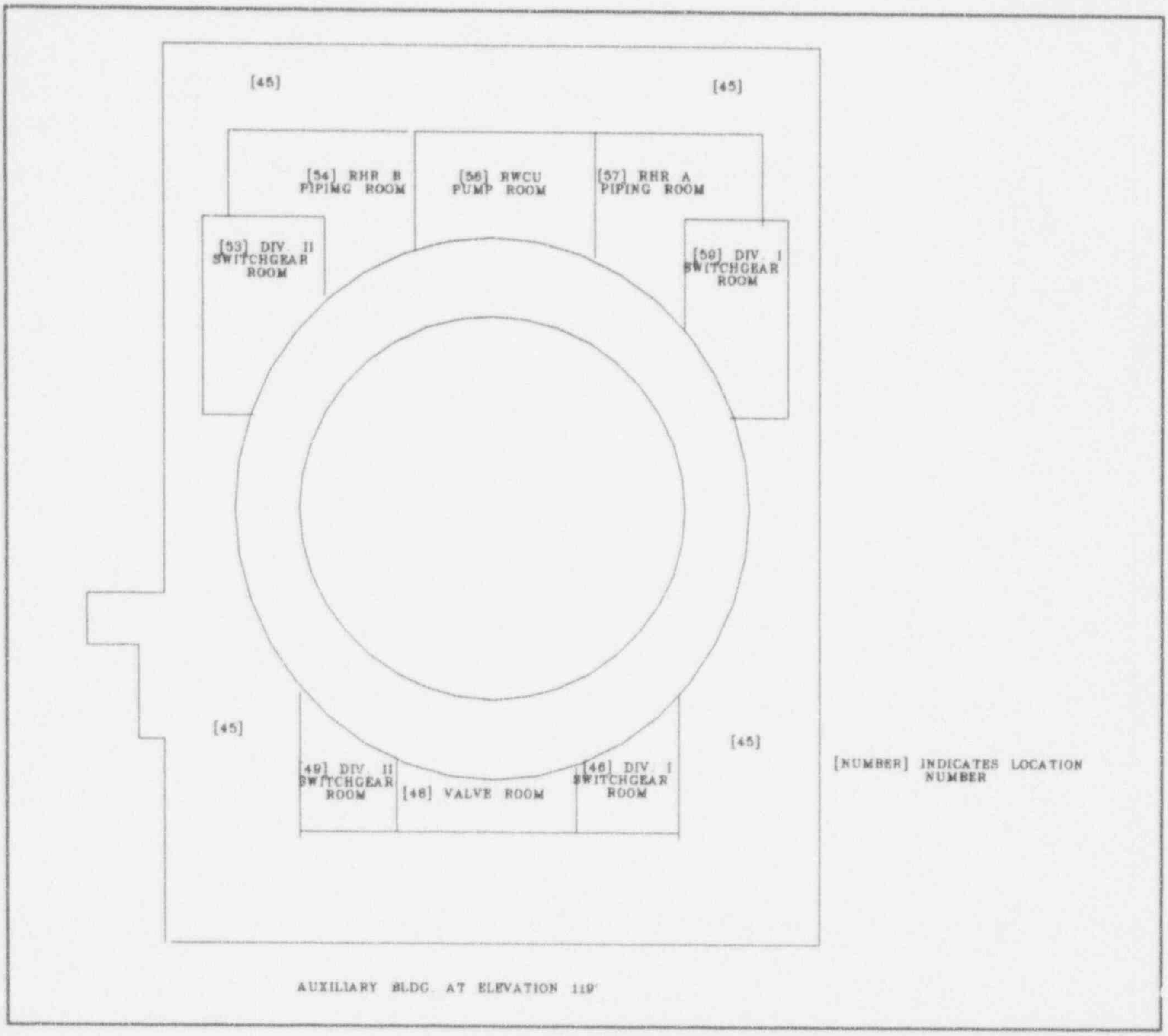

Figure A-2. Aux. Building, 119 ft Level

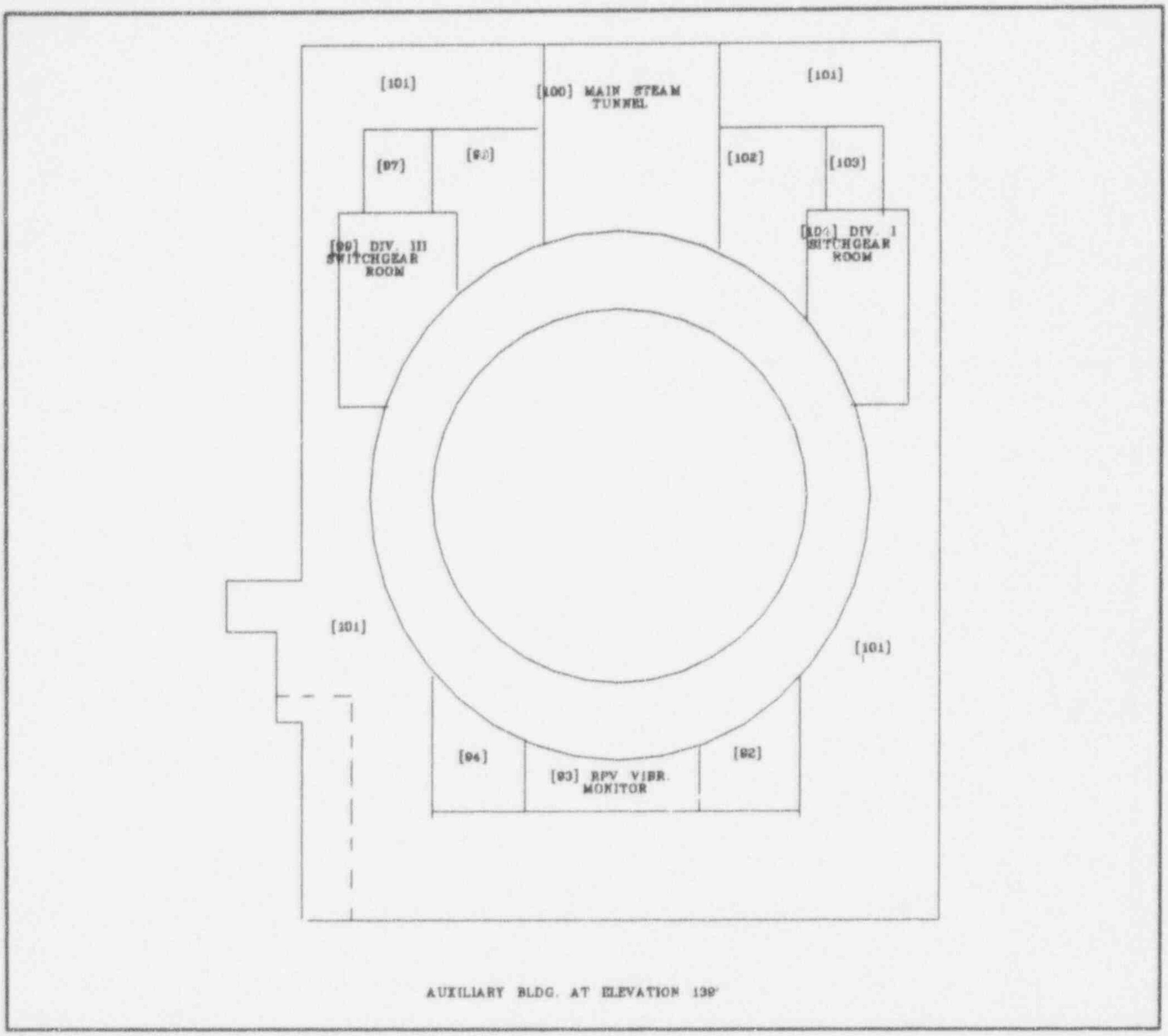

Figure A-3. Aux. Building, 133 ft Level

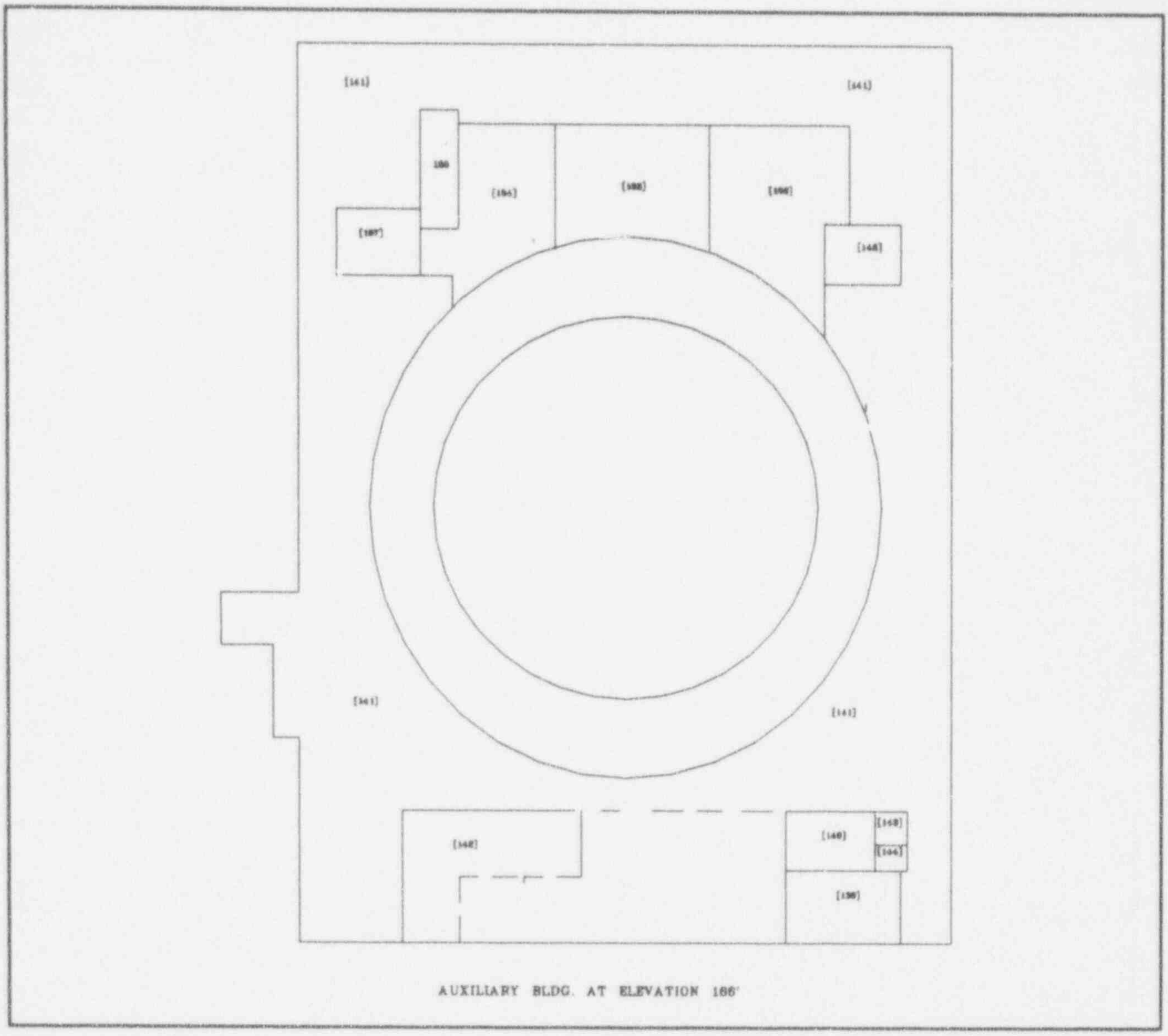

Figure A-4. Aux. Building, 166 ft Level

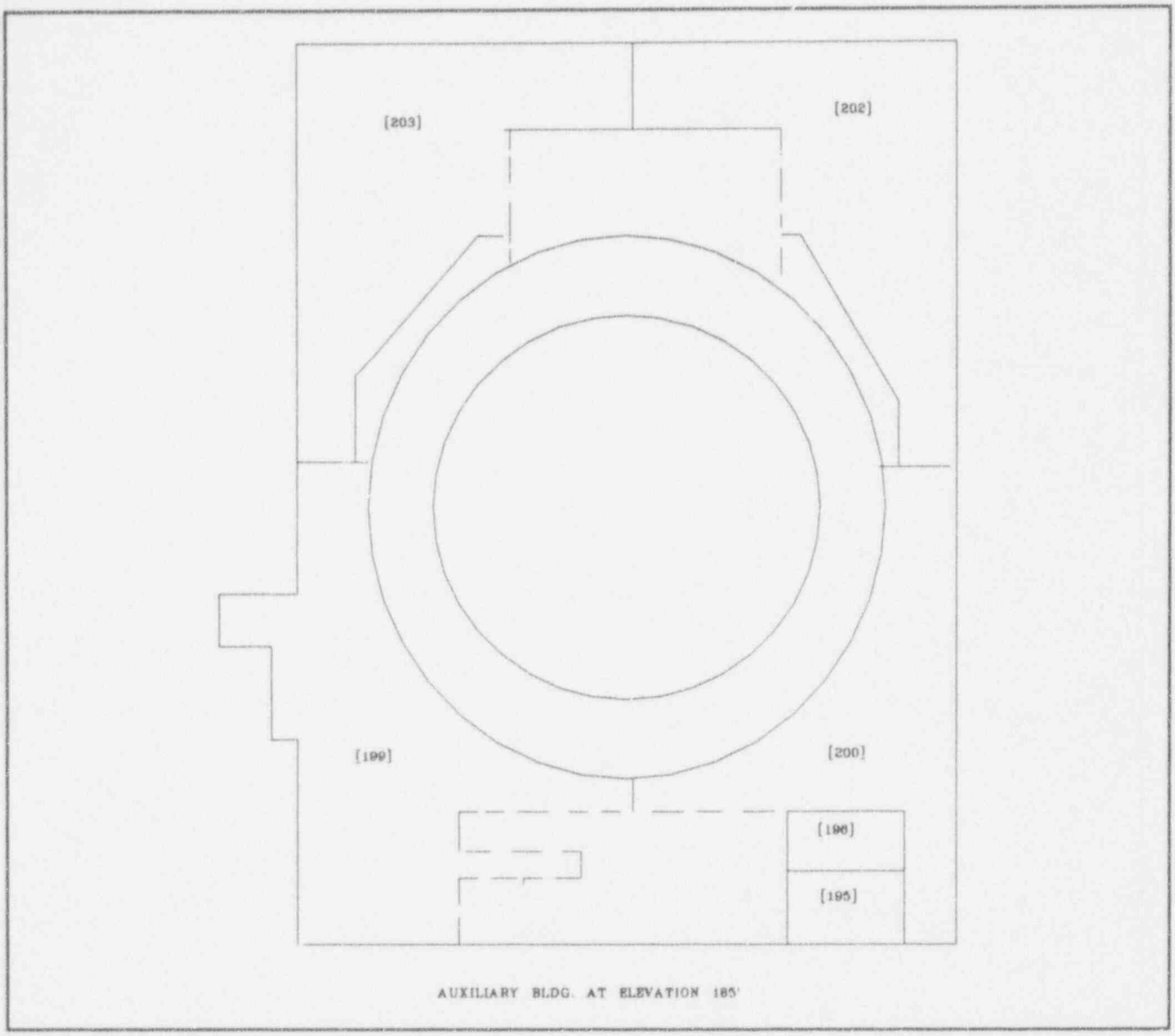

Figure A-5. Aux. Building, 185 ft Level

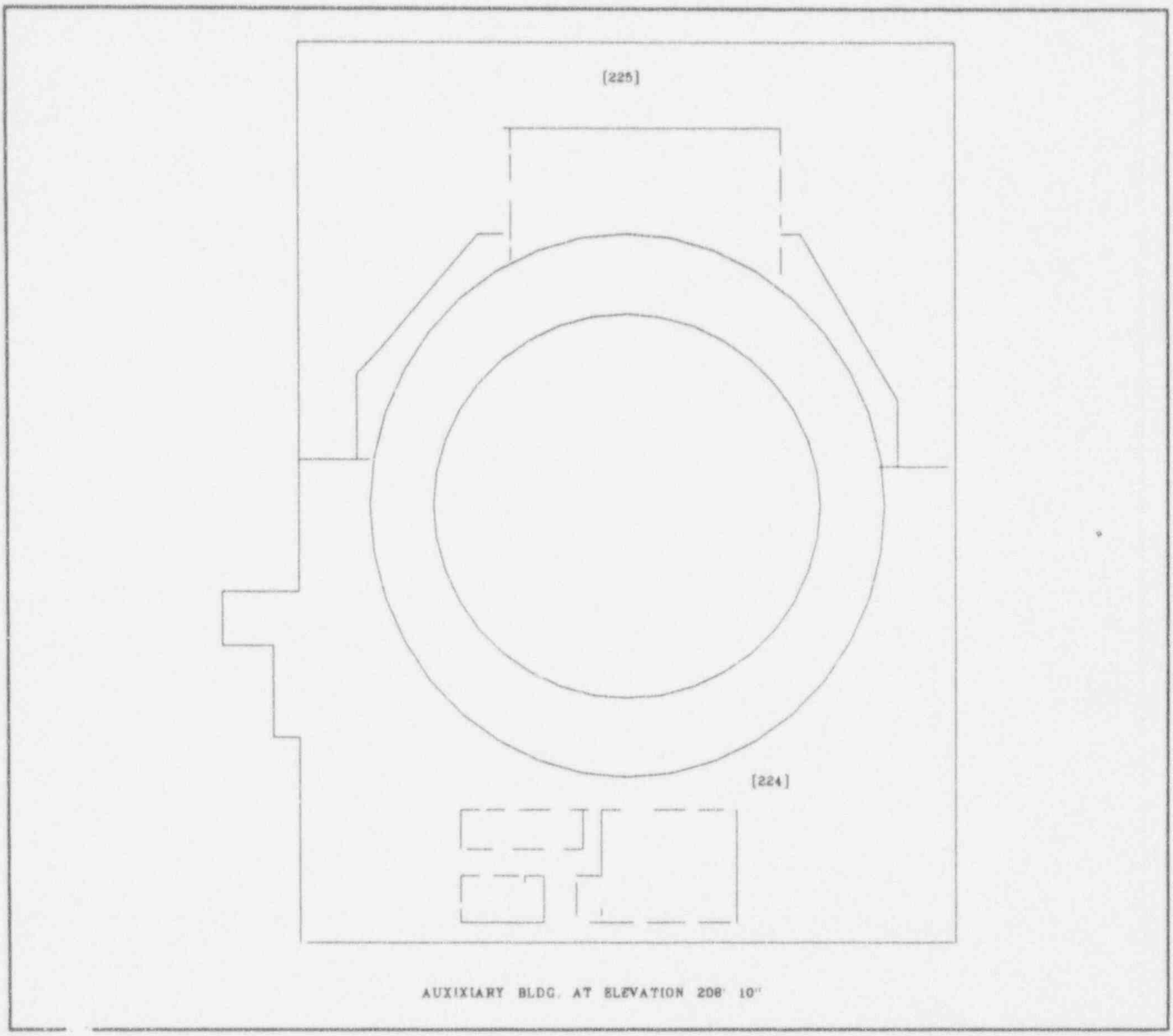

Figure A-6. Aux. Building, 208 ft Level

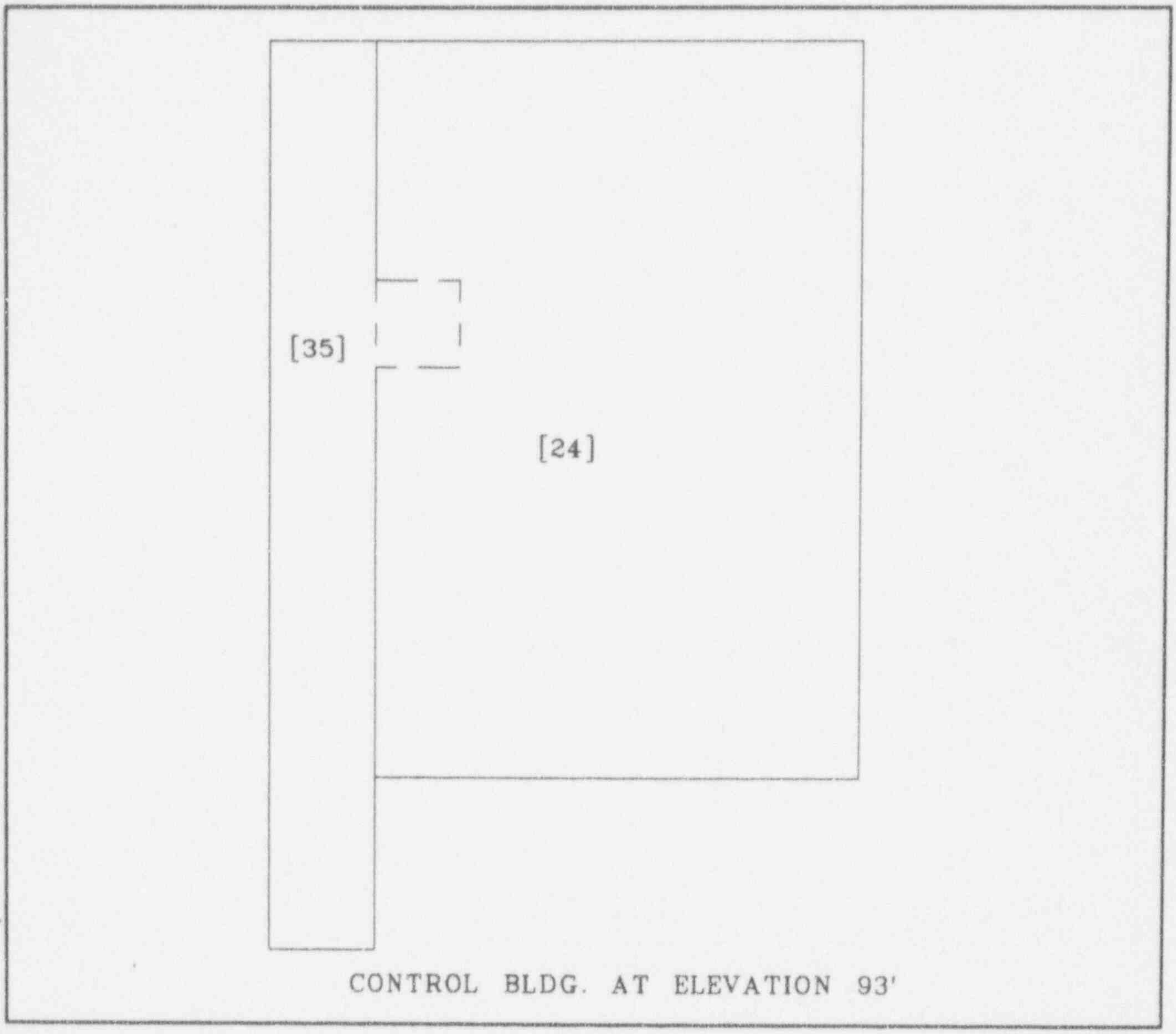

Figure A-7. Control Building, 93 ft Level

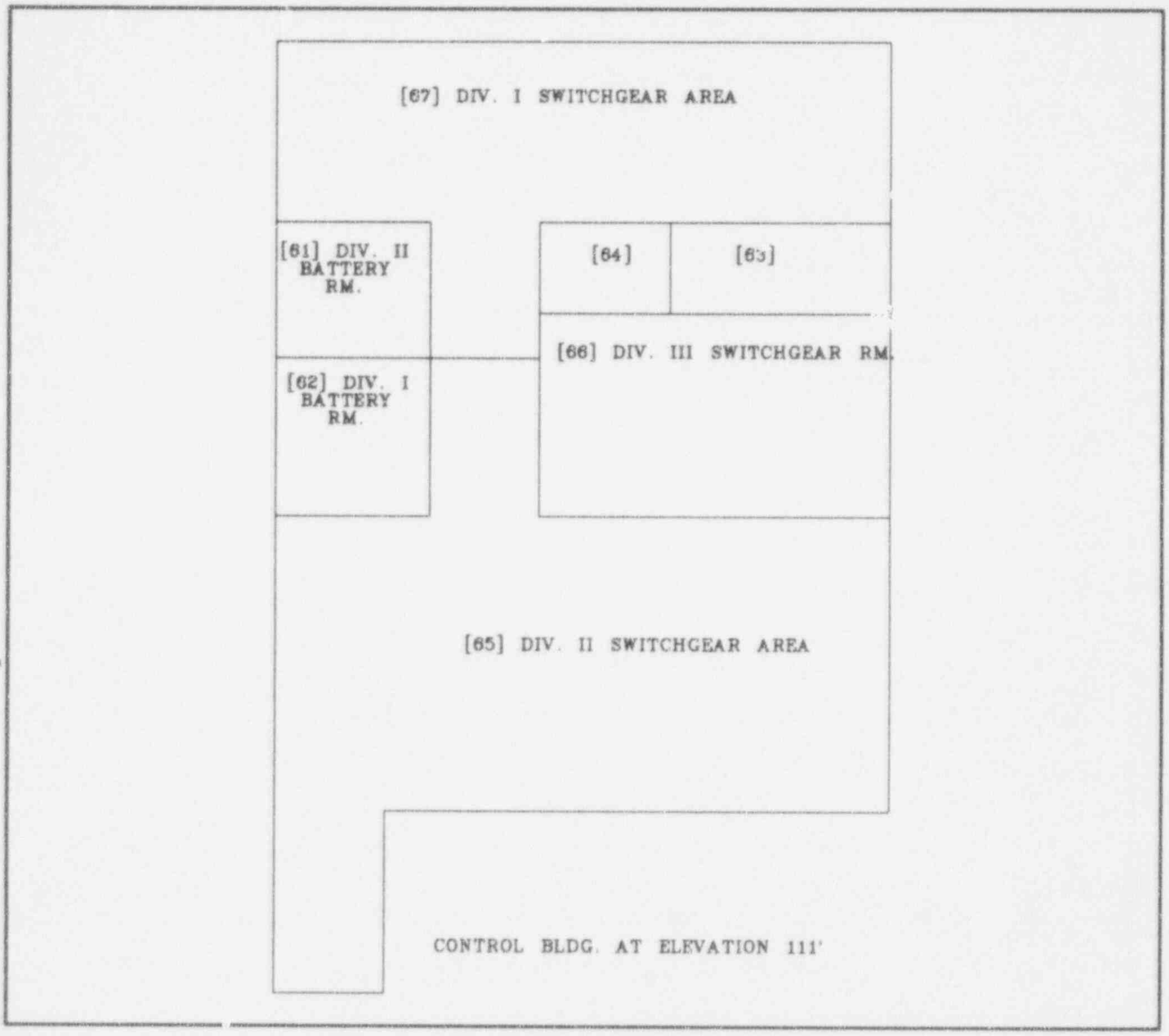

Figure A-8. Control Building, 111 ft Level

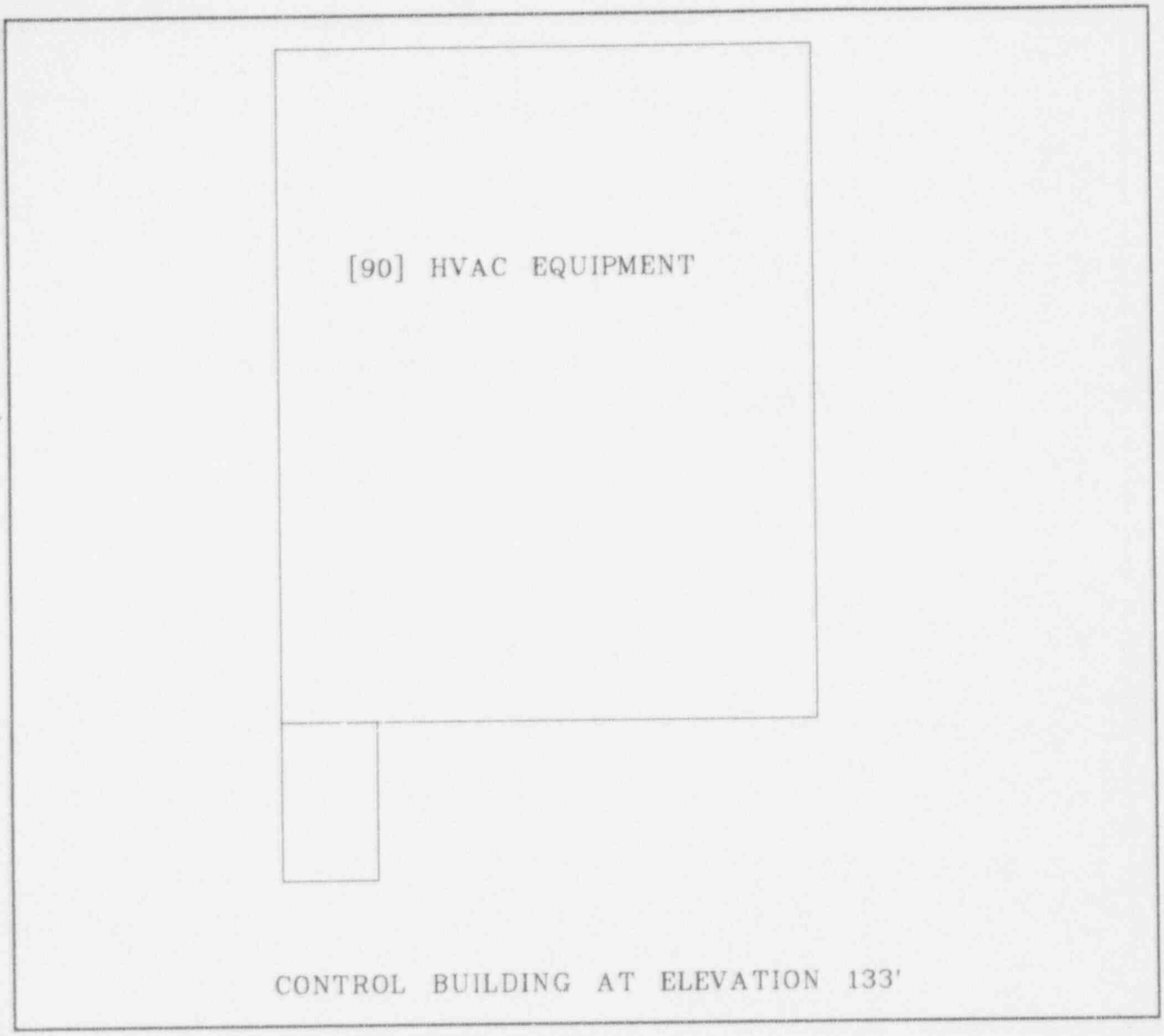

Figure A-9. Control Building, 133 ft Level

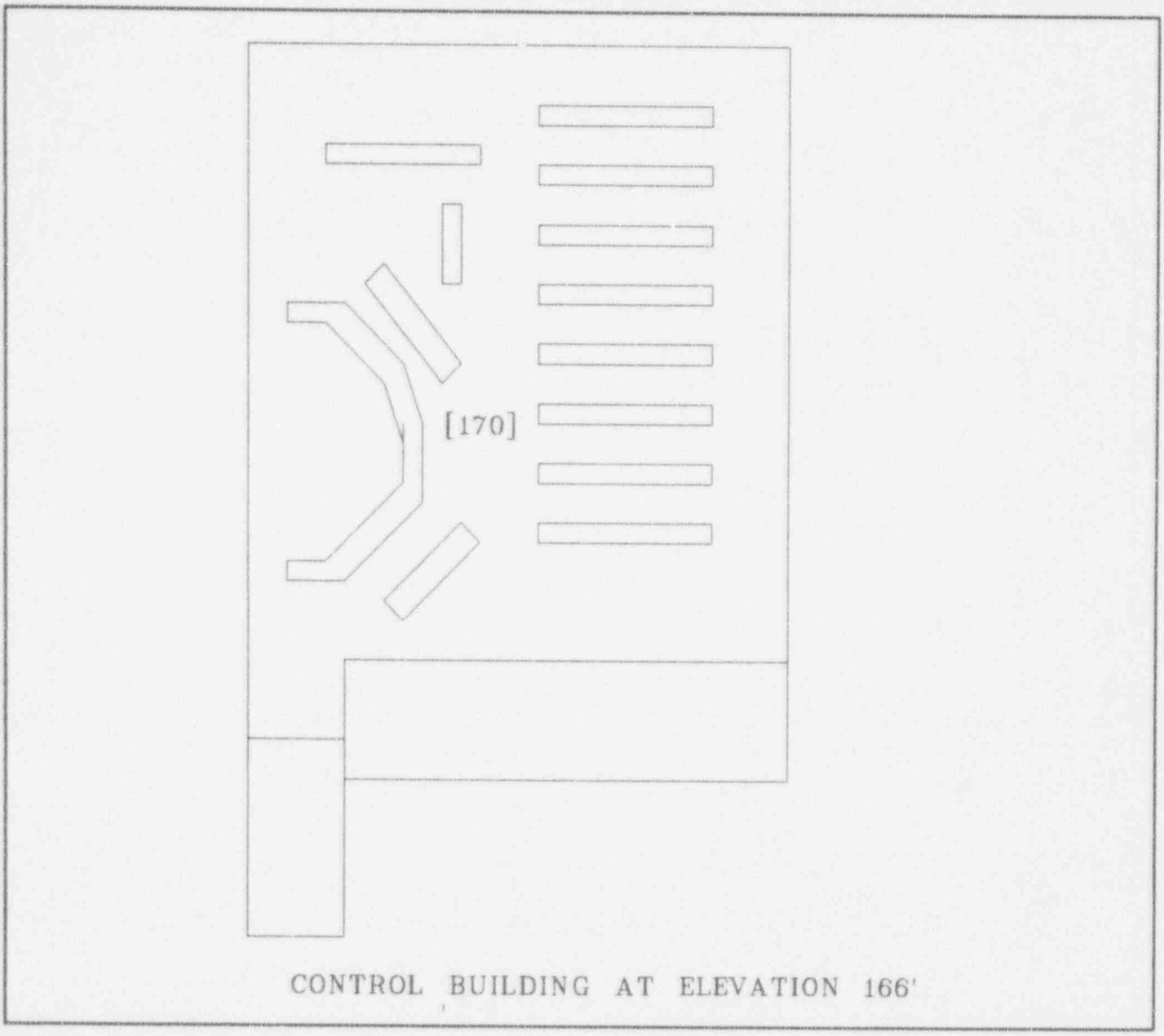

Figure A-10. Control Building, 166 ft Level

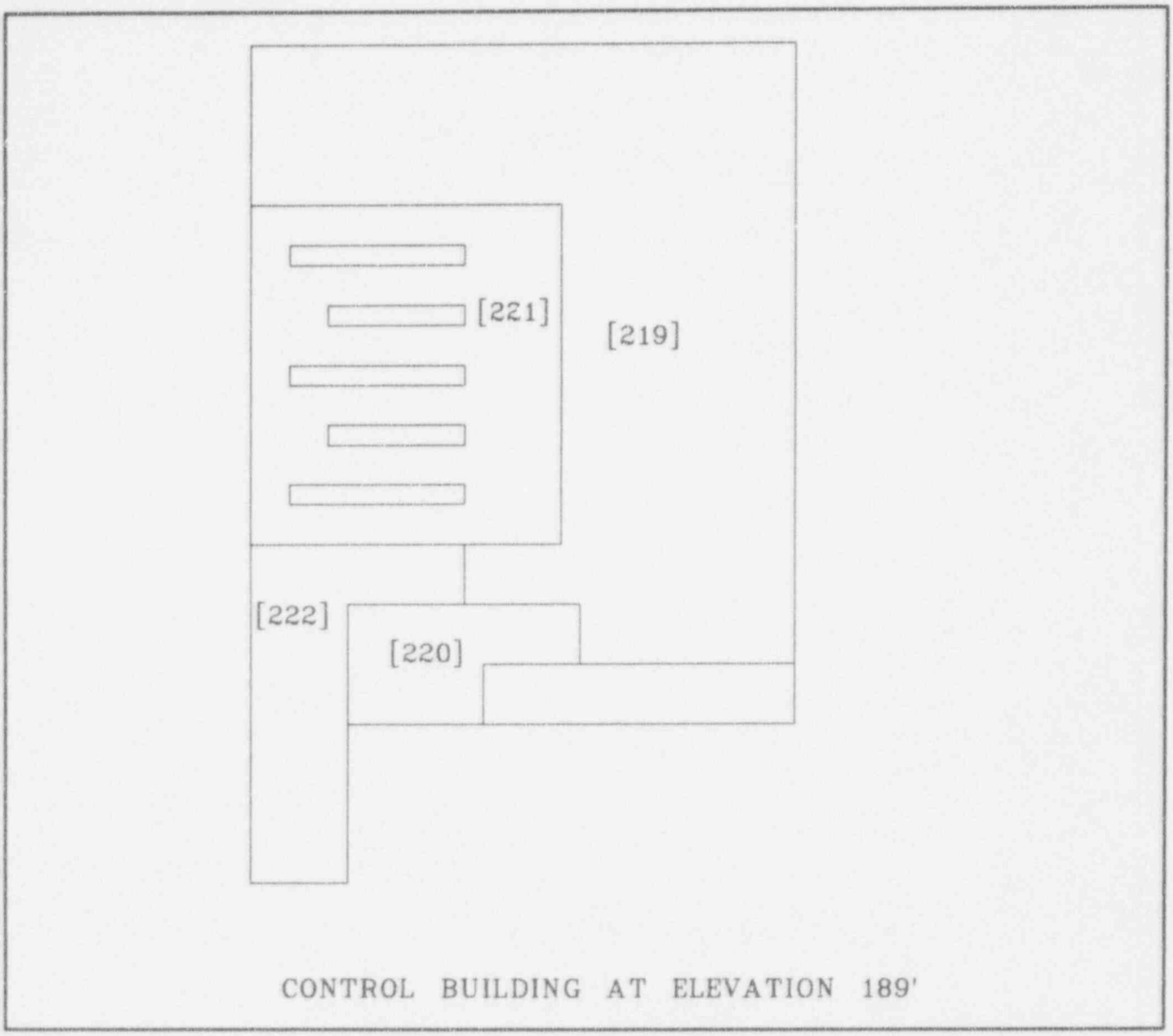

Figure A-11. Control Building, 189 ft Level

Appendix B

Flood Zone Cross References

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Contents

Table

Appendix B - Flood Zone Cross References

This appendix contains a summary of the components in each flood zone. This information is presented in Table B.1

Table B.1 Flood Zone Cross References

Flood Zone	Effective Area (ft²)	Components	Power Support	Components Vulnerability Height (ft)
1	1161	LPCS PUMP 1	AC BUS 15AA	8
		LPCS MOV 11	MCC 15B11	18
		LPCS MOV 1A	MCC 15B11	3
		SPMU LVL SENS 3A	PANEL 15P61	3
		SPMU LVL SENS 3C	PANEL 16P61	3
3	1161	EHV FAN COOLER 5B	MCC 16B11	10
		LPCI PUMP 2C		
		LPCI MOV 4C	AC BUS 16AB	8
		SPMU LVL	MCC 16B11	10
		SENS/TRANS 3B	PANEL 16P61	3
		SPMU LVL		
		SENS N003D	PANEL 16P31	3
		ADHRS MDP 5A-N		
		ADHRS MDP 5B-N	LCC 14BE1	1
		LPCI MOV 64C	LCC 14BE1	1
			MCC 16B11	25
6	18750	CCW MDP 1A-N	LCC 11BD5LCC	1.5
		C1CW MDP 1C-N	12BE2	1.5
		CCW MDP 1B-B	LCC 16BB3	1.5
		SSW MOV 68A	MCC 15B31	14
		CCW MOV 42	MCC 16B11	8
		CCW MOV 54	MCC 16B21	10
		CRD AOV 1A	IAS	3
		CRD MDP 1A-A	AC BUS 15AA	1.5
		CRD MDP 1B-B	AC BUS 16AB	1.5
		HPCS MOV 1	MCC 17BO1	3
		PSW SOV 120	PANEL 16P31	3
		PSW SOV 121	PANEL 16P31	3
		PSW SOV 123	PANEL 16P31	5
		PSW SOV 116	PANEL 16P31	7
		PSW SOV 117	PANEL 16P31	7
		PSW SOV 122	PANEL 16P31	5
		HPCS MOV11	MCC 17BO1	3
		SSW MOV 68B	MCC 16B31	14
		SSW MOV 94B	MCC 16B31	4.5
		SSW MOV 96B	MCC 16B31	4.5
		SSW MOV 14B	MCC 16B31	14
		SSW MOV 14A	MCC 15B51	14

Table B.1 Flood Zone Cross References (Continued)

Flood Zone	Effective Area (ft^2)	Components	Power Support	Components Vulnerability Height (ft)
12	824	EHV HPCS PUMP RM. FAN B1C	MCC 17BO1	10
		EHV LPCS PUMP RM. FAN B2A	MCC 14B41	10
		HPCS MOV 12C	MCC 17BO1	10
		HPCS MDP 1	AC BUS 17AC	6
		HPCS MOV 15	MCC 17BO1	10
		HPCS MOV 10	MCC 17BO1	7
		HPCS MOV 23	MCC 17BO1	4
14	840	LPCI MOV 3B	MCC 16B31	10
		LPCI-MOV 47B	MCC 16B31	
		LPCI-MOV 48B	MCC 16B31	2
		LPCI PUMP 2B-B	BUS 16AB	8
		LPCI MOV 4B	MCC 16B31	12
		LPCI MOV 64B-B	MCC 16B31	7
		LPCI MOV 66B	MCC 16B31	7
		SPC MOV 24B	MCC 16B31	15
15	978	EHV RCIC PUMP ROOM FAN 6A	MCC 15B11	10
		RCIC AOV 15	IAS	1
		RCIC MOV 13A	DC BUS 11DA	10
		RCIC MOV 19A	DC BUS 11DA	.5
		RCIC MOV 31A	DC BUS 11DA	6
		RCIC MOV 45A	DC BUS 11DA	
		RCIC MOV 46A	DC BUS 11DA	1
		RCIC MOV 10A	DC BUS 11DA	8
		RCIC TDP 1	STEAM	8
		RCIC MOV 32B	DC BUS 11DA	5
16	840	LPCI PUMP 2A-A	AC BUS 15AA	8
		LPCI MOV 4A	MCC 15B31	10
		LPCI MOV 66A	MCC 15B31	2
		SPC MOV 24A-A	MCC 15B31	23
		LPCI MOV 3A	MCC 15B31	10
		LPCI MOV 48A	MCC 15B31	4
		LPCI MOV 64A	MCC 15B31	7
18A	156			
18B	156			
19	525			
24	5474			

Table B.1 Flood Zone Cross References (Continued)

Flood Zone	Effective Area (ft^2)	Components	Power Support	Components Vulnerability Height (ft)
35	1171			
45	18750	FWS AOV 282A	PANEL P531	4
		FWS AOV 282B	PANEL P531	4
		LCC 11BD5	BOP BUS 11HD	.5
		LCC 14BE1	BOP BUS 14AE	.5
		LCC 12BE2	BOP BUS 12HE	.5
		FWS AOV 283A	PANEL P531	5
		FWS AOV 283B	PANEL P531	5
		ESF CST LVL TRANS 54C		3
		ESF LVL TRANS 35A		3
		ESF CST LVL TRANS 54G		3
		ESF RX LVL TRANS 63C		3
		SSW MOV 154	MCC 16B31	2.5
		SSW MOV 155A	MCC 15B31	2.5
		SSW MOV F155B	MCC 16B31	.75
		LCC 11BD1	BOP BUS 11HD	.5
46	614	MCC 15B11	LCC 15BA1	.5
		LCC 15BA3	LCC 15BA3	.5
		LCC 15BA1	BUS 15AA	.5
48	521	LPCS MOV 5A	MCC 15B31	10
		LPCI MOV42C	MCC 16B11	12
49	619	MCC 16B11	LCC 16BB1	.5
		LCC 16BB3	BUS 16AB	.5
		LCC 16BB1	BUS 16AB	.5
		MCC 14B11	LCC 14BE1	.5
53	824	MCC 16B31	LCC 16BB3	.5
54	1336	HPCS MOV 4-C	MCC 17BO1	5
		LPCI MOV 6B	MCC 16B31	5
		LPCI-MOV 27B	MCC 16B31	6
		SDC MOV 53B	MCC 16B31	7
56A	489	RWCU MDP 1A	LCC 11BD5	1
56B	489	RWCU MDP 1B	LCC 12BE2	1

Table B.1 Flood Zone Cross References (Continued)

Flood Zone	Effective Area (ft^2)	Components	Power Support	Components Vulnerability Height (ft)
56C	521	SDC MOV8	MCC 15B31	4
57	1336	EHV LPCI A FAN COOLER 3A LPCI MOV 6A LPCI MOV 27A SDC MOV 53A	MCC 15B11 MCC 15B31 MCC 15B31 MCC 15B31	10 5 6 10
59	824	MCC 15B31	AC BUS 15AA	.5
61	309	DCP BAT. 1A3 DCP BAT-CHAR. 1A4 DCP BAT-CHAR. 1A5	DC BUS 11DA LCC 15BA6 LCC 15BA3	.5 .5 .5
62	309	DCP BAT. 1B3 DCP BAT-CHAR. 1B4 DCP BAT-CHAR. 1B5	DC BUS 11DB LCC 16BB6 LCC 16BB3	.5 .5 .5
63	309	DCP BAT. 1C3 DCP BAT-CHAR. 1C4 DCP BAT-CHAR. 1C5	DC BUS 11DC MCC 17BO1 MCC 13B11	.5 .5 .5
64	309			
65	1334	AC BUS 16AB DC BUS 11DB DGX RELAY 1611 MCC 16B31 LCC 16BB6	- - DC BUS 11DB LCC 16BB3 AC BUS 16AB	.5 .5 .5 .5 .5
66	981	AC BUS 17AC DGX RELAY 1701 DGX RELAY 1704 DGX RELAY 1702 MCC 17B01 MCC 17B11	- DC BUS 11DC DC BUS 11DC DC BUS 11DC AC BUS 17AC AC BUS 17AC	.5 .5 .5 .5 .5 .5
67	1334	AC BUS 15AA DC BUS 11DA DGX RELAY 1903 LCC 15BA6	- - DC BUS 11DB AC BUS 15AA	.5 .5 .5 .5
86	2273	ACP DG13 SSW MOV 18B EHV DG13 RM. COOLER 02	- MCC 16B11 MCC 17BO1	

Table B.1 Flood Zone Cross References (Continued)

Flood Zone	Effective Area (ft^2)	Components	Power Support	Components Vulnerability Height (ft)
87	2273	ACP DG 12 EHV DG 12 RM. COOLER 1-B EHV MOV 1B-B	- LCC 16BB1 PANEL 1B711	
88	2273	BUS 11DC EHV DG 11 RM. COOLER 1-A EHV MOV 1A-A SSW MOV 18A ACP DG 11	- LCC 15BA1 PANEL 1B611 MCC 15B11 -	
90	5521	-	-	-
92	614	MCC 15B41	AC BUS 15AA	.5
93	522	CCW MOV 67	MCC 15B11	12
94	614	MCC 16B21	LCC 16BB2	.5
97	394	SDC MOV 120B SDC MOV 47B	MCC 16B31 MCC 16B31	-
98	840	-	-	-
99	1461	LCC 16BB4	AC BUS 16AB	
100	1461	RWCU MOV 46-N RWCU SOV 234 FWCU SOV 235 RWCU MOV 4A RWCU MOV 39-A RWCU MOV 34A RWCU MOV 54-A RWCU MOV 52-B RCIC MOV 64A RCIC TCV 32B RWCU MOV 35	MCC 11B12 PANEL 872 PANEL 871 MCC 15B11 MCC 15B11 MCC 15B11 MCC 15B31 MCC 16B41 DC BUS 11DA MCC 11B12	
101	18750	CCW MOV-P42-F105 CCW MOV-P42-F205 MCC 11B12 MCC 12B51 MCC 14B12 MCC 12B22	MCC 15B41 MCC 15B41 LCC 11BD1 LCC 12BE5 LCC 14BE1 LCC 12BE2	8 8 5 .5 .5 .5

Table B.1 Flood Zone Cross References (Continued)

Flood Zone	Effective Area (ft^2)	Components	Power Support	Components Vulnerability Height (ft)
102	840	-	-	-
103	494	LPCI MOV 47A	MCC 15B31	5
104	824	LCC 15BA4 LCC 15BA2	AC BUS 15AA AC BUS 15AA	.5 .5
138	494			
140	494	FPCCU MDP 1B FPCCU MDP 1A	LCC 16BB1 LCC 15BA3	1 1
141	18750	IAS AOV 13 IAS BOOSTER COMPRESSOR 2A-A IAS BOOSTER COMPRESSOR 2-B MCC 11B13 LCC 12BE5 IAS AOV 26A IAS AOV 26B	IAS - - LCC 11BD1 BOP BUS 12HE MCC 15B31 IAS 15B31	 - - .5 0.5
142	987			
143	124			
144	124			
148	465	MCC 15B21	LCC 15BA5	.5
150	840			
152	494			
154	494	CIV AOV 35 CIV AOV 36 CIV AOV 37	MCC 16B41 MCC 15B21 MCC 16B41	12 12 14
155	465	-		-
157	465	MCC 16B41	LCC 16BB4	5
195	817	FPCCU MOV 8A FPCCU MOV 8B		4 4
196	428	-		-
199	3671	-		-

Table B.1 Flood Zone Cross References (Continued)

Flood Zone	Effective Area (ft^2)	Components	Power Support	Components Vulnerability Height (ft)
200	3671	FPCCU MOV-28A FPCCU SOV 19 FPCCU SOV 45 FPCCU MOV 29A	MCC 15B11 MCC 15B11	7.5 12 7 6.75
202	3671	-		-
203	3671	-		-
219	3400	-		-
220	260	INSTRUMENT MOTOR GENERATOR		1
221	1470	B21 TRIP UNITS N692 A&E N694 A&E N691 A&E N697 A&E N698 A&E E51 TRIP UNITS N635 A&E		
222	400	-		-
224	9219			
225	4610			
SSW A	936	SSW-PUMP 1A-A SSW-PUMP 2-C MCC 15B51 LCC 15BA5 SSW MOV 1A	AC BUS 15AA AC BUS 17AC LCC 15BA5 AC BUS 15AA MCC 15B51	3 4 .5 .5
SSW B	936	SSW-PUMP 1B-B	AC BUS 16AB	3
FWS A		FWS PUMP 3A FW MDP	- LCC 11BD3	
FWS B		FWS PUMP 3B	-	

Table B.1 Flood Zone Cross References (Continued)

Flood Zone	Effective Area (ft^2)	Components	Power Support	Components Vulnerability Height (ft)
TB-93-1	9084	CONDENSATE BOOSTER PUMP A CONDENSATE BOOSTER PUMP B CONDENSATE BOOSTER PUMP C	BOP BUS 13AD BOP BUS 14AE BOP BUS 14AE	
TB-93-2	9084	-		-
TB-93-3	9084	-		-
TB-93-4	9084	-		-
TB-93-5	9084	-		-
TB-93-6	9084	TBCW PUMP A TBCW PUMP B TBCW PUMP C CONDENSATE PUMP A CONDENSATE PUMP B	BOP BUS 13AD BOP BUS 14AE BOP BUS 14AE	2.0 2.0 2.0 2.0 2.0
TB-113-1	9084	MCC 12B41 LCC 12BE4	LCC 12BE4 BOP BUS 12HE	0.5 0.5
TB-113-2	9084	-		-
TB-113-3	9084	MCC 13B11	LCC 13BD1	0.5
	9084	MCC 13B21	LCC 13BD2	0.5
TB-113-5	9084	MCC 11B21 LCC 12BE1 LCC 11BD2	LCC 11BD2 BOP BUS 12HE BOP BUS 12HE	0.5 0.5 0.5
TB-113-6	9084	MCC 14B22 MCC 12B11 LCC 12BE6 LCC 14BE2 LCC 13BD1	LCC 14BE2 LCC 12BE1 BOP BUS 12HE BOP BUS 14AE BOP BUS 13AD	0.5 0.5 0.5 0.5 0.5
TB-133-1	9084	-		-
TB-133-2	9084	-		-
TB-133-3	9084	MCC 13B12 MCC 14B21	LCC 13BD1 LCC 14BE2	0.5 0.5

Table B.1 Flood Zone Cross References (Continued)

Flood Zone	Effective Area (ft^2)	Components	Power Support	Components Vulnerability Height (ft)
TB-133-4	9084	BOP BUS 13AD BOP BUS 11HD	- -	0.5 0.5
TB-133-5	9084	-		-
TB-133-6	9084	-		-
TB-166-1	9084	-		-
TB-166-2	9084	-		-
TB-166-3	9084	-		-
TB-166-4	9084	-		-
TB-166-5	9084	-		-
TB-166-6	9084	-		-
CWP				
RWB	24467			
WTB-133	7200	SAS COMPRESR. 1A-N SAS COMPRESR. 1B-N IAS COMPRESR. 1-N IAS COMPRESR. 1B LCC 11BD3 IAS AOV 500 IAS AOV 504	BOP BUS 13AD BOP BUS 14AE BOP BUS 14AE AC BUS 16AB BOP BUS 11HD PANEL 16P31	0.5 0.5 0.5 0.5 0.5

Appendix C

Flood Source and Flood Locations

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Contents

Table

Appendix C - Flood Source and Flood Locations

This appendix provides information on the flood source(s) in each of the identified flood zones. Table C.1 presents this information.

Table C.1 Flood Source(s) in Each Flood zone

Flood Zones	Alarm	Source System	Pipe Id.	Flow Rate (GPM)
1	x	LPCS PUMP SUCTION FROM SUPPRESSION POOL	24" HBB-8	7,115
3	x	LPCI PUMP C SUCTION FROM THE SUPPRESSION POOL	24" GBB-62	7450
		ADHRS PUMP SUCTION	12" HBC-519	3600
		PSW SUPPLY TO ADHRS	12" HBC-522	1500
6	x	PSW TO COOLING TOWER DISCHARGE	24" JBD-150	15,000
		SSW LOOP A SUPPLY	20" HBC-79	-
		SSW LOOP B SUPPLY	20" HBC-79	12,000
		PSW SUPPLY	30" JBD-105	15,000
		PSW SUPPLY	36" HBC-223	15,000
		CCW PUMP DISCHARGE	14" JBD-327	3974
		CRD PIPING	6" HBD-382	240
12	x	HPCS SUCTION FROM CST	24" HBB-21	7,115
14	x	RHR PUMP B DISCHARGE PIPING	18" GBB-74	4500
15	x	RCIC PUMP SUCTION	6" HBB-49	825
16	x	RHR PUMP A DISCHARGE	18" GBB-18	-
18A		EQUIP/FLOOR DRAIN TANK	P45-A001	*5000 GAL
18B		FLOOR DRAIN TRANSFER TANK	P45-A002	*5000 GAL

Table C.1 Flood Source(s) in Each Flood Zone (Continued)

Flood Zones	Alarm	Source System	Pipe Id.	Flow Rate (GPM)
19		EQUIPMENT DRAIN TRANSFER PUMP DISCHARGE PIPING	6" HBD-771	100
24	x	-	-	-
35		-	-	
45	x	REFUELING STORAGE TANK PIPING	12" HBC-203	-
		CONDENSATE PIPING	12" HBD-30	-
		FIRE PROTECTION SYSTEM	10" JBD-202	4530
46		ESF ROOM COOLER	T46-B002A (2" HBC-93)	40
48	-	-	-	-
49		ESF ROOM COOLER	T46-B002B (2" HBC-93)	40
53		SPRAY INITIATOR: ESF ROOM COOLER	T46-B001B (1.5" HBC-93)	15
54		FROM RHR B HEAT EXCHANGER	20" GBB-78	4500
56A	x	RWCU PUMP OUTLET	4" DBZ-2	180
56B	x	RWCU PUMP OUTLET	4" DBZ-2	180
56C		SDC SUCTION LINE	20" GBB-31	4500
57		RHR PUMP A HEAT EXCHANGER	18" GBB-19	4500
59		ESF ROOM COOLER	T46-B001A	15
61		-	-	-
62		-	-	-
63		-	-	-
64		-		
65		FIRE WATER PIPING	10" JBD-253	4530
66		-		
67		-		

Table C.1 Flood Source(s) in Each Flood Zone (Continued)

Flood Zones	Alarm	Source System	Pipe Id.	Flow Rate (GPM)
86	x	SSW LOOP B SUPPLY TO DIESEL JACKET COOLER	10" HBC-86	2400
87	x	SSW LOOP A SUPPLY TO DIESEL JACKET COOLER	10" HBC-87	2400
88	x	SSW LOOP SUPPLY TO DIESEL JACKET COOLER	6" HBC-84	2400
90		PSW TO CONTROL RM A/C PIPING	6" JBD-162	161
92		ESF ROOM COOLER	T46-B005A	15
93	-	CCW TO CONTAINMENT OUTBOARD ISOLATION PIPING	10" JBD-309	1334
94		ESF ROOM COOLER	T46-B005B	15
97		RHR PUMP B DISCHARGE PIPING	18" GBB-74	4500
98		-	-	-
99		ESF ROOM COOLER	T46-B003B	40
100		FEEDWATER PIPING	24" DBB-73	
		RWCU PIPING INLET TO RWCU PUMPS	]6" DBA-9	360
101	x	SPCU FROM RHR PUMP C DISCHARGE	12" GBD-166	625
		PCW TO TURBINE BLDG	8" JBD-648	721
		PCW PIPE	10" JBD-644	1332
102		-	-	-
103		RHR PUMP A DISCHARGE	18" GBB-18	4,500
104		ESF ROOM COOLER	T46-B003A	40
138		1000 GAL RECEIVING TANK		~10,000 GAL
140	x	FUEL POOL DRAIN TANK		~5,000 GAL
141		FPCCU	14" HBC-208	1100

Table C.1 Flood Source(s) in Each Flood Zone (Continued)

Flood Zones	Alarm	Source System	Pipe Id.	Flow Rate (GPM)
142	x	FPCCU CASK STORAGE POOL DRAIN VALVE	G41-F033	2500
143		FPCCU PUMP OUTLET TO FPHX	8" HBC-19	1100
144		FPCCU PUMP OUTLET TO FPHX	8" HBC-19	1100
148		ESF ROOM COOLER	T46- BOO4A	15
150		-	-	-
152		-	-	-
154		-	-	-
155		-	-	-
157		SPRAY INITIATOR: ESF ROOM COOLER	T46-B004B	15
195		FUEL POOL FILTER/DEMIN TO FUEL POOL DISTRIBUTION HEADER	8" HBZ-1	1100
196		INLET TO FUEL POOL DRAIN TANK	10" HBC-13	1100
199		FPCCU PIPING FROM RHR TO FUEL POOL	14" HBC-208	2200
200		-	-	-
202		-	-	-
203		-		
		-	-	-
219	x	-	-	-
220	x	-	-	-
221		-	-	-
222		FWS PIPING	6" JBD-69	4530
224		-	-	-
225		-	-	-

Table C.1 Flood Source(s) in Each Flood Zone (Continued)

Flood Zones	Alarm	Source System	Pipe Id.	Flow Rate (GPM)
SSW A		SSW PUMP A DISCHARGE	24" HBC-79	-
SSW B		SSW PUMP B DISCHARGE	24" HBC-79	12,000
FWS A	x	FWS PIPING	10 JBD" 181	4530
FWS B	x	FWS PIPING	10 JBD" 181	4530
TB-93-1	x	TBCW	10" JBD-583	18,888
TB-93-2	x	TBCW	24" JBD-429	18,888
TB-93-3	x	CIRCULATING WATER TBCW	30 JBD-77 24" JBD-442	- 18,888
TB-93-4	x	PSW	24" JBD-77	15,000
TB-93-5	x	PSW TBCW	24" JBD-77 10" JBD-489	15,000 18,888
TB-93-6	x	CIRCULATING WATER PSW TBCW	30" JBD-77 24" JBD-77 24" JBD-442	- 15,000 18,888
TB-113-1	x	FEEDWATER	14" FBD-1	-
TB-113-2	x	FEEDWATER	24" DBD-21	-
TB-113-3	x	FEEDWATER	24" DBD-21	-
TB-113-4	x	FIREWATER	10" JBD-223	4530
TB-113-5	x	FIREWATER	10" JBD-223	4530
TB-113-6	x	FIREWATER	10 JBD-223	4530
TB-133-1	x	-	-	-
TB-133-2	x	-	-	-
TB-133-3	x	FEEDWATER	24" DBD-14	-
TB-133-4	x	PSW	8" JBD-136	500
TB-133-5	x	-	-	-
TB-113-6	x	-	-	-
TB-166-1	x	-	-	-
TB-166-2	x	-	-	-

Table C.1 Flood Source(s) in Each Flood Zone (Continued)

Flood Zones	Alarm	Source System	Pipe Id.	Flow Rate (GPM)
TB-166-3	x	-	-	-
TB-166-4	x	-	-	-
TB-166-5	x	-	-	-
TB-166-6	x	-	-	-
RWB	*x	-	-	-
CWP	x	CIRCULATING WATER PIPING	-	-
WTB-133	x	TBCW TO SAS AND IAS COMPRESSORS	4" JBD-466	280

*Flood volume in gallons (GAL)

Appendix D

Calculations

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Contents

Appendix D Calculations

D.1 Calculation #1

D.1.1. HEP for Failing to Close a Single Flood Door

There are actually two errors of omission possible here and either one will lead to failure. They are:

1. Failure to place someone by the door (or at least make someone responsible) given the Technical Specifications (TS) require it [D1].

2. Failure to close the door when the task in the potential flood area is completed.

For the first failure, it is assumed that there is not a written check-off provision and that the operator has a "short list" of items (< 10) to remember regarding the written TS requirements for posting a "door watch" when entering and leaving a flood area. From NUREG/CR-1278 [D2], Table 20-7, the HEP is given as 0.003 with an EF of 3.

For the second failure, the same assumptions are made (no written check-off provision and a short list of items), which again gives an HEP of 0.003 with an EF of 3 from Table 20-7. However, since the door watch will be accompanied by someone else that will also be aware of the need to ensure that the flood door is closed, credit for a check without written materials can also be given. Per Table 20-22 in Reference D2, the recovery HEP is 0.2 with an EF of 5. Thus, the HEP for the second failure is given by:

$$HEP2 = 0.003 \times 0.2 = 0.0006$$

The total HEP is given by:

$$\begin{aligned} HEPT &= HEP1 + HEP2 \\ &= 0.003 + 0.0006 \\ &= 0.0036 \end{aligned}$$

The EF can conservatively be assumed to be 5.

The above HEPT is a conservative estimate because functionally it assumes that if an operator fails to assign a door watch (HEP = 0.003), the door will not be closed. However, even if a door watch is assigned, there is still a 0.0006 probability of the door not getting closed.

D.1.2. Failure to Close Adjacent Flood Doors (Necessary to cause an initiating event).

Since two flood doors would have to be left open to lead to a flood caused initiating event, the potential for two doors being left open at the same time must be addressed. During shutdown, it is possible that a single operator or crew, during a single shift, would be responsible for assigning individuals to perform the "door watch" tasks to be performed in two or more adjacent rooms (i.e., rooms where a flood in one room could affect performance of systems in the others). Thus, the potential for a "common cause" failure in assigning the door watches per TS is possible. When there is little or no separation in time and the same individuals are handling task assignments, what happens in one case is more likely to be related to what happens in the next case. That is, a dependency may exist and an error in one instance may be related to an error in another. For the present analysis, it was conservatively assumed that complete dependence existed in the assignment of door watches for work in adjacent rooms with flood potential. Thus, it was assumed that a failure to assign a door watch for one room would also lead to a failure to assign a door watch for an adjacent room. With complete dependence, the HEP for the two events would be equal to the HEP for failing to assign a door watch for a single room.

D.2 Calculation #2

Evaluation of the Probability of Pipe Rupture During ECCS System Flow Test.

Surveillance flow tests are performed on the Emergency Core Cooling System (ECCS) every 92 days in accordance with to procedures OC-OP-1E22-Q-005 REV 22 for HPCS [D3] and OC-OP-1E12-0024 REV 23 for LPCI [D4]. The plant estimates that the tests can be performed within four hours. Therefore, the total time that the ECCS system is actively tested is sixteen hours per year. Since the fraction of time spent in POS 5 is 0.031 then the fraction of time spent performing surveillance tests on the ECCS while in POS 5 is equal to $(16/(0.031*24*365)) = 0.0589$.

D.3 Calculation #3

D.3.1. LPCI and LPCS inventory release from the Suppression Pool

The LPCS and LPCI pumps take suction from the suppression pool through suction strainers.

Height of strainer from pool floor for LPCS pump = 10 ft

Height of strainer from pool floor for LPCI pump = 15 ft. Assume that the suppression pool water level is at the high water level, the maximum depth of the suppression pool is 19 ft.

Area of the suppression pool is 7353 sqft.

Given a full guillotine break in the pump suction line, the water level in the suppression pool would fall until the pool level was below the pump suction strainers. Since it is assumed that in POS 5 Suppression Pool Makeup System (SPMU) is isolated from automatic initiation, the SPMU would not dump additional water into the suppression pool.

This implies that for a break in the LPCS system, the volume of water released would be 9 ft * 7353 sqft = 66,177 cuft.

For a break in the LPCI system, the volume of water released would be 4 ft * 7353 sqft = 29412 cuft

D.3.2 HPCS inventory release from the Condensate Storage Tank (CST).

In the standby position HPCS is usually lined up to the CST. Assuming that the total inventory of the CST (170,000 GAL) is released given a pipe guillotine rupture, the total volume = 170,000 gal*(231 cubic inches/gal) * (1 cuft/1728 cubic inches) = 22,725 cuft

References - Appendix D

D1. Grand Gulf Technical Specifications

D2. Swain, A.D., Guttmann, H.E., "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications," NUREG/CR-1278, August 1983.

D3. Grand Gulf Surveillance Test Procedure OC-OP-1E22-Q-005 REV 22.

D4. Grand Gulf Surveillance Test Procedure OC-OP-1E12-0024 REV 23.

Appendix E

Propagation Scenario Development

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Table

Appendix E - Propagation Scenario Development

This appendix describes in detail all the propagation scenarios developed by the processes outlined in Section 2.2. For each flood zone, the flood source, propagation pathways, equipment failure, and the consequences of the flood are described. A convention ' A > B ' was used to denote flood propagation from a specific flood zone A to another flood zone B. The estimation of potential flood frequencies are included in Table E.1. Note that the terms "flood zones" and "flood locations" are used interchangeably. Numerical designations for flood zones are given in Appendix A.

E.1 Flood Zone 1 : LPCS Pump Room

E.1.1 LPCS Pump Suction Line

Source

Random pipe rupture of LPCS pump suction line (24" HBB-8) from the suppression pool during system flow test. The resulting flow rate would be 7115 GPM [E1].

Propagation

1 > 1 with the water tight door DR-1A108 closed.

1 > through water tight door DR-1A108 to Auxiliary building corridor at elevation 93' and all adjacent corridor flood zones assuming that, in the worst case, all water tight doors were open.

Low Pressure Core Spray (LPCS) pump room has a water tight door and is equipped with its own sump and sump pump [E2]. In addition, the room is required by technical specifications to be manually monitored if open [E3].

Any leaks in the LPCS pump room would be identified by a high water level sump alarm in the control room.

If the water tight door is closed at the time of the flood then water would fill the LPCS pump room to a depth of 27.5 feet in 33 minutes. Since this pipe rupture event would occur during a flow test, when various system flow parameters would normally be monitored from the control room, 33 minutes should be sufficient time to detect and isolate the flood by closing LPCS MOV 1.

Given that the LPCS pump room watertight door DR-1A108 was left open and unattended, a flood occurred, and the flood was not detected by the sump alarm, then water would flow from the LPCS room to the auxiliary building corridor and corridor rooms.

Assuming that, in the worst case, the watertight doors on the HPCS pump room and the RHR C room were open, then water would accumulate to a depth of 1.5 feet in the auxiliary building corridor and corridor rooms.

Results

A review of Appendix B indicated that, as a result of the first scenario, LPCS components and SPMU level sensors 3A and 3C would be degraded. However, the scenario would not cause an initiating event since the failure of LPCS would not challenge the integrity of the reactor core.

In the second (worst case) scenario, LPCS components, Alternate Decay Heat Removal System (ADHRS) pumps 5A and 5B, Component Cooling Water (CCW) pumps A, B, and C, and Control Rod Drive (CRD) pumps A and B would fail. If the plant was operating on ADHRS at the time of the flood then the loss of the system constitutes an initiating event.

The performance of the Reactor Water Cleanup System (RWCU) pumps and heat exchangers, the Fuel Pool Cooling and Cleanup System (FPCCU) heat exchangers, and the Reactor Recirculation System (RRS) pumps would also be degraded due to a loss of CCW. Failure of the RRS pumps would constitute an initiating event as normal reactor leakage could degrade natural circulation which in turn would degrade the performance of shutdown decay heat removal.

The frequency of the worst case scenario was estimated from the product of the frequency of the pipe system break (conservatively assumed to be on the order 1E-4 per year), the probability that the water tight doors were left open (3.6E-3 from Appendix D), the fraction of time spent in testing (5.89E-2 Appendix D), and the fraction of time spent in the POS 5 (3.1E-2).

This frequency, calculated to be 6.0E-10 per year, was below the cut-off frequency of 1.0E-8 per year. Therefore, this flood scenario was screened out.

Source:

Random pipe rupture of LPCS pump suction line (24" HBB-8) from the suppression pool. The rupture was estimated to release 66,177 cubic feet of water when the

system was on standby (Appendix D).

Propagation

1 > 1 with the water tight door DR-1A108 closed.

1 > through water tight door DR-1A108 to Auxiliary building corridor at elevation 93' and all adjacent corridor flood zones assuming that, in the worst case, all water tight doors were open.

If the water tight door was closed at the time of the flood, then water would fill the room to a depth of 27.5 feet and come to equilibrium as the pressure in the LPCS pump room balances the pressure head of the water in the suppression pool.

Given that the LPCS pump room watertight door DR-1A108 was left open and unattended, a flood occurred, and the flood was not detected by the sump alarm, then water would flow from the LPCS room to the auxiliary building corridor and corridor rooms.

Assuming that, in the worst case, the watertight doors on the HPCS pump room and the RHR C room were open, water would accumulate to a depth of 3.5 feet in the auxiliary building corridor and corridor rooms.

Result

A review of Appendix B indicated that, as a result of the first scenario, LPCS components and SPMU level sensors 3A and 3C would be degraded. However, the scenario would not cause an initiating event since the failure of LPCS would not challenge the integrity of the reactor core.

In the second scenario, LPCS components, High Pressure Core Spray (HPCS) Motor Operated Valves (MOVs) 1 and 11, ADHRS pumps 5A and 5B, CCW pumps A, B, and C, and CRD pumps A and B would fail.

If the plant was operating on ADHRS at the time of the flood, then the loss of ADHRS would constitute an initiating event.

The RWCU pumps and heat exchangers, the FPCCU heat exchangers, and the RRS pumps would be degraded due to a loss of CCW. Failure of the RRS pumps would constitute an initiating event as normal reactor leakage would degrade natural circulation thus degrading the performance of shutdown decay heat removal.

The frequency of the worst case scenario was estimated as the product of the frequency of the pipe system break (conservatively assumed to be on the order 1E-4 per year), the probability that the water tight doors are left open (3.6E-3 Appendix D), and the fraction of time spent in the POS 5 (3.1E-2).

This frequency, calculated to be 1.1E-8/yr, was too low to be considered. Since other systems would still be available for mitigation, this flood scenario was screened out.

E.2 Flood zone 3 : RHR C Pump Room

E.2.1 LPCI C Pump Suction Line

Source

Random pipe rupture of LPCI C pump suction line (24" GBB-62) from the suppression pool during system flow test. The resulting flow rate being 7450 GPM.

Propagation

3 > 3 with the water tight door DR-1A109 closed.

3 > Auxiliary building corridor at the 93' elevation and adjacent corridor flood zones assuming that, in the worst case, all water tight doors were open.

Low Pressure Coolant Injection System-C (LPCI-C) pump room has a water tight door and is equipped with its own sump and sump pump. In addition, the room is required by technical specifications to be manually monitored if open. If the water tight door was closed at the time of the flood then water would fill the room to a depth of 27.5 feet in 32 minutes. Since this pipe rupture event occurred during a flow test, when various system flow parameters would normally monitored, 32 minutes should be sufficient time to detect and isolate the flood by closing LPCI MOV 4C.

Given that LPCI C pump watertight door DR-1A109 was left open and unattended, a flood occurred, and the flood was not detected by the sump alarm, then water would flow from the LPCI C room to the auxiliary building corridor and corridor rooms. Assuming that, in the worst case, the watertight doors on the HPCS pump room and the LPCS rooms were also open, then water would accumulate to a depth of 3.2 feet in the auxiliary building corridor and corridor rooms.

Result

A review of Appendix B indicated that, as a result of the first scenario, RHR pump C and ADHRS components would be degraded. However, the plant would not be operating ADHRS and testing RHR pump C flow at the same time because both ADHRS and RHR pump C use the same discharge line. Therefore, loss of ADHRS at the time of the flood would not constitute an initiating event. Therefore, this flood scenario was screened out.

In the second scenario, LPCS components, ADHRS pumps 5A and 5B, RHR pump C, CCW pumps A, B, and C, and CRD pumps A and B would fail. The Reactor Water Cleanup System (RWCU) pumps and heat exchangers, the Fuel Pool Cooling and Cleanup System (FPCCU) heat exchangers, and the RRS pumps would be degraded due to a loss of CCW. Failure of the RRS pumps would constitute an initiating event as normal reactor leakage would degrade natural circulation and degrade the performance of shutdown decay heat removal. Failure of CRD and RWCU would also cause initiating events.

The frequency of the worst case scenario was estimated as the product of the frequency of the pipe system break (1E-4 per year), the probability that the water tight doors are left open (3.6E-3 from appendix D), the fraction of time spent in testing (5.89E-2 Appendix D), and the fraction of time spent in the POS 5 (3.1E-2).

This frequency, calculated to be 6.0E-10 per year, was too low to be considered. Therefore, this flood scenario was screened out.

E.2.2 LPCI C Pump Suction Line

Source

Random pipe rupture of LPCI C pump suction line (24" GBB-62) from the suppression pool. This resulted in a discharge of 29,412 cubic feet of water when the system was on standby (Appendix D).

Propagation

3 > 3 with the water tight door DR-1A109 closed

3 > Auxiliary building corridor at the 93' elevation and adjacent corridor flood zones assuming that in the worst case all water tight doors were open.

Low Pressure Coolant Injection System-C (LPCI-C) pump room has a water tight door with its own sump and sump pump. In addition, the room is required by technical specifications to be manually monitored if open. If the water tight door was closed at the time of the flood then water would fill the room to a depth of 25 feet. As a result of this flood, LPCI pump C and ADHRS pumps would fail.

Given that LPCI C pump watertight door DR-1A109 was left open and unattended, a flood occurred, and the flood was not detected by the sump alarm, then water would flow from the LPCI C room to the auxiliary building corridor and corridor rooms.

Assuming that, in the worst case, the watertight doors on the HPCS pump room and the LPCS rooms were also open, then water would accumulate to a depth of 3.5 feet in the auxiliary building corridor and adjacent corridor rooms.

Result

A review of Appendix B indicated that, in the first scenario, the water would fail RHR pump C and ADHRS components. If the plant was operating ADHRS at the time of the flood, the loss of ADHRS would constitute an initiating event. Therefore, this flood scenario was not screened out.

In the second scenario, LPCS components, ADHRS pumps 5A and 5B, RHR pump C, CCW pumps A, B, and C, and CRD pumps A an B would fail.

If the plant was operating on ADHRS at the time of the flood, then the loss of ADHRS would constitute an initiating event.

The performance of RWCU pumps and heat exchangers, the FPCCU heat exchangers, and the RRS pumps would be degraded due to a loss of CCW. Failure of RRS would constitute an initiating event as normal reactor leakage would degrade natural circulation and thus degrade the performance of shutdown decay heat removal.

The frequency of the worst case scenario was estimated as the product of the frequency of the pipe system break (1E-4 per year), the probability that the water tight doors are left open (3.6E-3 Appendix D), and the fraction of time spent in the POS 5 (3.1E-2).

This frequency, calculated to be 1.1E-8/yr, was too low

to be considered. Since other systems would still be available for mitigation, this flood scenario was screened out.

E.2.3 ADHRS Pump Suction Line

Source

Random pipe rupture of ADHRS pump suction line (12" HBC-519) with a flow rate of 3600 GPM.

Propagation

3 > 3 with the water tight door DR-1A109 closed.

3 > Auxiliary building corridor at the 93' elevation and adjacent corridor flood zones assuming that in the worst case all water tight doors were open.

LPCI-C pump room has a water tight door and is equipped with its own sump and sump pump. In addition, the room is required by technical specifications to be manually monitored if open. During POS 5, the water level in the reactor can be raised to the steamlines (648").

Given a break in the ADHRS line in location 3, the water level in the reactor vessel would fall to level three (544.4") at which time the SDC suction line would be isolated by automatic closing of SDC MOVs 8 and 9. This would result in 22,191 gallons of water being discharged in flood zone 3.

If the water tight door was closed at the time of the flood then water would accumulate in flood zone 3 to a depth of 2.6 feet.

Given that LPCI C pump room watertight door DR-1A109 was left open and unattended, a flood occurred, and the flood was not detected by the sump alarm, water would flow from the LPCI C room to the auxiliary building corridor and corridor rooms.

Assuming that, in the worst case, the watertight doors on the HPCS pump room and the LPCS rooms were also open, then water would accumulate to a depth of approximately 2 inches in the auxiliary building corridor and corridor rooms.

Result

A review of Appendix B indicated that, as a result of the first scenario, RHR pump C and ADHRS components would be degraded.

Since the plant would be operating on ADHRS at the time of the flood, the loss of ADHRS would constitute an initiating event. Therefore, this flood scenario was not screened out.

In the second scenario, LPCS components, ADHRS pumps 5A and 5B, and RHR pump C would fail. The frequency of the worst case scenario was estimated as the product of the frequency of the pipe system break (1E-4 per year), the probability that the water tight doors were left open (3.6E-3 from appendix D), the fraction of time spent in testing (5.89E-2 Appendix D), and the fraction of time spent in the POS 5 (3.1E-2).

This frequency, calculated to be 6.0E-10 per year, was too low to be considered. Therefore, this flood scenario was screened out.

E.2.4 PSW Supply to ADHRS

Source

Random pipe rupture of PSW supply to ADHRS (12" HBC-522) with a flow rate of 1500 GPM.

Propagation

3 > 3 with the water tight door DR-1A109 closed.

3 > Auxiliary building corridor at the 93' elevation and adjacent corridor flood zones assuming that, in the worst case, all water tight doors were open.

LPCI-C pump room has a water tight door and is equipped with its own sump and sump pump. In addition, the room is required by technical specifications to be manually monitored if open. If the water tight door was closed at the time of the flood then water would fill the room to a depth of 10.4 feet in one hour.

Given that LPCI C pump watertight door DR-1A109 was left open and unattended, a flood occurred, and the flood was not detected by the sump alarm, then water would flow from the LPCI C room to the auxiliary building corridor and corridor rooms. Assuming that, in the worst case, the watertight doors on the HPCS pump room and the LPCS rooms were also open, then water would accumulate to a depth of 1.5 feet in the auxiliary building corridor and corridor rooms.

Result

A review of Appendix B indicated that, as a result of the first scenario, RHR pump C and ADHRS components would be degraded. PSW would also fail. Since the plant would be operating on ADHRS at the time of the flood, the loss of ADHRS would constitute an initiating event. Therefore, this flood scenario was not screened out.

In the second scenario, LPCS components, ADHRS pumps 5A and 5B, RHR pump C, CCW pumps A, B, and C, and CRD pumps A and B would fail. The Reactor Water Cleanup System (RWCU) pumps and heat exchangers, the Fuel Pool Cooling and Cleanup System (FPCCU) heat exchangers, and the RRS pumps would be degraded due to a loss of CCW.

Failure of the RRS pumps would constitute an initiating event as normal reactor leakage would degrade natural circulation and degrade the performance of shutdown decay heat removal.

Failure of CRD and RWCU would also cause initiating events.

The frequency of the worst case scenario was estimated as the product of the frequency of the pipe system break (1E-4 per year), the probability that the water tight doors are left open (3.6E-3 from appendix D), the fraction of time spent in testing (5.89E-2 Appendix D), and the fraction of time spent in the POS 5 (3.1E-2).

This frequency, calculated to be 6.0E-10 per year, was too low to be considered. Therefore, this flood scenario was screened out.

E.3 Flood zone 6 : Auxiliary Building Corridor at the 93' Elevation.

E.3.1 Plant Service Water Pipe Segment

Source

A rupture in the Plant Service Water (PSW) pipe segment 24" JBD-150 located in the South West quadrant of the auxiliary building was conservatively estimated to release water at a rate of 15,000 GPM.

Propagation

6 > Auxiliary building corridor and adjacent corridor flood zones (18A through door DR 1A110, 18B through DR 1A111, and 19 through DR 1A112) at the 93' elevation.

The water would spray equipment in the South West quadrant then propagate and flood all the adjacent corridor flood zones to a depth of approximately 6.4 feet.

Results

A review of Appendix B indicated that the flood at the south wall of the auxiliary building would directly fail the Component Cooling Water (CCW) pumps A, B, and C and the PSW system. The flood would then propagate to the rest of the auxiliary building where it would fail CRD pumps A and B and Air Operated Valve (AOV) 1A, SSW MOVs 94B and 96B as they were, HPCS MOVs 1 and 11 in their standby positions, and PSW Solenoid Operated Valves (SOVs) 120, 121, 122 and 123.

Loss of CRD, PSW, and CCW would constitute an initiating event. Consequently, this scenario was not screened out of the analysis.

E.3.2 CCW Pipe Segment

Source

A rupture in the CCW pipe segment 14" JBD-327 located at the South West quadrant of the auxiliary building would discharge water at a rate of 3974 GPM.

Propagation

6 > Auxiliary building corridor and adjacent corridor flood zones (18A through door DR 1A110, 18B through DR 1A111, and 19 through DR 1A112) at the 93' elevation.

The water would spray equipment in the South West quadrant of the auxiliary building then flood all the adjacent corridor flood zones to a depth of approximately 1.7 feet in one hour. In reality, because the CCW is a closed system and the makeup from the surge tank is only 550 gallons, the CCW pumps would loose Net Positive Suction Head (NPSH) and fail in less than an hour.

Results

A review of Appendix B indicated that the flood at the south wall of the auxiliary building would directly fail the CCW pumps A, B, and C. The flood would then propagate and fail CRD pumps A and B.

Loss of CCW and CRD would constitute an initiating event. Consequently, this scenario was not screened out of the analysis.

E.3.3 Standby Service Water Pipe Segment

Source

A rupture in the Standby Service Water (SSW) pipe segment 20" HBC-79 located at the southwest quadrant wall of the auxiliary building.

Propagation

Since SSW loop A was assumed to be out for maintenance in POS 5, with isolation from the SSW radial well source, the water remaining in the SSW pipe would drain negligibly into the corridor [E3].

Results

This source was not considered a potential threat to the integrity of the reactor core so it was screened out.

E.3.4 Standby Service Water Pipe Segment

Source

A rupture in the Standby Service Water (SSW) pipe segment 20" HBC-79 located at the southeast quadrant wall of the auxiliary building.

Propagation

Since SSW loop A was assumed to be out for maintenance in POS 5, with isolation from the SSW radial well source, the water remaining in the SSW pipe would drain negligibly into the area [E3].

Results

This source was not considered a potential threat to the integrity of the reactor core so it was screened out.

E.3.5 PSW Pipe Segment

Source

A rupture in the PSW pipe segment 24" JBD-150 located at the south east quadrant of the auxiliary building was conservatively assumed to release water at a rate of 15,000 GPM.

Propagation

6 > Auxiliary building corridor and adjacent corridor flood zones (18A through door DR 1A110, 18B through DR 1A111, and 19 through DR 1A112) at the 93' elevation.

The water would spray equipment in the southeast quadrant wall area then flood all the adjacent corridor flood zones to a depth of approximately 6.4 feet.

Results

A review of Appendix B indicated that the flood at the southeast quadrant of the auxiliary building would directly fail the PSW SOVs 116, 117, the PSW system, and SSW MOVs 14A and 68A in the position they were. The flood would then propagate to the rest of the auxiliary building where it would fail SSW MOVs 94B and 96B, CRD pumps A and B and AOV 1A, HPCS MOVs 1 and 11 in their standby state, CCW pumps A, B, and C, and PSW SOVs 120, 121, 122 and 123. The loss of CRD, PSW, CCW loop A would constitute an initiating event. Consequently, this scenario was not screened out of the analysis.

E.3.6 SSW Loop B Pipe

Source

A rupture in the SSW loop B pipe segment 20" HBC-79 located at the North West wall of the auxiliary building was assumed to release water at a rate of 12,000 GPM.

Propagation

6 > Auxiliary building corridor and adjacent corridor flood zones (18A through door DR 1A110, 18B through DR 1A111, and 19 through DR 1A112) at the 93' elevation.

The flood initiator would spray and fail all equipment at the northwest quadrant of the auxiliary building then flood the adjacent corridor flood zones to a depth of approximately 5.1 feet in one hour.

Results

A review of Appendix B indicated that the flood at the northwest quadrant of the auxiliary building would directly fail the SSW Loop B, CCW MOVs 42 and 54, CRD pumps A and B, HPCS MOVs 1 and 11 in their standby positions, and PSW S0Vs 120 and 121. The flood would then propagate to the rest of the auxiliary building where it would fail PSW SOVs 122 and 123, SSW MOVs 94B and 68B, CCW pumps A, B, and C and CRD AOV 1A. Loss of CRD, PSW, CCW, and SSW loop B would constitute an initiating event. Consequently, this scenario was not screened out of the analysis.

E.3.7 CCW Pipe Segment

Source

A rupture of the CCW pipe segment 14" JBD-327 located at the North West quadrant of the auxiliary building would discharge water at a rate of 3974 GPM.

Propagation

6 > Auxiliary building corridor and adjacent corridor flood zones (18A through door DR 1A110, 18B through DR 1A111, and 19 through DR 1A112) at the 93' elevation.

The water would spray equipment in the northwest quadrant then flood all the adjacent corridor flood zones to a depth of approximately 1.7 feet in one hour. In reality, because the CCW is a closed system and the makeup from the surge tank is only 550 gallons, the CCW pumps would loose NPSH and fail in less than an hour.

Results

A review of Appendices B and C indicated that the flood at the northwest quadrant of the auxiliary building would directly fail CRD pumps A and B, CCW MOVs 42 and 54, HPCS MOVs 1 and 11 in their standby positions, and PSW S0Vs 120 and 121. Loss of CCW, PSW, and CRD would constitute an initiating event. Consequently, this scenario was not screened out of the analysis.

E.3.8 CRD Pipe

Source

A rupture of the CRD pipe segment 6" HBD-382 located at the northwest quadrant of the auxiliary building released water at a rate of 240 GPM.

Propagation

6 > Auxiliary building corridor and adjacent corridor flood zones (18A through door DR 1A110, 18B through DR 1A111, and 19 through DR 1A112) at the 93' elevation.

The water would spray equipment in the northwest quadrant of the auxiliary building then flood all the adjacent corridor flood zones to a depth of less than 2 inches in one hour.

Results

A review of Appendix B indicated that the flood at the northwest quadrant of the auxiliary building would directly fail CRD, CCW MOVs 42 and 54, HPCS MOVs 1 and 11 in their standby positions, and PSW SOVs 120 and 121. Loss of CRD and PSW would constitute an initiating event. Consequently, this scenario was not screened out of the analysis.

E.3.9 Standby Service Water Pipe Segment

Source

Flood from the Standby Service Water (SSW) pipe segment 20" HBC-79 due to random pipe system failure at the North East corner of the auxiliary building. The flow rate was conservatively assumed to be the system flow rate of 12,000 GPM.

Propagation

6 > Auxiliary building corridor and adjacent corridor flood zones (18A through door DR 1A110, 18B through DR 1A111, and 19 through DR 1A112) at the 93' elevation.

The water would spray equipment in the North East corner of the auxiliary building then flood the adjacent corridor flood zones to a depth of approximately 5.1 feet within one hour.

Results

A review of Appendix B indicated that the flood at the North East corner of the auxiliary building would directly degrade SSW loop B flow, SSW-B Inlet to LPCI-B (SSW

MOVs 94B and 96B) and SSW-Xtie to LPCI (SSW MOVs 14B and 68B) in whatever state they were, HPCS MOVs 1 and 11 in their standby state, and PSW SOVs 122 and 123.

The flood would then propagate to the rest of the auxiliary building where it would fail CRD pumps A and B, CRD AOV 1A, CCW pumps A, B, and C, and PSW MOVs 120 and 121. Loss of CRD, PSW, CCW, and SSW loop B would constitute an initiating event. Consequently, this scenario was not screened out of the analysis.

E.3.10 Plant Service Water Pipe

Source

Flood from Plant Service Water (PSW) pipe segment 30" JBD-105 due to pipe failure at the North East corner of the auxiliary building. The flow rate was conservatively assumed to be the system flow rate of 15,000 GPM.

Propagation

6 > Auxiliary building corridor and adjacent corridor flood zones (18A through door DR 1A110, 18B through DR 1A111, and 19 through DR 1A112) at the 93' elevation.

The water would spray equipment in the North East corner of the auxiliary building then flood all corridor areas and adjacent locations to a depth of approximately 6.4 feet.

Results

A review of Appendix B indicated that the flood at the North East corner of the auxiliary building would directly degrade PSW flow, SSW-B Inlet to LPCI-B (SSW MOVs 14B and 68B) and SSW-Xtie to LPCI (SSW MOVs 94B and 96B) in whatever state they were, HPCS MOVs 1 and 11 in their standby states, and PSW SOVs 122 and 123. The flood would then propagate to the rest of the auxiliary building where it would fail CRD pumps A and B and AOV 1A, CCW pumps A, B, and C, and PSW SOVs 120 and 121.

Loss of CRD, PSW, CCW, and SSW loop B would constitute an initiating event. Consequently, this scenario was not screened out of the analysis.

E.3.11 PSW Pipe Segment

Source

PSW pipe segment 36" HBC-223 at the northwest corner of the auxiliary building with a flow rate of 15,000 GPM.

Propagation

6 > Auxiliary building corridor and adjacent corridor flood zones (18A through door DR 1A110, 18B through DR 1A111, and 19 through DR 1A112) at the 93' elevation.

Water would spray equipment in the northwest corner then flood corridor areas and adjacent flood zones to a depth of approximately 6.4 feet.

Results

A review of Appendix B indicated that the flood at the northwest corner of the auxiliary building would directly fail the CRD pumps A and B and AOV 1A , CCW MOVs 42 and 54, HPCS MOVs 1 and 11 in their standby states, and PSW SOVs 120 and 121. The flood would then propagate to the rest of the auxiliary building where it would fail CCW pumps A, B, and C, PSW MOVs 122 and 123, SSW MOVs 94B and 96B in whatever state they were, and CRD AOV 1A.

Loss of CRD, PSW, CCW and SSW loop B would constitute an initiating event. Consequently, this scenario was not screened out of the analysis.

E. 4 Flood zone 12 : HPCS Pump Room

E.4.1 HPC Pump Suction Line

Source

Random pipe rupture of HPCS pump suction line (24" HBB-21) from condensate storage tank during system flow test. The resulting flow rate being 7115 GPM.

Propagation

12 > 12 with the water tight door DR-1A104 closed.

12 > Auxiliary building corridor and all corridor locations at the 93' level assuming that in the worst case all water tight doors were open.

High Pressure Core Spray (HPCS) pump room has a

water tight door with its own sump and sump pump. In addition, the room is required by technical specifications to be manually monitored if open. Any leak in the HPCS pump room would be identified by a high sump alarm sounded in the control room. If the water tight door was closed at the time of the flood then water would fill the room to a depth of 27.5 feet in 24 minutes. Since this pipe rupture event would occur during a flow test, when various system flow parameters would normally be monitored, 24 minutes should be sufficient time to detect and isolate the flood by closing HPCS MOV 1.

Given that HPCS pump room watertight door DR-1A104 was left open and unattended, a flood occurred, and the flood was not detected by the sump alarm, then water would flow from the HPCS room to the auxiliary building corridor and corridor rooms.

Assuming that, in the worst case, the watertight doors on the LPCS pump room and the RHR C room were open, then water would accumulate to a depth of 3 feet in the auxiliary building corridor and corridor rooms.

Result

A review of Appendix B indicated that as a result of the first scenario only HPCS components would be degraded. Consequently, the scenario would not cause an initiating event since the failure of HPCS would not challenge the integrity of the reactor core.

In the second scenario, LPCS components, HPCS pump, ADHRS pumps 5A and 5B, RHR pump C, CCW pumps A, B, and C, and CRD pumps A an B would fail.

If the plant was operating on ADHRS at the time of the flood, then the loss of ADHRS would constitute an initiating event.

The RWCU pumps and heat exchangers, the FPCCU heat exchangers, and the RRS pumps would be degraded due to a loss of CCW.

Failure of the RRS pumps would constitute an initiating event as normal reactor leakage would degrade natural circulation thus degrading the performance of shutdown decay heat removal.

The frequency of the worst case scenario was estimated as the product of the frequency of the pipe system break (1E-4 per year), the probability that the water tight doors are left open (3.6E-3 from appendix D), the fraction of time spent in testing (5.89E-2 Appendix D), and the fraction of time spent in the POS 5 (3.1E-2).

This frequency, calculated to be 6.0E-10 per year, was too low to be considered. Therefore, this flood scenario was screened out.

E.4.2 Standby HPC Pump Suction Line

Source

Random pipe rupture of Standby HPCS pump suction from condensate storage tank piping 24" HBB-21 with a flow of 22,725 cubic feet of water (Appendix D).

Propagation

12 > 12 with the water tight door DR-1A104 closed.

12 > Auxiliary building corridor and all corridor locations assuming that, in the worst case, all water tight doors are open.

HPCS pump room has a water tight door with its own sump and sump pump. In addition, the room is required by technical specifications to be manually monitored if open. If the water tight door is closed at the time of the flood then water would fill the room to a depth of 27.5 feet.

If the HPCS pump room watertight door DR-1A104 was left open and unattended, a flood occurred, and the flood was not detected by the sump alarm, then water would flow to the auxiliary building corridor and adjacent corridor flood zones.

Assuming that, in the worst case, the watertight doors on the LPCI-C pump room and the LPCS rooms were also open, then water would accumulate to a depth of approximately one foot in the auxiliary building corridor and adjacent corridor rooms.

Result

A review of Appendix B indicated that, as a result of the first scenario, only HPCS components would be degraded. Consequently, the scenario would not cause an initiating event since the failure of HPCS would not challenge the integrity of the reactor core.

In the second scenario, ADHRS pumps 5A and 5B, RHR pump C, CCW pumps A, B, and C, and CRD pumps A an B would fail. If the plant was operating on ADHRS at the time of the flood, then the loss of ADHRS would

constitute an initiating event.

The RWCU pumps and heat exchangers, the FPCCU heat exchangers, and the RRS pumps would be degraded due to a loss of CCW. Failure of the RRS pumps would constitute an initiating event as normal reactor leakage would degrade natural circulation and thus degrade the performance of shutdown decay heat removal.

The frequency of the second case scenario is the product of the frequency of the pipe system break (1E-4 per year), the probability that the water tight doors are left open (3.6E-3 Appendix D), and the fraction of time spent in POS 5 (3.1E-2).

This frequency, calculated to be 1.1E-8/yr, was too low to be considered. Since other systems would still be available for mitigation, this flood scenario was screened out.

E. 5 Flood zone 14 : RHR Pump B and Heat Exchanger Room

E.5.1 Operating LPCI Pump B Discharge Piping

Source

Random pipe rupture of operating LPCI pump B discharge piping 18" GBB-74 with a flow rate of 4500 GPM.

Propagation

14 > 14

During POS 5, the water level in the reactor can be raised to the steamlines (648"). Given a break in the SDC loop B line in location 14, the water level in the reactor vessel would fall to level three (544.4 ") at which time SDC would automatically be isolated by the closing of SDC MOVs 8 and 9. This would result in 22191 gallons of water being discharged in flood zone 14.

At the 93' level of flood zone 14 there are no doors so water would accumulate to a depth of about 3.5 feet in the zone.

Results

A review of Appendix B indicated that, as a result of this scenario, LPCI MOVs 3B, 47B, 48B, 4B, 64B, 66B, 24B and pump 3B would fail. Since the plant would be operating on Shutdown Cooling (SDC) loop B at the time of the flood, then the loss of SDC B would constitute an initiating event. Therefore, this flood scenario was not screened out.

E.5.2 Operating LPCI Pump B Discharge Piping

Source

Random pipe rupture of standby LPCI pump B discharge piping 18" GBB-74 with a flow of 29412 cuft (Appendix D).

Propagation:

14 > 54 > Auxiliary building corridor and all corridor locations at elevation 119 ft > 16.

At the 93' level there are no doors so water would propagate to the 93' level of location 14, to the Auxiliary building corridor and to all corridor locations at elevation 119' accumulating to a height less than 4.4 inches.

Water flowing to location 57 could flow down to location 16. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at the 93' elevation, it was conservatively assumed that no water flowed down the stairs.

The same argument was used to neglect flow to the turbine building through door 1A201.

Results

A review of Appendix B indicated that, as a result of the scenario, LPCI-B would be disabled. Since the plant would not be operating on Shutdown Cooling (SDC) loop B at the time of the flood, the loss of the system would not constitute an initiating event. Therefore, this flood scenario was screened out.

E. 6 Flood zone 15 : RCIC Room

E.6.1 RCIC Pump Suction Piping

Source

Random pipe rupture of RCIC pump suction piping (6" HBB-49).

Propagation

Since RCIC is not operational in POS 5, a rupture of the pump suction piping would result in negligible water drain into location 15.

Results

This source was not considered a potential threat to the integrity of the reactor core so it was screened out.

E.7 Flood zone 16 : RHR Pump A and Heat Exchanger Room

E.7.1 Standby LPCI Pump A Discharge Piping

Source

Random pipe rupture of standby LPCI pump A discharge piping 18" GBB-18 with a discharge of 29412 cubic feet (Appendix D).

Propagation

16 > 57 > Auxiliary building corridor and all corridor locations at elevation 119 ft > 14.

At the 93' level there are no doors so water would propagate to the 93' level of location 16, to the Auxiliary building corridor, and to all corridor locations at elevation 119 ft accumulating to a height of less than 4.4 inches.

Water flowing to location 54 could flow down to location 14. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at the 93' elevation, it was conservatively assumed that no water flowed down the stairs.

The same argument was used to neglect flow to the turbine building through door 1A201.

Results

A review of Appendix B indicated that, as a result of the scenario, only LPCI-A would be disabled. Since the plant was not operating on SDC loop A at the time of the flood, then the loss of SDC A system would not constitute an initiating event. Therefore, this flood scenario was screened out.

E. 8 Flood zone 18A : Equipment Drain Transfer Tank Room

E.8.1 Floor Drain TransferTank P45-A001

Source

Rupture of floor drain transfer tank P45-A001 with a volume of 5000 gallons.

Propagation

18A > 18A

Catastrophic failure of the tank would result in the flooding of location 18A to a depth of 2.23 feet. This would be below the lowest propagation path out of the flood zone (elevation 103 feet); therefore, the flood would not propagate to other locations.

Results

A review of Appendix B indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.9 Flood zone 18B : Floor Drain Transfer Tank Room

E.9.1 Floor Drain Transfer Tank P45-A002

Source

Rupture of floor drain transfer tank P45-A002 with a volume of 5000 gallons.

Propagation

18B > 18B

Catastrophic failure of the tank would result in the flooding of location 18B to a depth of 2.2 feet. This would be below the lowest propagation path out of the zone (at elevation 103 feet); therefore, the flood would not propagate to other locations.

Results

A review of Appendix B indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.10 Flood zone 19 : Equipment Drain Transfer Pump Room

E.10.1 Equipment Drain Transfer Pump Discharge Pipinge

Source

Random pipe rupture of equipment drain transfer pump discharge piping 6" HBD-771 resulting in a flow rate of 100 GPM.

Propagation

19 > 18A > 18B and corridor rooms via DR-1A112.

In the worst case scenario, water would propagate into location 6 and corridor rooms via DR-1A112 and location 18 via DR-1A110 or DR-1A111. In these locations the water would accumulate to a depth of less than one inch.

Results

A review of Appendix B indicated that, as a result of the scenario no important equipment would fail; therefore, this scenario was screened out.

E.11 Flood zone 24 : Health Physics Area

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential safety equipment so it was screened out.

E.12 Flood zone 35 : Control Building Corridor at 111 Elevation

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential safety equipment so it was screened out.

E.13 Flood zone 45: Auxiliary Building Corridor at the 119' Elevation

E.13.1 Condensate Piping

Source

Random pipe rupture of condensate piping 12" HBD-30 at the southeast quadrant of the auxiliary building.

Propagation

None

The condensate system was not a potential source of water in POS 5.

Results:

This scenario was screened out.

E.13.2 Condensate Piping

Source

Random pipe rupture of condensate piping 12" HBD-30 at the South West quadrant of the auxiliary building.

Propagation

None

The condensate system was not considered a potential source of water in POS 5.

Results

This scenario was screened out.

E.13.3 Refuelling Storage Tank Piping

Source

Random pipe rupture of refuelling storage tank piping 12" HBC-203.

Propagation

None

This piping was not a potential source of water in POS 5.

Results

This scenario was screened out.

E.13.4 Fire Protection System Piping

Source

Fire protection system piping 10" JBD-202 at the South West wall of the auxiliary building with a flow rate of 4,530 GPM.

Propagation

45 > 45 > the auxiliary building corridor and rooms at the 119' elevation > 14 and 16

The Fire Water System (FWS) jockey pumps normally keep the FWS pressurized between 130 psig and 145 psig. A rupture in the FWS piping would expose the system to atmospheric conditions. Under these conditions, the FWS jockey pump would attemp to restore system pressure. The jockey pump would discharge at a flow rate of 30 GPM. Since this flow would be insufficient to overcome the effects of the rupture, the FWS Motor Driven Pump (MDP) would start automatically. This would be followed by an automatic start of one of the FWS Diesel Driven Pumps (DDPs) followed by a 15 second delay at which time the second DDP would start [E2].

Operators in the control rooms would be aware of the situation since both high sump level alarms and warnings would alert them that the FWS pumps were running. In this situation the flood could be isolated by stopping FWS pumps and closing appropriate isolation valves. Plant operators indicate this action could be accomplished in less than 15 minutes.

In 15 minutes, the total water release is 67,950 gallons. At the 119' elevation of the auxiliary building, water would accumulate to a depth of less than six inches in all locations. Water draining to locations 54 and 57 could flow down to locations 14 and 16.

Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at the 93' elevation, it was conservatively assumed that no water flowed down the stairs.

The same argument was used to neglect flow to the turbine building through door 1A201.

Results

A review of Appendices B and C indicated that, as a result of the scenario, FWS AOVs 282A and 282B, LCCs 11BD1 and 11BD5, and MCCs 11B11 and 11B51 would fail directly.

The loss of LCC 11BD5 results in the loss of CCW pump A and RWCU pump A. With the loss of CCW pump A, the standby CCW pump automatically starts on a low pressure signal of less than 100 psig [E2]. The loss of RWCU pump A would cause an initiating event, with makeup operating, so this flood scenario was not screened out.

E.13.5 Fire Protection System Piping

Source

Fire protection system piping 10" JBD-202 at the North West wall of the auxiliary building with a flow rate of 4,530 GPM.

Propagation

45 > 45 > the auxiliary building corridor and rooms at the 119' elevation > 14 and 16

With the 67,950 gallon release at the 119' elevation of the auxiliary, water would accumulate to a depth of less than six inches in all locations. Water draining to locations 54 and 57 could flow down to locations 14 and 16.

Since water flowing down stairs 1A12 and 1A10 would be not readily affect any equipment at the 93' elevation, it was conservatively assumed that no water flowed down

the stairs.

The same argument was used to neglect flow to the turbine building through door 1A201.

Results

A review of Appendix B indicated that, as a result of the scenario, FWS AOVs 283A and 283B, LCCs 14BE1 and 12BE2, and MCCs 12B21 and 14B11 would fail directly.

Failure of LCC 14BE1 would cause failure of ADHRS pumps A and B. Failure of LCC 12BE2 would fail RWCU pump B and CCW pump C. If the plant is operating on ADHRS at the time of the flood, then the loss of ADHRS would constitute an initiating event. Therefore, this flood scenario was not screened out.

E.13.6 Fire Protection System Piping

Source

Fire protection system piping 10" JBD-202 at the south east wall of the auxiliary building with a flow rate of 4,530 GPM.

Propagation

45 > 45 > the auxiliary building corridor and rooms at the 119' elevation > 14 and 16.

With the 67,950 gallon release at the 119' elevation of the auxiliary, water would accumulate to a depth of less than six inches in all locations. Water draining to locations 54 and 57 could flow down to locations 14 and 16.

Since water flowing down stairs 1A12 and 1A10 would be not readily affect any equipment at the 93' elevation, it was conservatively assumed that no water flowed down the stairs.

The same argument was used to neglect flow to the turbine building through door 1A201.

Results

A review of Appendix B indicated that no important safety equipment would fail as a result of this scenario. Therefore, the scenario was screened out.

E.13.7 Fire Protection System Piping

Source

Fire protection system piping 10" JBD-202 at the north east wall of the auxiliary building with a flow rate of 4,530 GPM.

Propagation

45 > 45 > the auxiliary building corridor and rooms at the 119' elevation > 14 and 16.

With the 67,950 gallon release at the 119' elevation of the auxiliary, water would accumulate to a depth of less than six inches in all locations. Water draining to locations 54 and 57 could flow down to locations 14 and 16.

Since water flowing down stairs 1A12 and 1A10 would be not readily affect any equipment at the 93' elevation, it was conservatively assumed that no water flowed down the stairs.

The same argument was used to neglect flow to the turbine building through door 1A201.

Results

A review of Appendix B indicated that no important safety equipment would fail as a result of this scenario. Therefore, the scenario was screened out.

E.14 Flood zone 46 : Division I Switchgear Room

E.14.1 ESF Room Cooler T46-B002A Piping

Source

ESF Room Cooler T46-B002A piping 2" HBC-93 with a flow rate of 40 GPM.

Propagation

46 > auxiliary building corridor at elevation 119'. Water would spray and fail all equipment in location 46 then drain at a negligible rate through door DR 1A214 to the auxiliary building corridor and corridor rooms at elevation 119.'

Results

A review of Appendix B indicated that, as a result of the scenario, MCC 15B11, LCC 15BA3, and LCC 15BA1 would fail directly. Loss of LCC 15BA1 would fail LPCS jockey pump, LPCS pump suction valve and discharge MOVs 1,5 and 11, RHR A room fan cooler 3, ESF switchgear cooler 2A, RWCU MOVs 4, 39, 33 and 250, and CCW MOVs 66, 67 and 116 in the state they were. Failure of LCC 15BA3 degrades FPCCU pump A, SDC A jockey pump, suction valve MOV 6A and others in the state they were. These losses would not constitute an initiating event. Therefore, this flood scenario was screened out.

E.15 Flood zone 48 : Valve Room

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.16 Flood zone 49 : Division II Switchgear Room

E.16.1 ESF Room Cooler T46-B002B Piping

Source

ESF Room Cooler T46-B002B piping 2" HBC-93 with a flow rate of 15 GPM.

Propagation

49 > auxiliary building corridor at elevation 119'.

Water would spray and fail all equipment in location 49 then drain at a negligible rate through door DR 1A212 to the auxiliary building corridor at elevation 119'.

Results

A review of Appendix B indicated that, as a result of the scenario, MCCs 16B11 and 14B11, and LCC 16BB1 and 16BB3 would fail. Failure of MCC 16B11 would fail LPCI-C injection valve MOV 42C and other LPCI B train valves as they were, SSW to PSW cross-tie MOV 42 as it was, and SSW Inlet valve to Division II diesel generator water cooler as it was. Failure of LCC 16BB3 degrades CCW pump B and fails LPCI B injection MOV 42B and other LPCI B train valves as they were. Failure of LCC 16BB1 causes the failure of FPCCU pump B. SSW train B valves would also fail as they were. Failure of MCC 14B11 would degrade ADHRS room cooling. With the loss of CCW pump A, the standby CCW pump automatically starts on a low pressure signal of less than 100 psig [10]. These failures would not lead to an initiating event so this scenario was screened out.

E.17 Flood zone 53 : Division II Switchgear Room

E.17.1 ESF Room Cooler T46-B001B Piping

Source

ESF Room Cooler T46-B001B piping 1.5" HBC-93 with a flow rate of 15 GPM.

Propagation

53 > auxiliary building corridor at elevation 119'.

Water would spray and fail all equipment in location 53 then drain at a negligible rate through door DR 1A210 to the auxiliary building corridor at elevation 119'.

Results

A review of Appendix B indicated that, as a result of the scenario, only equipment in location 53 would fail.

MCC 16B31 would fail causing the failure of LPCI-B MOVs 6B, 3B, 4B, 48B, 27B, 47B, 64B, and 66B as they were. These losses would not constitute an initiating event. Therefore, this flood scenario was screened out.

E.18 Flood zone 54 : RHR B Piping Room at Elevation 119'

E.18.1 SDC Piping

Source

SDC piping 18" GBB-31 with a flow rate of 4500 GPM.

Propagation

54 > auxiliary building corridor at elevation 119'.

During POS 5, the water level in the reactor can be raised to the steamlines (648"). Given a break in the SDC loop B line in location 54, the water level in the reactor vessel would fall to level three (544.4 ") at which time SDC would be isolated by the closing of SDC MOVs 8 and 9. This would result in 22191 gallons of water being discharged in flood zone 54 and the surrounding flood zones. As a result, water would accumulate to a depth of less than 2 inches in the auxiliary building corridor and corridor flood zones at the 119' elevation.

Results

A review of Appendix B indicated that SDC MOVs 6B, 27B, 53B and HPCS MOV 4 would fail as they were. The loss of SDC loop B as a result of the rupture would be an initiating event so this scenario was not screened out.

E.19 Flood zone 56A : RWCU Pump A Room

E.19.1 RWCU Pump Outlet Piping

Source

RWCU pump outlet piping 4" DBZ-2 with a flow rate of 180 GPM

Propagation

56A > 56A with the pressure tight doors closed.

56A > 56C, 56B and the auxiliary building corridor and rooms at the 119' elevation with RWCU rooms A and B pressure tight doors open (worst case).

During POS 5, the water level in the reactor can be raised to the steamlines (648"). Given a break in the RWCU loop A line in location 56A, the water level in the reactor vessel would fall to level three (544.4") at which time the SDC suction line would isolate by the closing of SDC MOVs 8 and 9. The water level in the reactor vessel would further fall to level two (491.4") at which time RWCU would be isolated automatically by the closing of RWCU MOVs 1 and 4. This would result in 33,544.5 gallons of water being discharged into the flood zone.

In the first Scenario, the flood would be contained in RWCU pump A room accumulating to a depth of 9.2 feet. In the worst case scenario, the water would flow from location 56A through 56C to locations 56B and the auxiliary building corridor and rooms at the 119' elevation accumulating to a depth of 2.7 inches.

Results

A review of Appendix B indicated that these scenarios would lead to similar results. However, the second scenario would be less likely than the first since both pressure tight doors would not normally be open. Considering only the first scenario, all modes of SDC, RWCU and RCIC components would be degraded. Loss of RWCU, with makeup operating or ECCS injection, could lead to an over-pressurization event. The loss of all SDC would also be an initiating event. Consequently, this scenario was not screened out.

E.20 Flood zone 56B : RWCU Pump B Room

E.20.1 RWCU Pump Outlet Piping

Source

RWCU pump outlet piping 4" DBZ-2 with a flow rate of 180 GPM

Propagation

56B > 56B with the pressure tight doors closed.

56B > 56 C, 56A and the auxiliary building corridor and rooms at the 119' elevation with RWCU rooms A and B pressure tight doors open (worst case).

During POS 5, the water level in the reactor can be raised to the steamlines (648"). Given a break in the RWCU loop B line in location 56 B, the water level in the reactor vessel would fall to level three (544.4") at which time the SDC suction line would be isolated

automatically by the closing of SDC MOVs 8 and 9. The water level in the reactor vessel would further fall to level two (491.4") at which time RWCU would be isolated automatically by the closing of RWCU MOVs 1 and 4. This would result in 33544.5 gallons of water being discharged in the flood zone.

In the first Scenario, the flood would be contained in RWCU pump B room accumulating to a depth of 9.2 feet. In the worst case scenario, the water would flow from location 56B through 56C to locations 56A and the auxiliary building corridor and rooms at the 119' elevation accumulating to a depth of 2.7 inches.

Results

A review of Appendix B indicated that these scenarios would lead to similar results. However, the second scenario would be less likely than the first since both pressure tight doors would not normally open.

Considering only the first scenario, all modes of SDC, RWCU and RCIC components would be degraded. Loss of RWCU, with makeup operating or ECCS actuation, could lead to an over-pressurization event. The loss of all SDC would also be an initiating event. Consequently, this scenario was not screened out.

E.21 Flood zone 56C : Access to RCIC Room

E.21.1 SDC Common Suction Piping

Source

SDC common suction piping 20" GBB-31 with a flow rate of 4500 GPM.

Propagation

56C > auxiliary building corridor at elevation 119'.

During POS 5, the water level in the reactor can be raised to the steamlines (648"). Given a break in the SDC common suction line in location 56C, the water level in the reactor vessel would fall to level three (544.4") at which time SDC would be isolated by the closing of SDC MOVs 8 and 9. This would result in 22,191 gallons of water being discharged in flood zone 56C and the surrounding flood zones . As a result, water would accumulate to a depth of less than 2 inches in the auxiliary building corridor and corridor flood zones at the 119' elevation.

Results

A review of Appendix B indicated that SDC MOV 8 would fail open. The loss of all SDC as a result of the break would be an initiating event and, therefore, was not screened out.

E.22 Flood zone 57 : RHR A Piping Room at Elevation 119'

E.22.1 LPCI Heat Exchanger Piping

Source

LPCI heat exchanger piping 18" GBB-19 with a flow rate of 4500 GPM.

Propagation

57 > 16

Flood would propagate down to location 16 at the 93' level.

Results

This flood scenario was a subset of the scenario already covered by LPCI pump A discharge piping (18" GBB-18) flood in location 16. Therefore, this scenario was screened out.

E.23 Flood zone 59 : Division I Switchgear Room

E.23.1 ESF Room Cooler T46-B001A Piping

Source:

ESF Room Cooler T46-B001A with a flow rate of 15 GPM

Propagation

59 > auxiliary building corridor at elevation 119'.

Water would spray and fail all equipment in location 59 then drain at a negligible rate through door DR 1A210 to the auxiliary building corridor at elevation 119'.

Results

A review of Appendix B indicated that, as a result of the scenario, MCC 15B31 would fail. LPCI-A MOVs and SDC common suction line MOV 8 would fail as they were due to the failure of MCC 15B31. These failures would not constitute an initiating event. Therefore, this flood scenario was screened out.

E.24 Flood zone 61 : Division II Battery Room

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.25 Flood zone 62 : Division I Battery Room

Source

None

Propagation

None

Results:

No failures would occur so this scenario was screened out.

E.26 Flood zone 63 : Division III Battery Room

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.27 Flood zone 64 : Emergency Hot Shutdown Rooms

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.28 Flood zone 65 : Division II Switchgear Room and Corridor

E.28.1 Firewater Piping

Source

Firewater piping 10" JBD-253 in corridor OC216 with a flow rate of 4530 GPM.

Propagation

Corridor OC216 > 61, 62, 63, 64, 65, and 67

The total volume of water that would be released was calculated to be 67,950 gallons. Assume that half the water entered the stairwell and elevator shaft while the rest flowed through DR 0C 219 to location 61, through door DR OC203, through DR OC211 to 62, through door DR OC209 to 63, through DR OC208 to 64, and through door DR OC216 to 66. Water would accumulate to a depth of 11 inches in these locations.

Results

A review of Appendix B indicated that, as a result of the scenario, Division 1, 2, and 3 power would be lost. This would lead to an initiating event and so the scenario was

not screened out.

E.29 Flood zone 66 : Division III Switchgear Room

Source

none

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.30 Flood zone 67 : Division I Switchgear Room

Source

none

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.31 Flood zone 86 : Division III Diesel Generator Room

E.31.1 Standby Diesel Jacket Water Cooler

Source

Standby Diesel Jacket Water Cooler 10" HBC-86 with a flow rate of 2400 GPM.

Propagation

86 > corridor > 87,88, and plant yard.

In one hour, water would flow from location 86 through door DR 1D304 to locations 87, 88, and the corridor over the 3 inch curb. The water would then propagate to the plant yard through door DR 1D312 after a 9 inch depth of water is achieved.

Results

A review of Appendix B indicated that, as a result of the scenario, diesel generators (DGs) 1, 2 and 3 would fail. Since the failure of the DGs would not challenge the integrity of the reactor core, this scenario was screened out of the analysis.

E. 32 Flood zone 87 : Division II Diesel Generator Room

E.32.1 Standby Diesel Jacket Water Cooler Source

Standby Diesel Jacket Water Cooler 10" HBC-87 with a flow rate of 2400 GPM.

Propagation

87 > 86,88, and plant yard

In one hour, water would flow from location 87 through door DR 1D303 to locations 86, 88, and the corridor over the 3 inch curb. The water would then propagate to the plant yard through door DR 1D312 after a 9 inch depth of water is achieved.

Results

A review of Appendix B indicated that, as a result of the scenario, diesel generators (DGs) 1, 2 and 3 would fail. Since the failure of the DGs does not challenge the integrity of the reactor core, this scenario was screened out of the analysis.

E.33 Flood zone 88 : Division I Diesel Generator Room

E.33.1 Standby Diesel Jacket Water Cooler

Source

Standby Diesel Jacket Water Cooler 6" HBC-84 with a flow rate of 2400 GPM.

Propagation

Propagation Development

88 > 86,87, and plant yard

In one hour, water would flow from location 88 through door DR 1D302 to locations 86, 87, and the corridor over the 3 inch curb. The water would then propagate to the plant yard through door DR 1D312 after a 9 inch depth of water is achieved.

Results

A review of Appendix B indicated that, as a result of the scenario, diesel generators (DGs) 1, 2 and 3 would fail. Since the failure of the DGs would not challenge the integrity of the reactor core, this scenario was screened out of the analysis.

E.34 Flood zone 90 : HVAC Equipment Room

E.34.1 PSW To Control Room A/C Piping

Source

PSW to control room A/C piping 6" JBD-162 with a flow rate of 161 GPM.

Propagation

90 > 90

Floods location 90 to a height of 2.8 inches.

Results

A review of Appendix B and C indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.35 Flood zone 92 : Electrical Penetration Room

E.35.1 ESF Room Cooler T46-B005A

Source

ESF Room Cooler T46-B005A with a flow rate of 15 GPM

Propagation

92 > 133' elevation corridor locations and rooms.

Water would spray equipment in location 92 then propagates through door DR 1A315 to the 133' elevation corridor locations and rooms. Water would accumulate to a height of 0.06 inches in all locations.

Results

A review of Appendix B indicated that, as a result of the scenario, MCC 15B41 would fail. Failure of MCC 15B41 would lead to the failure of LPCS and ESF Room Coolers 2 and 3A respectively, and CCW MOVs 105 and 205 in the state they were.

Since none of the systems' failures challenge the integrity of the core, this scenario was screened out.

E.36 Flood zone 93 : RPV Vibration Monitoring Room

E.36.1 CCW Containment Outboard Isolation Valve Piping

Source

CCW to containment outboard isolation valve piping 10" JBD-309 with a flow rate of 1334 GPM.

Propagation

93 > 133' elevation corridor locations and rooms.

Water would spray equipment in location 93 then propagate through door DR 1A314 to the 133' elevation corridor locations and rooms. Water would accumulate to a depth of less than 6 inches in these locations.

Results

A review of Appendix B indicated that, as a result of the scenario, CCW/SSW-XTIE valve MOV 67 would fail directly.

Since this failure would not challenge the integrity of the core, this scenario was screened out.

E.37 Flood zone 94 : Electrical Penetration Room

E.37.1 ESF Room Cooler T46-B005AB

Source

ESF Room Cooler T46-B005B with a flow rate of 15 GPM.

Propagation

94 > 133' elevation corridor locations and rooms.

Water would spray and fail all equipment in location 94 then drain at a negligible rate through door DR 1A313 to the auxiliary building corridor at elevation 139'.

Results

A review of Appendix B indicated that, as a result of the scenario, MCC 16B21 would fail. Failure of MCC 16B21 would fail CCW/SSW interfacing MOV 54. Since this failure would not challenge the integrity of the core, this scenario was screened out.

E.38 Flood zone 97 : RHR B Heat Exchanger

E.38.1 RHR Piping

Source

18" GBB-74 with a flow rate of 4500 GPM.

Propagation

97 > auxiliary building corridor at elevation 139'

During POS 5, the water level in the reactor can be raised to the steamlines (648"). Given a break in the SDC loop B line in location 97, the water level in the reactor vessel would fall to level three (544.4 ") at which time SDC would automatically be isolated by the closing of SDC MOVs 8 and 9. This would result in 22191 gallons of water being discharged in flood zone 97 and the surrounding flood zones . As a result, water would accumulate to a depth of less than 2 inches in the auxiliary building corridor and corridor flood zones at the 139' elevation.

Results

A review of Appendix B indicated that SDC MOVs 120B and 47B would fail. The loss of SDC loop B as a result of the break would be an initiating event so this scenario was not screened out.

E. 39 Flood zone 98 : RHR B Piping Room at Elevation 133'

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.40 Flood zone 99 : Division II Switchgear Room

E.40.1 ESF Room Cooler T46-B003B

Source

ESF Room Cooler T46-B003B with a flow rate of 40 GPM.

Propagation

99 > 101

Water would spray and fail all equipment in location 104 then drain at a negligible rate through door DR 1A307 to the auxiliary building corridor at elevation 139'.

Results

A review of Appendix B indicated that, as a result of the scenario, LCC 16BB4 which powers SPMU MOVs 1B and 2B would fail. Since these failures would not challenge the integrity of the core, this scenario was screened out.

E. 41 Flood zone 100 : Main Steam Tunnel

E.41.1 Feedwater Piping

Source

Feedwater piping 24" DBB-73 .

Propagation

Propagation Development

None

The condensate flow through the Feedwater system is not a potential source of water in POS 5.

Results

This scenario was screened out.

E.41.2 RWCU Inlet Piping

Source

RWCU inlet piping to RWCU pumps 6" DBA-9 with a flow of 360 GPM.

Propagation

100 > 100

100 > to the 133' elevation corridor locations and rooms.

During POS 5, the water level in the reactor can be raised to the steamlines (648"). Given a break in the RWCU suction line in location 100, the water level in the reactor vessel would fall to level three (544.4") at which time the SDC suction line would automatically be isolated by the closing of SDC MOVs 8 and 9. The water level in the reactor vessel would further fall to level two (491.4") at which time RWCU would be isolated automatically by the closing of RWCU MOV 1. This would result in 33544.5 gallons of water being discharged in the flood zone.

In the first scenario, the flood would be contained in flood zone 100 accumulating to a depth of 3 feet. In the worst case scenario, the water would flow from location 100 to the auxiliary building corridor and rooms at the 133' elevation accumulating to a depth of 2.7 inches.

Results

A review of Appendix B indicated that the scenarios would lead to similar result. Considering only the first scenario, all modes of SDC and RWCU would be degraded. Loss of RWCU, with makeup operating or ECCS actuation, could lead to an over-pressurization event. The loss of all SDC would also be an initiating event. Consequently, this scenario was not screened out.

E.42 Flood zone 101: Auxiliary Building Corridor at the 133' Elevation

E.42.1 PCW Piping

Source

PCW piping 10" JBD-644 at the southwest quadrant of the auxiliary building with a flow rate of 1232 GPM.

Propagation

101 > to the 133' elevation corridor locations and rooms.

Water would accumulate in all areas to a height of 5.6 inches. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs.

The same argument was used to neglect flow to the turbine building through door 1A301.

Results

A review of Appendix B indicated that, as a result of the scenario CCW MOVs 105 and 205 would fail. These losses would degrade cooling to FPCCU. Loss of FPCCU would not be an initiating event. Consequently, this scenario was screened out.

E.42.2 Plant Chilled Water (PCW) Pipe

Source

Plant Chilled Water (PCW) pipe leak 8" JBD-648 at the southeast quadrant of the auxiliary building with a flow rate of 721 GPM.

Propagation

101 > to the 133' elevation corridor locations and rooms.

The water would spray all equipment at the south wall then propagate to the above locations accumulating to a depth of 3.3 inches. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at the 93' elevation, it was conservatively assumed that

no water flowed down the stairs.

The same argument was used to neglect flow to the turbine building through door 1A301.

Results

A review of Appendix B indicated that, as a result of the scenario, MCC 11B12 would fail resulting in the failure of RWCU MOVs 35, 44, and 46 in the RWCU operating state. These failures would not cause an initiating event. Consequently, this scenario was screened out.

E.42.3 Suppression Pool Cooling and Cleanup Piping

Source

Suppression Pool Cooling and Cleanup (SPCCU) piping 12" GBD-166 at the North East quadrant of the auxiliary building with a flow rate of 625 GPM.

Propagation

101 > to the 133' elevation corridor locations and rooms.

The water would flood all areas to a depth of less than 3 inches. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs.

The same argument was used to neglect flow to the turbine building through door 1A301.

Results:

A review of Appendix B indicated that, as a result of the scenario, MCC 12B51 would fail resulting in the failure of RWCU MOVs 31, 107, 255 and 256 in the RWCU operating state. These failures would not cause an initiating event. Consequently, this scenario was screened out.

E.42.4 Suppression Pool Cooling and Cleanup Piping

Source:

Suppression Pool Cooling and Cleanup (SPCCU) piping 12" GBD-166 at the northwest quadrant of the auxiliary building with a flow rate of 625 GPM.

Propagation

101 > to the 133' elevation corridor locations and rooms.

Water would flood all areas to a depth of less than 3 inches. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs.

The same argument was used to neglect flow to the turbine building through door 1A301.

Results

A review of Appendix B indicated that, as a result of the scenario, MCC 14B12 would fail and degrade ADHRS MOV 424 in its operating state if the plant is on ADHRS. This failure would not cause an initiating event; therefore, this scenario was screened out.

E.42.5 PSW To Plant Chller Piping

Source

PSW to plant chiller piping 12" JBD-153 at the northwest quadrant of the auxiliary building with a flow rate of

E.43 Flood zone 102 : RHR A Piping Room at Elevation 133'

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.44 Flood zone 103 : RHR A Heat Exchanger Room

Source

Propagation Development

18" GBB-18 .

Propagation

None

RHR A was assumed to be out for maintenance in POS 5 so it was not a potential source of water.

Results

This scenario was screened out.

E.45 Flood zone 104 : Division I Switchgear Room

Source

ESF Room Cooler T46-B003A with a flow rate of 40 GPM.

Propagation

104 > 101

Water would spray and fail all equipment in location 104 then drain at a negligible rate through door DR 1A306 to the auxiliary building corridor at elevation 139'.

Results

A review of Appendix B indicated that, as a result of the scenario, LCC 15BA2 and 15BA4 would fail directly. The loss of LCC 15BA2 and 15BA4 would degrade SPMU components and SSW MOVs 64A which supplies cooling to the control room AC unit. Since these failures would not challenge the integrity of the core, this scenario was screened out.

E.46 Flood zone 138 : FPCCU Backwash Receiving Tank Room

Source

10,000 Gal. Receiving Tank

Propagation

138 > auxiliary building corridor and corridor rooms at elevation 166'

A catastrophic failure of the fuel pool drain tank would fail equipment in location 138 then propagate through door DR 1A414 to auxiliary building corridor and corridor rooms at elevation 166'. In these areas the water would accumulate to a depth of less than 0.76 inches.

Results

A review of Appendix B indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.47 Flood zone 140 : FPCCU Pump Room

E.47.1 Fuel Pool Drain Tank

Source

5000 gallon fuel pool drain tank.

Propagation

140 > auxiliary building corridor and corridor rooms at elevation 166'

A catastrophic failure of the fuel pool drain tank would fail equipment in location 140 then propagate through door DR 1A412 to auxiliary building corridor and corridor rooms at elevation 166'. In these areas the water would accumulate to a depth of less than 0.38 inches

Results

A review of Appendix B indicated that, as a result of the scenario, the FPCCU pumps A and B would fail. Since these failures would not challenge the integrity of the reactor core, this scenario was screened out.

E.48 Flood zone 141 : Auxiliary Building Corridor at Elevation 166'

E.48.1 FPCCU Piping

Source

FPCCU piping 14" HBC-208 at the northwest quadrant of the auxiliary building at elevation 166' with a

flow rate of 1100 GPM.

Propagation

141 > auxiliary building corridor and corridor rooms at elevation 166'.

The water would spray equipment in the break location then flow to auxiliary building corridor and corridor rooms at elevation 166'.
Here the water would accumulate to a depth of about 5 inches. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs. The same argument was used to neglect flow to the turbine building through door 1A401.

Results

A review of Appendix B indicated that, as a result of the scenario, LCC 12BE5, MCC 16B41, and ESF Switchgear room cooler T46-B001B would fail. The loss of MCC 16B41 would result in the failure of SPMU MOVs 1B and 2B in their standby state. Loss of MCC 12BE5 would fail RWCU MOVs 31, 107, 255, and 256 in RWCU operating state. These failures would not cause an initiating event. Consequently, this scenario was screened out.

E.49 Flood zone 142 : CRD Repair Room

E.49.1 Cask Storage Pool Drain Valve

Source

Fuel pool Cask Storage Pool Drain Valve G-41-F033 with a flow rate of 2500 GPM.

Propagation

142 > auxiliary building corridor and corridor rooms at elevation 166'.

Water would spray and fail equipment in location 142 then propagate through door DR 1A411 to the auxiliary building corridor and corridor rooms at elevation 166'. In these locations water would accumulate to a depth of 11.6 inches in one hour. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs. The same argument was used to neglect flow to the turbine building through door 1A401.

Results

A review of Appendix B indicated that, as a result of the scenario, MCCs 11B13, 15B21, and 16B41, FPCCU pumps A and B would fail. IAS Booster compressors and MOVs 17A, 17B, 513A, 513B, 518A, and 518B would also fail. The loss of MCC 16B41 would result in the failure SPMU MOVs 1B and 2B in their standby state. The loss of MCC 15B21 would result in the loss of SPMU MOV 2A and CIV MOVs 36 and 37. The loss of IAS Booster compressors and MOVs 17A and 17B would degrade the ability of ADS relief valves to perform. The loss of MCC 11B13 would fail RWCU MOVs 254 and 255 in the RWCU operating state. Since these failures would not challenge the integrity of the core, this scenario was screened out.

E.50 Flood zone 143 : Water Sampling Room

E.50.1 FPCCU Pump Outlet

Source

FPCCU pump outlet to fuel pool heat exchanger piping 8" HBC-19 with a flow rate of 1100 GPM.

Propagation

143 > auxiliary building corridor and corridor rooms at elevation 166'.

Water would spray and fail equipment in location 143 then propagate through door DR 1A410 to the auxiliary building corridor and corridor rooms at elevation 166'. In these locations water would accumulate to a depth of 5.1 inches in one hour. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs. The same argument was used to neglect flow to the turbine building through door 1A401

Results

A review of Appendix B indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.51 Flood zone 144 : FPCCU Backwash Transfer Pump Room

E.51.1 PPCCU Pump Outlet

Source

FPCCU pump outlet to fuel pool heat exchanger piping 8" HBC-19 with a flow rate 1100 GPM.

Propagation

144 > auxiliary building corridor and corridor rooms at elevation 166'.

Water would spray and fail equipment in location 144 then propagate through door DR 1A415 to the auxiliary building corridor and corridor rooms at elevation 166'. In these locations water would accumulate to a depth of 5.1 inches in one hour. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs. The same argument was used to neglect flow to the turbine building through door 1A401.

Results

A review of Appendix B indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.52 Flood zone 148 : Electrical Penetration Room

E.52.1 ESF Room Cooler

Source

ESF Room Cooler - T46-B004A with a flow rate of 15 GPM

Propagation

148 > 141

Water would spray and fail all equipment in location 148 then drain at a negligible rate through door DR 1A406 to the auxiliary building corridor at elevation 166'.

Results:

A review of Appendix B indicated that, as a result of the scenario, MCC 15B21 and T46-B004A would fail directly. Failure of MCC 15B21 disables CIV MOVs 36 and 37. Since these failures would not challenge the integrity of the core, this scenario was screened out.

E.53 Flood zone 150 : Access to Roof of Main Steam Tunnel

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.54 Flood zone 152 : Blowout Shaft and Roof of Main Steam Tunnel

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.55 Flood zone 154 : CMTM Cooling Vent Supply Fan Room

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.56 Flood zone 155 : CMTM Exhaust Filter Vent Room

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.57 Flood zone 157 : Electrical Penetration Room

E.57.1 ESF Room Cooler T46-B004B

Source

ESF Room Cooler T46-B004B with a flow rate of 15 GPM

Propagation

157 > 141

Water would spray and fail all equipment in location 157 then drain at a negligible rate through door DR 1A403 to the auxiliary building corridor at elevation 166'.

Results

A review of Appendix B and C indicated that, as a result of the scenario, MCC 16B41 and T46-B004B would fail directly. Failure of MCC 16B41 disables SSW MOV 81B, 64B, PSW crosstie to SSW MOV 67B, SPMU MOVs 1B and 2B. Since these failures did not challenge the integrity of the core, this scenario was screened out.

E.58 Flood zone 195 : FPCCU Filter Demin Room

E.58.1 Fuel Pool Piping

Source

Fuel pool piping 8" HBZ-1 with a flow rate of 1100 GPM.

Propagation

195 > auxiliary building corridor and corridor rooms at elevation 185'.

The flood would fill location 195 in 23.6 minutes. In the remaining 35.4 minutes water would propagate through DR 1A511 to auxiliary building corridor and corridor rooms at elevation 185' accumulating to a depth of less than 0.25 feet. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs.

Results

A review of Appendix B indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.59 Flood zone 196 : FPCCU Tank Room

E.59.1 Fuel Pool Drain Tank Pipe

Source

Piping to fuel pool drain tank 10" HBC-13 with a flow rate of 1100 GPM.

Propagation

196 > auxiliary building corridor and corridor rooms at elevation 185'.

The flood would fill location 196 in 12.4 minutes. In the remaining 47.6 minutes water would propagate through DR 1A510 to auxiliary building corridor and corridor rooms at elevation 185' accumulating to a height of less than 0.33 feet. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs.

Results

A review of Appendix B indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.60 Flood zone 199 : Northwest Quadrant of the Auxiliary Building Corridor at Elevation 185'

E.60.1 FPCCU Piping

Source

FPCCU piping 14" HBC-208 with a flow rate of 2200 GPM

Propagation

199 > auxiliary building corridor and corridor rooms at elevation 185'.

Water would flow from location 199 to auxiliary building corridor and corridor rooms at elevation 185 accumulating to a depth of less than 10 inches. Since water flowing down stairs 1A12 and 1A10 would not readily affect any equipment at lower elevations, it was conservatively assumed that no water flowed down the stairs.

Results

A review of Appendix B indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.61 Flood zone 200 : Southwest Quadrant of the Auxiliary Building Corridor at Elevation 185'

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.62 Flood zone 202 : North and Southeast Quadrant of the Auxiliary Building Corridor at Elevation 185'

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.63 Flood zone 219 : Upper Cable Room

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.64 Flood zone 220 : Instrument Motor Generator Room

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.65 Flood zone 221 : Control Cabinet Area

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

E.66 Flood zone 222 : Control Building Corridor at Elevation 189'

E.66.1 Firewater Piping

Source

Firewater piping 6" JBD-69 with a flow rate of 4530 GPM.

Propagation

222 > 221 >220 > 219

Water would enter the stairwell and elevator shaft, location 220 through door DR OC712, 221 through DR OC708, and 219 through OC709 and accumulate to a depth of less six inches.

Results

This scenario would not affect any important safety equipment so it was screened out.

E.67 Flood zone 224 : North and Southwest Quadrant of the Auxiliary Building Corridor at Elevation 208'

Source

None

Propagation

None

Results:

No failures would occur so this scenario was screened out.

E.68 Flood zone 225 : North and Southeast Quadrant of the Auxiliary Building Corridor at Elevation 208'

Source

None

Propagation

None

Results

No failures would occur so this scenario was screened out.

Flood zone SSW A : SSW A Pump Room

Source

SSW pump A discharge line with a small flow rate with the system out of operation.

Propagation

SSW A > Plant yard

Results

A review of Appendix B and C indicated that, as a result of the scenario, SSW-A, MCC 15B51 and LCC 15BA5 would fail directly. The loss of SSW loop A would not constitute an initiating event since it was assumed that SSW loop A would be out for maintenance during POS 5 [3]. Therefore, this flood scenario was screened out.

E.70 Flood zone SSW B : SSW B Pump Room

E.70.1 SSW Pump B Discharge Line

Source

SSW pump B discharge line with a flow rate of 12,000 GPM

Propagation

SSW B > Plant yard

Results

A review of Appendix B indicated that, as a result of the scenario, SSW loop B, MCC 16B51 and LCC 16BB5 would fail directly. This loss of SSW loop B constitutes an initiating event. Therefore, this flood scenario was not screened out.

E.71 Flood zone FWS A: Fire Water Pumphouse A

E.71.1 FWS Pump B Discharge Line

Source

FWS pump B discharge line 10 JBD" 181 with a flow rate of 4530 GPM

Propagation

FWS A > Plant yard

Results

A review of Appendix B indicated that, as a result of the scenario, FWS train A components would fail directly. Since these failure would not challenge the integrity of the core, this scenario was screened out.

E.72 Flood zone FWS B: Fire Water Pumphouse B

E.72.1 FWS Pump B Discharge Line

Source

FWS pump B discharge line 10 JBD" 181 with a flow rate of 4530 GPM

Propagation

FWS B > Plant yard

Results

A review of Appendix B indicated that, as a result of the scenario, FWS train B components would fail directly. Since these failure would not challenge the integrity of the core, this scenario was screened out.

E.73 Flood zone TB-93-1 : Turbine Building at Elevation 93'

E.73.1 TBCW Piping

Source

TBCW piping 18" JBD-583 with a flow rate of 18,888 GPM.

Propagation

TB-93-1 > TB-93

Because the TBCW is a closed system and the makeup from the surge tank is only 550 gallons, it was assumed that the break in the TBCW system would cause the TBCW pumps to loose NPSH and fail within ten minutes. In this time water would accumulate to a depth of about 5.5 inches in the turbine building.

At the 93' elevation, there is a submarine type watertight door between the auxiliary and the turbine building which would prevent turbine building water from entering the auxiliary building. Water entering the control building would enter the hot machine shop and the health physics area where no safety equipment would be degraded.

Results

The flood would fail Condensate booster pumps A, B, and C. The loss of Condensate booster pumps would not fail condensate. The loss of TBCW would cause an initiating event. Therefore, this scenario was not screened out.

E.74 Flood zone TB-93-2 : Turbine

Building at the 93' Elevation

E.74.1 TBCW Piping

Source

Turbine Building Cooling Water (TBCW) piping 24" JBD-429 with a flow rate of 18,888 GPM

Propagation

TB-93-2 > 24 and 35

Because the TBCW is a closed system and the makeup from the surge tank is only 550 gallons, it was assumed that the break in the TBCW system would cause the TBCW pumps to loose NPSH and fail within ten minutes. In this time water would accumulate to a depth of about 5.5 inches in the turbine building. At the 93' elevation, there is a submarine type watertight door between the auxiliary and the turbine building which would prevent turbine building water from entering the auxiliary building. Water entering the control building would enter the hot machine shop and the health physics area where no safety equipment would be degraded.

Results

A review of Appendix B indicated that, as a result of the scenario, the TBCW system would fail. Loss of TBCW would challenge the integrity of the reactor core. Therefore, this scenario was not screened out.

E.75 Flood zone TB-93-3 : Turbine Building at the 93' Elevation

E.75.1 Turbine Building Cooling Water Piping

Source

Turbine Building Cooling Water (TBCW) piping 24" JBD-442 with a flow rate of 18,888 GPM

Propagation

TB-93-3 > 24 and 35

Because the TBCW is a closed system and the makeup from the surge tank is only 550 gallons, it was assumed that the break in the TBCW system would cause the TBCW pumps to loose NPSH and fail within ten minutes. In this time water would accumulate to a depth of about 5.5 inches in the turbine building. At the 93' elevation, there is a submarine type watertight door between the auxiliary and the turbine building which would prevent turbine building water from entering the auxiliary building. Water entering the control building would enter the hot machine shop and the health physics area where no safety equipment would be degraded.

Results

A review of Appendix B indicated that, as a result of the scenario, the TBCW system would fail. Loss of TBCW would challenge the integrity of the reactor core. Therefore, this scenario was not screened out.

E.76 Flood zone TB-93-4 : Turbine Building at the 93' Elevation

E.76.1 Plant Service Water Piping

Source

Plant service water piping 24" JBD-77 with a flow rate of 15,000 GPM.

Propagation

TB-93-4 > 24 and 35

The water would accumulate to a depth of about 2.2 feet in the turbine building. At the 93' elevation, there is a submarine type watertight door between the auxiliary and the turbine building which would prevent turbine building water from entering the auxiliary building. Water entering the control building would enter the hot machine shop and the health physics area where no safety equipment would be degraded.

Results

A review of Appendix B indicated that, as a result of the scenario, PSW, TBCW pumps, and Condensate pumps would fail. The loss of PSW would cause an initiating event. Therefore, this scenario was not screened out.

E.76.2 Turbine Building Cooling Water Piping

Source

Propagation Development

Turbine Building Cooling Water (TBCW) piping 10" JBD-489 with a flow rate of 18,888 GPM

Propagation

TB-93-4 > 24 and 35

Because the TBCW is a closed system and the makeup from the surge tank is only 550 gallons, it was assumed that the break in the TBCW system would cause the TBCW pumps to loose NPSH and fail within ten minutes. In this time water would accumulate to a depth of about 5.5 inches in the turbine building. At the 93' elevation, there is a submarine type watertight door between the auxiliary and the turbine building which would prevent turbine building water from entering the auxiliary building. Water entering the control building would enter the hot machine shop and the health physics area where no safety equipment would be degraded.

Results

A review of Appendix B indicated that, as a result of the scenario, the TBCW system would fail. Loss of TBCW would challenge the integrity of the reactor core. Therefore, this scenario was not screened out.

E.77 Flood zone TB-93-5 : Turbine Building at the 93' Elevation

E.77.1 Plant Service Water Piping

Source

Plant service water piping 24" JBD-77 with a flow rate of 15,000 GPM

Propagation

TB-93-5 > 24 and 35

The water would accumulate to a depth of about 2.2 feet in the turbine building. At the 93' elevation, there is a submarine type watertight door between the auxiliary and the turbine building which would prevent turbine building water from entering the auxiliary building. Water entering the control building would enter the hot machine shop and the health physics area where no safety equipment would be degraded.

Results

A review of Appendix B indicated that, as a result of the scenario, PSW, TBCW pumps, and Condensate pumps would fail. The loss of PSW would cause an initiating event. Therefore, this scenario was not screened out.

E.77.2 Turbine Building Cooling Water Piping

Source

Turbine Building Cooling Water (TBCW) piping 10" JBD-489 with a flow rate of 18,888 GPM

Propagation

TB-93-6 > 24 and 35

Because the TBCW is a closed system and the makeup from the surge tank is only 550 gallons, it was assumed that the break in the TBCW system would cause the TBCW pumps to loose NPSH and fail within ten minutes. In this time water would accumulate to a depth of about 5.5 inches in the turbine building. At the 93' elevation, there is a submarine type watertight door between the auxiliary and the turbine building which would prevent turbine building water from entering the auxiliary building. Water entering the control building would enter the hot machine shop and the health physics area where no safety equipment would be degraded.

Results:

A review of Appendix B indicated that, as a result of the scenario, the TBCW system would fail. Loss of TBCW would challenge the integrity of the reactor core. Therefore, this scenario was not screened out.

E.78 Flood zone TB-93-6 : Turbine Building at the 93' Elevation

E.78.1 Plant Service Water Piping

Source

Plant service water piping 24" JBD-77 with a flow rate of 15,000 GPM

Propagation

TB-93-6 > 24 and 35

The water would accumulate to a depth of about 2.2 feet in the turbine building. At the 93' elevation, there is a submarine type watertight door between the auxiliary and the turbine building which would prevent turbine building water from entering the auxiliary building. Water entering the control building would enter the hot machine shop and the health physics area where no safety equipment would be degraded.

Results

A review of Appendix B indicated that, as a result of the scenario, the TBCW pumps A, B, and C and condensate pumps would fail. Loss of TBCW and PSW would challenge the integrity of the reactor core. Therefore, this scenario was not screened out.

E.78.2 Turbine Building Cooling Water Piping

Source

Turbine Building Cooling Water (TBCW) piping 10" JBD-489 with a flow rate of 18,888 GPM

Propagation

TB-93-6 > 24 and 35

Because the TBCW is a closed system and the makeup from the surge tank is only 550 gallons, it was assumed that the break in the TBCW system would cause the TBCW pumps to loose NPSH and fail within ten minutes. In this time water would accumulate to a depth of about 5.5 inches in the turbine building.

At the 93' elevation, there is a submarine type watertight door between the auxiliary and the turbine building which would prevent turbine building water from entering the auxiliary building.

Water entering the control building would enter the hot machine shop and the health physics area where no safety equipment would be degraded.

Results

A review of Appendix B indicated that, as a result of the scenario, the TBCW pumps A, B, and C and condensate pumps would fail. Loss of TBCW would challenge the integrity of the reactor core. Therefore, this scenario was not screened out.

E.79 Flood zones TB-113-1 : Turbine Building at Elevation 113'

E.79.1 Feedwater Piping

Source

Feedwater piping 14" FBD-1 .

Propagation

None

The condensate flow through the Feedwater system is not a potential source of water in POS 5.

Results

No failures would occur so this scenario was screened out.

E.79.2 Firewater Piping

Source

Firewater piping 10" JBD-223 with a flow rate of 4530 GPM.

Propagation : TB-113-1 > TB-113

The water would accumulate to a depth of about less than two inch in the turbine building at the 113 feet elevation.

Results

The flood would fail MCCs 12B41 and LCC 12BE4 directly. These failures would not lead to an initiating event. Therefore, this scenario was screened out.

E.80 Flood zones TB-113-2 : Turbine Building at elevation 113'

E.80.1 Feedwater Piping

Source

Feedwater piping 24" DBD-21.

Propagation Development

Propagation

None

Condensate flow through the Feedwater system is not a potential source of water in POS 5.

Results

No failures would occur so this scenario was screened out.

E.81 Flood zone TB-113-3 : Turbine Building at elevation 113'

E.81.1 Feedwater Piping

Source

Feedwater piping 24" DBD-21.

Propagation

None

The condensate flow through the Feedwater system is not a potential source of water in POS 5.

Results

No failures would occur so this scenario was screened out.

E.82 Flood zone TB-113-4 : Turbine Building at Elevation 113'

E.82.1 Firewater Piping

Source

Firewater piping 10" JBD-223 with a flow rate of 4530 GPM.

Propagation

TB-113-4 > TB-113

The water would accumulate to a depth of less than two inches in the turbine building at the 113 feet elevation.

Results

The flood would fail MCCs 13B21, 14B13, and 12B12 and LCC 13BD2 directly. The presence of a wall between the source and BOP Busses 12HE and 14AE would prevent their failure. The loss of MCCs 13B21, 14B13, and 12B12 and LCC 13BD2 would not cause an initiating event. Therefore, this scenario was screened out.

E.83 Flood zone TB-113-5 : Turbine Building at Elevation 113'

E.83.1 Firewater Piping

Source

Firewater piping 10" JBD-223 with a flow rate of 4530 GPM.

Propagation

TB-113-5 > TB-113

The water would accumulate to a depth of about less than two inches in the turbine building at the 113 feet elevation.

Results

The flood would fail MCC 11B21 and LCCs 12BE1, and 11BD2. The loss of LCC 12BE1 caused failure of Condensate pump suction MOVs 16B and 16C and discharge MOVs 24B and 24C. These failures would not challenge the integrity of the reactor core and so this scenario was screened out.

E.84 Flood zones TB-113-6 : Turbine Building at Elevation 113'

E.84.1 Firewater Piping

Source

Firewater piping 10" JBD-223 with a flow rate of 4530 GPM.

Propagation

TB-113-6 > TB-113

The water would accumulate to less than two inches depth in the turbine building at the 113 feet elevation.

Results

The flood would fail MCCs 14B22 and 12B11, and LCCs 12BE6, 14BE2, and 13BD1. The loss of MCC 12B11 caused failure of Condensate pump suction MOVs 16B and 16C and discharge MOVs 24B and 24C. These failures would not challenge the integrity of the reactor core so this scenario was screened out.

E.85 Flood zones TB-133-1 : Turbine Building at Elevation 133'

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential equipment so it was screened out.

E.86 Flood zones TB-133-2 : Turbine Building at Elevation 133'

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential safety equipment so it was screened out.

E.87 Flood zones TB-133-3 : Turbine Building at Elevation 133

E.87.1 Feedwater Piping

Source

Feedwater piping 24" DBD-14.

Propagation

None

The condensate flow through the Feedwater system is not a potential source of water in POS 5.

Results

This scenario was screened out.

E.88 Flood zones TB-133-4 : Turbine Building at Elevation 133

E.88.1 PSW Piping

Source

PSW piping 8" JBD-136 with a flow rate of 500 GPM.

Propagation

TB-133-4 > TB-133

The water would accumulate to a depth of about less than one inch in the turbine building at the 133 feet elevation.

Results

4.16 Kv BUS 13 AD and 6.9 Kv Bus 11 HD would fail directly as a result of this flood. The loss of 4.16 Kv BUS 13 AD would lead to the loss of Condensate pump A and TBCW pump A, RRS pump A, and SAS compressor C001A-N. PSW would also be lost as a result of the rupture. Loss of PSW is an initiating event: therefore, this scenario was not screened out.

E.89 Flood zones TB-133-5 : Turbine Building at Elevation 133'

Source

None

Propagation

None

Rsults

A review of Appendix B indicated that this flood zone

contained no essential safety equipment so it was screened out.

E.90 Flood zone TB-133-6 : Turbine Building at Elevation 133'

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential safety equipment so it was screened out.

E.91 Flood zone TB-166-1 : Turbine Building at Elevation 166'

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no important flood sources or essential safety equipment so it was screened out.

E.92 Flood zones TB-166-2 : Turbine Building at Elevation 166'

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential safety equipment so it was screened out.

E.93 Flood zone TB-166-3 : Turbine Building at Elevation 166'

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential safety equipment so it was screened out.

E.94 Flood zone TB-166-4 : Turbine Building at Elevation 166'

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential safety equipment so it was screened out.

E.95 Flood zones TB-166-5 : Turbine Building at Elevation 166'

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential safety equipment so it was

screened out.

E.96 Flood zone TB-166-6 : Turbine Building at Elevation 166'

Source

None

Propagation

None

Results

A review of Appendix B indicated that this flood zone contained no essential safety equipment so it was screened out.

E.97 Flood zone RWB : Radwaste Building

E.97.1 Tanks

Source

There are numerous waste, surge, flood, drain, and distillate sample tanks in the radwaste building.

Propagation

RWB > TB

A catastrophic tank rupture in the radwaste building could possibly drain water into the turbine building. However, the volume of water propagated to the turbine building would not be more significant than floods already considered in the turbine building.

Results

A review of Appendix B indicated that, as a result of the scenario, no critical components would be disabled. Therefore, this scenario was screened out.

E.98 Flood zone CWP : Circulating Water Pump House

Source

None

Propagation

None

The largest source in the Circulating Water Pump House would be a rupture in the circulating water system. However, the circulating water system is drained during POS 5 so this was not considered a potential flooding source.

Results

This scenario was screened out.

E.99 Flood zone WTB-133 : Water Treatment Building

E.99.1 TBCW Supply

Source

4" JBD-466 TBCW supply to Service Air System(SAS) and IAS compressors with a flow rate of 280 GPM.

Propagation

WTB-133 > WTB-133

Because the TBCW is a closed system and the makeup from the surge tank is only 550 gallons, it was assumed that the break in the TBCW system would cause the TBCW pumps to loose NPSH and fail within ten minutes. Water would, therefore, flow in zone WT-133 accumulating to a depth of less than 1 inch.

Results

A review of Appendix B indicated that, as a result of the scenario, TBCW SAS compressors COO1B-N and COO1A-N, IAS compressors C001-N and COO1B, and IAS AOVs 500 and 504 would fail directly due to a loss of cooling. The loss of all TBCW, IAS and SAS compressors would result in an initiating event. Therefore, this scenario was not screened out.

Table E.1. Frequencies of Potential Flood Events

Flood Zone	Scenario/ Source	Pipe Length (ft)	Valves Operated/ Manual	Pumps	Heat Exchangers /Tanks	Mean Rupture Event Frequency (per year)
3	24 GBB-62	113	2/1	1	0	2.4E-5
	12 HBC-519	188	0/7	2	2	5.7E-5
	12 HBC-522	118	0/4	0	0	1.6E-5
6	24 JBD-150 (SW)	197	3/0	0	0	1.4E-5
	24 JBD-150 (SE)	122	2/0	0	0	9.3E-6
	20 HBC-79B (NW)	127	0	0	0	2.3E-6
	20 HBC-79B (NE)	184	4/0	0	0	1.6E-5
	30 JBD-105 (NE)	127	2/0	0	0	9.3E-6
	36 HBC-223 (NW)	329	2/1	0	0	1.7E-5
	14 JBD-327 (SW)	155	3/9	3	1	8.1E-5
	14 JBD-327 (NW)	54	4/0	0	2	2.2E-5
	6" HBD-382 (NW)	241	15/2	2	0	8.6E-5
14	18 GBB-74	113	5/3	1	2	4.8E-5
45	10 JBD-202 (NW)	117	1/1	0	0	9.2E-6
	10 JBD-202 (SW)	164	0/1	0	0	6.5E-6
54	SDC B (18 GBB-31)	113	3/0	0	2	2.0E-5
56A	4 DBZ-1	30	1/3	1	0	2.6E-5
56B	4 DBZ-1	30	1/3	1	0	2.6E-5
56C	SDC (20 GBB-31)	113	1/0	0	0	5.6E-6
65	10 JBD-253	20	1	0	0	3.9E-6
97	SDC B (18 GBB-74)	113	2/0	0	0	9.1E-6
100	6" DBA-9	20	2	0	0	7.4E-6
SSW B	24 HBC-79	35	2/0	1	0	1.9E-5
TB-93-1	18 JBD-583	149	0/2	0	0	9.8E-6
TB-93-2	24 JBD-429	194	0	0	0	3.6E-6
TB-93-3	24 JBD-442	82	0	0	0	1.5E-6
TB-93-4	24 JBD-77	112	0	0	0	2.1E-6
	10 JBD-489	224	0	0	0	4.1E-6
TB-93-5	24 JBD-77	112	0	0	0	2.1E-6
	10 JBD-489	224	0	0	0	4.1E-6
TB-93-6	24-JBD-77	152	0/1	0	0	6.3E-6
	10 JBD-489	890	3/9	3	3	1.0E-4
TB-133-4	8 JBD-136	112	0	0	0	2.1E-6
WTB-133	4 JBD-466	140	1/2	0	0	1.3E-5

References - Appendix E

E.1 Grand Gulf System Descriptions.

E.2 Grand Gulf Nuclear Station Updated Final Safety Analysis Report.

E.3 Grand Gulf Nuclear Station Technical Specifications.

Appendix F

Discussion of Finalized Flood Scenarios

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Appendix F - Discussion of Finalized Flood Scenarios

F.1 Introduction

This appendix discusses the formulation of the initiating events associated with fluid boundary ruptures. Most of the events considered in this report are very similar to initiating events (IE) discussed in Reference F1. For some, the logic is exactly the same and required only a revision of the IE frequency to perform the analysis. In others, minor adjustments to the logic were required in addition to the revised IE frequency. These logic adjustments are noted in the discussion below. For a description of the initiating events, and the associated logic from which these flood events were derived, the reader is referred to Reference F1.

In a few cases, new event trees were developed for the first and second levels of screening. Beyond the second level for these events, existing event trees were compatible.

In all cases, Human Error Probabilities (HEPs) for operator actions were re-evaluated to assure that they were compatible with fluid boundary break and flood-induced initiating events.

When appropriate, breaks in two or more sources were lumped together under a common initiating event having a frequency equal to the sum of the individual break frequencies.

F.2 Initiating Event Descriptions

This section provides descriptions of potential flood initiating events and their nomenclature by flood zone and source.

F.2.1 Flood Zone 3

F.2.1.1 24 GBB-62

A rupture in Low Pressure Coolant Injection (LPCI) loop C suction line would fail LPCI-C and ADHRS components. If ADHRS was operating at the time of the rupture, then its loss would cause an initiating event. This pipe break and flood is equivalent to the E2D initiating event described in Reference F1. Its source/scenario designation is 24 GBB-62. Its event nomenclature is E2DF24 and its frequency is 2.4 E-5/yr.

F.2.1.2 12 GBB-519

A rupture in the Alternate Decay Heat Removal System (ADHRS) piping system would fail LPCI-C and ADHRS components. If ADHRS was operating at the time of the rupture, then its loss would cause an initiating event. This pipe break and flood is equivalent to the E2D initiating event described in Reference F1. Its source/scenario designation is 12 GBB-519. Its event nomenclature is E2DF57 and it has a frequency of 5.7 E-5/yr.

F.2.1.3 12 HBG-522

A rupture in the Plant Service Water (PSW) cooling loop to ADHRS would fail LPCI-C, ADHRS and PSW. If ADHRS was operating at the time of the rupture, then its loss would be the initiating event. The loss of PSW would also lead to an initiating event. The loss of PSW could lead to the loss of Turbine Building Cooling Water (TBCW), Component Cooling Water (CCW) and Instrument Air System (IAS). These failures would in turn lead to the loss of the Control Rod Drive (CRD), the Fire Water System (FWS), the Reactor Water Cleanup System (RWCU) letdown and the Reactor Recirculation System (RRS). This loss of instrument air makes this event very similar to the transient TIA initiating event described in Reference F1 with an attendant failure of LPCI-C. The source designation for this event is 12 HBC-522 and its initiating event nomenclature is TIAF16. Its frequency is 1.6 E-5/yr.

F.2.2 Flood Zone 6

Except for the rupture of PSW pipe segment (30" JBD-105) which failed Standby Service Water System (SSW) Motor Operated Valves (MOVs) 14B and 68B, all other PSW pipe ruptures in flood zone 6 caused very similar. The differences are that some ruptures would result in the failure of CCW MOVs 54 and 42, PSW Solenoid Operated Valves (SOVs) 116 and 117, and SSW MOVs 14A and 68A, while others would not. However, since PSW would be lost as result of the PSW pipe rupture, the failures of PSW SOVs 116 and 117 would be irrelevant. Similarly, the loss of PSW would fail the CCW system. Therefore, loss of CCW MOVs 42 and 54 would be irrelevant. In addition, since SSW loop A was assumed unavailable in POS 5, the failures of SSW MOVs 14A and 68A would also be irrelevant.

F.2.2.1 24 JBD-150 (SE & SW) and 36 HBC-223 (NW)

Because any of the postulated ruptures would result in the same failures, sources 24 JBD-150 (SE), 24 JBD-150

(SW) and 36 HBC-223 (NW) were combined into a common scenario listed as PSW-6 in Table 2.3 having a frequency of 4.0 E-5/yr. Since the failures induced by the pipe break and subsequent flood result in a loss of instrument air, this initiating event is very similar to the TIA event of Reference F1. Its initiating event nomenclature is TIAF40 and differs from TIA in that Standby Service Water cross-tie (SSW X-TIE) is not available as a source of core coolant injection. The only difference is that, in the flood event tree, SSW X-TIE would not be available as a source of injection into the reactor core.

F.2.2.2 30 JED-105 (NE)

A rupture in the PSW piping would directly degrade PSW flow, SSW-B Inlet to LPCI-B (SSW MOVs 14B and 68B) heat exchanger, and SSW-Xtie to LPCI (SSW MOVs 94B and 96B) in whatever state they were, HPCS MOVs 1 and 11 in their standby states, and PSW SOVs 122 and 123. The flood would also fail CRD pumps A and B and AOV 1A, CCW pumps A, B, and C, and PSW SOVs 120 and 121. A break in 30 JBD-105 also leads to a loss of instrument air making this scenario very similar to the TIA event of Reference F1. This initiating event was designated TIAF93 with a frequency of 9.3 E-6/yr. Its logic included a loss of SSW cross-tie.

F.2.2.3 20 HBC-79B (NW & NE)

An SSW loop B pipe rupture in the North West corner of the flood zone 6 would cause almost the same failures as a SSW loop B pipe rupture in the North East corner. The difference would be that the SSW loop B rupture in the north west corner would also fail CCW MOVs 42 and 54, and the SSW loop B rupture in the north east corner would also fail SSW MOVs 14B and 68B. However, since both floods failed PSW, the CCW system would fail. The loss of CCW MOVs 42 and 54 were irrelevant. In addition, SSW loop B would fail as a result of the rupture. The consequent failures of SSW MOVs 14B and 68B were also irrelevant.

Since the rupture of either of the 20 HBC-79 lines would result in the same failures, both were combined into scenario SSWB-6 in Table 2.3. With SSW train A unavailable in POS5, this initiator is similar to the T5A initiating event of Reference F1 (loss of all SSW). However, in this case SSW loop C would still be available for HPCS cooling. An additional difference is that for the flooding case Plant Service Water (PSW) fails, which results in CCS failure. This IE was designated T5AF19 with a frequency of 1.9 E-5/yr.

F.2.2.5 14 JBD-327 (SW)

A rupture in the Component Cooling Water (CCW) pipe in the South West corner of zone 6 would fail CCS pumps A, B, and C and, in so doing, the entire CCW system. CRD pumps A and B are also failed. This initiator is very similar to the T5D IE of Reference F1 (loss of all CCW) and was designated T5DF81 with a frequency of 8.1 E-5/yr.

F.2.2.5 14 JBD-327 (NW)

The CCW pipe rupture would fail CCW MOVs 42 and 54, the CCW system and CRD pumps A and B, and HPCS MOVs 1 and 11 in their standby positions as well as PSW SOVs 120 and 121. These failures lead to the loss of instrument air making this initiating event have the same effect as the TIA event of Reference F1 (loss of instrument air). This IE was designated TIAF22 with a frequency of 2.2 E-5/yr.

F.2.2.6 6 HBD-382 (NW)

The CRD pipe rupture of the auxiliary building would directly fail the CRD system, CCW MOVs 42 and 54, and HPCS MOVs 1 and 11 in their standby positions as well as PSW S0Vs 120 and 121. These failures lead to loss of instrument air also resulting in the same effects as the TIA event of Reference F1. This initiating event was designated TIAF86 with a frequency of 8.6 E-5/yr.

F.2.3 Flood Zone 14

F.2.3.1 18 GBB-74

This is a rupture in Shutdown Cooling (SDC) loop B. If SDC-B is operating at the time of the break, its loss resulting from the break would represent an initiating event. Suppression Pool Cooling loop B (SPC-B), LPCI-B, and Containment Spray loop B (CS-B) would also be unavailable. This IE is similar to the J2 event of Reference F1 (LOCA in an operating connected system) It was designated J2F48 with a frequency of 4.8 E-5/yr.

F.2.4 Flood Zone 45

F.2.4.1 10 JBD-202 (NW)

A rupture in the Fire Water System (FWS) piping would cause the failures of FWS Air Operated Valves (AOVs) 283A and 283B, Load Control Centers (LCCs) 14BE1 and 12BE2 and Motor Control Centers (MCCs) 12B21

and 14B11. Failure of LCC 14BE1 would cause the failures of ADHRS pumps A and B. Failure of LCC 12BE2 would fail RWCU pump B and CCW pump C. This initiator is similar to initiating event E2D of Reference F1 (loss of ADHRS only) with the additional failures of Reactor Water Cleanup (RWCU) pump B, the Firewater System, and CCW pump C. It was designated E2DF92 with a frequency of 9.2 E-6/yr.

F.2.4.2 10 JBD-202 (SW)

A rupture in the FWS piping in the South West corner of Zone 45 would cause the failures of FWS AOVs 282A and 282B, LCCs 11BD1 and 11BD5, and MCCs 11B11 and 11B51 directly. The loss of LCC 11BD5 resulted in the loss of CCW pump A and RWCU pump A. The loss of RWCU pump A would fail RWCU resulting in a situation in which makeup is greater that letdown. This would result in an over-pressurization event similar to the TIOP initiator of Reference F1 with the additional failure of FWS and CCW pump A. This IE was designated TIOPF65 with a frequency of 6.5 E-6/yr.

F.2.5 Flood Zone 54

F.2.5.1 18 GBB-31

A rupture in SDC-B piping system would fail SDC-B and HPCS MOV4. If SDC-B is operating at the time of the rupture, then its loss would constitute an initiating event. This event is similar to the E2B initiating event of Reference F1 (loss of operating RHR-SDC) with HPCS also failed. It was designated E2BF20 with a frequency of 2.0 E-5/yr.

F.2.6 Flood Zones 56A and 56B

F.2.6.1 4 DBZ-1

A rupture in Reactor Water Cleanup (RWCU) pump A or pump B outlet piping with makeup or Emergency Core Cooling System (ECCS) injection operating could lead to an over-pressurization event. The progression of the event beyond the initiation is dependent upon the status of the plant at the time of the pipe break and the options open to the operator.

A new initiating event, RWC26, and its corresponding event tree were developed for these pipe breaks. Two new transfer event trees, RRW and RARW were also developed and a fault tree for the autoisolation of RWCU (RWAIS) on the RWC26 event tree was constructed. The event trees are given in Appendix H.

A break in either the pump A or pump B will have exactly the same effect. However, since the breaks would occur in separate flood zones, each was treated as a separate initiating event designated RWC26A and RWC26B respectively. Each has the identical frequency of 2.6 E-5/yr.

F.2.7 Flood Zone 56C

F.2.7.1 20 GBB-31

A rupture in the SDC common suction line would disable all modes of RHR and would constitute a LOCA in an operating connected system. The initiating event was designated J2F56 with a frequency of 5.6 E-6/yr. and is listed in Table 2.3 as scenario SDC with source 20 GBB-31.

F.2.8 Flood Zone 65

F.2.8.1 10 JBD-253

A rupture in the FWS piping and the resulting flooding in zones 61-67 result in the loss of Divisions 1,2, and 3 AC and DC power sources. This event is similar to the TAB initiator of Reference F1 with additional operator actions for response to the flood induced failures. Balance of plant power (BOP) remains available. This event was designated TAB39 with a frequency of 3.9E-6/yr.

F.2.9 Flood Zone 97

F.2.9.1 18 GBB-74

This is a break in SDC loop during its operation. As such, it is equivalent to the J2 initiator of Reference F1. Its scenario designation in Table 2.3 is SDCB. Its initiating event nomenclature is J2F91 and it has a frequency of 9.1 E-6/yr.

F.2.10 Flood Zone 100

F.2.10.1 6 DBA-9

This event is very similar to the RWC26 initiating events of flood zones 56A and 56B. The difference is that it is a break in the RWCU common suction line instead of one of the RWCU pump outlet lines. All modes of SDC are lost and so is RWCU. MOV 1 is the only available

means of isolation and makeup continues to operate. This IE was designated RWC74 with a frequency of 7.4 E-6/yr.

F.2.11 Flood Zone SSW B

F.2.11.1 24 HBC-79

A rupture in the SSW loop B piping would fail SSW loop B. This scenario was recorded in Table 2.3 as 24 HBC-79 with event nomenclature T5AF19. The frequency of the flood from the SSW loop B pipe rupture in this location was estimated to be 1.9 E-5/yr.

Like the T5AF19 initiator in Flood Zone 6 (Scenario/Source SSWB-6), this event results in the loss of PSW which, in turn, leads to the loss of CCW. Thus, the accident is exactly equivalent to the first T5AF19 initiator and, since the initiating event frequencies are the same, the analysis outcomes will be the same..

F.2.12 Flood Zone TB-93

F.2.12.1 18 JBD-583, 24 JBD-29, 24 JBD-442, 10 JBD-489, 24 JBD-77

A rupture in any of the TBCW piping located in flood zones TB-93-1 to TB-93-5 would fail TBCW. A rupture in any of these five sources in sub-zones 1 through 5 of flood zone TB-93 would fair Turbine Building CoolingWater (TBCW) and lead directly to the loss of instrument air. These five sources were combined under scenarios TBCW-93-1-5 in Table 2.3. The loss of instrument air makes this scenario very similar to the TIA initiating event of Reference F1. It was designated TIAF23 with a frequency of 2.3 E-5/yr.

F.2.12.2 10 JBD-489

A rupture in any of the TBCW piping located in flood zones TB-93-6 would fail TBCW and condensate. The loss of TBCW leads to the loss of instrument air making this event very similar to the TIA initiating event of Reference F1. This IE was designated TIAF10 with a frequency of 1.0 E-4/yr.

F.2.12.3 24 JBD-77

Those sections of 24 JBD-77 pipe run through sub-zones 4 through 6 of flood zone TB-93. A rupture in any one of them would fail PSW, condensate, and TBCW. Thus, the three breaks were lumped together as scenario PSW-TB-93. The event would lead to a failure of instrument air making this scenario very similar to the TIA event of Reference F1. The initiating event was designated TIAF11 and has a frequency of 1.1 E-5/yr.

F.2.13 Flood Zone TB-133-4

F.2.13.1 8 JBD-136

A rupture in any of the PSW piping located in flood zone TB-133-4 would fail 4.16 Kv BUS 13 AD and 6.9 Kv Bus 11 HD. The loss of 4.16 Kv BUS 13 AD would lead to the loss of Condensate pump A and TBCW pump A, RRS pump A, and SAS compressor C001A-N. Normally, the loss of BOP BUS 11HD would lead to the failure of RRS pump A. However, in POS 5, when RRS pump A is operating at 25% rated speed, it would be on 4.16 Kv BUS 13 AD. In addition, RRS pump A was assumed to be unavailable in POS 5. PSW would also be lost as a result of the rupture.

Instrument air system (IAS) compressors would also fail making this event very similar to the TIA initiator of Reference F1. This initiating event was designated TIAF21 with a frequency of 2.1 E-6/yr.

F.2.14 Flood Zone WTB-133

F.2.14.1 4 JBD-466

A break in this TBCW line would cause the loss of that system. The resulting flood, spray and splashing would fail Service Air System and IAS compressors resulting in the loss of those systems. The loss of IAS makes this event very similar to the TIA initiator of Reference F1. It was designated TIAF13 with a frequency of 1.3 E-5/yr.

References - Appendix F

F.1 D. W. Whitehead, et al., "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 [illegible] During a Refueling Outage, Main R[illegible] NUREG/CR-6143, Vol. 2, Part 1, SA[illegible] 2440 Vol. 2.

Appendix G

Human Reliability Analysis

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Appendix G - Human Reliability Analysis

G.1 Introduction

This appendix describes the Human Reliability Analysis (HRA) performed for the internal flooding analysis of POS 5. As discussed in other sections of the report, many of the event trees for flood initiating events corresponded directly to IEs from the BWR LP&S internal events analysis [G5] and were used with only a modification of the initiating event name and its frequency. For 12 of the flood initiating events, it was also determined that with the exception of the initiating event frequencies, none of the event probabilites in the event trees and fault trees would differ from the corresponding initiating events from the accident frequencies project [G5]. For these flooding IEs, the surviving cutsets from [G5] were simply rerun with the new IE frequency. A list of the 12 IEs treated in this way are presented in Table G.1.1, along with the corresponding IE from [G5]. Documentation of the HRA for each these 12 initiators can be found by examinining the analysis for the corresponding initiator in Chapter 10 of [G5].

Of the remaining 12 IEs, nine were similar to IEs from [G5], but due to certain unavailabilities and failures, some event probabilities (including some human error probabilities (HEPs)) in the relevant trees had to be changed and the sequences requantified with the new event probabilities and new IE frequency (the same event and fault trees were used). Documentation of the HRA for these events is presented in this appendix. It should be noted that most of the human actions and their related HEPs did not change between the two analyses and therefore much of the HRA documentation is identical to that produced for the corresponding initiators in [G5]. A list of the nine IEs treated in this manner (and three others which are described below) and their corresponding IEs from [G5], are presented in Table G.1.2.

The remaining three flooding IEs required some new event trees. While HEPs for several new operator actions had to be determined for these IEs, many of the HEPs for various events in [G5] were applicable and this is reflected in the documentation. These three IEs are also listed in Table G.1.2, but no corresponding initiators from [G5] are listed.

As discussed above (and in Sections 1.1 and 2.3 of this report), most of the human actions and the related HEPs used in this report were the same as those used in [G5]. An important assumption made this possible. It was assumed that as long as the operators were not threatened by the flooding and as long as the flooding did not influence their ability to conduct certain actions, then the operators would respond to the specific losses and unavailabiliies (such a loss of IA) in the "usual" way, with the goal of preventing undesirable consequences. That is, unless the flooding physically prevented or hindered the operators from responding in particular ways, the "cause" of the initiating event was not assumed to have an impact. As noted earlier, in many cases the control room operators could be aware of a flood induced initiator before they knew the cause. However, any operator actions that were required to be performed outside the control room were examined to ensure that the particular flooding scenario would not influence the performance of those actions.

As similarly described in [G5], the 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) [NRC, NUREG/CR-4772]. 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 [NRC, NUREG/CR-1278]. 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. 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 [NRC, NUREG/CR-4550]. 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.

G.2 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 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 G.2.1 through G.2.133).

G.3 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 G.3.1 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. No attempt was made to include the contribution of human induced flood initiating events in the overall initiating event frequencies (see Section 2.1.2).

G.4 Post-Accident Human Reliability Analysis

G.4.1 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.

G.4.2 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 G.2.1 through G.2.133).

G.4.3 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 G.4.1 through G.4.9 was created. These tables present for each initiator listed in Table G.1.2, 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 at the end of Appendix G.

The calculation and supporting rationale for each of the individual HEPs using the ASEP HRAP procedure is presented in Tables G.2.1 through G.2.133. Each HEP is numbered. A simple listing of each of the post-accident human actions included in the analysis, its mean HEP, and its associated error factor is presented in Table G.4.10. 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:

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

G.5 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 G.5.1. The individual HEP calculations and the supporting rationale for each recovery action are found in Tables G.2.116 through G.2.126.

References for Appendix G

G1. A.D. Swain, "Accident Sequence Evaluation Program Human Reliability Analysis Procedure," NUREG/CR-4772, February, 1987.

G2. 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.

G3. USNRC, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," NUREG-1150, June, 1989.

G4. 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.

G5. D. W. Whitehead, et.al., "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," NUREG/CR-6143, Vol. 2, Part 1, SAND93-2440 Vol. 2, Part 1,

Table G.1.1
Flood Initiators Corresponding Directly to Internal Events
Initiators [G5] for Which Only the IE Frequency Was Changed

Flood Initiators	Corresponding Internal Events (IE) Initiators
E2DF24	E2D5H
E2DF57	E2D5H
T5DF81	T5D5H
J2F56	J2-5
J2F91	J2-5
TIAF22	TIA5H
TIAF86	TIA5H
TIAF23	TIA5H
TIAF10	TIA5H
TIAF11	TIA5H
TIAF21	TIA5H
TIAF13	TIA5H

Table G.1.2
Flood Initiators Requiring Changes in Event Probabilities
and Their Corresponding Internal Events Initiators [G5]

Flood Initiators	Corresponding Internal Events (IE) Initiators
TIAF16	TIA5H
TIAF40	TIA5H
TIAF93	TIA5H
T5AF19	T5A5H
J2F48	J2-5
E2DF93	E2D5H
TIOPF65	TIOP5H
E2BF20	E2B5H
TAB39	TAB5H
*RWC26A	--
*RWC26B	--
*RWC74	--

* These flood initiators required new event trees and did not have a corresponding initiator from the internal events analysis [G5].

Table G.2.1.1
HEP 1 Calculation

Human Action Event (1)	OPSDC (1)
Event Tree(s) (2)	SDC, ADH, TIA5H, TIAF16, TIAF40, TIAF93, E1B5H, E2B5H, E2BF20, T5D5H, E2T5H, S3-5, S3H-5,
Initiators (3)	RWC26, RWC74, T1, TAB5H, TAB39, TIA5H, TIAF16, TIAF40, TIAF93, E1B5H, E2B5H, E2BF20, T5D5H, E2T5H, S3-5, S3H-5, TIOF5, TIHP5, TIOP5, TIOPF65, 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 G.2.1.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T₀) 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	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. 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.	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 G.2.1.3
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)
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).	One	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 diagosis of loss of SDC).	Complete dependence was assumed between the control room diagnosing the loss of SDC, attempting a restart when appropriate, and entering the relevant ONEP. 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 most cases, the operators need only enter the relevant procedures (also see column 3 of this table).

Table G.2.1.4
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)
Detect/ Diagnose a loss of SDC	37 minutes	0	37 minutes	SEA Calculation C90-492-01-A16

Table G.2.1.5
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 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 G.2.1.6
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 G.2.1.7
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 G.2.1.8
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 G.2.1.9
Post-Diagnosis Stress-Level Identification

Action (1)	T_m <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 1-3 for rationale).

Table G.2.1.10
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. 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	10	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 G.2.2.1
HEP 2 Calculation

Human Action Event (1)	OPSDC (2)
Event Tree(s) (2)	ADH, TIA5H, TIAF16, TIAF40, TIAF93, E1D5H, E2D5H, E2DF93, T5D5H, S3-5, S3-5H, E2V5H,
Initiators (3)	RWC26, RWC74, T1, TIA5H, TIAF16, TIAF40, TIAF93,, E1D5H, E2D5H, E2DF93, T5D5H, S3-5, S3-5H, E2V5H, TIOF5, TIHP5, TIOP5, TIOPF65, 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 G.2.2.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.2.3
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	1. Enter ONEP for IDHR 2. Start standby RHR/SDC loop per SOI 04-1-01-E12-1 - 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 (follwing 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 G.2.2.4
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_a) (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 G.2.2.5
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)					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	
- 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	Travel and performance time for opening breaker was established on the basis of discussions with plant personnel.

Table G.2.2.6
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 G.2.2.7
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 G.2.2.8
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 G.2.2.9
Post-Diagnosis Stress-Level Identification
per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_m < 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)
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 G.2.2.10
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	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	--	0.02 0.032 0.025 0.046 Total Median HEP= 0.025 Total Mean HEP = 0.046	5 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 G.2.3.1
HEP 3 Calculation

Human Action Event (1)	OPDHR (1)
Event Tree(s) (2)	L, LA, LP, LAP
Initiators (3)	RWC26, RWC74, T1-5, TIA5H, TIAF16, TIAF40, TIAF93, TDB5H, T5D5H, E1B5H, E1D5H, E2D5H, E2DF93, 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, OPDHRLAP.E1V, OPDHR.TLM, OPDHR.TRP, OPDHR.TIH, OPDHROP.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 G.2.3.2
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 G.2.3.3
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 G.2.3.4
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 G.2.3.5
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 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 G.2.3.6
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 G.2.3.7
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 G.2.3.8
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 and without much time, the actions were assumed to be dynamic, per ASEP.	

Table G.2.3.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_E <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)
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 G.2.3.10
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. = 0.15 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.	0.05 0.081 0.20 0.48 Total Median HEP = 0.20 Total Mean HEP = 0.48	(5) (10)	The error factor associated with the dominant HEP was assigned.

Table G.2.4.1
HEP 4 Calculation

Human Action Event (1)	LCMK (1)
Event Tree(s) (2)	L, LA, LP, LAP, TIOP5, TIOPF65
Initiators (3)	RWC74, RWC26, TIOP5, TIOPF65, 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 G.2.4.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T₀) 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 G.2.4.3
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 G.2.4.4
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 G.2.4.5
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 G.2.4.6
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 G.2.4.7
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 G.2.4.8
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 G.2.4.9
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 overpress-urization	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 G.2.4.10
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. = 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	0.004 0.01 0.004 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 HEPs was assigned.

Table G.2.5.1
HEP 5 Calculation

Human Action Event (1)	OP1SV (17)
Event Tree(s) (2)	F, FP
Initiators (3)	RWC74, RWC26, 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 G.2.5.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
ECCS systems are not available and core cooling and makeup are needed. The question is whether they will flood with only 1 SRV open.	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. The control room gets feedback regarding the opening and closing of SRVs.	

Table G.2.5.3
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	- 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 G.2.5.4
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 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. Functionally, OP1SV is OPFLD, except that only 1 SRV is available. OP1SV is asked only when OPFLD succeeds.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16 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.

Table G.2.5.5
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	1 minute 13 min. Total	

Table G.2.5.6
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 G.2.5.7
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 G.2.5.8
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 G.2.5.9
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 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 G.2.5.10
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. = 0.1 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.	0.02 0.032 0.12 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	(5) (10)	The error factor associated with the dominant HEP was assigned.

Table G.2.6.1
HEP 6 Calculation

Human Action Event (1)	OPECS (1)
Event Tree(s) (2)	E, EA, EP, EX
Initiators (3)	RWC74, RWC26, T1, TIA5H, TIAF16, TIAF40, TIAF93, TAB5H, TAB39, TDB5H, T5D5H, E1B5H, E2B5H, E2BF20, E1D5H, E2D5H, E2DF93, TORV5, TRPT5, E1V5H, E2V5H, E1T5H, E2T5H, TIOF5, TIHP5, TLM5H, TIOP5, TIOPF65
Sequence Locator Files (4)	OPECS&.EP, OPECSHY2.EP, OPECSHYD.EP, OPCSDC12.EX, OPECSDC5.TIA, OPECSDC9.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 is 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 G.2.6.2
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. 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 G.2.6.3
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	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 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 G.2.6.4
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_a) (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 G.2.6.5
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)	1 minute 3 min. Total	

Table G.2.6.6
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 G.2.6.7
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 G.2.6.8
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 G.2.6.9
Post-Diagnosis Stress-Level Identificationper 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 assumpt[illegible] of extremely high stress. Each human action event was examined as a function of the context.

Table G.2.6.10
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. = 0.001 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 G.2.7.1
HEP 7 Calculation

Human Action Event (1)	OP1SV (1)
Event Tree(s) (2)	E, EA, EP, EX
Initiators (3)	RWC74, RWC26, T1, TIA5H, TIAF16, TIAF40, TIAF93, TAB5H, TAB39, TDB5H, T5D5H, E1B5H, E2B5H, E2BF20, E1D5H, E2D5H, E2DF93, TORV5, TRPT5, E1V5H, E2V5H, E1T5H, E2T5H, TIOF5, TIHP5, TLM5H, TIOP5, TIOPF65
Sequence Locator Files (4)	OPECS&.EP, OPECSHY2.EP, OPECSHYD.EP, OPCSDC12.EX, OPECSDC5.TIA, OPECSDC9.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 G.2.7.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.7.3
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)
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 (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 init[illegible]ed from 04-1-01-E22-1, Step 5.[illegible]

Table G.2.7.4
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 G.2.7.5
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)	1 minute 8 min. Total action time	

Table G.2.7.6
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 G.2.7.7
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 G.2.7.8
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 G.2.7.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_m < 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)
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 G.2.7.10
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. = 0.03 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.	0.02 0.032 0.05 0.112 Total Median HEP = 0.05 Total Mean HEP = 0.112	(5) (10)	Since both HEPs contribute to the total HEP, the largest of the two EFs was assigned.

Table G.2.8.1
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 G.2.8.10
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 availablity of LPCI. See rationale under Event Context (6) in Table 8-1 (HEP 8).

Table G.2.9.1
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 G.2.9.10
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)
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 G.2.10.1
HEP 10 Calculation

Human Action Event (1)	OPECS (2)
Event Tree(s) (2)	E, HPSWR
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93, TAB5H, TAB39, T5A5H, T5AF19, TDB5H, T5D5H, E1B5H, E2B5H, E2BF20, 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 is 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 G.2.10.2
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. 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 G.2.10.3
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 explicitly called by the procedure.

Table G.2.10.4
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)	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 G.2.10.5
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)), 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)	1 minute 8 min. Total	

Table G.2.10.6
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 G.2.10.7
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 G.2.10.8
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 G.2.10.9
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], 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 G.2.10.10
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. = 0.04 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.	0.02 0.032 0.04 0.138 Total Median HEP = 0.04 Total Mean HEP = 0.138	(5) (10)	The error factor from the dominant HEP was used.

Table G.2.11.1
HEP 11 Calculation

Human Action Event (1)	OP1SV (2)
Event Tree(s) (2)	E, HPSWR
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93, TAB5H, TAB39, T5A5H, T5AF19, TDB5H, T5D5H, E1B5H, E2B5H, E2BF20, 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 G.2.11.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.11.3
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 G.2.11.4
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 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 G.2.11.5
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 G.2.11.6
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 G.2.11.7
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 G.2.11.8
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 G.2.11.9
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], 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 G.2.11.10
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 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.	0.02 0.032 0.05 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	(5) (10)	The EF from the dominant HEP was assigned.

Table G.2.12.1
HEP 12 Calculation

Human Action Event (1)	OPSOF (1)
Event Tree(s) (2)	HPSWR
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93, TAB5H, TAB39, TDB5H, E1B5H, E2B5H, E2BF20, T5A5H, T5AF19, 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 G.2.12.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.12.3
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 G.2.12.4
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)
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 G.2.12.5
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	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 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.

Table G.2.12.6
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 G.2.12.7
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 G.2.12.8
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 G.2.12.9
Post-Diagnosis Stress-Level Identificationper Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_F < 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)
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 G.2.12.10
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. = 0.01 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 G.2.13.1
HEP 13 Calculation

Human Action Event (1)	OPECS (3)
Event Tree(s) (2)	EA, EAP
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93, E1D5H, E2D5H, E2DF93
Sequence Locator Files (4)	OPECSEQ9.EAP, OPCADH21.TIA, OPECSA12.E1D, OPECSA07.E2D,
Event Description (5)	OPECS is 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 G.2.13.2
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. 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 G.2.13.3
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	Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B 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) 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 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 G.2.13.4
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.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table G.2.13.5
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 IDHR 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.	15 minutes 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 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 G.2.13.6
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	20 minutes	3 minutes	

Table G.2.13.7
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 SO!, the lower bound was not judged to be appropriate.		Med. = 0.4 (EF= 10) Mean = 1.06 or 1.0	

Table G.2.13.8
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 G.2.13.9
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						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 G.2.13.10
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. = 0.4 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 G.2.14.1
HEP 14 Calculation

Human Action Event (1)	OPECS (7)
Event Tree(s) (2)	EA, EAP
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93
Sequence Locator Files (4)	OPECSEQ8.EAP, OPCADH20.TIA
Event Description (5)	OPECS is 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 G.2.14.2
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. 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 G.2.14.3
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	Per RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B 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) 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 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 G.2.14.4
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.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table G.2.14.5
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.	15 minutes 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 G.2.14.6
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 G.2.14.7
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 G.2.14.8
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	

Table G.2.14.9
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]	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 G.2.14.10 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 = 0.02 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 G.2.15.1
HEP 15 Calculation

Human Action Event (1)	OP1SV (3)
Event Tree(s) (2)	EA, EAP
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93
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 G.2.15.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.15.3
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)
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 RHR SOI (Step 6.6 or 6.8) Manual realignment from ADHR to RHR C or RHR B 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) Per IDHR ONEP (Step 5.1.3c) Initiate ECCS water solid operation 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.	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 G.2.15.4
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 G.2.15.5
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 G.2.15.6
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 G.2.15.7
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 G.2.15.8
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 G.2.15.9
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 G.2.15 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	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 G.2.16.1
HEP 16 Calculation

Human Action Event (1)	OPECS (8)
Event Tree(s) (2)	EA, EAP
Initiators (3)	TAB5H, TAB39, TDR5H, T5A5H, T5AF19, E1D5H, E2D5H, E2DF93.
Sequence Description Files (4)	OPECSADH.TAB, OPECSADH.TDB, OPECS3.T5A, OPECSADH.E1D, OPECSADP.E1D, 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 G.2.16.2
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. 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 G.2.16.3
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.	1. Isolate ADHR from the control room (if necessary) by closing 8 or 9 valve. 2. Per IDHR ONEP (Step 5.1.3c) - 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 explicitly called by the procedure.

Table G.2.16.4
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.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table G.2.16.5
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)	1 minute 3 min. Total time for actions	

Table G.2.16.6
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 G.2.16.7
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 G.2.16.8
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 G.2.16.9
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	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 G.2.16.10
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. = 0.01 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 G.2.17.1
HEP 17 Calculation

Human Action Event (1)	OPECS (4)
Event Tree(s) (2)	EA
Initiators (3)	TAB5H, TAB39, TDB5H
Sequence Locator Files (4)	OPECADH5.TAB, OPECSADH.TDB
Event Description (5)	OPECS is 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 G.2.17.2
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. 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 G.2.17.3
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	Isolate ADHR to prevent overpressurizing low pressure piping (not explicitly called by procedure) 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 G.2.17.4
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_{a}) (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 G.2.17.5
Operator Action Performance Time

Activities (1)	Locatio n (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)	1 minute 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 G.2.17.6
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 G.2.17.7
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 G.2.17.8
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 G.2.17.9
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						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 G.2.17.10
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. = 0.4 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 G.2.18.1
HEP 18 Calculation

Human Action Event (1)	OPECS (9)
Event Tree(s) (2)	E, EP
Initiators (3)	RWC74, RWC26, T1-5, TIA5H, TIAF16, TIAF40, TIAF93, TDB5H, T5A5H, T5AF19, T5D5H, E1B5H, E2B5H, E2BF20, 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 is 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 G.2.18.2
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. 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 G.2.18.3
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	Per IDHR ONEP (Step 5.1.3c) - 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 G.2.18.4
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.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table G.2.18.5
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	1 minute 8 min. Total	

Table G.2.18.6
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 G.2.18.7
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 G.2.18.8
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 G.2.18.9
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 G.2.18.10
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 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.	0.02 0.032 0.06 0.138 Total Median HEP = 0.06 Total Mean HEP = 0.138	(5) (10)	The error factor associated with the dominant HEP was assigned.

Table G.2.19.1
HEP 19 Calculation

Human Action Event (1)	XTIEB
Event Tree(s) (2)	SDC, ADH, TIA5H, TIAF16, TIAF40, TIAF93,
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93
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 G.2.19.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.19.3
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 G.2.19.4
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 perform the cross-tie.	60 minutes	0	60 Minutes	SEA Calculation C90-492-01-A16

Table G.2.19.5
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. Perform the DG 3 to train 2 cross-tie	Outside CR		30 minutes	30 minutes	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. Adding the new loads from the control room was determined to require approximately 5 minutes. Travel and performance times are grouped under the performance time column.
2. Add new loads	CR	--	5 minutes	5 minutes	

Table G.2.19.6
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 G.2.19.7
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 G.2.19.8
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)
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 G.2.19.9
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)
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 G.2.19.10
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. 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	0.004 0.01 0.028 0.073 Total Median HEP = 0.028 Total Mean HEP = 0.073	(5) (10)	Since both the diagnosis and action HEPs made significant contributions to the total HEP, the larger of the error factors was assigned.

Table G.2.20.1
HEP 20 Calculation

Human Action Event (1)	OPSDC (3)
Event Tree(s) (2)	SDC, ADH, TIA5H, TIAF16, TIAF40, TIAF93, E1B5H, E2B5H, E2BF20, E1D5H, E2D5H, E2DF93, T5D5H, S3-5, S3H-5, E2V5H, E2T5H
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93, T5D5H, E1B5H, E2B5H, E2BF20, E1D5H, E2D5H, E2DF93, E1T5H, E1V5H, S3-5, S3H-5, E2V5H, E2T5H, TIOF5, TIHP5, TIOP5, TIOPF65, 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)	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. 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.
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 G.2.20.10
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)
OPSDC in this case consists only of a diagnosis. See Table G.2.20-1, for the rationale for the assignment of a mean HEP value of 0.6.	Mean = 0.6	–	Mean = 0.6		

Table G.2.23.1
HEP 23 Calculation

Human Action Event (1)	OPLEC, 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 OPLEC, e.g., OPLECRAP.E1D
Event Description (5)	OPLEC 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)	For the scenarios for which HEP 23 applies, OPLEC is completely dependent on OPDHR. OPDHR is the operator action to control level and OPLEC had to occur in the same time period as OPDHR (10 minutes). If CDS was unavailable and OPDHR succeeded, then OPLEC succeeded (OPLEC 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 OPLEC was set to fail (1.0). Credit was not taken in OPDHR-OPLEC 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. If OPLEC 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 OPLEC in the sense that if OPLEC 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.
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 G.2.23.10
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)
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 G.2.25.1
HEP 25 Calculation

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)	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. 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). 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.
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).

Table G.2.25.2
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 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 G.2.25.3
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 G.2.25.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{sw}) (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 G.2.25.5
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)
1. Jumpering relays and opening valves to vent. Note. In scenarios where a LOCA signal has occured, IA would have to be restored. It was assumed that if the operators decided to vent in these scenarios, they would restore IA if neccessary. More than adequate time would be available.	Main and upper control rooms.	--	--	Travel and performance time was conservatively estimated to be approximately one hour (power is available). 1 hour	
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). 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	In worse case, actions could be required outside CR	--	4 hours	4 hours 5 hours total action time	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 G.2.25.6
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 G.2.25.7
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 G.2.25.8
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 G.2.25.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_m <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)
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 G.2.25.10
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. = 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	0.004 0.01 0.004 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 HEPs was assigned.

Table G.2.26.1
HEP 26 Calculation

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.E1T, 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)

Table G.2.26.2
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 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 G.2.26.3
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 G.2.26.4
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_e) (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 G.2.26.5
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 very conservatively estimated to be approximately 4 hours. This would be a "worst case" scenario. Total action time = 4 hours	

Table G.2.26.6
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 G.2.26.7
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 G.2.26.8
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 G.2.26.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_E < 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)
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 G.2.26.10
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. 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	0.004 0.0104 0.004 0.0106 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 G.2.27.1
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)	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. 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.
Applicable Procedures (7)	EP-3 (Containment Control), SPMU EOI (04-1-01-E30-1)

Table G.2.27.6
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 G.2.27.7
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.			Med. = 0 Mean = 0 If OPSPM or SPMUN succeed, then the diagnosis part of SPMKP or SPMKN will also succeed.	

Table G.2.27.8
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 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 G.2.27.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	$T_m < 2h$ 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)
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 G.2.27.10
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 Mean = 0	--	Med. 0 Mean 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 mat not be sufficient time to correct any errors since many of the activities may have taken place outside the control room.	0.02 0.032 0.02 0.032 Total Median HEP = 0.02 Total Mean HEP = 0.032	(5) (5)	The error factor associated with the dominant HEP (only HEP in this case) was assigned.

Table G.2.28.1
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 G.2.28.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.28.3
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	- 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 G.2.28.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{ol}) (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	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table G.2.28.5
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	1 minute 8 min. Total	

Table G.2.28.6
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 G.2.28.7
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 G.2.28.8
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 G.2.28.9
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]	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 G.2.28.10
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 flooding with SSWXT.	Med. = 0.02 Mean = 0.032	Credit for a second check was not given because of the time limitations.	0.02 0.032 0.06 0.138 Total Median HEP = 0.06 Total Mean HEP = 0.138	(5) (10)	The error factor associated with the dominant HEP was assigned.

Table G.2.29.1
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 G.2.29.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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.	0	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.	BWRs basically operate by steaming. Thus, it is not an "unusual" response to the problem. 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.

Table G.2.29.3
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 G.2.29.4
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.	23 minutes	0	23 minutes	SEA Calculation C90-492-029-A16

Table G.2.29.5
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 G.2.29.6
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 G.2.29.7
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 G.2.29.8
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 G.2.29.3 for rationale).

Table G.2.29.9
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)
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 G.2.29.3 for rationale).

Table G.2.29.10
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)
Decide to [illegible]am the vessel.	Diagnosis and Actions: Median = 0.04 Mean = 0.106	N/A	Median = 0.04 Mean = 0.106	10	

Table G.2.30.1
HEP 30 Calculation

Human Action Event (1)	OPSOF (2)
Event Tree(s) (2)	OF, OFP
Initiators (3)	All transients, H1-5H, J2-5, J2F48
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 G.2.30.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.30.3
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 G.2.30.4
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)
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 G.2.30.5
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	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 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.

Table G.2.30.6
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 G.2.30.7
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 G.2.30.8
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 G.2.30.9
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)
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 G.2.30.10
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. = 0.015 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> 0.019 0.05 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 G.2.33.1
HEP 33 Calculation

Human Action Event (1)	OPFLD (2)
Event Tree(s) (2)	F, FX, FAX, FNP
Initiators (3)	TIAF93, TIAF40, T1-5, TDB5H, T5A5H, T5AF19, E1B5H, E2B5H, E2BF20
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 an 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 G.2.33.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{cr}) (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 G.2.35.1
HEP 35 Calculation

Human Action Event (1)	OPDHR (2)
Event Tree(s) (2)	L, LA
Initiators (3)	T5D5H, E1B5H, E1D5H, E2D5H, E2DF93, 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 G.2.35.2
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 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 G.2.35.3
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 G.2.35.4
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 G.2.35.5
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 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 G.2.35.6
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 G.2.35.7
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 G.2.35.8
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 G.2.35.9
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 ex[illegible]y high stress. Each human action event was examined as a function of the context.

Table G.2.35.10
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. = 0.2 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 G.2.40.1
HEP 40 Calculation

Human Action Event (1)	OP1SV (7)
Event Tree(s) (2)	E, EA
Initiators (3)	T5D5H, E1D5H, E2D5H, E2DF93
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 G.2.40.2
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 G.2.40.3
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	A. Realize the need and isolate RWCU to stop letdown. B. Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation 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 G.2.40.4
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 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 G.2.40.5
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	1 minute 9 minutes (approx.) Total time for all actions.	

Table G.2.40.6
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 G.2.40.7
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.		Median = 0.08 (EF= 10) Mean = 0.213 Note. Apparently an error was made in reading Figure 8-1 in determining the median HEP for 14 minutes. Appproximately 0.05 would be a better "reading" of the median value from Figure 1. Thus, the HEP for the diagnosis may be slightly conservative.	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 G.2.40.8
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 G.2.40.9
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)
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 G.2.40.10
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 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).	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	(5)	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.
B. OPECS actions - ensure 1 SRV open - check closed MSIVs	Median = 0.02 Mean = 0.032		Med. Mean 0.02 0.032	(5)	
C. Initiate LPCI(C), (B), or HPCS	Median = 0.02 Mean = 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	<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 G.2.41.1
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 G.2.41.10
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 G.2.42.1
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 G.2.42.2
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 G.2.42.3
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	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 G.2.42.4
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 G.2.42.5
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	--	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 G.2.42.6
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 G.2.42.7
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 HRAP Table 8-3, the upper bound value from ASEP HRAP 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 HRAP Table 8-3, the upper bound diagnosis value was assigned.

Table G.2.42.8
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 G.2.42.9
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 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 G.2.42.10
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 = 0.002 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 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 G.2.49.1
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 HRAP 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 G.2.49.10
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)
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 G.2.50.1
HEP 50 Calculation

Human Action Event (1)	OPECS (14)
Event Tree(s) (2)	E, EA, EP, EAP
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93, 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 is 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 G.2.50.2
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. 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 G.2.50.3
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 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 G.2.50.4
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.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table G.2.50.5
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	1 minute 3 minutes (approx.) Total time for all actions.	Note. ADHR is isolated by procedure in attempting to align SDC(B) in OPSDC.

Table G.2.50.6
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 G.2.50.7
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 G.2.50.8
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 G.2.50.9
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 G.2.50.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{cr}) (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 soild 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 0.02 0.032 0.03 0.059 Total median HEP = 0.03 Total mean HEP = 0.059	(5) (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 G.2.51.1
HEP 51 Calculation

Human Action Event (1)	OP1SV (9)
Event Tree(s) (2)	E, EA, EP, EAP
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93, 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 G.2.51.2
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 G.2.51.3
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 G.2.51.4
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 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 G.2.51.5
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)	1 minute 8 min. Total action time	

Table G.2.51.6
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 G.2.51.7
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 G.2.51.8
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 G.2.51.9
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)
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 G.2.51.10
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. = 0.03 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.	0.02 0.032 0.05 0.112 Total Median HEP = 0.05 Total Mean HEP = 0.112	(5) (10)	Since both HEPs contribute to the total HEP, the largest of the two EFs was assigned.

Table G.2.52.1
HEP 52 Calculation

Human Action Event (1)	SDCUI (1)
Event Tree(s) (2)	ADEP, ADEPP, ADEPS
Initiators (3)	T1-5, TRPT5, TIOP5, TIOPF65, 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 G.2.52.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
RWCU or forced recirculation is lost during a HYDRO test. Depressuriztion 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 G.2.52.3
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 the these scenarios is SDC (RHR/SDC or ADHR).	One	Align an initiate an SDC system.	Alignment of SDC is a frequently performed action during LP&S conditions. It is proceduralized.

Table G.2.52.4
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)
Align and initiate an SDC system.	8.7 hours	0	8.7 hours	SEA Calculation C90-492-052-A16

Table G.2.52.5
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)
Align (unisolate) and start SDC system.	Control Room	--	5 minutes	5 minutes	

Table G.2.52.6
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 G.2.52.7
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 depressuriztion occurs.

Table G.2.52.8
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 G.2.52.9
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)
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 G.2.52.10
Total HEP

Action (1)	Original Operator HEP (HEP_{o}) (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	0.0008 0.0033 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.

1

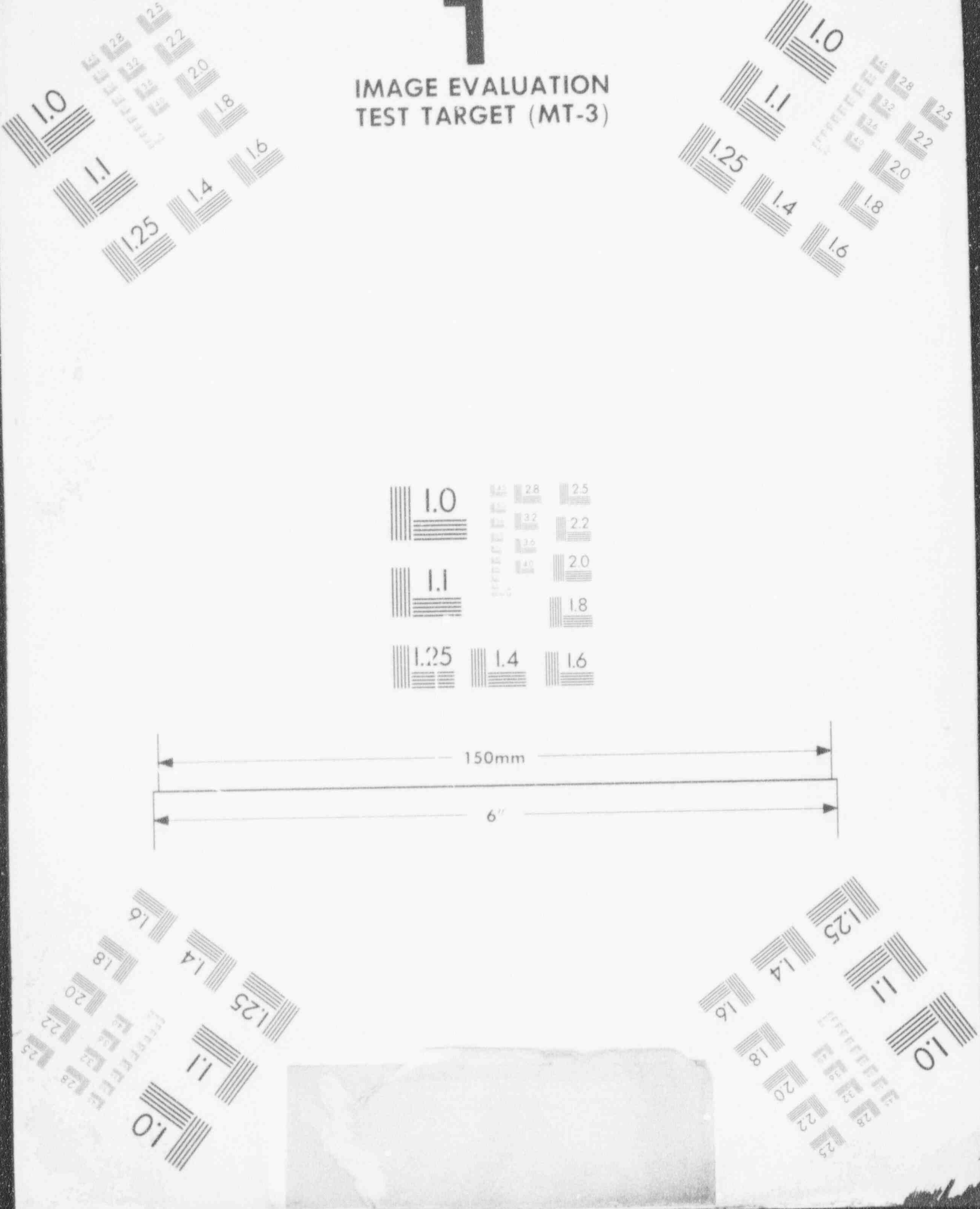
IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)



1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

Table G.2.56.1
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 G.2.56.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.56.3
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 G.2.56.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{sw}) (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 G.2.56.5
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 G.2.56.6
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 G.2.56.7
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 G.2.56.8
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 G.2.56.9
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 G.2.56.10
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	8.0E-4 3.3E-3 8.3E-4 3.6E-3 Total Median HEP = 8.3E-4 Total Mean HEP = 3.6E-3	(5) (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 G.2.57.1
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)	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). 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).
Applicable Procedures (7)	EP-2 (RPV Control), Inadequate Decay Heat Removal ONEP (05-57-02-III-1)

Table G.2.57.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.57.3
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 G.2.57.4
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)
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 G.2.57.5
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)
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 G.2.57.6
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 G.2.57.7
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 G.2.57.8
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 G.2.57.9
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)
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 G.2.57.10
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	0.004 0.01 0.024 0.063 Total median HEP = 0.024 Total mean HEP = 0.063	(5) (10)	Second check HEPs are multiplied by the original HEP for each action. The error factor associated with the dominant HEP was assigned.

Table G.2.58.1
HEP 58 Calculation

Human Action Event (1)	OPDHR (3)
Event Tree(s) (2)	L, LP,
Initiators (3)	RWC74, RWC26, T1-5, T5D5H, TLM5H, TRPT5, TIOP5, TIOPF65, 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, OPDHRLAP.E1V, OPDHR.TLM, OPDHR.TRP, OPDHR.TIH, OPDHROP.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 G.2.58.2
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 G.2.58.1, 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 G.2.58.3
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 G.2.58.4
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 G.2.58.5
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 G.2.58.6
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 G.2.58.7
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 G.2.58.8
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 G.2.58.9
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 G.2.58.10
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. = 0.01 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.	0.05 0.081 0.06 0.108 Total Median HEP = 0.06 Total Mean HEP = 0.108	(5) (10)	Since both HEPs contribute to the total HEP, the larger error factor was assigned.

Table G.2.71.1
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 G.2.71.10
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)
Close an open containment.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table G.2.73.1
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

Table G.2.73.10
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)
Sequences with OPCMT, OPSTL, and OPICT in trees with OPCMT did not be analyzed.	Not analyzed	N/A	Not analyzed		

Table G.2.77.1
HEP 77 Calculation

Human Action Event (1)	OPDHR (4)
Event Tree(s) (2)	L, LA, LP,
Initiators (3)	TIOP5, TIOPF65
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 G.2.77.2
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.	0	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 G.2.77.3
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 G.2.77.4
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_a) (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 G.2.77.5
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 G.2.77.6
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 G.2.77.7
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 G.2.77.8
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 G.2.77.9
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 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 G.2.77.10
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. = 0.015 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.	0.05 0.081 0.065 0.12 Total Median HEP = 0.065 Total Mean HEP = 0.12	(5) (10)	Since both HEPs contribute to the total HEP, the larger error factor was assigned.

Table G.2.78.1
HEP 78 Calculation

Human Action Event (1)	OPECS (18)
Event Tree(s) (2)	EA
Initiators (3)	TIOP5, TIOPF65, TLM5H, TRPT5
Sequence Locator Files (4) -	OPECSAD5.TIO, OPECSAD5.TLM, OPECSAD5.TRP
Description (5)	OPECS is 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 (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. 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).
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 G.2.78.2
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 G.2.78.3
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	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 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.	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 G.2.78.4
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.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table G.2.78.5
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	1 minute 8 min. Total	

Table G.2.78.6
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 G.2.78.7
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 G.2.78.8

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 G.2.78.9

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 G.2.78.10
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 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.	0.02 0.032 0.06 0.138 Total Median HEP = 0.06 Total Mean HEP = 0.138	(5) (10)	The error factor associated with the dominant HEP was assigned.

Table G.2.79.1
HEP 79 Calculation

Human Action Event (1)	OPECS (19)
Event Tree(s) (2)	E, EA
Initiators (3)	TIOP5, TIOPF65, E1T5H
Sequence Locator Files (4)	OPECSP.TIO, OPECSP.E1T
Event Description (5)	OPECS is 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 G.2.79.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T₀) 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 G.2.79.3
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	1. Stop makeup (CRD). 2. 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 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 G.2.79.4
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.	23 minutes	0	23 Minutes	SEA Calculation C90-492-01-A16

Table G.2.79.5
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	1 minute 4 minutes (approx.) Total time for all actions.	

Table G.2.79.6
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 G.2.79.7
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 G.2.79.8
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 G.2.79.9
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 G.2.79.10
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 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) <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 G.2.80.1
HEP 80 Calculation

Human Action Event (1)	OP1SV (14)
Event Tree(s) (2)	E, EA
Initiators (3)	TIOP5, TIOPF65, 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 G.2.80.2
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 G.2.80.3
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	1. Stop makeup (CRD). 2. Per IDHR ONEP (Step 5.1.3c) initiate ECCS water solid operation 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 G.2.80.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{sd}) (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 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.

Table G.2.80.5
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	1 minute 9 minutes (spprox.) Total time for all actions.	

Table G.2.80.6
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 G.2.80.7
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 G.2.80.8
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 G.2.80.9
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 G.2.80.10
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. = 0.035 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 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> 0.043 0.11 Total median HEP = 0.043 Total mean HEP = 0.11	(5) <u>(5)</u> (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 G.2.81.1
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, E2BF20, 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 G.2.81.10
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)
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 G.2.82.1
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 G.2.82.10
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)
Open MSIVs for steaming.	Med. = 1.0 Mean = 1.0	--	Med. = 1.0 Mean = 1.0		

Table G.2.85.1
HEP 85 Calculation

Human Action Event (1)	LCMK (2)
Event Tree(s) (2)	L, LA, LP, LAP
Initiators (3)	RWC74, RWC26, T1-5, TLM5H, TIOP5, TIOPF65, 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 G.2.85.10
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)
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 G.2.87.1
HEP 87 Calculation

Human Action Event (1)	OPDHR (5)
Event Tree(s) (2)	L, LA, LP,
Initiators (3)	TIOP5, TIOPF65, 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 G.2.87.2
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 G.2.87.1, 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 G.2.87.3
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 G.2.87.4
Time Available to Diagnose and i'erform 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 increase level to avoid inadequate core cooling.	115 minutes	0	115 Minutes	SEA Calculation C90-492-01-A16

Table G.2.87.5
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, Sιep 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 G.2.87.6
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 G.2.87.7
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 G.2.87.8
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 G.2.87.9
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 G.2.87.10
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	0.004 0.01 0.006 0.015 Total Median HEP = 0.006 Total Mean HEP = 0.015	(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 G.2.90.1
HEP 90 Calculation

Human Action Event (1)	OPMSV (4)
Event Tree(s) (2)	F
Initiators (3)	RWC74, RWC26, 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 G.2.90.2
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 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 G.2.90.3
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 G.2.90.4
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_s) (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 G.2.90.5
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 G.2.90.6
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 G.2.90.7
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 G.2.90.8
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 G.2.90.9
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)
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 G.2.90.10
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	0.004 0.01 0.006 0.014 Total Median HEP = 0.006 Total Mean HEP = 0.01	(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 G.2.101.1
HEP 101 Calculation

Human Action Event (1)	OPECS (5)
Event Tree(s) (2)	EX
Initiators (3)	T1-5, TIA5H, TIAF16, TIAF40, TIAF93
Sequence Locator Files (4)	OPCADH14.EAX, OPCSDC13.EX, OPCADH14.TIA, OPSDC13.TIA
Event Description (5)	OPECS is 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 likeiihood 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 therfore were not included.

Table G.2.101.10
Total HEP

Action (1)	Original Operator HEP (HEP_{op}) (2)	Independent Check/Correction HEP (HEP_{cr}) (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 failure 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 G.2.102.1
HEP 102 Calculation

Human Action Event (1)	OPECS (6)
Event Tree(s) (2)	HPSWA
Initiators (3)	T1-5, TAB5H, TAB39, TIA5H, TIAF16, TIAF40, TIAF93
Sequence Locator Files (4)	OPECS&.HPA, OPECAD10.TAB, OPCADH26.TIA
Event Description (5)	OPECS is 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 G.2.102.2
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. 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 G.2.102.3
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 G.2.102.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_m) (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 G.2.102.5
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 perfromance 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 availble injection system.	CR	--	1 minute (Table 8-1, Step 5b)	1 minute 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 G.2.102.6
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 G.2.102.7
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 G.2.102.8
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 G.2.102.9
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						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 G.2.102.10
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. = 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 G.2.105.1
HEP 105 Calculation

Human Action Event (1)	OP1SV (4)
Event Tree(s) (2)	EA, EAP
Initiators (3)	TAB5H, TAB39, TDB5H, T5A5H, T5AF19, E1D5H, E2D5H, E2DF93
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 G.2.105.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.105.3
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	1. Isolate ADHR from the control room (if necessary) by closing 8 or 9 valve. 2. Per IDHR ONEP (Step 5.1.3c) - 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.	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. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table G.2.105.5
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.	1 minute 8 min. Total action time	

Table G.2.105.6
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 G.2.105.7
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 G.2.105.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.105.3
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	1. Isolate ADHR from the control room (if necessary) by closing 8 or 9 valve. 2. Per IDHR ONEP (Step 5.1.3c) - 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.	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. HPCS is initiated from 04-1-01-E22-1, Step 5.2.

Table G.2.105.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{sw}) (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 G.2.105.5
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.	1 minute 8 min. Total action time	

Table G.2.105.6
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 G.2.105.7
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 G.2.105.8
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 G.2.105.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_m < 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)
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 G.2.105.10
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. = 0.03 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.	0.02 0.032 0.05 0.112 Total Median HEP = 0.05 Total Mean HEP = 0.112	(5) (10)	Since both HEPs contribute to the total HEP, the largest of the two EFs was assigned.

Table G.2.106.1
HEP 106 Calculation

Human Action Event (1)	OP1SV (5)
Event Tree(s) (2)	E, EP
Initiators (3)	RWC74, RWC26, T1-5, TIA5H, TIAF16, TIAF40, TIAF93, TDB5H, T5A5H, T5AF19, T5D5H, E1B5H, E2B5H, E2BF20, 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 G.2.106.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Deciding to proceed with ECCS water solid operation when only 1 SRV is available. Some form of SDC is needed.	0	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 G.2.106.3
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) - 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 G.2.106.4
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 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 G.2.106.5
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	1 minute 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 G.2.106.6
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 G.2.106.7
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 G.2.106.8
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 G.2.106.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

Action (1)	T_E < 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)
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 G.2.106.10
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, 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.	0.02 0.032 0.12 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	(5) (10)	The EF from the dominant HEP was assigned.

Table G.2.108.1
HEP 108 Calculation

Human Action Event (1)	OP1SV (13)
Event Tree(s) (2)	E, EP
Initiators (3)	TIOP5, TIOPF65, 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 G.2.108.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.108.3
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	1. Isolate ADHR from the control room by closing 8 or 9 valve. 2. Per IDHR ONEP (Step 5.1.3c) - 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.	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 G.2.108.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{sd}) (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 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.

Table G.2.108.5
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	1 minute 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 G.2.108.6
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 G.2.108.7
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 G.2.108.8
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 G.2.108.9
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 G.2.108.10
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 additional concerns which might be facing operators as a function of the specific initiators.	0.02 0.032 0.05 0.302 Total Median HEP = 0.12 Total Mean HEP = 0.302	(5) (10)	The EF from the dominant HEP was assigned.

Table G.2.116.1
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 G.2.116.2
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 G.2.116.3
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	- Unisolate IA if necessary - Initiate two pump CRD injection.	

Table G.2.116.4
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)
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 G.2.116.5
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	1 minute 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 G.2.116.6
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 G.2.116.7
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 G.2.116.8
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 G.2.116.9
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)
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 G.2.116.10
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 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		0.02 0.032 0.04 0.065 Total Median HEP = 0.04 Total Mean HEP = 0.065	(5) (5)	The error factor associated with the dominant HEPs was assigned.

Table G.2.117.1
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 not 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 G.2.117.2
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 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 G.2.117.3
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 G.2.117.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{sw}) (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 G.2.117.5
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	1 minute 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 G.2.117.6
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 G.2.117.7
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 HRAP Table 8-3, the median value from ASEP Figure 8-1 for 96 minutes diagnosis time was assigned.		Median = 1.0E-4 EF = 30 Mean = 9.0E-4 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.	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 G.2.117.8
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 G.2.117.9
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 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 G.2.117.10
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 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	0.0008 0.0033 0.0009 0.0042 Total Median HEP = 0.0009 Total Mean HEP = 0.0042	(5) (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 G.2.118.1
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)	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. 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.
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 G.2.118.2
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 G.2.118.3
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	- Unisolate IA if necessary - Initiate two pump CRD injection.	

Table G.2.118.4
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)
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 G.2.118.5
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	1 minute 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 G.2.118.6
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 G.2.118.7
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 G.2.118.8
Post-Diagnosis Action Type Identificationper 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 G.2.118.9
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)
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 G.2.118.10
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 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 G.2.119.1
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)	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. Note. If the environment in containment permitted it, they operators would also want to close the lower personnel lock into the drywell.
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19)

Table G.2.119.2
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 G.2.119.3
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 G.2.119.4
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_a) (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 G.2.119.5
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 G.2.119.6
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 G.2.119.7
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.		Median = 0.01 EF = 10 Mean = 0.027	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 G.2.119.8
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 G.2.119.9
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)
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 G.2.119.10
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 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.	0.02 0.032 0.05 0.09 Total Median HEP = 0.05 Total Mean HEP = 0.09	(5) (10)	Since all HEPs made significant contributions to the total HEP, the larger error factor was assigned.

Table G.2.120.1
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)	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. Note. If the environment in containment permitted it, they operators would also want to close the lower personnel lock into the drywell.
Applicable Procedures (4)	EP-2 (RPV Control, Rev. 19)

Table G.2.120.2
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 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 G.2.120.3
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 G.2.120.4
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)
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 G.2.120.5
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 G.2.120.6
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 G.2.120.7
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 G.2.120.8
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 G.2.120.9
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)
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 G.2.120.10
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 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.	0.02 0.032 0.041 0.067 Total Median HEP = 0.041 Total Mean HEP = 0.067	(5) (5)	The error factor from the dominant HEP was assigned.

Table G.2.121.1
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 G.2.121.2
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 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 G.2.121.3
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 G.2.121.4
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_a) (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 G.2.121.5
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 G.2.121.6
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 G.2.121.7
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 G.2.121.8
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 G.2.121.9
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 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 G.2.121.10
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 check was not given in this instance (see Column 6 for rationale).	0.02 0.032 0.02 0.032 Total Median HEP = 0.02 Total Mean HEP = 0.032	(5) (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 G.2.122.1
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 G.2.122.2
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 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 G.2.122.3
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 G.2.122.4
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)
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 G.2.122.5
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 G.2.122.6
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 G.2.122.7
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 G.2.122.8
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 G.2.122.9
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 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 G.2.122.10
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	0.0008 0.0033 0.0009 0.0042 Total Median HEP = 0.0009 Total Mean HEP = 0.0042	(5) (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 G.2.123.1
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 G.2.123.2
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 G.2.123.3
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	Per EP-2, Attachment 26: 1. As many as 10 different hose connections must be made in the Auxiliary Building for complete 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 G.2.123.4
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)
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 G.2.123.5
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 G.2.123.3 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 G.2.123.6
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 G.2.123.7
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 G.2.123.8
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 G.2.123.3 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 G.2.123.9
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)
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 G.2.123.10
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 align and initiate FW to provide level for steaming.	Median = 0.003 Mean = 0.008	--	Med. Mean 0.003 0.008	(10)	
2. As many as 10 different hose connections must be made in the Auxiliary Building for complete 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.	0.004 0.0104 0.015 0.05 Total Median HEP = 0.015 Total Mean HEP = 0.05	(5) (5)	The error factor associated with the dominant HEPs was assigned.

Table G.2.124.1
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 am "immediate emergency action" per ASEP HRAP. 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 G.2.124.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
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 G.2.124.3
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 G.2.124.4
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_s) (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 G.2.124.5
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	1 minute 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 G.2.124.6
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 G.2.124.7
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 G.2.124.8
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 G.2.124.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

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)
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 G.2.124.10
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	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	0.001 0.0027 0.021 0.053 Total Median HEP = 0.021 Total Mean HEP = 0.053	(10) (10)	The error factors were the same for both HEPs.

Table G.2.125.1
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 G.2.125.2
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 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 G.2.125.3
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 G.2.125.4
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)
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 G.2.125.5
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 G.2.125.6
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 G.2.125.7
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 G.2.125.8
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 G.2.125.9
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)
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 G.2.125.10
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 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	0.0008 0.0033 0.01 0.03 Total Median HEP = 0.01 Total Mean HEP = 0.03	(5) (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 G.2.126.1
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

Table G.2.126.10
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 G.2.127.1
HEP 127 Calculation

Human Action Event (1)	OPDHR1 (1)
Event Tree(s) (2)	RWC26
Initiators (3)	RWC26
Sequence Locator Files (4)	OPDHR26.FLD
Event Description (5)	OPDHR1 is the operator action to diagnose and isolate a break in the RWCU line by closing RWCU isolation valves. In this event, to be successful the operators must isolate the break before level 3 is reached and SDC auto-isolates.
Event Context (6)	For the OPDHR1 (1) calculation (HEP 127), the initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR is this case the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. A level 4 alarm will sound within 4 minutes after the break. It was assumed that the level 4 alarm and the continued decrease in level would indicate to the operators that letdown should be isolated. This was assumed to be the case even if they are not yet aware of a break or where it is located. That is, a substantial loss of level should indicate a need to stop letdown in any way possible Isolating RWCU is an obvious place to start. If OPDHR1 fails, SDC will auto-isolate on level 3. Numerous alarms and indications will alert the operators to the loss of SDC.
Applicable Procedures (7)	No specific procedures, but the rapid loss of level and associated alarms will indicate the need to stop letdown.

Table G.2.127.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Break in RWCU line, resulting in a need to isolate the break before level 3 is reached and SDC auto-isolates.	4 minutes	A level 4 alarm will sound within 4 minutes after the break. It was assumed that the level 4 alarm and the continued decrease in level would indicate to the operators that letdown should be isolated. This was assumed to be the case even if they are not yet aware of a break or where it is located. That is, a substantial loss of level should indicate a need to stop letdown in any way possible. Isolating RWCU is an obvious place to start. If OPDHR1 fails, SDC will auto-isolate on level 3. Numerous alarms and indications will alert the operators to the loss of SDC	

Table G.2.127.3
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)
Break in RWCU line, resulting in a need to isolate the break before level 3 is reached and SDC auto-isolates.	One	The operators need to close the 1 or the 4 valve.	Since RWCU is the normal means of letdown during LP&S, the operators will be familiar with how to isolate the system (i.e., stop draindown).

Table G.2.127.4
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 isolate RWCU prior to vessel water level reaching level 3.	27.3 minutes	4 minutes	Approx. 23 minutes	SEA Calculation C90-492-01-A16

Table G.2.127.5
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)
Isolate RWCU, by closing 1 or 4 valve.	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.

Table G.2.127.6
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 in response to a loss of level from a break in the RWCU line and a level 4 signal.	23 minutes	1 minute	22 minutes	

Table G.2.127.7
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 in response to loss of level.	Per ASEP Table 8-3, the median value from Figure 8-1 for 22 minutes diagnosis time was assigned.		Med. = 0.005 Mean = 0.01	The site interviews indicated that (obviously) the operators are aware of the need for SDC during LP&S. They would also (obviously) be concerned about a dramatic loss of level and would certainly want to isolate the break to prevent isolation of SDC. Even if they were unaware of the break location, isolation of RWCU would be a natural response to a loss of level.

Table G.2.127.8
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)
Isolate RWCU.	N/A	Interviews indicated that the operators would be knowledgeable about the need for the actions.	No	Step-by-step. The operators would know how to close the relevant valves from the control room.	

Table G.2.127.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

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)
Isolate RWCU before vessel water level 3 is reached.	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 G.2.127.10
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. = 0.005 Mean = 0.01	--	Med. Mean 0.005 0.01	(10)	
2. Isolate RWCU by closing 1 or 4 valve.	Med. = 0.02 Mean = 0.032	Credit for a second check was taken because of the immediate feedback from continued loss of level. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01 0.009 0.02 Total Median HEP = 0.009 Total Mean HEP = 0.02	(5) (10)	Second check HEPs are multiplied by the original HEP for each action. Since all the HEPs make significant contributions to the total HEP, the larger error factor was assigned.

Table G.2.128.1
HEP 128 Calculation

Human Action Event (1)	OPDHR1 (2)
Event Tree(s) (2)	RWC74
Initiators (3)	RWC74
Sequence Locator Files (4)	OPDHR74.FLD
Event Description (5)	OPDHR1 is the operator action to diagnose and isolate a break in the RWCU line by closing RWCU isolation valves. In this event, to be successful the operators must isolate the break before level 3 is reached and SDC auto-isolates. Note: This event is identical to OPDHR1 (1), HEP 127, except that the amount of time available to respond is different because of the location and size of the break in the RWCU line.
Event Context (6)	For the OPDHR1 (2) calculation (HEP 128), the initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR is this case the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. A level 4 alarm will sound within 4 minutes after the break. It was assumed that the level 4 alarm and the continued decrease in level would indicate to the operators that letdown should be isolated. This was assumed to be the case even if they are not yet aware of a break or where it is located. That is, a substantial loss of level should indicate a need to stop letdown in any way possible. Isolating RWCU is an obvious place to start. If OPDHR1 fails, SDC will auto-isolate on level 3. Numerous alarms and indications will alert the operators to the loss of SDC.
Applicable Procedures (7)	No specific procedures, but the rapid loss of level and associated alarms will indicate the need to stop letdown.

Table G.2.128.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Break in RWCU line, resulting in a need to isolate the break before level 3 is reached and SDC auto-isolates.	4 minutes	A level 4 alarm will sound within 4 minutes after the break. It was assumed that the level 4 alarm and the continued decrease in level would indicate to the operators that letdown should be isolated. This was assumed to be the case even if they are not yet aware of a break or where it is located. That is, a substantial loss of level should indicate a need to stop letdown in any way possible. Isolating RWCU is an obvious place to start. If OPDHR1 fails, SDC will auto-isolate on level 3. Numerous alarms and indications will alert the operators to the loss of SDC	

Table G.2.128.3
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)
Break in RWCU line, resulting in a need to isolate the break before level 3 is reached and SDC auto-isolates.	One	The operators need to close the 1 or the 4 valve.	Since RWCU is the normal means of letdown during LP&S, the operators will be familiar with how to isolate the system (i.e., stop draindown).

Table G.2.128.4
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 isolate RWCU prior to vessel water level reaching level 3.	13.3 minutes	4 minutes	Approx. 9 minutes	SEA Calculation C90-492-01-A16

Table G.2.128.5
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)
Isolate RWCU, by closing 1 or 4 valve.	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.

Table G.2.128.6
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)
The operators need to diagnose the need to isolate RWCU in response to a loss of level from a break in the RWCU line and a level 4 signal.	9 minutes	1 minute	8 minutes	

Table G.2.128.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to isolate RWCU in response to loss of level.	Per ASEP Table 8-3, the median value from Figure 8-1 for 8 minutes diagnosis time was assigned.		Med. = 0.15 Mean = 0.4	The site interviews indicated that (obviously) the operators are aware of the need for SDC during LP&S. They would also (obviously) be concerned about a dramatic loss of level and would certainly want to isolate the break to prevent isolation of SDC. Even if they were unaware of the break location, isolation of RWCU would be a natural response to a loss of level.

Table G.2.128.8
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)
Isolate RWCU.	N/A	Interviews indicated that the operators would be knowledgeable about the need for the actions.	No	Step-by-step. The operators would know how to close the relevant valves from the control room.	

Table G.2.128.9
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)
Isolate RWCU before vessel water level 3 is reached.	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 G.2.128.10
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. = 0.15 Mean = 0.4	--	Med. Mean 0.15 0.4	(10)	
2. Isolate RWCU by closing 1 or 4 valve.	Med. = 0.02 Mean = 0.032	Credit for a second check was taken because of the immediate feedback from continued loss of level. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01 0.154 0.41 Total Median HEP = 0.154 Total Mean HEP = 0.41	(5) (10)	Second check HEPs are multiplied by the original HEP for each action. The EF from the dominant HEP was assigned.

Table G.2.129.1
HEP 129 Calculation

Human Action Event (1)	OPLEC (1)
Event Tree(s) (2)	RRW
Initiators (3)	RWC26
Sequence Locator Files (4)	OPLEC26.FLD
Event Description (5)	OPLEC is the operator action to provide makeup with an ECCS system in order to bring level back-up to where it should be after the operators have isolated a break in the RWCU line.
Event Context (6)	For the OPLEC (1) calculation (HEP 129), the initiator is a break in the RWCU line. The operators have detected the loss of level and isolated RWCU before level 3 was reached (OPDHR1 succeeded). It was assumed that a level 4 alarm occurred within 4 minutes after the break. The decision and action to return level to normal must occur in the same time period as the OPDHR1 operator event.
Applicable Procedures (7)	No specific procedures, but with the loss of level, the operators would want to return level to the normal point for LP&S conditions (approximately 36 inches from instrument zero, which is above level 4).

Table G.2.129.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Break in RWCU line has been isolated and the operators need to restore level.	4 minutes	A level 4 alarm will sound within 4 minutes after the break. It was assumed that the level 4 alarm occurred before the operators isolated RWCU. Since the operators have recognized the loss of level and isolated letdown, the need to restore level should be apparent.	

Table G.2.129.3
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)
Break in RWCU line which has been isolated by the control room. Operators need to restore level.	One	The operators need to "bump" level up with an ECCS system. LPCI is assumed to be the system of choice.	Operators are aware of the need to maintain level at a assigned point during LP&S.

Table G.2.129.4
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_a) (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 restore level. They have isolated the break.	27.3 minutes	4 minutes	Approx. 23 minutes	SEA Calculation C90-492-01-A16

Table G.2.129.5
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)
Isolation of RWCU must occur in the same time period. Thus, the action time will be subtracted from the total available time.	CR		1 minute (see OPDHR1, HEP 127)	1 minute	
Initiate LPCI or any ECCS system and restore level.	CR	--	2 minute	2 minute (1 minute assumed to decide which system to use after diagnosing the need, and 1 minute to carry-out the action. Total Action time = 3 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 G.2.129.6
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)
The operators need to diagnose the need to restore level and initiate LPCI or any ECCS system.	23 minutes	3 minute	20 minutes	

Table G.2.129.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Restore level with ECCS after isolation of break in RWCU line.	Per ASEP Table 8-3, the median value from Figure 8-1 for 20 minutes diagnosis time was assigned.		Med. = 0.01 Mean = 0.027	The site interviews indicated that (obviously) the operators are aware of the need for SDC during LP&S. They would also (obviously) be concerned about a dramatic loss of water level and would want to restore level to the normal place after a break had been isolated.

Table G.2.129.8
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)
Initiate LPCI	N/A	The necessary actions would be obvious.	No	Step-by-step. The operators know how to initiate LPCI.	

Table G.2.129.9
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 LPCI and bring vessel level up to LP&S normal.	N/A[1]	N/A	No[2]	N/A	Moderately High	Several systems available and substantial time before core damage. Break is isolated.

[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 G.2.129.10
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 LPCI and "bump" vessel level to normal.	Med. = 0.02 Mean = 0.032	Credit for a second check was taken because in this context the operators are aware of the loss of level and when using a system like LPCI, they would expect to see the level going up very soon. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01 0.014 0.037 Total Median HEP = 0.014 Total Mean HEP = 0.037	(5) (10)	Second check HEPs are multiplied by the original HEP for each action. Since all the HEPs make significant contributions to the total HEP, the larger error factor was assigned.

Table G.2.130.1
HEP 130 Calculation

Human Action Event (1)	OPLEC (2)
Event Tree(s) (2)	RRW
Initiators (3)	RWC74
Sequence Locator Files (4)	OPLEC74.FLD
Event Description (5)	OPLEC is the operator action to provide makeup with an ECCS system in order to bring level back-up to where it should be after the operators have isolated a break in the RWCU line.
Event Context (6)	For the OPLEC (2) calculation (HEP 130), the initiator is a break in the RWCU line. The operators have detected the loss of level and isolated RWCU before level 3 was reached (OPDHR1 succeeded). It was assumed that a level 4 alarm occurred within 4 minutes after the break. The decision and action to return level to normal must occur in the same time period as the OPDHR1 operator event. This event is identical to OPLEC (1), HEP 129, except that because of the size of the break, the time available to respond is less for HEP 130.
Applicable Procedures (7)	No specific procedures, but with the loss of level, the operators would want to return level to the normal point for LP&S conditions (approximately 36 inches from instrument zero, which is above level 4).

Table G.2.130.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Break in RWCU line has been isolated and the operators need to restore level.	4 minutes	A level 4 alarm will sound within 4 minutes after the break. It was assumed that the level 4 alarm occurred before the operators isolated RWCU. Since the operators have recognized the loss of level and isolated letdown, the need to restore level should be apparent.	

Table G.2.130.3
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)
Break in RWCU line which has been isolated by the control room. Operators need to restore level.	One	The operators need to "bump" level up with an ECCS system. LPCI is assumed to be the system of choice.	Operators are aware of the need to maintain level at a assigned point during LP&S.

Table G.2.130.4
Time Available to Diagnose and Perform the Task

Action (1)	Time by Which Operator Must Act (T_{sw}) (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 restore level. They have isolated the break.	13.3 minutes	4 minutes	Approx. 9 minutes	SEA Calculation C90-492-01-A16

Table G.2.130.5
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)
Isolation of RWCU must occur in the same time period. Thus, the action time will be subtracted from the total available time.	CR		1 minute (see OPDHR1, HEP 127)	1 minute	
Initiate LPCI or any ECCS system and restore level.	CR	--	2 minute	2 minute (1 minute assumed to decide which system to use after diagnosing the need, and 1 minute to carry-out the action. Total Action time = 3 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 G.2.130.6
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 restore level and initiate LPCI or any ECCS system.	9 minutes	3 minute	6 minutes	

Table G.2.130.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Restore level with ECCS after isolation of break in RWCU line.	Per ASEP Table 8-3, the median value from Figure 8-1 for 6 minutes diagnosis time was assigned.		Med. = 0.2 Mean = 0.53	The site interviews indicated that (obviously) the operators are aware of the need for SDC during LP&S. They would also (obviously) be concerned about a dramatic loss of water level and would want to restore level to the normal place after a break had been isolated. However, 6 minutes is not much time and they be attending to other concerns, e.g., the cause and nature of the break etc.

Table G.2.130.8
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 LPCI	N/A	The necessary actions would be obvious.	No	Step-by-step. The operators know how to initiate LPCI.	

Table G.2.130.9
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 LPCI and bring vessel level up to LP&S normal.	N/A[1]	N/A	No[2]	N/A	Moderately High	Several systems available and substantial time before core damage. Break is isolated.

[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 G.2.130.10
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. = 0.2 Mean = 0.53	–	Med. Mean 0.2 0.53	(10)	
2. Initiate LPCI and "bump" vessel level to normal.	Med. = 0.02 Mean = 0.032	Credit for a second check was taken because in this context the operators are aware of the loss of level and when using a system like LPCI, they would expect to see the level going up very soon. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01 0.204 0.54 Total Median HEP = 0.204 Total Mean HEP = 0.54	(5) (10)	Second check HEPs are multiplied by the original HEP for each action. The error factor from the dominant HEP was assigned.

Table G.2.131.1
HEP 131 Calculation

Human Action Event (1)	OPSDC1 (1)
Event Tree(s) (2)	RWCHI
Initiators (3)	RWC26, RWC74
Sequence Locator Files (4)	OPSDCH26.FLD, OPSDCH74.FLD
Event Description (5)	OPSDC1 is the operator action to diagnose the need for unisolating and starting SDC and opening an SRV if necessary.
Event Context (6)	For the OPSDC1 (1) calculation (HEP 131), the initiator is a break in the RWCU line during a HYDRO test. There is less than a minute before the vessel will drain down to level 2 and RWCU isolates (which also isolates the break). It is assumed that the operators will fail to stop the drain down before level 2 is reached in the less than 1 minute time frame. HPCS should auto-start on level 2, and in this scenario it either succeeds or fails. If HPCS successfully auto-starts and then auto-stops on level 8 (HPCAO), level will be restored and the operators will need to unisolate and start some form of SDC. IF HPCS fails to auto-start, but the operators successfully bring level up with LPCI (OPLEC1 succeeds), then SDC will also be needed. Thus, in both of the two scenarios, level is restored and OPSDC1 is asked. OPSDC1 is the operator action to diagnose the need for unisolating and starting SDC and opening an SRV if necessary. The operators may need to open an SRV if pressure is still high for the use of SDC (SDC(B) or ADHR).
Applicable Procedures (7)	The use of SDC during shutdown is specified in shutdown procedures and other shutdowm related procedures, e.g., in Refueling Integrated Operating Instruction, 03-1-01-5. Alignment of SDC is covered in the RHR SOI (04-1-01-E12-1).

Table G.2.131.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Vessel level has been restored after a loss of level due to a break in the RWCU line. Initiate of SDC is needed.	0	Level 4, 3, & 2 alarms would sound as level dropped and the auto-start of HPCS would be indicated. Increasing level would also be indicated and in the sequences where HPCS auto-isolates at level 8, additional alarms would occur. If the operators are bringing level-up, they would obviously be aware of the context. At this point the need for SDC should be obvious and the operators would check pressure levels and open an SRV if necessary.	

Table G.2.131.3
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)
Break in RWCU line during HYDRO test, which has been isolated by the control room. Level dropped, but at this point has been restored. Operators need to initiate SDC.	One	The operators need to align some normal means of SDC (SDC(B) or ADHR.	Operators are aware of the need and procedures cover how to align SDC.

Table G.2.131.4
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 initiate SDC after level has been restored after a break in the RWCU line. Open one SRV if necessary.	37 minutes	0	Approx. 37 minutes (conservative estimate)	SEA Calculation C90-492-01-A16

Table G.2.131.5
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)
Initiate some normal means of SDC (SDC(B) or ADHR) and open an SRV if necessary. Alignment can be accomplished from the CR.	CR	--	5 minutes	5 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 G.2.131.6
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 some normal means of SDC (SDC(B) or ADHR) and open an SRV if necessary.	37 minutes	5 minute	32 minutes	

Table G.2.131.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Level has been restored after a break in RWCU line during a HYDRO test Operators need to start SDC.	Per ASEP Table 8-3, the median value from Figure 8-1 for 32 minutes diagnosis time was assigned.		Med. = 0.001 Mean = 0.0027	The site interviews indicated that (obviously) the operators are aware of the need for SDC during LP&S.

Table G.2.131.8
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 SDC and open an SRV if necessary.	N/A	The necessary actions would be obvious and they are proceduralized.	No	Step-by-step.	

Table G.2.131.9
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 SDC and open an SRV if necessary	N/A[1]	N/A	No[2]	N/A	Moderately High	Several systems available and substantial time before core damage. Break is isolated.

[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 G.2.131.10
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. = 0.001 Mean = 0.0027	--	Med. Mean 0.001 0.0027	(10)	
2. Open an SRV , if necessary, and start SDC.	Med. = 0.02 Mean = 0.032	Credit for a second and third check was taken because in this context the operators would be closely monitoring the relevant parameters. HEPs for failure to provide a second and third check were: Med. = .2 Mean = .323	0.0008 0.0033 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 and the third check HEP is multiplied by the result. Since all the HEPs make significant contributions to the total HEP, the larger error factor was assigned.

Table G.2.132.1
HEP 132 Calculation

Human Action Event (1)	OPLEC1 (1)
Event Tree(s) (2)	RWCHI
Initiators (3)	RWC26, RWC74
Sequence Locator Files (4)	OPLECH26.FLD, OPLECH74.FLD
Event Description (5)	OPLEC1 is the operator action to provide makeup with an ECCS system in order to bring level back up to where it should be after break in the RWCU line has been isolated.
Event Context (6)	For the OPLEC1 (1) calculation (HEP 132), the initiator is a break in the RWCU line during a HYDRO test. There is less than a minute before the vessel will drain down to level 2 and RWCU isolates (which also isolates the break). It is assumed that the operators will fail to stop the drain down before level 2 is reached in the less than 1 minute time frame (OPDHR1 fails). HPCS should auto-start on level 2, but in this scenario it fails. Thus, the operators need to diagnose the need the bring level back up with LPCI. They may need to open an SRV if pressure is still high for the use of LPCI.
Applicable Procedures (7)	No specific procedures, but with the loss of level, the operators would want to return level to the normal point for LP&S conditions (approximately 36 inches from instrument zero, which is above level 4).

Table G.2.132.2
Sequence Timing and Indications

Event/Occurrence (of most interest) (1)	Time (T_o) Operator Alerted (2)	Annunciator/Indication (3)	Comments/ Source of Information (4)
Break in RWCU line has been isolated, HPCS has failed to auto-start, and the operators need to restore level.	0	Vessel level would reach level 2 in less than a minute. Several level alarms would sound and the failure of HPCS to auto-start would also be alarmed. With the break isolated, the need to restore level should be apparent.	

Table G.2.132.3
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)
Break in RWCU line which has been isolated, but HPCS has failed to auto-start. The operators need to restore level.	One	The operators need to restore level. LPCI is assumed to be the system of choice.	Operators are aware of the need to maintain level at an assigned point during LP&S.

Table G.2.132.4
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 restore level. The break has auto-isolated and HPCS has failed to auto-start.	10 minutes	0 minutes	Approx. 10 minutes. This is a conservative estimate given that the event occurred during a HYDRO test which would come late in the shutdown.	SEA Calculation C90-492-01-A16

Table G.2.132.5
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)
Initiate LPCI and restore level. Open SRV if necessary.	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.

Table G.2.132.6
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 restore level and initiate LPCI.	10 minutes	1 minute	9 minutes	

Table G.2.132.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Restore level with LPCI after isolation of break in RWCU line and failure of HPCS to auto-start on level 2 signal.	Per ASEP Table 8-3, the lower bound value from Figure 8-1 for 9 minutes diagnosis time was assigned.		Med. = 0.015 Mean = 0.04	The site interviews indicated that (obviously) the operators are aware of the need for SDC during LP&S. They would also (obviously) be concerned about a dramatic loss of water level and would want to restore level to the normal place after a break had been isolated, particularly when a level 2 signal had occurred and HPCS had failed to start. Thus, the lower bound value was judged appropriate.

Table G.2.132.8
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 LPCI and open SRV if necessary.	N/A	The necessary actions would be obvious.	No	Step-by-step. The operators know how to initiate LPCI.	

Table G.2.132.9
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 LPCI and bring vessel level up to LP&S normal.	N/A[1]	N/A	No[2]	N/A	Moderately High	Several systems available and substantial time before core damage. Break is isolated.

[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 G.2.133.1
HEP 133 Calculation

Human Action Event (1)	OPADH (1)
Event Tree(s) (2)	TAB39
Initiators (3)	TAB39
Sequence Description Files (4)	OPADH39.FLD
Event Description (5)	OPADH includes diagnosing the need to perform the necessary steps to initiate ADHR for SDC after a flood has resulted in the loss of all DIV 1, 2, & 3 AC and DC power.
Event Context (6)	For the OPADH (1) calculation (HEP 133), a flood has occurred and all DIV 1, 2, 3, AC and DC power is lost. Offsite power is still available. The operators can provide SDC with ADHR if they unisolate IA (requires using air bottles to open AV 26 A & B), unisolate PSW from the CR once IA is restored (open F120 & F121), manually (locally) open MV 8 and 9 valves to unisolate SDC, and then start ADHR from the CR. The task must be accomplished before pressure reaches 50 psi. Per calculation, 2 hours would be available to diagnose the need and carry-out the actions.
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 G.2.133.2
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. Need for some form of SDC. With only BOP power available, ADHR is the only available system.	O	Loss of power and systems would be alarmed. In the context of being in shutdown the operators would be aware of the need for some form of SDC. Through training the crew will be aware that ADHR will be the only available SDC system. The operators will have to diagnose the necessary actions.	

Table G.2.133.3
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 the loss of all DIV 1, 2, 3, AC and DC power (from the effects of flooding), normal SDC would be lost. ADHR in on BOP power and offsite power is available. The operators need to diagnose the need to take the steps necessary to align ADHR for SDC.	One	1. Unisolate IA. Would require the operators to use air (nitrogen) bottles to manually unisolate AV 26 A & B. 2. Unisolate PSW by opening F120 and F121 from the CR (BOP). This would provide cooling to TBCW, which cools the IA compressors. 3. Unisolate SDC and make ADHR available by manually (locally) opening MV 8 and 9 valves. Start ADHR.	The activities required to align ADHR in this context are not explicitly called by the procedure. However, given the loss of power during shutdown (which would not be missed), the operators would be likely to realize the need for SDC. They would be aware that ADHR is BOP and would try to determine the actions necessary to achieve the goal. The diagnosis and related actions would clearly be within a normal crew's capabilities.

Table G.2.132.8
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 LPCI and open SRV if necessary.	N/A	The necessary actions would be obvious.	No	Step-by-step. The operators know how to initiate LPCI.	

Table G.2.132.9
Post-Diagnosis Stress-Level Identification per Step 10, Table 8-1 of ASEP HRAP

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)
Initiate LPCI and bring vessel level up to LP&S normal.	N/A[1]	N/A	No[2]	N/A	Moderately High	Several systems available and substantial time before core damage. Break is isolated.

[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 G.2.132.10
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. = 0.015 Mean = 0.04	--	Med. Mean 0.015 0.04	(10)	
2. Initiate LPCI and "bump" vessel level to normal. Open SRV if necessary.	Med. = 0.02 Mean = 0.032	Credit for a second check was taken because in this context the operators are aware of the loss of level and when using a system like LPCI, they would expect to see the level going up very soon. HEPs for failure to provide a second check were: Med. = .2 Mean = .323	0.004 0.01 0.019 0.05 Total Median HEP = 0.019 Total Mean HEP = 0.05	(5) (10)	Second check HEPs are multiplied by the original HEP for each action. Since all the HEPs make significant contributions to the total HEP, the larger error factor was assigned.

Table G.2.133.1
HEP 133 Calculation

Human Action Event (1)	OPADH (1)
Event Tree(s) (2)	TAB39
Initiators (3)	TAB39
Sequence Description Files (4)	OPADH39.FLD
Event Description (5)	OPADH includes diagnosing the need to perform the necessary steps to initiate ADHR for SDC after a flood has resulted in the loss of all DIV 1, 2, & 3 AC and DC power.
Event Context (6)	For the OPADH (1) calculation (HEP 133), a flood has occurred and all DIV 1, 2, 3, AC and DC power is lost. Offsite power is still available. The operators can provide SDC with ADHR if they unisolate IA (requires using air bottles to open AV 26 A & B), unisolate PSW from the CR once IA is restored (open F120 & F121), manually (locally) open MV 8 and 9 valves to unisolate SDC, and then start ADHR from the CR. The task must be accomplished before pressure reaches 50 psi. Per calculation, 2 hours would be available to diagnose the need and carry-out the actions.
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 G.2.133.2
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. Need for some form of SDC. With only BOP power available, ADHR is the only available system.	O	Loss of power and systems would be alarmed. In the context of being in shutdown the operators would be aware of the need for some form of SDC. Through training the crew will be aware that ADHR will be the only available SDC system. The operators will have to diagnose the necessary actions.	

Table G.2.133.3
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 the loss of all DIV 1, 2, 3, AC and DC power (from the effects of flooding), normal SDC would be lost. ADHR in on BOP power and offsite power is available. The operators need to diagnose the need to take the steps necessary to align ADHR for SDC.	One	1. Unisolate IA. Would require the operators to use air (nitrogen) bottles to manually unisolate AV 26 A & B. 2. Unisolate PSW by opening F120 and F121 from the CR (BOP). This would provide cooling to TBCW, which cools the IA compressors. 3. Unisolate SDC and make ADHR available by manually (locally) opening MV 8 and 9 valves. Start ADHR.	The activities required to align ADHR in this context are not explicitly called by the procedure. However, given the loss of power during shutdown (which would not be missed), the operators would be likely to realize the need for SDC. They would be aware that ADHR is BOP and would try to determine the actions necessary to achieve the goal. The diagnosis and related actions would clearly be within a normal crew's capabilities.

Table G.2.133.4
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_a) (3)	Maximum Time Available to Perform the Identified Operator Activities (T_m) (4)	Comments/ Source of Information (5)
Align ADHR for SDC after a loss of all DIV 1, 2, 3, AC and DC power. BOP is available.	2 hours	Approx. 10 minutes after loss of power. The operators would know immediately of the loss of power. However, it was assumed that the operators would initially be concerned with trying to restore power and that they would not immediately attend to other indicators. While the selection of 10 minutes is arbitrary, it is assumed that the crew would concern themselves with the loss of SDC fairly soon.	110 minutes	SEA Calculation (per SNL request on July 21, 1993.

Table G.2.133.5
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. Would require the operators to use air (nitrogen) bottles to manually unisolate AV 26 A & B.	AV 26A is in Aux. Bldg. AV 26B is in Turbine Bldg.	--	1 hour (estimate includes travel and performance time.	1 hour	Time estimate is based PRA analysts familiarity with plant and the nature of the required actions.
2. Unisolate PSW. Open PSW valves F120 and F121 from the control room. May need to start PSW from CR.	CR	--	2 minutes	2 minute	Per Table 8-1, Step 5b, a 1 min. travel and manipulation time was assumed for each set of actions). The steps necessary to unisolate and start PSW were assumed to be completely dependent.
3. Manually (locally) open RHR MV 8 and 9 to unisolate SDC and allow use of ADHR. Start ADHR from the CR.	One valve is in the drywell and the other in containment.	--	30 minutes	30 minutes Approx. 90 minutes total action time.	Operators may need to suit-up to carry-out the necessary actions. However, much of the task could be carried-out in parallel with unisolating IA. Thus, 30 minutes is a conservative estimate.

Table G.2.133.6
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 ADHR for SDC after a loss of all DIV 1, 2, 3, AC and DC power. BOP is available.	110 minutes	90 minutes	20 minutes	

Table G.2.133.7
Diagnosis Analysis

Action (1)	Failure to Diagnose (2)	Skill-Based (3)	Adjusted/ Final HEP (4)	Comments/ Source of Information (5)
Diagnose need to align ADHR for SDC after a loss of all DIV 1, 2, 3, AC and DC power. BOP is available. Operators must diagnose the need and identify the steps necessary to unisolate IA, PSW, and SDC, and start ADHR.	Per Table 8-3, the upper bound value from Figure 8-1 for 20 minutes diagnosis time was assigned.		Median = 0.1 Mean = 0.27	The upper bound value from Figure 8-1 was selected because the necessary steps are not explicitly proceduralized and the pattern of actions are probably not explicitly trained. However, such diagnosis and actions were judged to be within the capabilities of a normal crew.

Table G.2.133.8
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 ADHR for SDC after a loss of all DIV 1, 2, 3, AC and DC power.	N/A	The necessary actions are not complicated given a successful diagnosis and determination of how to proceed.	No	Step-by-Step	

Table G.2.133.9
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 ADHR for SDC after a loss of all DIV 1, 2, 3, AC and DC power.	N/A[1]	N/A	No[2]	N/A	Moderately High	Substantial time before core damage and vessel level is not low.

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 G.2.133.10
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. = 0.1 Mean = 0.27	--	Med. Mean 0.1 0.27	(10)	
2. Unisolate IA	Median = 0.02 Mean = 0.032	Credit for a second check was not given for any of the actions because of the time limitations and the several separate actions required outside the CR.	0.02 0.032	(5)	
3. Unisolate PSW	Median = 0.02 Mean = 0.032		0.02 0.032	(5)	
4. Unisolate SDC and start ADHR	Median = 0.02 Mean = 0.032		0.02 0.032 0.16 0.367 Total Median HEP = 0.16 Total Mean HEP = 0.367	(5) (10)	Since both the diagnosis and action HEPs made significant contributions to the total HEP, the larger of the two EFs was assigned.

Table G.3.1
PRE-ACCIDENT HUMAN ACTIONS AND THEIR MEAN HEPs

Primary Name	Mean Probability	Event Description
ADR-XHE-RE-XV410	3.000E-002	FAILURE TO RESTORE MANUAL VALVE XV410 OPEN
CRD-XHE-RE-X217B	8.000E-003	OPERATOR FAILS TO RESTORE XV217B FOLLOWING MAINTENANCE
CSS-MOV-RE-MV28A	8.000E-003	FAILURE TO RESTORE CSS TRAIN A INJECTION VALVE AFTER MAINTENANCE
CSS-MOV-RE-MV28B	8.000E-003	FAILURE TO RESTORE CSS TRAIN B INJECTION VALVE AFTER MAINTENANCE
ESF-CCF-MC-697/8	6.750E-005	COMMON MODE MISCALIBRATION OF RX PRESS SENSORS PS-N697/698
ESF-CCF-MC-CSTLV	6.750E-005	COMMON MODE MISCALIBRATION OF CST LEVEL INSTRUMENTS
ESF-CCF-MC-DPRES	6.750E-005	MISCALIBRATION OF DRYWELL PRESSURE SENSORS 94
ESF-CCF-MC-LTO91	2.700E-004	COMMON MODE MISCALIBRATION OF REACTOR LEVEL SENSORS/TRANSM.
ESF-CCF-MC-N674	2.700E-004	COMMON MODE MISCALIBRATION OF LEVEL LS-N674C/L
ESF-CCF-MC-N679	2.700E-004	COMMON MODE FAILURE OF REACTOR PRESSURE SWITCHES N679A/B/C/D
ESF-CCF-MC-N680	2.700E-004	COMMON MODE MISCALIBRATION OF LEVEL 3 SENSORS N680A/B/C/D
ESF-CCF-MC-N681	2.700E-004	COMMON MODE MISCALIBRATION OF LEVEL 1 LIS-N681-A/B/C/D
ESF-CCF-MC-PT662	2.700E-004	COMMON MODE MISCALIBRATION OF CONTAINMENT PRESSURE SENSORS
ESF-CCF-MC-PT694	2.700E-004	MISCALIBRATION OF DRYWELL PRESSURE SENSORS 694
ESF-CCF-MC-VSLVL	6.750E-005	COMMON MODE MISCALIBRATION OF REACTOR LEVEL SENSORS/TRANSM.
HCS-XHE-RE-HPCS	5.500E-004	FAILURE TO RESTORE HPCS AFTER MAINTENANCE
IAS-MDC-RE-COO1B	1.000E+000	FAILURE TO PROPERLY RESTORE STANDBY IA COMPR.AFTER MAINT.
IAS-XHE-MC-PS	1.000E+000	MISCALIBRATION OF PRESSOR SENSOR FOR STANDBY IA COMPRESSOR
LCI-MOV-RE-MV4A	8.000E-003	MV4A MOTOR-OPERATED VALVE PS-131 IS LEFT CLOSED DUE TO TEST
LCI-MOV-RE-MV4B	8.000E-003	PS-128 MOV MV4B LEFT CLOSED BECAUSE OF TESTING

Table G.3.1
PRE-ACCIDENT HUMAN ACTIONS AND THEIR MEAN HEPs

Primary Name	Mean Probability	Event Description
LCI-MOV-RE-MV4C	8.000E-003	MV4C (PS-124) IS LEFT CLOSED AFTER TEST
LCI-XHE-RE-LCIC	5.500E-004	FAILURE TO RESTORE LPCI TRAIN C AFTER MAINTENANCE
RHR-XHE-RE-HXA	1.000E-004	FAILURE TO RESTORE RHR A HEAT EXCHANGER COMP. AFTER MAINTENANCE
RHR-XHE-RE-HXB	1.000E-004	FAILURE TO RESTORE RHR B HEAT EXCHANGER COMP. AFTER MAINTENANCE
RHR-XHE-RE-RHRA	9.000E-004	FAILURE TO RESTORE RHR TRAIN A AFTER MAINTENANCE
RHR-XHE-RE-RHRB	9.000E-004	FAILURE TO RESTORE RHR TRAIN B AFTER MAINTENANCE
SAS-MDC-RE-COO1B	1.000E+000	FAILURE OF THE OPERATOR TO RESTORE MDC COO1B AFTER MAINTENANCE
SPM-XHE-RE-M603A	8.000E-003	MODE SELECTOR SWITCH HS-M603A NOT IN AUTO
SPM-XHE-RE-M603B	8.000E-003	MODE SELECTOR SWITCH HS-M603B NOT IN AUTO
SSW-XHE-RE-SSWA	2.500E-004	FAILURE TO RESTORE SSW TRAIN A AFTER MAINTENANCE
SSW-XHE-RE-SSWB	2.500E-004	FAILURE TO RESTORE SSW TRAIN B AFTER MAINTENANCE
SSW-XHE-RE-SSWC	3.700E-004	FAILURE TO RESTORE SSW TRAIN C AFTER MAINTENANCE
SSW-XHE-RE-TAB1	1.000E-003	FAILURE TO RESTORE SSW TRAIN A AFTER MAINTENANCE (TAB 1)
SSW-XHE-RE-TAB2	1.800E-003	FAILURE TO RESTORE SSW TRAIN A AFTER MAINTENANCE (TAB 2)
SSW-XHE-RE-TAB3	1.500E-003	FAILURE TO RESTORE SSW TRAIN B AFTER MAINTENANCE (TAB 3)
SSW-XHE-RE-TAB4	1.800E-003	FAILURE TO RESTORE SSW TRAIN B AFTER MAINTENANCE (TAB 4)

TABLE G.4.1
TIAF16, TIAF40, and TIAF93 HEP/Sequence Cross References

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
OPECS	HEP 18	OPCSEL32.TIA

TABLE G.4.1
TIAF16, TIAF40, and TIAF93 HEP/Sequence Cross References (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
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
OPFLD	HEP 33	OPFLDTIA.FLD
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
OPIS	HEP 41	OPSTH.TIA

TABLE G.4.1
TIAF16, TIAF40, and TIAF93 HEP/Sequence Cross References (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
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
OPLEC	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
OPOMS	HEP 82	OPSTMMK2.TIA
OPOMS	HEP 82	OPSTMMKU.TIA

TABLE G.4.1
TIAF16, TIAF40, and TIAF93 HEP/Sequence Cross References (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
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
OPSTM	HEP 29	OPSTMFS2.TIA
OPSTM	HEP 29	OPSTMMK2.TIA
OPSTM	HEP 29	OPSTMMKU.TIA

TABLE G.4.1
TIAF16, TIAF40, and TIAF93 HEP/Sequence Cross References (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
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

TABLE G.4.2
T5AF19 HEP/Sequence Cross References

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
OPIS	HEP 57	OPSTHT5A.FLD
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

TABLE G.4.2
T5AF19 HEP/Sequence Cross References (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSTH	HEP 42	OPSTH.T5A
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 G.4.3
J2F48 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 G.4.4
E2DF93 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 G.4.4
E2DF93 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 G.4.5
TIOPF65 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	OPECSP.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	OPESADH.TIO
OPECS	HEP 78	OPECSAD5.TIO
OPECS	HEP 79	OPECSP.TIO
OPFLD	HEP 28	OPFLDE.TIO
OPHIS	HEP 8	OPECSAD5.TIO
OPHIS	HEP 8	OPECSADH.TIO
OPHIS	HEP 8	OPECSP.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 G.4.5
TIOPF65 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 G.4.6
E2BF20 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	OPSTHE2B.FLD
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

Table G.4.6
E2BF20 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPSPM	HEP 26	OPICT.E2B
OPSTH	HEP 42	OPSTHF.E2B
OPSTH	HEP 42	OPSTHFNC.E2B
OPSTH	HEP 42	OPSTHE2B.FLD
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 G.4.7
TAB39 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
OPADH	HEP 132	OPADH39.FLD
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

Table G.4.7
TAB39 HEP/Sequence Cross Reference (Continued)

Operator Actions	HEP Calculation Number	Sequence Locator File Name
OPMSV	HEP 9	OPECSHYD.TAB
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 G.4.8
RWC26[1] HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LCMK	HEP 4	OPDHR226.FLD
LCMK	HEP 4	OPDHRH26.FLD
LCMK	HEP 85	OPDHR226.FLD
LCMK	HEP 85	OPDHRH26.FLD
OP1SV	HEP 5	OPFLDRM6.FLD
OP1SV	HEP 7	OPECSR26.FLD
OP1SV	HEP 106	OPECSNL6.FLD
OPCMT	HEP 73	OPICTF26.FLD
OPDHR	HEP 3	OPDHR226.FLD
OPDHR	HEP 58	OPDHRH26.FLD
OPDHR1	HEP 127	OPDHR26.FLD
OPECS	HEP 6	OPECSR26.FLD
OPECS	HEP 18	OPECSNL6.FLD
OPFLD	HEP 29	OPFLDRM6.FLD
OPHIS	HEP 8	OPECSNL6.FLD
OPHIS	HEP 8	OPECSR26.FLD
OPICT	HEP 71	OPICTE26.FLD
OPICT	HEP 71	OPICTF26.FLD
OPLEC	HEP 129	OPLEC26.FLD
OPLEC1	HEP 132	OPLECH26.FLD
OPMSV	HEP 9	OPECSNL6.FLD
OPMSV	HEP 9	OPECSR26.FLD
OPMSV	HEP 90	OPFLDRM6.FLD
OPSDC	HEP 1	OPDHR26.FLD
OPSDC	HEP 2	OPDHR26.FLD
OPSDC1	HEP 131	OPSDCH26.FLD
OPSPM	HEP 26	OPICTE26.FLD
OPVNT	HEP 25	OPICTE26.FLD
OPVNT	HEP 25	OPICTF26.FLD
RM-LT	HEP 56	OPDHR226.FLD
RM-LT	HEP 56	OPDHRH26.FLD
SPMKP	HEP 27	OPICTE26.FLD

[1]Applies to RWC26A and RWC26B.

Table G.4.9
RWC74 HEP/Sequence Cross Reference

Operator Actions	HEP Calculation Number	Sequence Locator File Name
LCMK	HEP 4	OPDHR274.FLD
LCMK	HEP 4	OPDHRH74.FLD
LCMK	HEP 85	OPDHR274.FLD
LCMK	HEP 85	OPDHRH74.FLD
OP1SV	HEP 5	OPFLDRM4.FLD
OP1SV	HEP 7	OPECSR74.FLD
OP1SV	HEP 106	OPECSNL4.FLD
OPDHR	HEP 3	OPDHR274.FLD
OPDHR	HEP 58	OPDHRH74.FLD
OPDHR1	HEP 128	OPDHR74.FLD
OPECS	HEP 6	OPECSR74.FLD
OPECS	HEP 18	OPECSNL4.FLD
OPFLD	HEP 28	OPFLDRM4.FLD
OPHIS	HEP 8	OPECSNL4.FLD
OPHIS	HEP 8	OPECSR74.FLD
OPICT	HEP 71	OPICT274.FLD
OPICT	HEP 71	OPICTE74.FLD
OPIS	HEP 41	OPSTHR74.FLD
OPLEC	HEP 130	OPLEC74.FLD
OPLEC1	HEP 132	OPLECH74.FLD
OPMSV	HEP 9	OPECSNL4.FLD
OPMSV	HEP 9	OPECSR74.FLD
OPMSV	HEP 90	OPFLDRM4.FLD
OPSDC	HEP 1	OPDHR74.FLD
OPSDC	HEP 2	OPDHR74.FLD
OPSDC1	HEP 131	OPSDCH74.FLD
OPSPM	HEP 26	OPICT274.FLD
OPSPM	HEP 26	OPICTE74.FLD
OPSTH	HEP 42	OPSTHR74.FLD
OPVNT	HEP 25	OPICT274.FLD
OPVNT	HEP 25	OPICTE74.FLD
RM-LT	HEP 56	OPDHR274.FLD
RM-LT	HEP 56	OPDHRH74.FLD
SPMKP	HEP 27	OPICT274.FLD
SPMKP	HEP 27	OPICTE74.FLD

Table G.4.10
Post-Accident Human Actions and Their HEPs and Error Factors

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	OPISV (17)	0.302	10
6	OPECS (1)	0.035	5
7	OPISV (1)	0.112	10
8	OPHIS (1)	0 OR 1.0	--
9	OPMSV (1)	1.0	--
10	OPECS (2)	0.138	10
11	OPISV (2)	0.302	10
12	OPSOF (1)	0.06	10
13	OPECS (3)	1.0	--
14	OPECS (7)	0.10	10
15	OPISV (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 G.4.10
Post-Accident Human Actions and Their HEPs and Error Factors (Continued)

HEP NUMBER[1.]	HUMAN ACTION[2,3]	HEP	ERROR FACTOR
29	OPSTM (1)	0.106	10
30	OPSOF (2)	0.05	10
33	OPFLD (2)	1.0	--
35	OPDHR (2)	0.70	--
40	OPISV (7)	0.31	10
41	OPIS (1)	1.0	--
42	OPSTH (1)	0.025	5
49	OPSTM (2)	1.0	--
50	OPECS (14)	0.059	10
51	OPISV (9)	0.112	10
52	SDCUI (1)	3.5E-3	5
56	RM-LT (1)	3.6E-3	5
57	OPIS (2)	0.063	10
58	OPDHR (3)	0.108	10
71	OPICT (1)	1.0	--
77	OPDHR (4)	0.12	10
78	OPECS (18)	0.138	10
79	OPECS (19)	0.023	5
80	OPISV (14)	0.11	10
81	OPISA (1)	0	--
82	OPOMS (1)	1.0	--
85	LCMK (2)	0	--
87	OPDHR (5)	0.015	5
90	OPMSV (4)	0.01	5
101	OPECS (5)	1.0	--
102	OPECS (6)	1.0	--
105	OPISV (4)	0.112	10
106	OPISV (5)	0.302	10
108	OPISV (13)	0.302	10

Table G.4.10
Post-Accident Human Actions and Their HEPs and Error Factors (Continued)

HEP NUMBER[1]	HUMAN ACTION[2,3]	HEP	ERROR FACTOR
127	OPDHR1 (1)	0.02	10
128	OPDHR1 (2)	0.41	10
129	OPLEC (1)	0.037	10
130	OPLEC (2)	0.54	10
131	OPSDC (1)	0.006	10
132	OPLEC1 (1)	0.05	10
133	OPADH (1)	0.367	10

[1]Some HEP numbers are missing simply because not all numbers in the sequence were used.
[2]Multiple HEPs were determined for some operator actions. The occurrence number is presented in parentheses ().
[3]Descriptions of the operator actions appear in the HEP calculation tables (Tables G.2.1 through G.2.133) and in Section 6.

Table G.5.1
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-1	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

[1]Descriptions of the recovery actions appear in the HEP calculation tables (Tables G.2.115 through G.2.126).

File Name: LCMK.TIO

Initiator: TIOPF65

Event Tree: TIOPF65

Human Error Events:

	Mean HEPs	EF	Code#
LCMK	0.011	5	HEP 4

TIOP initator. Random isolation of RWCU resulting in over-pressurization. With letdown isolated and makeup continuing to run, level and pressure will begin to increase. Operators will get an alarm at level 8 and may receive additional pressure related alarms. In addition, operators have approximately 2 and one-half hours to detect the problem and control makeup. In this time period level and pressure would be monitored.

File Name: OPADH39.FLD

Initiator: TAB39

Event Tree: TAB39

Human Error Events:

	Mean HEPs	EF	Code#
OPADH	0.367	10	HEP 132

The initiator is a loss of all DIV 1, 2, 3 AC and DC power. Offsite power is still available. The operators can provide SDC with ADHR if they unisolate IA (requires using air bottles to open AV 26 A & B), unisolate PSW from the CR once IA is restored (open F120 & F121), manually (locally) open MV 8 and 9 valves to unisolate SDC, and then start ADHR from the CR. The task must be accomplished before pressure reaches 50 psi. Per calculation, 2 hours would be available to diagnose the need and carry-out the actions.

File Name: OPCADH14.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EAX (from TIAF16 or TIAF40 or TIAF93, Seq. 30)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	1.0		HEP 101

In this scenario, a loss of IA, along with a LOSP occurs. The DIV 1/2 diesel generators fail to start and HPCS is unavailable. Thus, a cross-tie of the HPCS generator to DIV 2 (1) is called for, per the ONEP for Loss of AC power. SDC needs to be restored. If the control room diagnoses the fact that SDC(B) will isolate on 135 psi when the cross-tie (XTIEB) is completed (OPSDC success), then they will prepare for initiating ECCS water solid operation per the IDHR ONEP (OPECS). If they fail to realize that SDC(B) will not be available (OPSDC fails), then OPECS will most likely fail since the diagnosis, the retrievel of procedures, the opening of two SRVs and the checking closed of the MSIVs must be done in parallel with the cross-tie for sufficient time to be available. In the present scenario, OPSDC fails.

File Name: OPCADH20.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EA (from TIAF16 or TIAF40 or TIAF93, Seq. 20)

EAP (from TIAF16 or TIAF40 or TIAF93, Seq. 24)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.10	10	HEP 14
	OPMSV	1.0		HEP 9
	OP1SV	0.44	10	HEP 15
	OPHIS	1.0		HEP 8
*	OPISA	0		HEP 81

The initiator is a loss of IA. In some sequences a LOSP also occurs, but the diesels start and load (DV1-2 succeeds). ADHR is lost as a result of the initiator, but the operators diagnose the loss of SDC (OPSDC succeeds) and attempt to establish SDC(B). SDC(B) fails to start. OPECS involves ensuring that ADHR is isolated and aligning LPCI(C) for initiating ECCS water solid operation.

* OPISA is completely dependent on OPECS. If OPECS is successful, OPISA = 0 (success), otherwise OPISA is a failure, 1.0.

File Name: OPCADH21.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EA (from TIAF16 or TIAF40 or TIAF93, Seq. 21)

EAP (from TIAF16 or TIAF40 or TIAF93, Seq. 25)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	1.0		HEP 13

In this loss IA scenario, OPSDC has failed. That is, the control room has failed to detect/realize the loss of SDC (ADHR) in 37 minutes. Because of the failure of OPSDC and the time and actions required to isolate ADHR and align and start ECCS (per "abnormal operations" in the RHR SOI) and perform the related OPECS action from the IDHR ONEP, OPECS fails (as do the remaining associated human actions).

File name: OPCADH26.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: HPSWA (from TIAF16 or TIAF40 or TIAF93, Seq. 26)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	1.0		HEP 102

In this scenario, a loss of IA is followed by a LOSP. The DV1-2 diesels fail to start. HPCS is working (available). OPECS in this case involves deciding to initiate ECCS water solid operation with HPCS. The most significant difference between this and HPSWR (from SDC tree) is that the operators must also diagnose need to isolate ADHR during OPECS. This is a non-trivial difference because with the LOSP and loss of Div 1/2 (or TAB39 initiator and a LOSP), operators will now have to isolate the 8 or 9 valve locally. When 15 min. is assumed for accomplishing this action and the other OPECS actions are considered, insufficient time remains for making the relevant diagnoses.

File Name: OPCSDC10.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EP (from TIAF16 or TIAF40 or TIAF93, Seq. 10)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

In this scenario, a LOSP has occurred, but the diesels successfully start and load (DIV 1/2 succeeds). OPSDC in this case has failed. That is, in 37 min. the control room has not diagnosed the loss of SDC or entered the IDHR ONEP. However, at this point additional alarms could sound, e.g., a low level or high pressure alarm, and by requirememts (every 30 min.) the reactor temperature and/or pressure chart recorders would very likely be checked (to reveal increases) in the 23 additional minutes available for this event. Operators must diagnose the need to initiate ECCS water solid operation.

HRA

File Name: OPCSDC11.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: HPSWR (from TIAF16 or TIAF40 or TIAF93, Seq. 11)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.138	10	HEP 10
	OP1SV	0.302	10	HEP 11
*	OPHIS	0		HEP 8
	OPMSV	1		HEP 9
	OPSOF	0.06	10	HEP 12

In this loss of IA scenario, a LOSP has occurred and the diesels fail to start (DV1-2 fails). HPCS is working (available). OPECS in this case, involves deciding to go water solid with HPCS.

* OPHIS is essentially included in the OPECS event in this scenario. Thus, failure probabability for OPHIS should be set to 0 when OPECS is successful.

File Name: OPCSDC12.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EX (from TIAF16 or TIAF40 or TIAF93, Seq. 14)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPMSV	1.0		HEP 9
OPHIS	1.0		HEP 8

In these scenarios a loss of Instrument Air occurs and is followed later in the scenario with a LOSP. The diesel generators fail to start (DV1-2 fails) and HPCS is unavailable. Thus, a cross-tie of the HPCS generator to DIV 2 (1) is called for (XTIEB), per the ONEP for loss of AC power. Some form of SDC is needed. If the control room diagnoses the likelihood that SDC(B) will isolate on 135 psi. when the diesel generator cross-tie is completed (OPSDC success), then they will prepare for OPECS. If they fail to do this (OPSDC fails), OPECS will fail. In these sequences, OPSDC has succeeded and the control realizes SDC will not be available. Thus, OPECS involves following the IDHR ONEP and proceeding with ECCS water solid operation. See file OPXTIE.HEP and HEP Calculations 19 and 20 for additional information.

File Name: OPCSDC13.TIA

Initiator: TIA

Event Tree: EX (from TIAF16 or TIAF40 or TIAF93, Seq. 15)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	1.0		HEP 101

In this scenario, a loss of IA occurs along with a LOSP. DIV 1/2 diesel generators fail to start, and HPCS is unavailable. Thus, a cross-tie of the HPCS generator to DIV 2 (1) is called for, per the ONEP for Loss of AC power. SDC needs to be restored. If the control room diagnoses the fact that SDC(B) will isolate on 135 psi when the cross-tie (XTIEB) is completed (OPSDC success), then they will prepare for initiating ECCS water solid operation per the IDHR ONEP (OPECS). If they fail to realize that SDC(B) will not be available (OPSDC fails), then OPECS will most likely fail since the diagnosis, the retrievel of procedures, the opening of two SRVs and the checking closed of the MSIVs must be done in parallel with the cross-tie for sufficient time to be available. In the present scenario, OPSDC fails.

File Name: OPCSEL32.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: E (from L, Seq. 32 and 48, from TIAF16 or TIAF40 or TIAF93, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

In this scenario, a loss of IA has occurred. SDC(B) continues to run. CRD and RWCU auto-isolate and forceed recirculation is lost. With the loss of makeup (CRD) and forced recirculation, the potential for a disconnect between the core and the downcomer regions of the core arises. With inadequate level or recirculation, a "functional" loss of SDC can occur. OPDHR is the the operator action to diagnose the functional loss of SDC and initiate level control. In these sequences, OPDHR has failed. That is, the operators fail to diagnose the disconnect between the core and the downcomer and the resulting functional loss of SDC in the 10 minutes allowed for OPDHR. However, at this point some additional indicators would be coming available and the operators should notice increases in pressure and temperature on chart recorders per periodic checks (required every 30 minutes). Operators must diagnose the need to initiate ECCS water solid operation.

HRA

File Name: OPCSEL32.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: E (from L, Seq. 32 and 48, from TIAF16 or TIAF40 or TIAF93, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

In this scenario, a loss of IA has occurred. SDC(B) continues to run. CRD and RWCU auto-isolate and forceed recirculation is lost. With the loss of makeup (CRD) and forced recirculation, the potential for a disconnect between the core and the downcomer regions of the core arises. With inadequate level or recirculation, a "functional" loss of SDC can occur. OPDHR is the the operator action to diagnose the functional loss of SDC and initiate level control. In these sequences, OPDHR has failed. That is, the operators fail to diagnose the disconnect between the core and the downcomer and the resulting functional loss of SDC in the 10 minutes allowed for OPDHR. However, at this point some additional indicators would be coming available and the operators should notice increases in pressure and temperature on chart recorders per periodic checks (required every 30 minutes). Operators must diagnose the need to initiate ECCS water solid operation.

Initiator: E2DF93

Event Tree: LA (from E2DF93, Seq. 4,)

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR	0.70	10	HEP 35
LCMK	0		HEP 85

In this loss of SDC scenario there is no LOSP. OPSDC and SDCB(S) were successful. At some point, either CRD or forced recirculation fail, which requires the operators to diagnose the potential for core/downcomer disconnect and the need for makeup. Failure of these systems should provide alarms and indications to the control room. The operators will need to diagnose the need to isolate RWCU. The Operator must diagnose need to increase makeup with CRD (if available) or an ECCS system.

diagnose the potential for core/downcomer disconnect. Operator must diagnose need to isolate RWCU and increase makeup with CRD (if available) or ECCS. With only 10 min. allowed for this event, the level decrease may be subtle (depending on scenario) and at this point in time SDC is operating.

* In regards to LCMK, since increasing flow with CRD would be a possible option in some scenarios, operators would have 2.5 hrs to control level and could forget to do so. Thus, when LCMK is preceded by CRD success, then LCMK = 0.011. However, when CDS or an ECCS system is used, it is assumed that the operators would not just walk away from a system injecting 4000+ GPM. For these cases, the HEP for LCMK would be 0.

** The value for the operator action to control level in the long-term (RM-LT) was usually placed in the data base.

File Name: OPECSNL4.FLD

Initiator: RWC74

Event Tree: E (from RRW, Seq. 32, from RWC74, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

In this scenario, a break in the RWCU line occurs. The operators successfully isolate RWCU and the break. However, they initially fail to bring level back up (OPLEC fails). SDC(B) continues to run. If it is conservatively assumed that forced recrirculation is lost or that they were not on forced recirculation, then without additional level a disconnect betweeen the core and the downcomer will occur with a resulting "functional" loss of SDC. While changes in temperature may be subtle because the water in the downcomer continues to be cooled, the operators should notice increases in pressure per periodic checks (required every 30 minutes). Moreover, with the additional time in the given context, they should at least realize the need to restore level and enter the IDHR ONEP. The operators must diagnose the need to initiate ECCS water soild operation.

File Name: OPDHR226.FLD

Initiator: RWC26

Event Tree: L (from RRW, Seq. 9, 22, from RWC26, Seq. 2)

LA (from RARW, Seq. 9, 10, 22, 23, from RWC26, Seq. 9)

Human Error Events:

		Mean HEPs	EF	Code#
	OPDHR	0.48	10	HEP 3
*	LCMK	0 or 0.011	10	HEP 85 or 4
**	RM-LT	3.6E-3	5	HEP 56

The initiator is a break in the RWCU line. In this scenario, the operators successfully isolate RWCU before level 3 is reached and therefore SDC does not auto-isolate. SDC(B) or ADHR continue to run or , if ADHR fails, then SDC(B) starts. At some point in the scenario, forced recirculation and/or CRD (makeup) are lost. Operators must diagnose the need to control level in order to avoid a "functional" loss of SDC due to a disconnect between the core and the downcomer.

* In regards to LCMK, since increasing flow with CRD would be a possible option in some scenarios, operators would have 2.5 hrs to control level and could forget to do so. Thus, when LCMK is preceded by CRD success, then LCMK = 0.011. However, when CDS or an ECCS system is used, it is assumed that the operators would not just walk away from a system injecting 4000+ GPM. For these cases, the HEP for LCMK would be 0.

** The HEP for RM-LT is relevant to sequences where CRD fails, but forced recirculation continues to run. RM-LT should not be reached in the other sequences in the L tree.

File Name: OPDHR26.FLD

Initiator: RWC26

Event Tree: RWC26

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR1 (27.3 min)	0.02	10	HEP 127
OPSDC (RHR)	8.5E-4	10	HEP 1
OPSDC (ADHR)	0.046	10	HEP 2

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR is this case the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. A level 4 alarm will sound within 4 minutes after the break. It was assumed that the level 4 alarm and the continued decrease in level would indicate to the operators that letdown should be isolated. This was assumed to be the case even if they are not yet aware of a break or where it is located. That is, a substantial loss of level should indicate a need to stop letdown in any way possible. Isolating RWCU is an obvious place to start.

If OPDHR fails, SDC will auto-isolate on level 3. Numerous alarms and indications will alert the operators to the loss of SDC.

File Name: OPDHR274.FLD

Initiator: RWC74

Event Tree: L (from RRW, Seq. 9, 22, from RWC74, Seq. 2)

LA (from RARW, Seq. 9, 10, 22, 23, from RWC74, Seq. 9)

Human Error Events:

		Mean HEPs	EF	Code#
	OPDHR	0.48	10	HEP 3
*	LCMK	0 or 0.011	10	HEP 85 or 4
**	RM-LT	3.6E-3	5	HEP 56

The initiator is a break in the RWCU line. In this scenario, the operators successfully isolate RWCU before level 3 is reached and therefore SDC does not auto-isolate. SDC(B) or ADHR continue to run or , if ADHR fails, then SDC(B) starts. At some point in the scenario, forced recirculation and/or CRD (makeup) are lost. Operators must diagnose the need to control level in order to avoid a "functional" loss of SDC due to a disconnect between the core and the downcomer.

* In regards to LCMK, since increasing flow with CRD would be a possible option in some scenarios, operators would have 2.5 hrs to control level and could forget to do so. Thus, when LCMK is preceded by CRD success, then LCMK = 0.011. However, when CDS or an ECCS system is used, it is assumed that the operators would not just walk away from a system injecting 4000+ GPM. For these cases, the HEP for LCMK would be 0.

** The HEP for RM-LT is relevant to sequences where CRD fails, but forced recirculation continues to run. RM-LT should not be reached in the other sequences in the L tree.

File Name: OPDHR74.FLD

Initiator: RWC74

Event Tree: RWC74

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR1 (13.3 min)	0.41	10	HEP 128
OPSDC (RHR)	8.5E-4	10	HEP 1
OPSDC (ADHR)	0.046	10	HEP 2

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR is this case the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. A level 4 alarm will sound within 4 minutes after the break. It was assumed that the level 4 alarm and the continued decrease in level would indicate to the operators that letdown should be isolated. This was assumed to be the case even if they are not yet aware of a break or where it is located. That is, a substantial loss of level should indicate a need to stop letdown in any way possible. Isolating RWCU is an obvious place to start.

If OPDHR fails, SDC will auto-isolate on level 3. Numerous alarms and indications will alert the operators to the loss of SDC.

File Name: OPDHR.TIO

Initiator: TIOPF65

Event Tree: L (from SDC, Seq. 1, from TIOPF65, Seq. 2)
LA (from ADH, Seq. 1, 2, from TIOPF65, Seq. 3)
LP (from SDC, Seq. 5, from TIOPF65, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR	0.12	10	HEP 77

TIOPF65 represents the occurrence of a mismatch between letdown and makeup (because of a decrease in letdown), which leads to a potential overpressurization of the vessel. In this scenario, 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). Thus, once the correct diagnosis is made, the decision is "dynamic" in the sense that the operators are not "directly" procedure driven.

HRA

File Name: OPDHR&.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: L (from TIAF16 or TIAF40 or TIAF93, Seq. 3)
LP (from TIAF16 or TIAF40 or TIAF93, Seq. 7)
LA (from TIAF16 or TIAF40 or TIAF93, Seq. 18)
LAP (from TIAF16 or TIAF40 or TIAF93, Seq. 22)

Human Error Events:

OPDHR	0.48	10	HEP 3

In this scenario, SDC(B) was successful, but forced recirculation is lost. The operator must diagnose the need to increase makeup. Since this is a TIA sequence, CRD will not be available for increased flow.

Note. OPDHR in this case includes use of some ECCS system for makeup. Thus, events downstream of a successful OPDHR which involve initiation of ECCS should be set to 0 (success).

File Name: OPDHRH26.FLD

Initiator: RWC26

Event Tree: L (from RWCHI, Seq. 2, 16, from RWC26, Seq. 17)

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR	0.108	10	HEP 58
LCMK (CDS or ECCS)	0		HEP 85
LCMK (CRD)	0.011	5	HEP 4
RM-LT	3.6E-3	5	HEP 56

In this scenario, the operators are in a HYDRO test when a break occurs in the RWCU line. Level quickly drops to level 2 and an auto-isolation of RWCU isolates the break. HPCS auto-starts on the level 2 signal and auto-stops at level 8. The operators recognize the need for SDC and start SDC(B). Operators must now diagnose the need to provide makeup due to the potential for an eventual disconnect between the core and the downcomer without level control (OPDHR). The disconnect is possible because of a loss of makeup and/or a loss of forced recirculation.

At this point, the operators have done everything correctly and the ONEP for IDHR has been pulled (SDC was initiated). Given the previous events, the operators will be likely to have an awareness of the need for makeup. OPDHR in this case could include an attempt to use CDS or ECCS, if CRD is not available. Given the injection rates for CDS or ECCS, it was assumed that the operators would control level once they began injection, i.e., not just walk away. If CRD continued to run, level control was not necessarily assumed to occur. RM-LT represents the operators providing long-term makeup for level control

HRA

File Name: OPDHRH74.FLD

Initiator: RWC74

Event Tree: L (from RWCHI, Seq. 2, 16, from RWC74, Seq. 17)

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR	0.108	10	HEP 58
LCMK (CDS or ECCS)	0		HEP 85
LCMK (CRD)	0.011	5	HEP 4
RM-LT	3.6E-3	5	HEP 56

In this scenario, the operators are in a HYDRO test when a break occurs in the RWCU line. Level quickly drops to level 2 and an auto-isolation of RWCU isolates the break. HPCS auto-starts on the level 2 signal and auto-stops at level 8. The operators recognize the need for SDC and start SDC(B). Operators must now diagnose the need to provide makeup due to the potential for an eventual disconnect between the core and the downcomer without level control (OPDHR). The disconnect is possible because of a loss of makeup and/or a loss of forced recirculation.

At this point, the operators have done everything correctly and the ONEP for IDHR has been pulled (SDC was initiated). Given the previous events, the operators will be likely to have an awareness of the need for makeup. OPDHR in this case could include an attempt to use CDS or ECCS, if CRD is not available. Given the injection rates for CDS or ECCS, it was assumed that the operators would control level once they began injection, i.e., not just walk away. If CRD continued to run, level control was not necessarily assumed to occur. RM-LT represents the operators providing long-term makeup for level control

File Name: OPDHRHYD.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: L (from ADEP, Seq. 3, from OVPR, Seq. 4,
from HYDRO, Seq. 5, from TIAF16 or TIAF40 or TIAF93, Seq 33)

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR	0.108	10	HEP 58
LCMK	0		HEP 85

In this scenario, the operators are in a HYDRO test when a loss of IA occurs. FCIRC, CRD, and RWCU are lost. No LOSP. An SRV opens on its safety set point and fails to close, resulting in depressurization. The operators recognize the need to isolate RWCU and unisolate SDC(B). SDC(B) successfully runs (SDCUI). Operators have 8.7 hrs. to accomplish SDCUI. Operator must now diagnose the need to provide makeup due to the potential for an eventual disconnect between the core and the downcomer without level control.

At this point, the operators have done everything correctly and the ONEP for IDHR has been pulled. Given the previous events, the operators will be likely to have an awareness of the need for makeup. OPDHR in this case includes an attempt to use CDS or ECCS Given the injection rates for CDS or ECCS, it was assumed that the operators would control level once they began injection, i.e., not just walk away.

HRA

File Name: OPDHRHYD.TIO

Initiator: TIOPF65

Event Tree: L (from ADEP, Seq. 3, from OVPR, Seq. 4, from TIOPF65, Seq 19)

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR	0.108	10	HEP 58
LCMK (CDS or ECCS)	0		HEP 85
LCMK (CRD)	0.011	5	HEP 4
RM-LT	3.6E-3	5	HEP 56

In this scenario, the operators are conducting a HYDRO test when a mismatch between letdown and makeup occurs. No LOSP. An SRV opens on its safety set point and fails to close, resulting in depressurization. The operators recognize the need to unisolate and initiate SDC(B) (SDCUI succeeds). SDC(B) successfully runs. Operators have 8.7 hrs. to accomplish SDCUI. Operators must now diagnose the need to provide makeup due to the potential for an eventual disconnect between the core and the downcomer without level control (OPDHR).

At this point, the operators have done everything correctly and the ONEP for IDHR has been pulled (SDC was initiated). Given the previous events, the operators will be likely to have an awareness of the need for makeup. OPDHR in this case could include an attempt to use CDS or ECCS, if CRD is not available. Given the injection rates for CDS or ECCS, it was assumed that the operators would control level once they began injection, i.e., not just walk away. If CRD continued to run, level control was not necessarily assumed to occur. RM-LT represents the operators providing long-term makeup for level control

File Name: OPDHRHYR.TIO

Initiator: TIOPF65

Event Tree: L (from ADEP, Seq. 2, from OVPR, Seq. 4, from TIOPF65, Seq 19)

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR	0.015	5	HEP 87
LCMK (CDS or ECCS)	0		HEP 85
LCMK (CRD)	0.011	5	HEP 4
RM-LT	3.6E-3	5	HEP 56

In this scenario, the operators are in a HYDRO test when a mismatch between letdown and makeup occurs. No LOSP. An SRV opens on safety set point and fails to close, resulting in depressurization. RWCU continues to run in recirculation mode (RWCUC). The operators need to diagnose the need to provide makeup due to the potential for an eventual disconnect between the core and the downcomer without level control (OPDHR). Since letdown in this scenario will be relatively small and RWCU is providing core cooling as long as the level stays high, the operators have 115 min. to diagnose the need and provide makeup. Since the IDHR ONEP will not be immediately indicated, the operators will have to diagnose the potential disconnect on their own. Given the initiator, the liklihood that the operators will check level during the time available, and the fact that operators showed an awareness of the disconnect problem during interviews, the control room crew would have a reasonable probability of an appropriate response. OPDHR in this case could include an attempt to use CDS or ECCS, if CRD is not available. Given the injection rates for CDS or ECCS, it was assumed that the operators would control level once they began injection, i.e., not just walk away. If CRD continued to run, level control was not necessarily assumed to occur (LCMK). RM-LT represents the operators providing long-term makeup for level control

File Name: OPDHRHYR.TIO

Initiator: TIOPF65

Event Tree: L (from ADEP, Seq. 2, from OVPR, Seq. 4, from TIOPF65, Seq 19)

Human Error Events:

	Mean HEPs	EF	Code#
OPDHR	0.015	5	HEP 87
LCMK (CDS or ECCS)	0		HEP 85
LCMK (CRD)	0.011	5	HEP 4
RM-LT	3.6E-3	5	HEP 56

In this scenario, the operators are in a HYDRO test when a mismatch between letdown and makeup occurs. No LOSP. An SRV opens on safety set point and fails to close, resulting in depressurization. RWCU continues to run in recirculation mode (RWCUC). The operators need to diagnose the need to provide makeup due to the potential for an eventual disconnect between the core and the downcomer without level control (OPDHR). Since letdown in this scenario will be relatively small and RWCU is providing core cooling as long as the level stays high, the operators have 115 min. to diagnose the need and provide makeup. Since the IDHR ONEP will not be immediately indicated, the operators will have to diagnose the potential disconnect on their own. Given the initiator, the liklihood that the operators will check level during the time available, and the fact that operators showed an awareness of the disconnect problem during interviews, the control room crew would have a reasonable probability of an appropriate response. OPDHR in this case could include an attempt to use CDS or ECCS, if CRD is not available. Given the injection rates for CDS or ECCS, it was assumed that the operators would control level once they began injection, i.e., not just walk away. If CRD continued to run, level control was not necessarily assumed to occur (LCMK). RM-LT represents the operators providing long-term makeup for level control

File name: OPECAD10.TAB

Initiator: TAB39

Event Tree: HPSWA (from ADH, Seq. 10, from TAB39, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	1.0		HEP 102

In this scenario, the only AC bus has failed and is followed by a LOSP. Thus, no DV1-2. HPCS is working (available). OPECS in this case involves deciding to initiate ECCS water solid operation with HPCS. The most significant difference between this and HPSWR (from SDC tree) is that the operators must also diagnose need to isolate ADHR during OPECS. This is a non-trivial difference because with the LOSP and loss of Div 1/2 (or TAB39 initiator and a LOSP), operators will now have to isolate the 8 or 9 valve locally. When 15 min. is assumed for accomplishing this action and the other OPECS actions are considered, insufficient time remains for making the relevant diagnoses.

HRA

File Name: OPECADH5.TAB

Initiator: TAB39

Event Tree: EA (from ADH, Seq. 5, from TAB39, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	1.0		HEP 17

In this loss of AC bus scenario, OPSDC has failed. That is, the control room has failed to detect the loss of SDC (ADHR) in 37 min, given that the only useful AC bus has failed (B train) and rendered any useful B systems unavailable. Because of this failure and the need to diagnose the need to isolate ADHR and start HPCS (for which no step by step procedures are available, i.e., the IDHR ONEP indicates use of any available ECCS system but nothing about isolating ADHR), the HEP derived for OPECS is equal to 1.0. The critical problem here is that a control room failure to diagnose the loss of the operating SDC in this circumstance does not bode well for doing so in OPECS, in which the need to isolate ADHR must be determined without procedures.

File Name: OPECS.J2

Initiator: J2F48

Event Tree: E (from A5ISJ, Seq. 1, 6, from J2F48, Seq. 2)
EP (from A5ISJ, Seq. 2, 7, from J2F48, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 61
OP1SV	0.302	10	HEP 107
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

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 a 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.

Note: Relative to the HEPs used for OPECS and OP1SV in other similar sequences, the values used above were somewhat conservative. More appropriate HEPs, in terms of consistency with the current analysis, would have been HEP 64 (0.043) for OPECS and HEP 63 (0.08) for OP1SV. Where important, the differences will be considered and taken into account during recovery.

File Name: OPECS3.T5A

Initiator: T5AF19

Event Tree: E (from T5AF19, Seq. 3)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.059	10	HEP 16
	OP1SV	0.112	10	HEP 105
*	OPHIS	0		HEP 8
	OPMSV	1.0		HEP 9

In this scenario, a loss of SSW has occurred. SDC(B) fails and the operators recognize the loss of SDC (OPSDC succeeds). The control room has entered the relevant ONEPs. They are instructed by the IDHR ONEP to initiate ECCS water solid operation with any available system. Given the initiator, HPCS is the only available system.

* OPHIS is completely dependent on OPECS. If OPECS succeeds, then OPHIS succeeds.

Note. The HEP used above for OPECS (HEP 16) assumed that the operators might be required to isolate the SDC low pressure piping by closing the 8 or 9 valve from the control room. In actuality, isolating the low pressure piping would probalbly not be required in this scenario. Thus, HEP 6 for OPECS (0.035) would have been a more appropriate and consistent HEP in the context of the overall analysis. However. the use of HEP 16 is just slightly more conservative.

File Name: OPECS4.T5A

Initiator: T5AF19

Event Tree: E (from T5AF19, Seq. 4)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.138	10	HEP 18
	OP1SV	0.302	10	HEP 106
*	OPHIS	0		HEP 8
	OPMSV	1.0		HEP 9

In this scenario, a loss of SSW has occurred. SDC(B) is lost. OPSDC in this case has failed. That is, in 37 min. the control room has not diagnosed the loss of SDC or entered the IDHR ONEP. However, at this point additional alarms could sound, e.g., a low level or high pressure alarm, and by requirememts (every 30 min.) the reactor temperature and/or pressure chart recorders would very likely be checked (to reveal increases) in the 23 additional minutes available for this event. Operators must diagnose the need to initiate ECCS water solid operation.

* OPHIS is completely dependent on OPECS. If OPECS succeeds, the OPHIS succeeds.

File Name: OPECSA07.E2D

Initiator: E2DF93

Event Tree: EA (from E2DF93, Seq. 7)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	1.0		HEP 13

In this loss of ADHR scenario, OPSDC has failed. That is, the control room has failed to detect/realize the loss of SDC (ADHR) in 37 minutes. Because of the failure of OPSDC and the time and actions required to isolate ADHR and align and start ECCS (per "abnormal operations" in the RHR SOI), and perform the related OPECS action from the IDHR ONEP, OPECS fails (as do the remaining associated human actions).

File Name: OPECSAD5.TIO

Initiator: TIOPF65

Event Tree: EA (from ADH, Seq. 5, from TIOPF65, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 78
OP1SV	0.302	10	HEP 108
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9
OPISA	0		HEP 81

In this TIOPF65 scenario, LCMK has succeeded with the operators controlling level to handle the mismatch between letdown and makeup. Later in the scenario, ADHRS fails and OPSDC in this case has failed. That is, in 37 min. the control room has not diagnosed the loss of SDC or entered the IDHR ONEP. However, by requirememts (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.

File Name: OPECSADH.E2D

Initiator: E2DF93

Event Tree: EA (from E2DF93, Seq. 6)
EAP (from E2DF93, Seq. 10)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.059	10	HEP 16
	OP1SV	0.112	10	HEP 105
*	OPHIS	0		HEP 8
	OPMSV	1.0		HEP 9
*	OPISA	0		HEP 81

The above scenario reflects a loss of ADH. In some cases the initiator is followed by a LOSP and the diesels successfully start and load (DV1-2 succeeds). The operators recognize the loss of SDC (OPSDC succeeds) and attempt to start SDC(B), but it fails to start. OPECS involves isolating ADHR from control room (if necessary) by closing 8 or 9 valve and initiating HPCS from CR for ECCS water solid operation per the IDHR ONEP. With the loss of ADH and and failure of SDC(B), it is conservatively assumed that neither LPCI(C) nor (B) are available.

* OPHIS and OPISA are completely dependent on OPECS. If OPECS succeeds, then OPHIS and OPISA succeed.

File Name: OPECSADH.TAB

Initiator: TAB39

Event Tree: EA (from ADH, Seq. 4, from TAB39, Seq. 5)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.059	10	HEP 16
	OP1SV	0.112	10	HEP 105
*	OPHIS	0		HEP 8
	OPMSV	1.0		HEP 9
*	OPISA	0		HEP 81

In this scenario, OPSDC has succeeded and the appropriate ONEP has been entered prior to start of OPECS. That is, operators have diagnosed the loss of ADH in the context of the loss of the 1E AC bus and entered the IDHR ONEP. OPECS involves isolating ADH from control room (if necessary) by closing the 8 or 9 valve and initiating HPCS from the CR.

* OPHIS and OPISA are completely dependent on OPECS If OPECS succeeds, then OPHIS and OPISA succeed.

File Name: OPECSADH.TIO

Initiator: TIOPF65

Event Tree: EA (from ADH, Seq. 4, from TIOPF65, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	1		HEP 8
OPMSV	1		HEP 9
OPISA	0		HEP 81

TIOPF65 initiator, which is a mismatch between letdown and makeup potentially leading to over-pressurization. Operators successfully control letdown and makeup (LCMK OK). Later in the scenario, a random isolation of ADHRS occurs. OPSDC has succeeded and the operators have attempted to start SDC(B), but it fails. The appropriate ONEP has been entered prior to start of OPECS. That is, operators have diagnosed the loss of ADHR, attempted a restart with no luck, and entered the IDHR ONEP. By procedure they are directed to initiate ECCS water solid operation. LPCI(C) is assumed the system of choice. LPCI(C) was placed in standby during OPSDC and ADHR is isolated. No credit was taken for HPCS at this point if LPCI(C) failed.

File Name: OPECSALB.E2D

Initiator: E2DF93

Event Tree: EA (from LA, Seq. 5, 38, 32, 48, from E2DF93, Seq. 4)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.12	10	HEP 39
	OP1SV	0.31	10	HEP 40
*	OPHIS	0		HEP 8
	OPMSV	1.0		HEP 9
*	OPISA	0		HEP 81

The above scenario reflects a loss of the ADHR system. The operators detect the loss and align SDC(B). The operators initially fail to detect the need for level control during the 10 minutes allowed for OPDHR (OPDHR fails). The operators must diagnose the need to isolate RWCU from the control room and initaite ECCS water solid operations (OPECS). With the loss of ADHR, LPCI(C) is assumed unavailable. Since RHR(B) aligned for SDC, HPCS may be the system of choice for ECCS injection.

* In this scenario OPHIS and OPISA is set equal to 0 (success) because they are both completely dependent on OPECS, which succeeds.

File Name: OPECSDC4.TAB

Initiator: TAB39

Event Tree: E (from SDC, Seq. 4, from TAB39, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 10
OP1SV	0.302	10	HEP 11
OPHIS	0		HEP 8
OPMSV	1.0		HEP 9
OPSOF	0.06	10	HEP 12

In this scenario, the only AC bus is gone, thus no power to Divisions 1 or 2. A LOSP has not occurred. OPSDC in this case has failed. That is, in 37 min. the operators have not diagnosed the loss of SDC in the context of the loss of the bus and therefore has not pulled the IDHR ONEP. However, at this point an additional alarm would be likely to sound (low level) and by requirememts (every 30 min.) the reactor temperature and pressure chart recorders should be checked in the 23 min. available for this event. Temperature and pressure increases would be revealed. With the additional time and some new indicators, it was assumed that the HEP computations for OPECS etc. would parallel those from other cases where the need for HPCS must be diagnosed and the related OPECS actions carried-out without a successful OPSDC event.

File Name: OPECSDC5.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: E (from TIAF16 or TIAF40 or TIAF93, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	1		HEP 8
OPMSV	1		HEP 9

In this scenario, OPSDC has succeeded and the appropriate ONEP has been entered prior to start of OPECS. That is, the control room has diagnosed loss of SDC(B) (a random failure occurring sometime after the loss of Instrument Air), and they have entered the IDHR ONEP. The ONEP directs the control room to initiate ECCS water solid operation.

HRA

File Name: OPECSDC6.E2B

Initiator: E2BF20

Event Tree: E (from E2BF20, Seq. 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

An isolation of SDC is the initiator. OPSDC in this case has failed. That is, in 37 min. the control room has not diagnosed the loss of SDC or entered the IDHR ONEP. However, at this point additional alarms could sound, e.g., a low level or high pressure alarm, and by requirememts (every 30 min.) the reactor temperature and/or pressure chart recorders would very likely be checked (to reveal increases) in the 23 additional minutes available for this event. Operators must diagnose the need to initiate ECCS water solid operation.

File Name: OPECSDC6.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: E (from TIAF16 or TIAF40 or TIAF93, Seq. 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

A loss of IA is the initiator. It is followed at some point by a random failure of SDC(B). OPSDC in this case has failed. That is, in 37 min. the control room has not diagnosed the loss of SDC or entered the IDHR ONEP. However, at this point additional alarms could sound, e.g., a low level or high pressure alarm, and by requirememts (every 30 min.) the reactor temperature and/or pressure chart recorders would very likely be checked (to reveal increases) in the 23 additional minutes available for this event.
Operators must diagnose the need to initiate ECCS water solid operation.

HRA

File Name: OPECSDC9.TAB

Initiator: TAB39

Event Tree: HPSWR (from SDC, Seq. 9, from TAB39, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 10
OP1SV	0.302	10	HEP 11
OPHIS	0		HEP 8
OPMSV	1		HEP 9
OPSOF	0.06	10	HEP 12

In this loss of the only AC bus initiator, a LOSP has also occurred. HPCS is working (available). OPECS in this case, involves deciding to go water solid with HPCS.

* OPHIS in this case is included in the OPECS event. Thus, failure probabability for OPHIS should be set to 0 when OPECS is successful.

File Name: OPECSDC9.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EP (from TIAF16 or TIAF40 or TIAF93, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	1		HEP 8
OPMSV	1		HEP 9

In this loss of Instrument Air scenario, a LOSP has occurred and DV1-2 has succeeded. OPSDC has succeeded and the appropriate ONEP has been entered prior to the start of OPECS. That is, the control room has diagnosed the loss of SDC(B) (a random failure occurring sometime after the loss of Instrument Air), and entered the IDHR ONEP. The ONEP directs the control room to initiate ECCS water solid operation.

HRA

File Name: OPECSHPR.E2B

Initiator: E2BF20

Event Tree: HPSWR (from E2BF20, Seq. 10)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.138	10	HEP 10
	OP1SV	0.302	10	HEP 11
*	OPHIS	0		HEP 8
	OPMSV	1		HEP 9
	OPSOF	0.06	10	HEP 12

In this scenario, all of RHR loop B has failed. A LOSP has occurred and the diesels have failed to start (DV1_2 fails). HPCS is working (available). OPECS in this case, involves deciding to go water solid with HPCS.

* OPHIS in this case is covered in the OPECS event. Thus, failure probabability for OPHIS should be set to 0 when OPECS is successful.

File Name: OPECSHPR.T5A

Initiator: T5AF19

Event Tree: HPSWR (from T5AF19, Seq. 6)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.138	10	HEP 10
	OP1SV	0.302	10	HEP 11
*	OPHIS	1 or 0		HEP 8
	OPMSV	1		HEP 9
	OPSOF	0.06	10	HEP 12

In this scenario, a loss of SSW has occurred and is followed at some later point with a LOSP. SDC(B) is lost, but HPCS is working (available). OPECS in this case, involves deciding to go water solid with HPCS. This situation is similar to that in T1-5 and TAB39.

* OPHIS in this case is covered in the OPECS event. Thus, failure probabability for OPHIS should be set to 0 when OPECS is successful.

File Name: OPECSHY2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: E (from ADEP, Seq. 6, 8, from OVPR, Seq. 4,
from HYDRO, Seq. 5, from TIAF16 or TIAF40 or TIAF93, Seq. 33)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	1.0		HEP 8
OPMSV	1		HEP 9

In this scenario, in HYDRO when a loss of IA occurs. No LOSP. FCIRC, CRD, CDS, and RWCU are lost. The SRVs open on safety setpoint and fail to close (SAFEC). Depressurization occurs. In ADEP tree either SDCUI fails (8.7 hours for this event) because the operators fail to accomplish the necessary steps to initiate SDC(B) or ADHR (in 8.7 HRS.) or SDCUI succeeds, but SDC(B) and ADHR1 fails due to hardware. Thus, enter E tree and operator action to initiate ECCS water solid operation (OPECS). Many indications for plant status will be available and up to 8.7 hours could have elapsed before needing OPECS related actions (because HYDRO test is done late in the outage and little decay heat would be left). Upon entering OPECS, it is at least assumed that the operators have diagnosed the loss of SDC and RWCU in the context of a loss of IA and entered the IDHR ONEP and other relevant procedures. Thus, OPECS is entered in a way that is similar to scenarios where OPSDC was successful and the operators have diagnosed the loss of SDC.

File Name: OPECSHYD.TAB

Initiator: TAB39

Event Tree: E (from ADEP, Seq. 6, 8, from OVPR, Seq. 4,
from HYDRO, Seq. 5, from TAB39, Seq. 7)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	0		HEP 8
OPMSV	1		HEP 9

In this scenario, in HYDRO when TAB39 initiator occurs. RWCU is lost. No LOSP. The SRVs open on safety setpoint and fail to close (SAFEC). Depressurization occurs. In ADEP tree either SDCUI fails (8.7 hours for this event) because the operators fail to accomplish the necessary steps to initiate ADHRS (in 8.7 HRS.) or SDCUI succeeds, but ADHR1 fails due to hardware. Thus, enter E tree and operator action to initiate ECCS water solid operation (OPECS). Many indications for plant status will be available and up to 8.7 hours could have elapsed before needing OPECS related actions (because HYDRO test is done late in the outage and little decay heat would be left). Upon entering OPECS, it is at least assumed that the operators have diagnosed the loss of SDC and RWCU in the context of a loss of the available AC bus and entered the IDHR ONEP and other relevant procedures (loss of AC Power). Thus, OPECS is entered in a way that is similar to scenarios where OPSDC was successful and the operators have diagnosed the loss of SDC. These values are conservative given the preceeding 8.7 hours, but with such low decay heat levels, the operators may not be very concerned.

Since the OPECS actions in this case demand the use of HPCS, OPHIS (operator action to initiate HPCS) will be 0 (success) if OPECS is successful.

File Name: OPECSHYD.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: E (from L, Seq. 32, 48, from ADEP, Seq. 3,
from OVPR, Seq. 4, from HYDRO, Seq. 5,
from TIAF16 or TIAF40 or TIAF93, Seq. 33)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.059	10	HEP 50
OP1SV	0.112	10	HEP 51
OPHIS	1		HEP 8
OPMSV	1		HEP 9

In this scenario, the operators are conducting a HYDRO test when a loss of IA occurs. RWCU isolates and CRD is lost. The SRVs open on safety setpoint and fail to close (SAFEC). Depressurization occurs. The operators take the necessary steps to initiate SDC(B) (SDCUI succeeds, 8.7 hours for this event). In the L tree, the operators fail to recognize a potential disconnect between core and downcomer which results in inadequate circulation and fail to provide level control (OPDHR fails in the 10 minutes allowed). The operators have an additional 23 min. in OPECS to detect and respond to the loss of SDC and additional indicators would become available. Periodic checks of the chart recorders for increases in temperature and pressure would be due during the time for OPECS. The operators must diagnose the need to initiate ECCS water solid operation. OPECS in this scenario is entered in a way that is similar to scenarios where OPSDC was successful and SDC(B) was initiated. LPCI(C) is assumed the system of choice, so OPHIS (initiation of HPCS) is set to fail (1.0).

File Name: OPECSLEA.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EA (from LA, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

EAP (from LAP, Seq. 8, 15, from TIAF16 or TIAF40 or TIAF93, Seq. 22)

Human Error Events:

		Mean HEPs	EF	Code#
	OPECS	0.059	10	HEP 50
	OPMSV	1.0		HEP 9
	OP1SV	0.112	10	HEP 51
	OPHIS	1.0		HEP 8
*	OPISA	0		HEP 81

The initiator is a loss of IA. In some sequences, a LOSP also occurs at some point. The operators diagnose the loss of ADHR (OPSDC succeeds) and successfully align and start SDC(B). Forced recirculation and RWCU are lost. RWCU auto-isolates. In some sequences, CRD is also lost. The operators initially fail to recognize the disconnect between the core and the downcomer resulting in inadequate recirculation and fail to control letdown and makeup (OPDHR fails). The operators have an additional 23 min. in OPECS to detect and respond to the loss of SDC and additional indicators would become available. Periodic checks of the chart recorders for increases in temperature and pressure would be due during the time for OPECS. The operators must diagnose the need to initiate ECCS water solid operation. ADHR has been isolated.

* OPISA is completely dependent on OPECS. If OPECS is successful, OPISA = 0 (success).

HRA

File Name: OPECSLP8.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EP (from LP, Seq. 8, 15, from TIAF16 or TIAF40 or TIAF93, Seq. 7)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

A loss of IA is the initiator. At some point a LOSP also occurs, but the diesels start and load (DIV 1/2 succeees). SDC(B) contiunes to run. CRD, RWCU, and forced recirculation is lost. With loss of makeup (CRD) and forced recirculation, the potential for a disconnect between the core and the downcomer regions of the core arises. With inadequate level or recirculation, a "functional" loss of SDC to the core can occur. OPDHR is the the operator action to diagnose the functional loss of SDC and initiate level control. In these sequences, OPDHR has failed. That is, the operators fail to diagnose the disconnect between the core and the downcomer and the resulting functional loss of SDC in the 10 minutes allowed for OPDHR. However, at this point some additional indicators would be coming available and the operators should notice increases in pressure and temperature on chart recorders per periodic checks (required every 30 minutes). Operators must diagnose the need to initiate ECCS water solid operation.

File Name: OPECSNL4.FLD

Initiator: RWC74

Event Tree: E (from RRW, Seq. 32, from RWC74, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

In this scenario, a break in the RWCU line occurs. The operators successfully isolate RWCU and the break. However, they initially fail to bring level back up (OPLEC fails). SDC(B) continues to run. If it is conservatively assumed that forced recirculation is lost or that they were not on forced recirculation, then without additional level a disconnect betweeen the core and the downcomer will occur with a resulting "functional" loss of SDC. While changes in temperature may be subtle because the water in the downcomer continues to be cooled, the operators should notice increases in pressure per periodic checks (required every 30 minutes). Moreover, with the additional time in the given context, they should at least realize the need to restore level and enter the IDHR ONEP. The operators must diagnose the need to initiate ECCS water soild operation.

HRA

File Name: OPECSNL6.FLD

Initiator: RWC26

Event Tree: E (from RRW, Seq. 32, from RWC26, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

In this scenario, a break in the RWCU line occurs. The operators successfully isolate RWCU and the break. However, they initially fail to bring level back up (OPLEC fails). SDC(B) continues to run. If it is conservatively assumed that forced recrirculation is lost or that they were not on forced recirculation, then without additional level a disconnect betweeen the core and the downcomer will occur with a resulting "functional" loss of SDC. While changes in temperature may be subtle because the water in the downcomer continues to be cooled, the operators should notice increases in pressure per periodic checks (required every 30 minutes). Moreover, with the additional time in the given context, they should at least realize the need to restore level and enter the IDHR ONEP. The operators must diagnose the need to initiate ECCS water soild operation.

File Name: OPECSNL6.FLD

Initiator: RWC26

Event Tree: E (from RRW, Seq. 32, from RWC26, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.138	10	HEP 18
OP1SV	0.302	10	HEP 106
OPHIS	1.0		HEP 8
OPMSV	1.0		HEP 9

In this scenario, a break in the RWCU line occurs. The operators successfully isolate RWCU and the break. However, they initially fail to bring level back up (OPLEC fails). SDC(B) continues to run. If it is conservatively assumed that forced recirculation is lost or that they were not on forced recirculation, then without additional level a disconnect betweeen the core and the downcomer will occur with a resulting "functional" loss of SDC. While changes in temperature may be subtle because the water in the downcomer continues to be cooled, the operators should notice increases in pressure per periodic checks (required every 30 minutes). Moreover, with the additional time in the given context, they should at least realize the need to restore level and enter the IDHR ONEP. The operators must diagnose the need to initiate ECCS water soild operation.

File Name: OPECSP.TIO

Initiator: TIOPF65

Event Tree: E (from AISD, Seq. 1, from TIOPF65, Seq. 4)

EA (from AIAD, Seq. 2, from TIOPF65, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.023	5	HEP 79
OP1SV	0.11	10	HEP 80
OPHIS	1		HEP 8
* OPMSV			

TIOPF65 initiator, which is a mismatch between letdown and makeup potentially leading to over-pressurization. Operators fail to successfully control letdown and makeup (LCMK fails). Later in the scenario SDC isolates on high pressure. Pump trip alarm would occur and level 7 and 8 alarms would sound if haven't already. Pressure would be up. Operators will have entered IDHR ONEP. Will need to stop makeup (CRD), start LPCI, and perform related OPECS actions for initiating ECCS water solid operation. In the EA tree, OPISA must succeed because ADHR auto-isolates.

* Since the vessel would not pressurize with the MSIVs open, ISMSV must be closed and OPMSV will not be asked.

File Name: OPECSR26.FLD

Initiator: RWC26

Event Tree: E (from RWC26, Seq. 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	1		HEP 8
OPMSV	1		HEP 9

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR is this case is the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. In these sequences, OPDHR fails and SDC isolates on level 3 and RWCU auto-isolates on level 2. The operators recognize the loss of SDC (OPSDC succeeds).
OPECS is the operator action to initiate ECCS water solid operation as indicated by the IDHR ONEP. LPCI(C) or (B) and HPCS are available for ECCS. At this point, credit is taken for LPCI only, so OPHIS is set to 1.0.

HRA

File Name: OPECSR74.FLD

Initiator: RWC74

Event Tree: E (from RWC74, Seq. 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	1		HEP 8
OPMSV	1		HEP 9

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR is this case is the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. In these sequences, OPDHR fails and SDC isolates on level 3 and RWCU auto-isolates on level 2. The operators recognize the loss of SDC (OPSDC succeeds).
OPECS is the operator action to initiate ECCS water solid operation as indicated by the IDHR ONEP. LPCI(C) or (B) and HPCS are available for ECCS. At this point, credit is taken for LPCI only, so OPHIS is set to 1.0.

File Name: OPECSRTE.E2D

Initiator: E2DF93

Event Tree: EA (from RA, Seq. 28, from LA Seq. 31, 37, 47, from E2DF93, Seq. 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	0		HEP 8
OPMSV	1		HEP 9

In this loss of ADHR scenario, OPSDC has succeeded and SDC(B) was started. CRD fails. OPDHR succeeds and CDS initiation is attempted, so operators are aware of the need for level control. Appropriate ONEP has been entered (IDHR ONEP). RWCU has been isolated. CDS fails. Level control with ECCS (OPLEC in R tree) fails because time available was spent in OPDHR initiating CDS and because procedures do not cleary call for ECCS injection in conjunction with SDC. In OPECS, HPCS is assumed the system of choice for ECCS water solid because LPCI(C) is assumed unavailable from the loss of and "non-restorability" of ADHRS and because RHR(B) is aligned for SDC. Operators need only initiate HPCS from the control room and perform the related OPECS actions. OPHIS must be set equal to 0 (success) if OPECS succeeds.

HRA

File Name: OPECSSDC.E2B

Initiator: E2BF20

Event Tree: E (from E2BF20, Seq. 5)

EP (from E2BF20, Seq, 8)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	1		HEP 8
OPMSV	1		HEP 9

In this scenario, SDC(B) fails along with all of train B RHR. OPSDC has succeeded and appropriate ONEP has been entered prior to start of OPECS. That is, the operators have diagnosed the loss of SDC(B), and entered the IDHR ONEP. In this scenario the operators do not attempt to restore SDC(B) (the initiator is more than just an isolation), the system has failed. Either there was no LOSP or DV1-2 was successful. The ONEP directs the operators to go ECCS water solid. LPCI(C) and HPCS are available for ECCS. At this point, credit is taken for LPCI only, so OPHIS is set to 1.0.

File Name: OPECSSDC.TAB

Initiator: TAB39

Event Tree: E (from SDC, Seq. 3, from TAB39, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	0		HEP 8
OPMSV	1		HEP 9

In this scenario, OPSDC has succeeded and the appropriate ONEPs have been entered prior to OPECS. That is, the control room has diagnosed the loss of SDC in the context of a loss of the available AC bus and entered the I[illegible]HR ONEP. With no DV1-2, HPCS is the system available for ECCS water solid operation, rather than LPCI(C).

Since OPECs in this case requires the use of HPCS, OPHIS must be set to 0 (success) when OPECS succeeds.

File Name: OPECSSDC.TIO

Initiator: TIOPF65

Event Tree: E (from SDC, Seq. 3, from TIOPF65, Seq. 2)

EP (from SDC, Seq. 7, from TIOPF65, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPECS	0.035	5	HEP 6
OP1SV	0.112	10	HEP 7
OPHIS	1		HEP 8
OPMSV	1		HEP 9

TIOPF65 initiator, which is a mismatch between letdown and makeup potentially leading to over-pressurization. Operators successfully control letdown and makeup (LCMK OK). Later in the scenario, a random isolation of SDC(B) occurs. OPSDC has succeeded and appropriate ONEP has been entered prior to start of OPECS. That is, operators have diagnosed the loss of SDC(B), attempted a restart with no luck, and entered the IDHR ONEP. By procedure they are directed to initiate ECCS water solid operation.

File Name: OPFLD.E2B

Initiator: E2BF20

Event Tree: F (from E, Seq. 5, 10, 11, 16, 21, 22,
from E2BF20, Seq. 5, 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	1.0		HEP 33

Total loss of SDC is the initiator. OPSDC succeeds or fails, but a loss of all RHR train B is assumed (ECSBF). No LOSP. OPECS succeeds, but LPCI(C) fails to inject or insufficient level in SP. Only system assumed available for continuous injection is FW. (Actually HPCS and CDS would be available, but not used in F tree. They will be asked later. Thus, we go to F tree for operators initiation of flooding (OPFLD). However, OPFLD cannot succeed in the present context because there is insufficient time allowed to complete FW hookup. Operators only allowed 23 min. for OPFLD.

File Name: OPFLD.E2B

Initiator: E2BF20

Event Tree: F (from E, Seq. 5, 10, 11, 16, 21, 22,
from E2BF20, Seq. 5, 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	1.0		HEP 33

Total loss of SDC is the initiator. OPSDC succeeds or fails, but a loss of all RHR train B is assumed (ECSBF). No LOSP. OPECS succeeds, but LPCI(C) fails to inject or insufficient level in SP. Only system assumed available for continuous injection is FW. (Actually HPCS and CDS would be available, but not used in F tree. They will be asked later. Thus, we go to F tree for operators initiation of flooding (OPFLD). However, OPFLD cannot succeed in the present context because there is insufficient time allowed to complete FW hookup. Operators only allowed 23 min. for OPFLD.

File Name: OPFLD.T5A

Initiator: T5AF19

Event Tree: FX (from T5AF19, Seq. 7)

F (from E, Seq. 4, 9, 11, 15, 22, from T5AF19, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	1.0		HEP 33

Loss of SSW is the initiator. In the FX scenario, a LOSP occurs and HPCSA fails. XTIEB succeeds and OPSDC succeeds. That is, the operators successfully cross-tie the HPCS diesel and realize that SDC has been lost. However, no systems are available for continuous injection (in any form) except FW. Thus, we go to FX tree for the operators initiation of flooding (OPFLD) with FW.

In the sequences that transfer through the E tree, a LOSP has not occurred and the operators recognize the loss of SDC. In the E tree, the operators attempt to initiate ECCS water solid operation with HPCS, but HPCS fails or there is insufficient level in the SP.
Transfer to F tree for vessel/containment flooding with FW. SSWXT unavailable.

However, the operator action to initiate flooding (OPFLD) cannot succeed in these sequences because there is insufficient time allowed to complete the FW hookup. OPFLD only allowed 23 min.

HRA

File Name: OPFLD.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: F (from E, Seq. 5, 10, 11, 16, 21, 22,
from TIAF16 or TIAF40 or TIAF93, Seq. 5)

F (from E, Seq. 5, 10, 11, 16, 21, 22,
from L, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93,
Seq. 3)

F (from EA, Seq. 5, 10, 11, from TIAF16 or TIAF40 or TIAF93, Seq 20)

F (from R, Seq. 11, 22, 27, from L, Seq. 31, 47,
from TIAF16 or TIAF40 or TIAF93, Seq. 3)

Human Error Events:

		Mean HEPs	EF	Code#
	OPFLD	0.138	10	HEP 28
*	OPMSV	1.0		HEP 34
*	OP1SV	0.302	10	HEP 5

A loss of IA is the initiator. SDC fails and operators recognize the loss (OPSDC succeeds) or SDC(B) continues to run. Regardless, either OPECS succeeds at some point or OPDHR and OPLEC succeed, but all ECCS fails (either systems or no SP level). The operators may decide to flood with SSWXT.

* Use the these value only when coming from R trees. Ignore when coming from E trees.

File Name: OPFLD2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: FP (from EAP, Seq. 5, 10, from LAP, Seq. 8, 15, from TIAF16 or TIAF40 or TIAF93, Seq. 22)

F (from E, Seq. 11, from L, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

F (from RA, Seq. 11, 22, from LA, Seq. 31, 47, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

		Mean HEPs	EF	Code#
	OPFLD	0.138	10	HEP 28
*	OPMSV	1.0		HEP 34
*	OP1SV	0.302	10	HEP 5

A loss of IA is the initiator. SDC fails and operators recognize the loss (OPSDC succeeds) or SDC(B) continues to run. Regardless, either OPECS succeeds at some point or OPDHR and OPLEC succeed, but all ECCS fails (either systems or no SP level). The operators may decide to flood with SSWXT.

* Use the these value only when coming from R trees. Ignore when coming from E trees.

File Name: OPFLDE.E2D

Initiator: E2DF93

Event Tree: F (from EA, Seq. 4, 9, from E2DF93, Seq. 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	0.138	10	HEP 28

Isolation of ADH is the initiator. No LOSP. OPSDC succeeds. Operators attempt to start SDC(B), but it fails. OPECS succeeds. The operators initiate HPCS (all LPCI assumed unavailable), but HPCS fails to start. The operators must diagnose the need for flooding and inject with SSWXT.

File Name: OPFLDE.TIO

Initiator: TIOPF65

Event Tree: F (from E, Seq. 5, 10, from SDC, Seq. 3, from TIOPF65, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	0.138	10	HEP 28

Mismatch between letdown and makeup initiator. Operators successfully attempt to control level. SDC(B) fails to continue to run. No LOSP. OPSDC succeeds and operators recognize loss of SDC(B) but it fails to restart. OPECS succeeds, but LPCI fails to operate on demand. Operators must diagnose the need to flood vessel/containment with SSWXT.

File Name: OPFLDE2.E2D

Initiator: E2DF93

Event Tree: F (from EA, Seq. 4, 9, from LA, Seq. 38,
from E2DF93, Seq. 4)

F (from EA, Seq. 4, 9, from R, Seq. 28,
from LA, Seq. 37, from E2DF93, Seq. 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	0.138	10	HEP 28

A complete loss of ADHR is the initiator. No LOSP. SDC(B) is started, but the operators fail to control level after a loss of CRD or they attempt to control level with CRD and it failed. Eventually, the operators attempt to initiate ECCS water solid operation (OPECS succeeds), but HPCS fails to start (LPCI(C) unavailable due to the initiator. The operators have the option of flooding the vessel/containment with SSWXT.
MSIVs are closed.

File Name: OPFLDE2.J2

Initiator: J2F48

Event Tree: F (from E, Seq. 5, 10, 11, 22,
from A5ISJ, Seq. 1, from J2F48, Seq.2)

F (from E, Seq. 5, 10, 11, from A5ISJ, Seq. 6,
from J2F48, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	0.138	10	HEP 28

A break in the SDC line outside containment is the initiator. The break is isolated with closure of MV 8 or MV 9. SDC and RHR(B) train is lost. Isolation of 8\9 valves occurs with level 3 signal. If a LOSP occurs, the diesels start and load (DV1-2 OK). The operators attempt to initiate ECCS water solid operation per the IDHR ONEP (OPECS succeeds). However, either the SP level is too low or LPCI fails to operate on demand. Operators must diagnose the need to flood vessel/containment with SSWXT. MSIVs are closed.

File Name: OPFLDF.TAB

Initiator: TAB

Event Tree: F (from EA, Seqs. 4, 9, 11, from ADH, Seq. 4, from TAB39, Seq. 5)

F (from E, Seqs. 4, 9, 15, 16, 20, 21, from SDC, Seq. 3, from TAB39, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	1.0		HEP 33

A loss of AC bus is the initiator. OPSDC either succeeds or fails and OPECS succeeds, but all ECCS fails (either the systems or no SP level). SSWXT is unavailable, but the operators have the option of flooding with FW. However, there is insufficient time available for aligning FW in OPFLD. Thus, OPFLD set to 1.0 (failure).

File Name: OPFLDP.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: FP (from EP, Seq. 11, from TIAF16 or TIAF40 or TIAF93, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	0.138	10	HEP 28

A loss of IA is the initiator. OPSDC succeeds and OPECS suceeds. The operators attempt to go ECCS water solid, but all ECCS fails (either systems or no SP level). The operators have the option of flooding with SSWXT.

HRA

File Name: OPICT.E2B

Initiator: E2BF20

Event Tree: EC (from E, Seq. 2, 7, 13, 18,
from E2BF20, Seq. 5, 6,)

ECP (from EP, Seq. 2, 7, 13, 18,
from E2BF20, Seq. 8, 9)

Human Error Events:

		Mean HEPs	EF	Code#
*	OPICT	1.0		HEP 71
**	OPVNT	0.011 or 1	5	HEP 25
	OPSPM	0.011	5	HEP 26
	SPMKP	0.032	5	HEP 27

Loss of SDC(B) is the initiator. If a LOSP occurs, DV1-2 OK. OPSDC succeeds or fails, but no SDC system. OPECS succeeds. Operators go water solid with LPCI(C). SPC and CS are assumed to fail. The operators will need to provide makeup to SP (OPSPM) and makeup to SPMU (or SP).

** Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1. For the above sequences, venting is possible only when E2BF20 sequences 5 and 6 are used (NO LOSP).

* No time to close containment if open.

File Name: OPICT.E2D

Initiator: E2DF93

Event Tree: EC (from EA, Seq. 3, 8, from E2DF93, Seq. 6)

ECP (from EAP, Seq. 3, 8, from E2DF93, Seq. 10)

Human Error Events:

		Mean HEPs	EF	Code#
*	OPICT	1.0		HEP 71
**	OPVNT	0.011 or 1	5	HEP 25
	OPSPM	0.011	5	HEP 26
	SPMKP	0.032	5	HEP 27

Loss of ADHR is the initiator. If a LOSP occurs, DV1-2 OK. OPSDC succeeds. SDC(B) fails, resulting in no SDC. OPECS succeeds. The operators go water solid with HPCS. Given failures of ADHR and SDC(B), LPCI is assumed to be unavailable. SPC and CS are assumed to fail. The operators will need to provide makeup to the SP (OPSPM) and makeup to SPMU (or SP).

** Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1. For the above sequences, venting is possible only when E1D5H sequence 6 is used (NO LOSP).

* No time to close containment if open.

File Name: OPICT.T5A

Initiator: T5AF19

Event Tree: EC (from E, Seq. 3, 8, 14, 19,
from T5AF19 Seq. 3, 4, 12, 13)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	0.011	5	HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

Loss of SSW is the initiator. SDC(B) is lost and OPSDC succeeds or fails. The operators go water solid with HPCS (OPECS succeeds). SPC and CS fail. The operators will need to provide makeup to SP (OPSPM) and makeup to SPMU or the SP (SPMKP).

File Name: OPICT.TAB

Initiator: TAB

Event Tree: EC (from E, Seq. 3, 14, 19, from SDC, Seq. 3, from TAB39, Seq.3)

EC (from E, Seq. 3, 8, from SDC, Seq. 4, from TAB39, Seq. 3)

EC (from E, Seq. 3, 8, 14, 19, from ADH, Seq. 4, from TAB39, Seq. 5.

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	1.0		HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

Loss of AC bus is the initiator. SDC is lost and OPSDC succeeds or fails. The operators initiate ECCS water solid operation with HPCS (OPECS succeeds). SPC and CS fail. With no SPC or CS and water solid with HPCS, the operators will need to provide makeup to the SP (OPSPM) The operators also may need to provide additional makeup (SPMKP) to SPMU or the SP.

HRA

File Name: OPICT.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EC (from E, Seq. 2, 7, 13, 18, from TIAF16 or TIAF40 or TIAF93, Seq. 5)

EC (from EA, Seq. 2, 7, from TIAF16 or TIAF40 or TIAF93, Seq. 20)

EC (from E, Seq. 2, 7, 13, 18, from L, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 3)

EC (from EA, Seq. 2, 7, 13, 18, from L, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	1.0		HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

Loss of IA is the initiator. SDC is either lost, continues to run, or is restablished. If SDC works, the operators fail to control level (OPDHR fails). Regardless, the operators eventually realize the need to initiate ECCS water solid operation with LPCI(C) (OPECS succeeds).

SPC and CS fail. With no SPC or CS and water solid with LPCI, the operators will need to provide makeup to SP with SPMU (OPSPM). The operatorss will also need to provide additional makeup (SPMKP) to SPMU or directly to the SP).

Assumed cannot vent because of loss of IA. Need both Divs. of power and IA to vent.

File Name: OPICT2.E2D

Initiator: E2DF93

Event Tree: EC (from EA, Seq. 3, 8, from LA, Seq. 5, 32, 38, 48, from E2DF93, Seq. 4)

EC (from EA, Seq. 3, 8, from RA, Seq. 28, from LA, Seq. 31, 37, 47, from E2DF93, Seq. 4)

Human Error Events:

		Mean HEPs	EF	Code#
*	OPICT	1.0		HEP 71
**	OPVNT	0.011	5	HEP 25
	OPSPM	0.011	5	HEP 26
	SPMKP	0.032	5	HEP 27

A complete loss of ADHR is the initiator. SDC(B) is started. CRD is lost. The operators attempt to control level with CDS, but it is unavailable or fails or they initially fail to control level. OPLEC fails. OPECS succeeds--water solid with HPCS (LPCI(C) unavailable due to initiator). SPC and CS are assumed to fail. The operators will need to provide makeup to SP (OPSPM) and makeup to SPMU (or SP).

* No time to close containment if open.

** Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1.

File Name: OPICT274.FLD

Initiator: RWC74

Event Tree: EC (from E, Seq. 2, 7, from RRW Seq. 32,
from RWC74, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	0.011	5	HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR1 is this case is the operator action to isolate letdown (RWCU) before level 3 is reached and SDC auto-isolates. In these sequences, OPDHR1 succeeds. The operators initially fail to bring level back up (OPLEC fails), but eventually the operators successfully initiate ECCS water solid operation with LPCI(C) (OPECS succeeds). The operators will need to vent to remove heat buildup in containment (OPVNT) if possible and provide makeup to SP (OPSPM) and makeup to SPMU or SP (SPMKP).

Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1. Insufficient time is available to close containment, if it is open.

File Name: OPICTE26.FLD

Initiator: RWC26

Event Tree: EC (from E, Seq. 2, 7, from RRW Seq. 32,
from RWC26, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	0.011	5	HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR1 is this case is the operator action to isolate letdown (RWCU) before level 3 is reached and SDC auto-isolates. In these sequences, OPDHR1 succeeds. The operators initially fail to bring level back up (OPLEC fails), but eventually the operators successfully initiate ECCS water solid operation with LPCI(C) (OPECS succeeds). The operators will need to vent to remove heat buildup in containment (OPVNT) if possible and provide makeup to SP (OPSPM) and makeup to SPMU or SP (SPMKP).

Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1. Insufficient time is available to close containment, if it is open.

File Name: OPICTE74.FLD

Initiator: RWC74

Event Tree: EC (from E, Seq. 2, 7, from RWC74, Seq. 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	0.011	5	HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR1 is this case is the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. In these sequences, OPDHR1 fails and SDC isolates on level 3 and RWCU auto-isolates on level 2. The operators recognize the loss of SDC (OPSDC succeeds). The operators diagnose the loss of SDC (OPSDC succeeds). The operators successfully initiate ECCS water solid operation with LPCI(C) (OPECS succeeds). The operators will need to vent to remove heat buildup in containment (OPVNT) if possible and provide makeup to SP (OPSPM) and makeup to SPMU or SP (SPMKP).

Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1. Insufficient time is available to close containment, if it is open.

File Name: OPICTE.J2

Initiator: J2F48

Event Tree: EC (from E, Seq. 2, 7, from A5ISJ, Seq. 1,
from J2F48, Seq. 2)

Human Error Events:

		Mean HEPs	EF	Code#
*	OPICT	1.0		HEP 71
**	OPVNT	0.011	5	HEP 25
	OPSPM	0.011	5	HEP 26
	SPMKP	0.032	5	HEP 27

A break in the SDC line outside containment is the initiator. The break is isolated with closure of MV 8 or MV 9. SDC and RHR(B) train is lost. Isolation of 8\9 valves occurs with level 3 signal. OPECS succeeds--water solid with LPCI(C). Since no LOSP and no loss of IA, venting is possible. Operators will need to provide makeup to SP (OPSPM) and makeup to SPMU or SP (SPMKP).

** Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1.

* No time to close containment if open.

File Name: OPICTE.TIO

Initiator: TIOPF65

Event Tree: EC (from E, Seq. 2, 7, from SDC, Seq. 3,
from TIOPF65, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	0.011	5	HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

Mismatch between letdown and makeup initiator. SDC(B) fails to continue to run. OPSDC succeeds. OPECS succeeds--water solid with LPCI(C). SPC and CS are assumed to fail. Operators will need to vent to remove heat buildup in containment (OPVNT) and provide makeup to SP (OPSPM) and makeup to SPMU or SP (SPMKP).

Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1. Insufficient time is available to close containment if it is open.

File Name: OPICTE2.J2

Initiator: J2F48

Event Tree: EC (from E, Seq. 2, 7, 13, 18, from A5ISJ, Seq. 1, from J2F48, Seq. 2)

EC (from E, Seq. 2, 7, 13, 18, from A5ISJ, Seq. 6, from J2F48, Seq. 2)

ECP (from EP, Seq. 2, 7, from A5ISJ, Seq. 2, from J2F48, Seq. 2)

Human Error Events:

		Mean HEPs	EF	Code#
*	OPICT	1.0		HEP 71
**	OPVNT	1.0 or 0.011	5	HEP 25
	OPSPM	0.011	5	HEP 26
	SPMKP	0.032	5	HEP 27

A break in the SDC line outside containment is the initiator. The break is isolated with closure of MV 8 or MV 9. SDC and RHR(B) train is lost. Isolation of 8\9 valves occurs with level 3 signal. OPECS succeeds--water solid with LPCI(C). If a LOSP occurs, the diesels start and load (DV1-2 OK). Operators will need to vent, if possible, and provide makeup to SP (OPSPM) and makeup to SPMU or SP (SPMKP).

** Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1.

* No time to close containment if open.

HRA

File Name: OPICTE2.TIO

Initiator: TIOPF65

Event Tree: EC (from EA, Seq. 2, 7, from ADH, Seq. 2, from TIOPF65, Seq. 9)

EC (from E, Seq. 2, 7, from AISD, Seq. 1, from TIOPF65, Seq. 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	0.011	5	HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

Mismatch between letdown and makeup initiator. Operators fail to control level (LCMK) and SDC(B) or ADHR isolates on high pressure. OPECS succeeds--water solid with LPCI(C). SPC and CS are assumed to fail. Operators will need to vent to remove heat buildup in containment and provide makeup to SP (OPSPM) and makeup to SPMU or SP (SPMKP).

Can vent only if IA and both trains of power are available. If sequence has LOSP or loss of IA or loss of AC bus, OPVNT = 1. Insufficient time is available to close containment if it is open.

File Name: OPICTEC2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: ECP (from EP, Seq. 2, 7, from LP, Seq. 8, 15,
from TIAF16 or TIAF40 or TIAF93, Seq. 7)

ECP (from EAP, Seq. 2, 7, from LAP, Seq. 8, 15,
from TIAF16 or TIAF40 or TIAF93, Seq. 22)

EC (from EA, Seq. 2, 7, 13, 18, from LA, Seq. 32, 48,
from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	1.0		HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

A loss of IA is the initiator. If at some point a LOSP also occurs, the diesels start and load (DV1-2 OK). SDC(B) runs, but the operators fail to control level. The opertators initiate ECCS water solid operation with LPCI (OPECS succeeds). SPC and CS fail. With no SPC or CS and water solid with LPCI, the operators will need to provide makeup to SP (OPSPM). They will also need to provide additional makeup (SPMKP) to SPMU or the SP. Cannot vent.

File Name: OPICTECP.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: ECP (from EP, Seq. 2, 7, from TIAF16 or TIAF40 or TIAF93, Seq. 9

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	1.0		HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

A loss of IA is the initiator. SDC(B) is lost and OPSDC succeeds. The opertators initiate ECCS water solid operation with LPCI (OPECS succeeds).SPC and CS fail. With no SPC or CS and water solid with LPCI, the operators will need to provide makeup to SP (OPSPM). They will also need to provide additional makeup (SPMKP) to SPMU or the SP.

File Name OPICTFC.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: FC (from F, Seq. 1, from anywhere else)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	0		HEP 25
OPCMT	Success		HEP 73

54 hours are allowed for OPVNT and OPCMT. Since mission time is only 24 hrs., all sequences with these events can be dropped, i.e., not analyzed.

HRA

File Name: OPICTF26.FLD

Initiator: RWC26

Event Tree: FC (from F, Seq. 1, from RARW, Seq. 13, 26, from RWC26, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	0		HEP 25
OPCMT	0		HEP 73

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR is this case is the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. In these sequences, OPDHR succeeds and the operators isolate letdown. OPLEC is the operator action to provide makeup with an ECCS system to bring level up to where it should be. It was assumed that level would be "bumped" back up with an ECCS system while CRD continued to run. OPLEC occurs concurrently in time with OPDHR and in these sequences the operators attempt to control level, but ECCS fails. The operators decide to flood containmemt with SSWXT and are successful. Since power and IA are available in these sequences, venting is possible. Operators will need to vent to remove heat build-up in containment (OPVNT). In this scenario, operators have 54 hours to vent. In addition, long term opening of containmemt (OPCMT) (if it is closed or venting fails), is also called for in 54 hours. Since mission time is 24 hours, failure probability for these events is set to 0.

Insufficient time is available to close containment if it is open.

File Name: OPICTHYD.TAB

Initiator: TAB39

Event Tree: EC (from E, Seq. 3, 8,
from ADEP, Seq 6,
from OVPR, Seq. 4, from HYDRO, Seq. 5,
from TAB39, Seq. 7)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	1.0		HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

Loss of AC bus during HYDRO test. SRV opens on safety setpoint and fail to close (SAFEC). Depressurization occurs. In ADEP tree SDCUI succeeds (8.7 hours for this event). The operators take necessary steps to initiate SDC(B) and isolate RWCU, but SDC(B) fails. Thus, enter E tree and OPECS succeeds. The operators initiate ECCS water solid with HPCS and at least one SRV is open. With loss of bus, venting is not possible. SPC and CS are assumed to fail. The operators will need to provide makeup to SP (OPSPM) and makeup to SPMU (or SP).

HRA

File Name: OPICTHYD.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: EC (from E, Seq. 2, 7, 13, 18,
from L, Seq. 32, 48, from ADEP, Seq 3,
from OVPR, Seq. 4, from HYDRO, Seq. 5,
from TIAF16 or TIAF40 or TIAF93, Seq. 33)

Human Error Events:

	Mean HEPs	EF	Code#
OPICT	1.0		HEP 71
OPVNT	1.0	5	HEP 25
OPSPM	0.011	5	HEP 26
SPMKP	0.032	5	HEP 27

A loss of IA occurs during a HYDRO test. An SRV opens on safety setpoint and fail to close (SAFEC). Depressurization occurs. In ADEP tree, SDCUI succeeds (8.7 hours for this event). The operators take necessary steps to initiate SDC(B) and isolate RWCU. In the L tree, operators fail to recognize potential disconnect between core and downcomer and fail to initiate makeup (OPDHR fails). Thus, enter E tree and OPECS succeeds. The operators go water solid with LPCI(C) and at least one SRV is open. With the loss of IA, venting is not possible. SPC and CS are assumed to fail. The operators will need to provide makeup to SP (OPSPM) and makeup (SPMKP) to SPMU (or SP).

File Name: OPLCRL31.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: R (from L, Seq 31 or 47, from TIAF16 or TIAF40 or TIAF93 Seq. 3)

RP (from LP, Seq. 7 or 14, from TIAF16 or TIAF40 or TIAF93, Seq. 7)

RA (from LA, Seq. 31, 47, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPLEC	0		HEP 23
LCHPC	0		HEP 23
LC-LP	0		HEP 23

A loss of IA and in some cases a LOSP. DV1-2 succeeds. RWCU auto-isolates when power or IA is lost. CRD is gone. OPSDC succeeds and SDC(B) runs. OPDHR succeeds and CDS is unavailable. OPLEC is completely dependent on OPDHR which involves diagnosing the need for makeup.

It was assumed that if either HPCS or LPCI were selected and initiated for injection to increase level, the operators would control level. That is, the actions are assumed to be completely dependent. If they selected HPCS, then LCHPC will be successful. If the used LPCI, then LC-LP will be successful. Essentially, it was assumed that if they diagnose the need for LPCI or HPCS, they will know the injection rates and not simply walk away.

When power or IA is lost, RWCU isolates automatically, resulting in little drain down. Thus, the 10 min. allowed for OPDHR (and therefore OPLEC) is very conservative. Consequently, in sequences where power or IA is lost, credit was taken for operators initiating both LPCI and HPCS if one of them failed to start due to hardware.

HRA

File Name: OPLEC26.FLD

Initiator: RWC26

Event Tree: RRW (from RWC26, Seq. 2)
RAWR From RWC26, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPLEC (27.3 min)	0.037	10	HEP 129

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR is this case is the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. In these sequences, OPDHR succeeds and the operators isolate letdown. OPLEC is the operator action to provide makeup with an ECCS system to bring level up to where it should be. It was assumed that level would be "bumped" back up with an ECCS system while CRD continued to run. OPLEC occurs concurrently in time with OPDHR.

* At this point credit is taken only for LPCI. HPCS may be asked later.

File Name: OPLEC74.FLD

Initiator: RWC74

Event Tree: RRW (from RWC74, Seq. 2)
RAWR From RWC74, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPLEC (13.3 min)	0.54	10	HEP 130

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR is this case is the operator action to isolate letdown (RWCU) before level 3 is reached, which results in SDC auto-isolating. In these sequences, OPDHR succeeds and the operators isolate letdown. OPLEC is the operator action to provide makeup with an ECCS system to bring level up to where it should be. It was assumed that level would be "bumped" back up with an ECCS system while CRD continued to run. OPLEC occurs concurrently in time with OPDHR.

* At this point credit is taken only for LPCI. HPCS may be asked later.

File Nar : OPLECH26.FLD

Initiator: RWC26

Event Tree: RWCHI (from RWC26, Seq. 17)

Human Error Events:

	Mean HEPs	EF	Code#
OPLEC1	0.05	10	HEP 132

The initiator is a break in the RWCU line during a HYDRO test. There is less than a minute before the vessel will drain down to level 2 and RWCU isolates (which also isolates the break). It is assumed that the operators will fail to stop the drain down before level 2 is reached in the less than 1 minute time frame. HPCS should auto-start on level 2, but in this scenario it fails. Thus, the operators need to diagnose the need the bring level back up with LPCI. They may need to open an SRV if pressure is still high for the use of LPCI.

File Name: OPLECH74.FLD

Initiator: RWC74

Event Tree: RWCHI (from RWC74, Seq. 17)

Human Error Events:

	Mean HEPs	EF	Code#
OPLEC1	0.05	10	HEP 132

The initiator is a break in the RWCU line during a HYDRO test. There is less than a minute before the vessel will drain down to level 2 and RWCU isolates (which also isolates the break). It is assumed that the operators will fail to stop the drain down before level 2 is reached in the less than 1 minute time frame (OPDHR1 fails). HPCS should auto-start on level 2, but in this scenario it fails. Thus, the operators need to diagnose the need the bring level back up with LPCI. They may need to open an SRV if pressure is still high for the use of LPCI.

File Name: OPLECR.TIO

Initiator: TIOPF65

Event Tree: R (from L, Seq. 31, 47, from SDC Seq. 1, from TIOPF65, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPLEC	0		HEP 23
LCHPC	0		HEP 23
LC-LP	0		HEP 23

Mismatch between letdown and makeup is the initiator. OPLEC is completely dependent on OPDHR. Since RHR/SDC continues to run, ECCS will be the logical choice for level control. Thus, if OPDHR succeeds, then OPLEC (which is initiation of ECCS for level contol) will also succeed. It was assumed that if either HPCS or LPCI were selected and initiated for injection to increase level, the operators would control level. That is, initiating and controlling level were assumed to be completely dependent. If they selected HPCS, then LCHPC will be successful. If they used LPCI, then LC-LP will be successful. Essentially, it was assumed that if they diagnose the need for LPCI or HPCS, they will know the injection rates and not simply walk away.

When power is lost, RWCU isolates automatically, resulting in little drain down. Thus, the 10 min. allowed for OPDHR (and therefore OPLEC) is very conservative. Consequently, in sequences where power is lost (and other isolation of RWCU sequences) , credit was taken for operators initiating both LPCI and HPCS if one of them failed to start due to hardware failure.

File Name: OPLECRAP.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: RAP (from LAP, Seq 7, 14, from TIAF16 or TIAF40 or TIAF93, Seq. 22)

Human Error Events:

	Mean HEPs	EF	Code#
OPLEC	0		HEP 23
LCHPC	0		HEP 23
LC-LP	0		HEP 23

A loss of IA and at some point a LOSP. RWCU auto-isolates. CRD is gone. OPSDC succeeds and SDC(B) runs. OPDHR succeeds and CDS is unavailable. OPLEC is completely dependent on OPDHR which involves diagnosing the need for makeup.

It was assumed that if either HPCS or LPCI were selected and initiated for injection to increase level, the ops. would control level. That is, the actions are assumed to be completely dependent. If the operators selected HPCS, then LCHPC will be successful. If they used LPCI, then LC-LP will be successful. Essentially, it was assumed that if they diagnose the need for LPCI or HPCS, they will know the injection rates and not simply walk away.

When power is lost, RWCU isolates automatically, resulting in little drain down. Thus, the 10 min. allowed for OPDHR (and therefore OPLEC) is very conservative. Consequently, in sequences where power is lost, credit was taken for operators initiating both LPCI and HPCS if one of them failed to start due to hardware.

HRA

File Name: OPSDC.E2B

Initiator: E2BF20

Event Tree: E2BF20

Human Error Events:

	Mean HEPs	EF	Code#
OPSDC	8.5E-4	30	HEP 1
OPSDC (XTIEB case)	0.6	10	HEP 20

Loss of SDC(B) (not just isolation) is the initiator. In this scenario the operators must diagnose the loss of SDC(B). In some sequences (no LOSP), the diagnosis will be based solely on the alarms associated with the specific loss of SDC(B), i.e., low flow, pump trip due to loss of suction etc. In other relevant (non-XTIEB) sequences, a LOSP will occur sometime after the initiator and DV1-2 will succeed.

For the sequences where the operators must cross-tie the HPCS diesel generator to the B train (LOSP and DV1-2 fails with HPCS unavailable), OPSDC is very different. In these scenarios, OPSDC involves diagnosing the likelihood that SDC(B) will isolate on 135 psi when XTIEB is completed (and thus not be available) and then entering the relevant ONEP to prepare for going water solid (OPECS). If the control room fails to make this diagnosis in the time available for OPSDC, the time available for OPECS might not be used appropriately. That is, the operators could simply waste the time for OPSDC and OPECS with the notion that they will restart SDC(B) when they get the XTIEB done and then not have any time for diagnosing and carrying-out the actions related to OPECS (starting low pressure system (LPCI (C)) and opening SRVs etc.). As indicated by the HEP for OPSDC (see HEP 20), the correct diagnosis is non-trivial.

File Name: OPSDC.E2B

Initiator: E2BF20

Event Tree: E2BF20

Human Error Events:

	Mean HEPs	EF	Code#
OPSDC	8.5E-4	30	HEP 1
OPSDC (XTIEB case)	0.6	10	HEP 20

Loss of SDC(B) (not just isolation) is the initiator. In this scenario the operators must diagnose the loss of SDC(B). In some sequences (no LOSP), the diagnosis will be based solely on the alarms associated with the specific loss of SDC(B), i.e., low flow, pump trip due to loss of suction etc. In other relevant (non-XTIEB) sequences, a LOSP will occur sometime after the initiator and DV1-2 will succeed.

For the sequences where the operators must cross-tie the HPCS diesel generator to the B train (LOSP and DV1-2 fails with HPCS unavailable), OPSDC is very different. In these scenarios, OPSDC involves diagnosing the likelihood that SDC(B) will isolate on 135 psi when XTIEB is completed (and thus not be available) and then entering the relevant ONEP to prepare for going water solid (OPECS). If the control room fails to make this diagnosis in the time available for OPSDC, the time available for OPECS might not be used appropriately. That is, the operators could simply waste the time for OPSDC and OPECS with the notion that they will restart SDC(B) when they get the XTIEB done and then not have any time for diagnosing and carrying-out the actions related to OPECS (starting low pressure system (LPCI (C)) and opening SRVs etc.). As indicated by the HEP for OPSDC (see HEP 20), the correct diagnosis is non-trivial.

File Name: OPSDC.T5A

Initiator: T5AF19

Event Tree: T5AF19

Human Error Events:

		Mean HEPs	EF	Code#
*	OPSDC	8.5E-4	30	HEP 1

A loss of SSW will result in numerous indications and alarms if it fails or performance is reduced. The ONEP for loss of SSW notes the resulting loss of RHR/SDC(B). Loss of SDC(B) will also be alarmed.
A loss of ADH is random in this scenario, but SDC(B) will not be available. Thus, in both the RHR and ADH branches of T5AF19, the operators need only diagnose the need and pull the ONEPs for loss of SSW and IDHR. An attempt to align SDC(B) is not indicated.

* In this scenario, the HEP for OPSDC will not differ for the case where the HPCS diesel generator must be cross-tied (XTIEB succeeds case), as it has in other sequences. Given the loss of SSW, the operators will not need to be concerned about isolation of SDC at 135 psi, SDC will not be available anyway. Thus, they just need to diagnose the situation and pull the relevant procedures as in HEP 1.

File Name: OPSDC.TAB

Initiator: TAB39

Event Tree: SDC (from TAB39, Seq.3)

ADH (from TAB39, Seq. 5)

Human Error Event:

	Mean HEP	EF	Code#
OPSDC	8.5E-4	30	HEP 1

OPSDC in this case includes the operators detecting loss of operating SDC (RHR or ADHRS) loop in the context of loss of AC bus(es) and entering the ONEP for IDHR. It was assumed that if the operators detected the loss of the all SDC in the given context of being in shutdown with the loss of the AC bus and no other normal SDC loop available, they would enter the appropriate ONEP. Thus, complete dependence was assumed between determining the loss of the operating SDC system (in context of loss of AC bus) and entering the appropriate ONEP. With the loss of the AC bus, numerous indications would occur and in the shutdown context, maintaining SDC would clearly be a concern.

HRA

File Name: OPSDC.TIO

Initiator: TIOPF65

Event Tree: SDC (from TIOPF65, Seq. 2)
ADH (from TIOPF65, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPSDC (SDC)	8.5E-4	10	HEP 1
OPSDC (ADH)	0.046	10	HEP 2
OPSDC (preceeded by XTIEB)	0.6	10	HEP 20

TIOP initator. Mismatch between letdown and makeup resulting in over-pressurization. Initiator is generally assumed to result from an isolation or at least partial isolation of RWCU. With letdown isolated and makeup continuing to run, level and pressure will begin to increase. Operators will get an alarm at level 8 and may receive additional pressure related alarms. In addition, operators have approximately 2 and one-half hours to detect the problem and control makeup (LCMK). In this time period level and pressure would be monitored. If LCMK succeeds, transfer to SDC or ADH tree depending on initial SDC (RHR or ADHRS). With LCMK success, operator actions are identical to those in other transients, e.g., T1.

File Name: OPSDCADH.E2D

Initiator: E2DF93

Event Tree: E2DF93

Human Error Event:

	Mean HEPs	EF	Code #
OPSDC	0.046	10	HEP 2
OPSDC (XTIEB Case)	0.6	10	HEP 20

Loss of ADHR system is the initiator. In this scenario the operators must detect the loss of ADHRS, diagnose the need for an alternative mode of SDC (i.e. the operators enter the IDHR ONEP), and attempt to initiate a standby source of SDC, per SOI 04-1-01-E12-1. In sequences with no LOSP, the diagnosis will be based solely on the alarms associated with the specific loss of ADHRS, i.e., low flow, pump trip due to loss of suction etc. In other relevant (non-XTIEB) sequences, a LOSP will occur sometime after the initiator and DV1-2 will succeed. With the loss of ADHR and success of DV1-2, it was assumed that the operators would try to start SDC(B) per procedure.

For the sequences where a cross-tie of the diesel generators is asked and XTIEB succeeds, the operators must recognize that once XTIEB is complete, it will be likely that SDC(B) will have isolated (or will isolate) due to the rising pressure, on 135 psi. The operators should be planning for use of some other means of SDC. In this case, LPCI (B) will be the only available ECCS system. LPCI(C) and HPCS are gone. LPCI(C) is assumed unavailable because it shares common piping with ADHRS which has been lost.

HRA

File Name: OPSDCADH.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: TIAF16 or TIAF40 or TIAF93 (For ADHRS branches of TIAF16 or TIAF40 or TIAF93, except when XTIEB succeeds)

Human Error Event:

	Mean HEP	EF	Code#
OPSDC	0.046	10	HEP 2

The initiator is a loss of Instrument Air. If a LOSP occurs, a diesel generator successfully starts (DV1-2). Operators were initially using the ADHRS for SDC. OPSDC in this scenario involves the operators detecting the loss of the operating ADHRS and diagnosing the need for an alternative mode of SDC. Upon entering the IDHR ONEP, the operators are instructed to initiate any standby sources of SDC. In this case RHR/SDC(B) may be available and will be initiated per SOI 04-1-01-E12-1.

File Name: OPSDCH26.FLD

Initiator: RWC26

Event Tree: RWCHI (from RWC26, Seq. 17)

Human Error Events:

	Mean HEPs	EF	Code#
OPSDC1	0.006	10	HEP 131

The initiator is a break in the RWCU line during a HYDRO test. There is less than a minute before the vessel will drain down to level 2 and RWCU isolates (which also isolates the break). It is assumed that the operators will fail to stop the drain down before level 2 is reached in the less than 1 minute time frame. HPCS should auto-start on level 2, and in this scenario it either succeeds or fails. If HPCS succeessfully auto-starts and then auto-stops on level 8 (HPCAO), level will be restored and the operators will need to unisolate and start some form of SDC. IF HPCS fails to auto-start, but the operators successfully bring level up with LPCI (OPLEC1 succeeds), then SDC will also be needed. Thus, in both of the two scenarios, level is restored and OPSDC1 is asked. OPSDC1 is the operator action to diagnose the need for unisolating and starting SDC and opening an SRV if necessary. The operators may need to open an SRV if pressure is still high for the use of SDC (SDC(B) or ADHR).

File Name: OPSDCH74.FLD

Initiator: RWC74

Event Tree: RWCHI (from RWC74, Seq. 17)

Human Error Events:

	Mean HEPs	EF	Code#
OPSDC1	0.006	10	HEP 131

The initiator is a break in the RWCU line during a HYDRO test. There is less than a minute before the vessel will drain down to level 2 and RWCU isolates (which also isolates the break). It is assumed that the operators will fail to stop the drain down before level 2 is reached in the less than 1 minute time frame. HPCS should auto-start on level 2, and in this scenario it either succeeds or fails. If HPCS succeessfully auto-starts and then auto-stops on level 8 (HPCAO), level will be restored and the operators will need to unisolate and start some form of SDC. IF HPCS fails to auto-start, but the operators successfully bring level up with LPCI (OPLEC1 succeeds), then SDC will also be needed. Thus, in both of the two scenarios, level is restored and OPSDC1 is asked. OPSDC1 is the operator action to diagnose the need for unisolating and starting SDC and opening an SRV if necessary. The operators may need to open an SRV if pressure is still high for the use of SDC (SDC(B) or ADHR).

File Name: OPSDCSDC.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: TIAF16 or TIAF40 or TIAF93 (For RHR Loop B branches of TIAF16 or TIAF40 or TIAF93, except when XTIEB succeeds)

Human Error Event:

	Mean HEP	EF	Code#
OPSDC	8.5E-4	30	HEP 1

In this scenario the operators must detect a loss of the operating RHR/SDC loop, which has occurred sometime after a loss of IA, and enter the IDHR ONEP. The loss of SDC is either random or due to a LOSP witn DV1-2 successful. It was assumed that if the operators detected the loss of the operating SDC loop in the given context of being in shutdown with no other SDC loop available, they would enter the appropriate ONEP. Thus, complete dependence was assumed between determining the loss of the operating SDC system and entering the appropriate ONEP. In addition, in the case of a LOSP, it was also assumed that if the control room diagnos..s the loss of SDC, they will attempt a restart of SDC(B) (a simple task at control panel).

File name: OPSOF.E2B

Initiator: E2BF20

Event Tree: OF (from E, Seq. 50, from E2BF20, Seq. 5, 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPSOF	0.05	10	HEP 30

A loss of the operating SDC system occurs. The operators initiate ECCS water solid operation (OPECS succeeds), but the operators fail to check closed open MSIVs (in the 4 min. allowed during OPECS). Water will begin to flood down the steam lines. OPSOF asks whether or not the operators will stop any flooding through the main steam lines. The operators must terminate the injecting system and close MSIVs.

File name: OPSOF.E2B

Initiator: E2BF20

Event Tree: OF (from E, Seq. 50, from E2BF20, Seq. 5, 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPSOF	0.05	10	HEP 30

A loss of the operating SDC system occurs. The operators initiate ECCS water solid operation (OPECS succeeds), but the operators fail to check closed open MSIVs (in the 4 min. allowed during OPECS). Water will begin to flood down the steam lines. OPSOF asks whether or not the operators will stop any flooding through the main steam lines. The operators must terminate the injecting system and close MSIVs.

File Name: OPSOF.J2

Initiator: J2F48

Event Tree: OF (from E, Seq. 50, from A5ISJ, Seq. 1, 6,
from J2F48, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPSOF	0.05	10	HEP 30

A break in the SDC line outside containment is the initiator. The break is isolated with closure of MV 8 or MV 9. SDC and RHR(B) train is lost. Isolation of 8\9 valves occurs with level 3 signal. If a LOSP occurs, the diesels start and load (DV1-2 OK). The operators initiate ECCS water solid operation per the IDHR ONEP (OPECS succeeds). but MSIVs are open. OPSOF is operator action to stop flooding down open main steam lines and 20 min. is available for this task. In addition to increasing level alarms, operators may get additional alarms from steam line drain valves etc. and would get low SP alarm eventually.

File name: OPSOF.T5A

Initiator: T5AF19

Event Tree: OF (from E, Seq. 50, from T5AF19, Seq. 3, 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPSOF	0.05	10	HEP 30

The initiator is a loss of SSW. The operators initiate ECCS water solid operation (OPECS succeeds), but the operators fail to check closed any open MSIVs (in the 4 min. allowed during OPECS). Water will begin to flood down the steam lines. OPSOF asks whether or not the operators will stop flooding through the MSIVs.

File name: OPSOF.TAB

Initiator: TAB39

Event Tree: OFP (from EA, Seq. 80, from ADH, Seq. 4, from TAB39, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPSOF	0.05	10	HEP 30

A loss of an AC bus is the initiator. The operators initaite ECCS water solid operation (OPECS succeeds), but the operators fail to check closed open MSIVs (in the 4 min. allowed during OPECS). Water will begin to flood down steam lines. OPSOF asks whether or not the operators will stop the flooding through the MSIVs.

File name: OPSOF.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: OFP (from EP, Seq. 50, from TIAF16 or TIAF40 or TIAF93, Seq. 5)

OF (from EA, Seq. 80, from TIAF16 or TIAF40 or TIAF93, Seq. 20

OF (from E, Seq. 50, from L, Seq. 32, from TIAF16 or TIAF40 or TIAF93, Seq. 3

Human Error Events:

	Mean HEPs	EF	Code#
OPSOF	0.05	10	HEP 30

Loss of IA is the initiator. The operators initiate ECCS water solid operation (OPECS succeeds), but the operators fail to check closed open MSIVs (in the 4 min. allowed during OPECS). Water will begin to flood down steam lines. OPSOF asks whether or not the operators will stop the flooding through the MSIVs.

File name: OPSOF2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: OF (from EA, Seq. 80, from LA, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18

Human Error Events:

	Mean HEPs	EF	Code#
OPSOF	0.05	10	HEP 30

Loss of IA is the initiator. ADHR is lost. SDC(B) starts, but the operators fail to control level (OPDHR fails). The operators initiate ECCS water solid operation (OPECS succeeds) per procedure, but the operators fail to check closed open MSIVs. Water will begin to flood down the steam lines. OPSOF asks whether or not the operators will stop the flooding through the MSIVs.

File name: OPSOF9.TIA

Initiator: TIA

Event Tree: OFP (from EP, Seq. 50, from TIAF16 or TIAF40 or TIAF93, Seq. 9

Human Error Events:

	Mean HEPs	EF	Code#
OPSOF	0.05	10	HEP 30

Loss of IA is the initiator. The operators initiate ECCS water solid operation (OPECS succeeds), but the operators fail to check closed open MSIVs (in the 4 min. allowed during OPECS). Water will begin to flood down steam lines. OPSOF asks whether or not the operators will stop the flooding through the MSIVs.

File Name: OPSTE51.E2B

Initiator: E2BF20

Event Tree: S (from E, Seq. 51, from E2BF20, Seq. 5, 6)

SP (from EP, Seq. 51, from E2BF20, Seq 8, 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

A loss of SDC(B) is the initiator. If a LOSP occurs, the diesel starts and loads (DV1-2 succeeds). The operators may recognize the initial loss of SDC and attempt to restore it some sequences, but they fail to control level (OPDHR fails) and fail to initiate ECCS water solid operation (OPECS fails). These activities are clearly called out by procedure. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam the vessel (a non-proceduralized action). Credit is taken for deciding to steam at high pressure in the P tree, for which there is significantly more time available.

File Name: OPSTE51.J2

Initiator: J2F48

Event Tree: S (from E, Seq. 51, from A5ISJ, Seq. 1,
from J2F48, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

Loss of SDC as result of break in SDC line outside containment which isolates (MV 8 or MV 9 isolates). A LOSP does not occur. OPECS fails. Failure of OPECS in this instance implies an operator failure to provide makeup with ECCS and go water solid. These activities are clearly called out by the IDHR procedure, given the loss of SDC. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam which is a non-proceduralized action. Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

HRA

File Name: OPSTE51.T5A

Initiator: T5AF19

Event Tree: S (from E, Seq. 51, from T5AF19, Seq. 3, 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

A loss of SSW is the initiator. The operators may recognize the initial loss of SDC, but no normal means of SDC are available. They fail to initiate ECCS water solid operation (OPECS fails). These activities are clearly called out by procedure. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam the vessel (a non-proceduralized action). Credit is taken for deciding to steam at high pressure in the P tree, for which there is significantly more time available.

File Name: OPSTE51.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from E, Seq. 51, from TIAF16 or TIAF40 or TIAF93, Seq. 5)

S (from E, Seq. 51, from L, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

Loss of IA is the initiator. No LOSP. Random failure of SDC(B) and OPSDC succeeds or SDC(B) continues to run and OPDHR fails. Regardless, the operators fail to accomplish OPECS. 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. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

HRA

File Name: OPSTE512.J2

Initiator: J2F48

Event Tree: S (from E, Seq. 51, from A5ISJ, Seq. 6, from J2F48, Seq. 2)

SP (from EP, Seq. 29, from A5ISJ, Seq. 2, from J2F48, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

Loss of SDC as result of break in SDC line outside containment which isolates (MV 8 or MV 9 isolates). If a LOSP occurs, the diesels start and load (DV1-2 OK). OPECS fails. Failure of OPECS in this instance implies an operator failure to provide makeup with ECCS and go water solid. These activities are clearly called out by the IDHR procedure, given the loss of SDC. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam which is a non-proceduralized action. Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

File Name: OPSTE51P.TIA

Initiator: TIA

Event Tree: SP (from EP, Seq. 51, from TIAF16 or TIAF40 or TIAF93, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

A loss of IA is the initiator. A LOSP occurs at some point, but the diesel starts and loads (DV1-2 OK). A random failure of SDC(B) occurs and OPSDC succeeds. However, the operators fail to initiate ECCS water solid operation (OPECS fails). These activities are clearly called out by procedure. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

HRA

File Name: OPSTE52.T5A

Initiator: T5AF19

Event Tree: SNP (from HPSWR, Seq. 52, from T5AF19, Seq. 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

Loss of SSW initiator. A LOSP occurs at some point and the diesel fails to start (DV1-2 fails). SDC, LPCI, and SSWXT etc., are gone, but HPCS is available. However, OPECS fails. Failure of OPECS in this instance implies a failure to provide makeup with HPCS (only ECCS system available) and go water solid. These activities are clearly called out by procedure. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

File Name: OPSTE81.E2D

Initiator: E2DF93

Event Tree: S (from EA, Seq. 81, from E2DF93, Seq. 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

A loss of ADHR is the initiator. No LOSP. OPSDC succeedsand the operators attempt to start SDC(B), but it fails. The operators fail to accomplish OPECS. 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. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

File Name: OPSTE81.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from EA, Seq. 81, from TIAF16 or TIAF40 or TIAF93, Seq. 20, 21)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

Loss of IA is the initiator. No LOSP. ADHR is lost. If OPSDC succeeds, SDC(B) fails to start. Regardless, the operators fail to accomplish OPECS. 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. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

File Name: OPSTE812.E2D

Initiator: E2DF93

Event Tree: S (from EA, Seq. 81, from LA, Seq. 38, from E2DF93, Seq. 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

An complete loss of ADHR is the initiator. OPSDC succeeds and SDC(B) is started. The operators fail to control level after a loss of CRD (OPDHR fails). With the functional loss of SDC, initiation of ECCS water solid operation is indicated, but 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. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

HRA

File Name: OPSTE812.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from EA, Seq. 81, from LA, Seq. 32, 48,
from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

Loss of IA is the initiator. No LOSP. ADHR is lost. SDC(B) is started, but the operators fail to control level (OPDHR fails). The operators then fail to accomplish OPECS. 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. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

File Name: OPSTE851.TAB

Initiator: TAB39

Event Tree: S (from E, Seq. 51, from SDC, Seq. 3, 4,
from TAB39, Seq. 3)

S (from EA, Seq. 81, from ADH, Seq. 4,
from TAB39, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

Loss of AC bus is the initiator. SDC(B) or ADHR fails. OPSDC succeeds or fails, but OPECS fails. Failure of OPECS in this instance implies a failure to provide makeup with HPCS and go water solid. These activities are clearly called out by procedure. Thus, if OPECs fails, there is no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

File Name: OPSTE851.TAB

Initiator: TAB39

Event Tree: S (from E, Seq. 51, from SDC, Seq. 3, 4,
from TAB39, Seq. 3)

S (from EA, Seq. 81, from ADH, Seq. 4,
from TAB39, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

Loss of AC bus is the initiator. SDC(B) or ADHR fails. OPSDC succeeds or fails, but OPECS fails. Failure of OPECS in this instance implies a failure to provide makeup with HPCS and go water solid. These activities are clearly called out by procedure. Thus, if OPECs fails, there is no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for this scenario.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

File Name: OPSTEM74.FLD

Initiator: TRPT5

Event Tree: S (from E, Seq. 51, from RRW, Seq. 32, from RWC74, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR1 in this case is the operator action to isolate letdown (RWCU) before level 3 is reached and SDC auto-isolates. In these sequences, OPDHR1 succeeds. However, the operators initially fail to bring level back up (OPLEC fails) and they then fail to initiate ECCS water solid operation per the IDHR ONEP (failure of OPECS). Since these activities are clearly called out by the IDHR procedure given the loss of SDC, the lack of action by the operators indicates no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for these scenarios.

Credit for steaming (at high pressure) is taken in the P tree, where sustantially more time is available to make the correct diagnosis.

HRA

File Name: OPSTH.J2

Initiator: J2F48

Event Tree: P (from S, Seq. 35, from E, Seq. 51,
from A5ISJ, Seq. 1, from J2F48, Seq. 2)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTH	0.025	5	HEP 42

Break in SDC line outside containment is the initiator. Break is isolated, as is the low pressure piping (8/9 valves isolate at level 3). OPECS fails. OPSTM fails for any number of possible reasons, but mainly because of OPECS failure. If OPECS fails, something is wrong and hard to give credit for OPSTM (a non-proceduralized action). This sends us to the P tree. Operators could steam on safety set point of 1SRV. OPSTH is steaming at high pressure (CDR or HPCS) and the operators have 4 hours for this task.

File Name: OPSTH.T5A

Initiator: T5AF19

Event Tree: P (from S, Seq. 35, from E, Seq. 51,
from T5AF19, Seq. 3, 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	1.0		HEP 41
OPSTH	0.025	5	HEP 42

A loss of SSW is the initiator. SDC(B) fails and RWCU (letdown) does not auto-isolate. The operators either recognize the loss of SDC or initially fail to do so (OPSDC succeeds or fails). Regardless, they fail to initiate ECCS water solid operation per the IDHR ONEP (OPECS fails). The operators fail to steam at low pressure (OPSTM fails) and the P tree is entered. OPIS is the operator action to isolate the SDC low pressure piping if the auto-isolation at 135 psi fails. OPIS must occur in the same time period as OPSTM. If OPECS fails in the current context, something is wrong and it is difficult to give credit for OPSTM or OPIS in the time available. If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get low level isolations (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct dignosis and perform the necessary actions.

File Name: OPSTH.TAB

Initiator: TAB

Event Tree: P (from S, Seq. 10, 35, from E, Seq. 23, 24, from SDC, Seq. 3, from TAB39, Seq. 3)

Human Error Events:

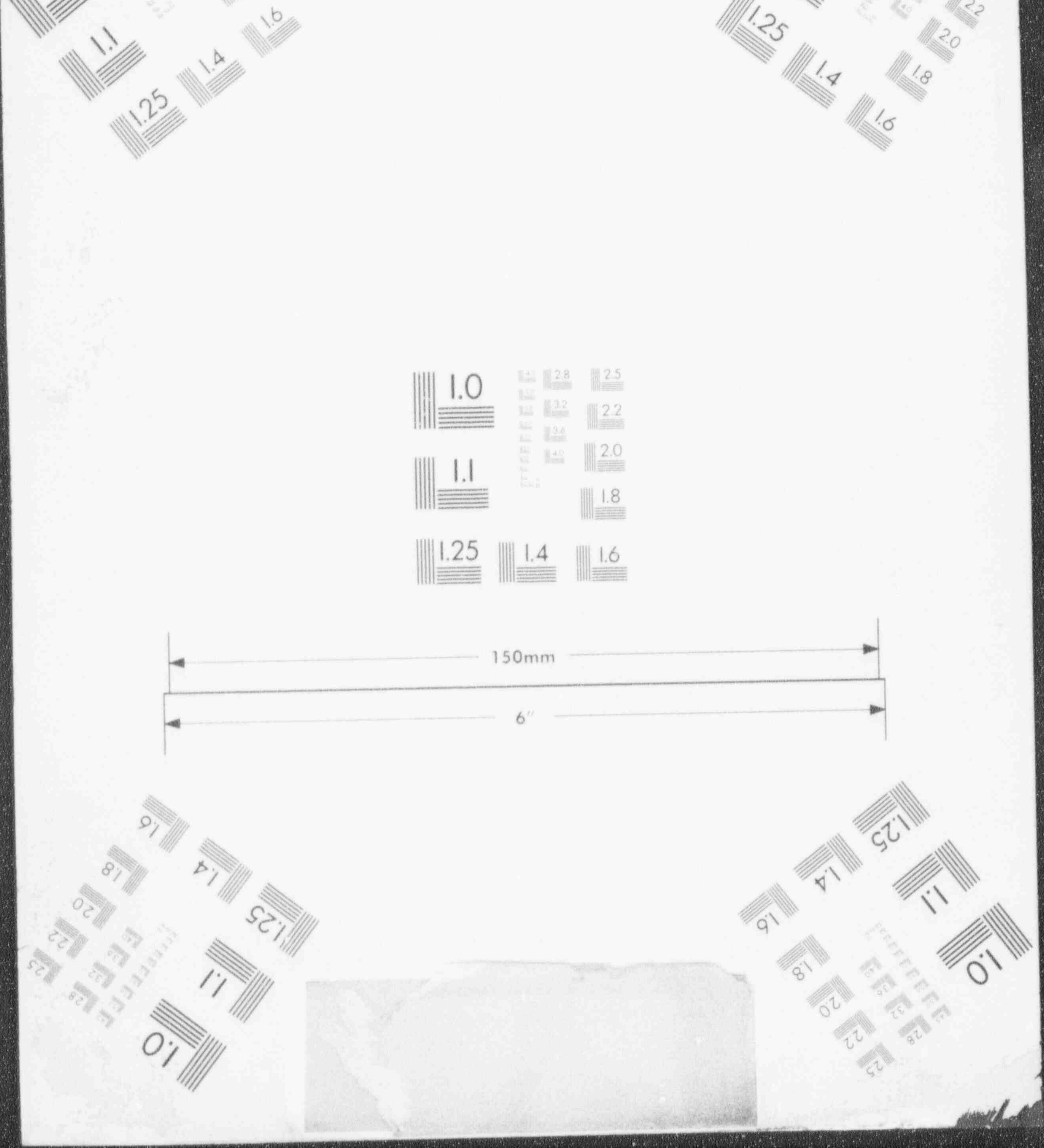
	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

Loss of AC bus is the initiator. SDC(B) fails and the operators either detect the loss or initially fail to do so (OPSDC succeeds or fails). RWCU auto-isolates on the loss of power. The operators attempt to initiate ECCS water solid operation with HPCS (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 go water solid and tried to open two SRVs. With no SRVs available, the operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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 min.).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

1

IMAGE EVALUATION TEST TARGET (MT-3)



1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6″

1

IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

File Name: OPSTH.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: P (from S, Seq. 35, from E, Seq. 51,
from TIAF16 or TIAF40 or TIAF93, Seq. 5)

Huma :ror Events:

	Mean HEPs	EF	Code#
OPIS	1.0		HEP 41
OPSTH	0.025	5	HEP 42

A loss of IA is the initiator. SDC(B) fails. The operators recognize the loss of SDC (OPSDC succeeds). However, they fail to initiate ECCS water solid operation per the IDHR ONEP (OPECS fails). The operators fail to steam at low pressure (OPSTM fails) and the P tree is entered. OPIS is the operator action to isolate the SDC low pressure piping if the auto-isolation at 135 psi fails. OPIS must occur in the same time period as OPSTM. If OPECS fails in the current context, something is wrong and it is difficult to give credit for OPSTM or OPIS in the time available. If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get low level isolations (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct dignosis and perform the necessary actions.

HRA

File Name: OPSTH2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: P (from S, Seq. 35, from E, Seq. 51,
from L, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93,
Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	1.0		HEP 41
OPSTH	0.025	5	HEP 55

Loss of IA is the initiator. SDC(B) continues to run but the operators fail to control level (OPDHR fails). They also fail to initiate ECCS water solid operation with the functional loss of SDC that occurs from no level control (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. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam. Thus, OPSTM fails for this scenario. This sends us to the P tree. OPIS must occur concurrently with OPSTM. If OPECS (and OPSTM) fails, something is wrong and hard to give credit for OPIS which is operator action to isolate low pressure piping if auto isolation at 135 psi fails. If the operators and logic fail to isolate low pressre piping, when something breaks, drain down will occur and should get a low level isolation (RHRIL and SDCIL). If these succeed (or RHRIP), the operators could steam on safety set point of 1SRV. OPSTH is steaming at high pressure (CRD or HPCS). The operators have 4 hours to accomplish the relevant tasks.

File Name: OPSTH3.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: P (from S, Seq. 35, from E, Seq. 81,
from L, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93,
Seq. 18)

PP (from SP, Seq. 29, from EP, Seq. 51,
from LP, Seq. 8, 15, from TIAF16 or TIAF40 or TIAF93,
Seq. 7)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	1.0		HEP 41
OPSTH	0.025	5	HEP 55

Loss of IA is the initiator. If a LOSP occurs, the diesels start and load (DV1-2). SDC(B) continues to run but the operators fail to control level (OPDHR fails). They also fail to initiate ECCS water solid operation with the functional loss of SDC that occurs from no level control (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. Thus, if OPECS fails, there is no reason to expect the control room to consciously decide to steam. Thus, OPSTM fails for this scenario. This sends us to the P tree. OPIS must occur concurrently with OPSTM. If OPECS (and OPSTM) fails, something is wrong and hard to give credit for OPIS which is operator action to isolate low pressure piping if auto isolation at 135 psi fails. If the operators and logic fail to isolate low pressre piping, when something breaks, drain down will occur and should get a low level isolation (RHRIL and SDCIL). If these succeed (or RHRIP), the operators could steam on safety set point of 1SRV. OPSTH is steaming at high pressure (HPCS). The operators have 4 hours to accomplish the relevant tasks.

File Name: OPSTH4.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: P (from S, Seq. 29, from EP, Seq. 51,
from TIAF16 or TIAF40 or TIAF93, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	1.0		HEP 41
OPSTH	0.025	5	HEP 42

A loss of IA is the initiator. SDC(B) fails and the operators initially fail to recognize the loss of SDC (OPSDC succeeds). They also fail to initiate ECCS water solid operation per the IDHR ONEP (OPECS fails). The operators fail to steam at low pressure (OPSTM fails) and the P tree is entered. OPIS is the operator action to isolate the SDC low pressure piping if the auto-isolation at 135 psi fails. OPIS must occur in the same time period as OPSTM. If OPECS fails in the current context, something is wrong and it is difficult to give credit for OPSTM or OPIS in the time available. If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get low level isolations (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct dignosis and perform the necessary actions.

File Name: OPSTH5.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: P (from S, Seq. 35, from EA, Seq. 81,
from TIAF16 or TIAF40 or TIAF93, Seq. 20, 21)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	1.0		HEP 41
OPSTH	0.025	5	HEP 42

A loss of IA is the initiator. ADHR and SDC(B) fails. The operators recognize or initially fail to recognize the loss of SDC (OPSDC succeeds). However, they fail to initiate ECCS water solid operation per the IDHR ONEP (OPECS fails). The operators fail to steam at low pressure (OPSTM fails) and the P tree is entered. OPIS is the operator action to isolate the SDC low pressure piping if the auto-isolation at 135 psi fails. OPIS must occur in the same time period as OPSTM. If OPECS fails in the current context, something is wrong and it is difficult to give credit for OPSTM or OPIS in the time available. If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get low level isolations (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct dignosis and perform the necessary actions.

HRA

File Name: OPSTHCFF.T5A

Initiator: T5AF19

Event Tree: P (from S, Seq. 35, from F, Seq. 21,
from E, Seq. 4, 9, 11, 20, 22,
from T5AF19, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

A loss of SSW is the initiator. No LOSP. OPSDC succeeds or not, but SDC fails. The operators attempt to initiate ECCS water solid operation (OPECS succeeds), but either HPCS fails or no water in the SP). Operators either fail to decide to flood or fail because of inadequate time available to align FW. They then fail to decide to steam (OPSTM fails). The operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHCFF.TAB

Initiator: TAB39

Event Tree: P (from S, Seq. 35, from F, Seq. 3, 6, 21,
from E, Seq. 4, 9, 11, 15, 20, 22,
from SDC, Seq. 3
from TAB39, Seq. 3)

P (from S, Seq. 35, from F, Seq. 3, 6, 21,
from EA, Seq. 4, 9, 11, 15, 20, 22,
from ADH, Seq. 4
from TAB39, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

A loss of AC bus is the initiator. No LOSP. OPSDC succeeds or not, but SDC fails. The operators attempt to initiate ECCS water solid operation (OPECS succeeds), but either HPCS fails or no water in the SP). Operators either fail to decide to flood or fail because of inadequate time available to align FW. They then fail to decide to steam (OPSTM fails). The operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHCFF.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: P (from S, Seq. 35, from F, Seq. 3, 21,
from E, Seq. 5, 10, 11, from TIAF16 or TIAF40 or TIAF93,
Seq. 5)

P (from S, Seq. 35, from F, Seq. 3, 21,
from EA, Seq. 5, 10, 11, from TIAF16 or TIAF40 or TIAF93,
Seq. 20)

P (from S, Seq. 35, from F, Seq. 3, 21,
from EA, Seq. 5, 10, 11, from L, Seq. 32, 48,
from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

Loss of IA is the initiator. SDC(B) continues to run but the operators fail to control level (OPDHR fails) or SDC fails. The operators attempt to initiate ECCS water solid operation (OPECS succeeds), but either the ECCS system fails or no water in the SP). Operators either fail to decide to flood or fail because SSWXT fails ot there is inadequate time available to align FW. They then fail to decide to steam (OPSTM fails). The operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHF.E2B

Initiator: E2BF20

Event Tree: P (from S, Seq. 35, from F, Seq. 21,
from E, Seq. 5, 10, 11, 22,
from E2BF20, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

A complete loss of SDC(B) is the initiator. No LOSP. The operators attempt to initiate ECCS water solid operation (OPECS succeeds), but either ECCS fails or there is no water in the SP. The operators do not decide to flood. They also fail to decide to steam at low pressure (OPSTM fails). The operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds and they attempt to flood), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

HRA

File Name: OPSTHFNC.E2B

Initiator: E2BF20

Event Tree: P (from S, Seq. 35, from EC, Seq. 4, 5, 6, 8, 9, 10, 12, 40, 41, 42, 68, 69, 70, from E, Seq. 2, 7, 13, 18, from E2BF20, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025		HEP 42

A complete loss of SDC(B) is the initiator. No LOSP. The operators attempt to initiate ECCS water solid operation (OPECS succeeds) and LPCI succeeds. Eventually, ECCS fails in long-term because the operators are unable or fail to provide adequate makeup to the SP. The operators fail to decide to steam at low pressure (OPSTM fails). The operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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). If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHFNC.T5A

Initiator: T5AF19

Event Tree: P (from S, Seq. 35, from EC, Seq. 4, 6, 8, 10, 12, 14, 40, 42, 68, 69, 70, from E, Seq. 3, 8, 19,
from T5AF19, Seq. 3, 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

A loss of SSW is the initiator. No LOSP. SDC is lost in some way. The operators attempt to initiate ECCS water solid operation (OPECS succeeds) and HPCS succeeds. Eventually, HPCS fails in long-term because the operators are unable or fail to provide adequate makeup to the SP. The operators fail to decide to steam at low pressure (OPSTM fails). The operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHFNC.TAB

Initiator: TAB39

Event Tree: P (from S, Seq. 35, from EC, Seq. 4, 8, 10, 12, 14, 40, 42, 68, 69, 70, from E, Seq. 3, 8, from SDC, Seq. 3, from TAB39, Seq. 3)

P (from S, Seq. 35, from EC, Seq. 4, 8, 10, 12, 14, 40, 42, 68, 69, 70, from EA, Seq. 3, 8, from ADH, Seq. 4, from TAB39, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

A loss of AC bus is the initiator. No LOSP. SDC is lost in some way. The operators attempt to initiate ECCS water solid operation (OPECS succeeds) and HPCS succeeds. Eventually, HPCS fails in long-term because the operators are unable or fail to provide adequate makeup to the SP. The operators fail to decide to steam at low pressure (OPSTM fails). The operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHFNC.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: P (from S, Seq. 35, from EC, Seq. 4, 8, 40, 68, 69, 70, from E, Seq. 2, 7, from TIAF16 or TIAF40 or TIAF93, Seq. 5)

P (from S, Seq. 35, from EC, Seq. 4, 8, 40, 68, 69, 70, from EA, Seq. 2, 7, from LA, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025		HEP 42

Loss of IA is the initiator. SDC(B) continues to run but the operators fail to control level (OPDHR fails) or SDC fails. The operators attempt to initiate ECCS water solid operation (OPECS succeeds) and LPCI succeeds. Eventually, ECCS fails in long-term because the operators are unable or fail to provide adequate makeup to the SP. The operators fail to decide to steam at low pressure (OPSTM fails). The operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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). If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHOF.E2B

Initiator: E2BF20

Event Tree: P (from S, Seq. 12, 35, from OF, Seq. 1,
from E, Seq. 50, from E2BF20, Seq. 5, 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

A complete loss SDC(B) is the initiator. No LOSP. The operators attempt to initiate ECCS water solid operation per procedure (OPECS succeeds), but MSIVs are open and flooding down steam lines occurs. The operators diagnose the need, stop ECCS, and close the open MSIVs (OPSOF succeeds). The operators either fail to decide to steam (OPSTM fails) or they attempt to steam, but 1SRV fails to open. With no SRVs open, the operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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). If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHOF.T5A

Initiator: T5AF19

Event Tree: P (from S, Seq. 12, 24, 35, from OF, Seq. 1, from E, Seq. 50, from T5AF19, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

A loss of SSW is the initiator. No LOSP. SDC is lost. OPECS succeeds, but MSIVs are open and flooding down steam lines occurs. The operators diagnose the need, stop ECCS, and close the open MSIVs (OPSOF succeeds). The operators either fail to decide to steam (OPSTM fails) or they attempt to steam, but 1SRV fails to open. With no SRVs open, the operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHOF.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: P (from S, Seq. 12, 35, from OF, Seq. 1,
from EA, Seq. 80, from LA, Seq. 32, 48,
from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

Loss of IA is the initiator. SDC(B) continues to run but the operators fail to control level (OPDHR fails). OPECS succeeds, but MSIVs are open and flooding down steam lines occurs. The operators diagnose the need, stop ECCS, and close the open MSIVs (OPSOF succeeds). The operators either fail to decide to steam (OPSTM fails) or they attempt to steam, but 1SRV fails to open. With no SRVs open, the operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHOSV.J2

Initiator: J2F48

Event Tree: P (from S, Seq. 12, 35, from OF, Seq. 1,
from E, Seq. 50, from A5ISJ, Seq. 1, 6,
from J2F48, Seq. 2)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTH	0.025	5	HEP 42
*	OPIS	0		HEP 57

A break in the SDC line outside containment is the initiator. The break is isolated with closure of MV 8 or MV 9. SDC and RHR(B) train is lost. Isolation of 8\9 valves occurs with level 3 signal. If a LOSP occurs, the diesels start and load (DV1-2 OK). The operators attempt to initiate ECCS water soild operation (OPECS succeeds), but MISIVs are open and the operators stop the flooding down the open steam lines (OPSOF succeeds and MSIVs are closed). The operators either fail to decide to steam the vessel at low pressure (a non-proceduralized action) or they attempt to steam but cannot get an SRV open. The operators will be aware of the fact that pressure and temperature will be increasing. As long as the operators initiate some source of makeup, they can steam at high pressure. OPSTH is the operator action to steam at high pressure (CRD or HPCS) and the operators have 4 hours for this task.

* SDC was isolated earlier in the sequence. If OPIS is asked, it should be set to succeed.

HRA

File Name: OPSTHSRV.E2B

Initiator: E2BF20

Event Tree: P (from S, Seq. 12, 35, from E, Seq. 23, 24, from E2BF20, Seq. 5)

Human Error Events:

		Mean HEPs		Code#
*	OPIS	0.063	10	HEP 57
	OPSTH	0.025	5	HEP 42

An loss of SDC(B) is the initiator. No LOSP. SDC is not restorable. The operators attempt to initiate ECCS water solid operation (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 go water solid and tried to open two SRVs. With no SRVs available, the operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

Note. If SDC does not need to be isolated because of the initiator, then OPIS should be set to 0 (success).

File Name: OPSTHSRV.T5A

Initiator: T5AF19

Event Tree: P (from S, Seq. 12, 35 from E, Seq. 23, 24,
from T5AF19, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

A loss of SSW is the initiator. No LOSP. OPSDC succeeds and the operators attempt to initiate ECCS water solid operation (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 go water solid and tried to open two SRVs. With no SRVs available, the operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHSRV.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: P (from S, Seq. 12, 35, from EA, Seq. 23, 24, 39, from LA, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	0.025	5	HEP 42

Loss of IA is the initiator. SDC(B) starts but the operators fail to control level (OPDHR fails). The operators attempt to initiate ECCS water solid operation (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 go water solid and tried to open two SRVs. With no SRVs available, the operators should be aware of the fact that 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. Thus, in this scenario where operators are attempting to follow procedure (OPECS succeeds), whether or not the operators consciously decide to steam (OPSTM succeeds or fails) 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).

If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get a low level isolation (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct diagnosis and perform the necessary actions.

File Name: OPSTHST3.J2

Initiator: J2F48

Event Tree: P (from S, Seq. 35, from F, Seq. 3, 21,
from E, Seq. 5, 10, 11, from A5ISJ, Seq. 1,
from J2F48, Seq. 2)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTH	0.025	5	HEP 42
*	OPIS	0		HEP 57

A break in the SDC line outside containment is the initiator. The break is isolated with closure of MV 8 or MV 9. SDC and RHR(B) train is lost. Isolation of 8\9 valves occurs with level 3 signal. If a LOSP occurs, the diesels start and load (DV1-2 OK). The operators attempt to initiate ECCS water solid operation per the IDHR ONEP (OPECS succeeds). ECCS fails to run or there is insufficient SP level. The operators fail to decide to flood or SSWXT fails in an attempt to flood. The operators fail to decide to steam (OPSTM, which is a non-proceduralized action, fails). At this point, the SRVs are assumed to be closed. Pressure and temperature will have increased and many indicators (including alarms) should be available. To successfully steam at high pressure, the operators need to provide makeup. The operators have four hours to realize the need and take the steps to steam at high pressure (on safety set point of 1SRV). CRD and HPCS are potentially available.

* SDC was isolated earlier in the sequence. If OPIS is asked, it should be set to succeed.

HRA

File Name: OPSTHST4.J2

Initiator: J2F48

Event Tree: P (from S, Seq. 35,
from EC, Seq. 4, 6, 8, 10, 12, 40, 42, 68, 69, 70,
from E, Seq. 2, 7, from A5ISJ, Seq. 1, 6
from J2F48, Seq. 2)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTH	0.025	5	HEP 42
*	OPIS	0		HEP 57

A break in the SDC line outside containment is the initiator. The break is isolated with closure of MV 8 or MV 9. SDC and RHR(B) train is lost. Isolation of 8\9 valves occurs with level 3 signal. If a LOSP occurs, the diesels start and load (DV1-2 OK). The operators successfully initiate ECCS water solid operation (OPECS succeeds), but ECCS fails in the long-term due to inadequate makeup to the suppression pool. The operators fail to decide to steam at low pressure (OPSTM fails). Over time, temperature and pressure will increase and the operators will have the option of steaming at high pressure. OPSTH is the operator action to steam at high pressure and the operators have 4 hours for this task. CRD or HPCS may be available.

* SDC was isolated earlier in the sequence. If OPIS is asked, it should be set to succeed.

File Name: OPSTHSTM.E2B

Initiator: E2BF20

Event Tree: P (from SP, Seq. 29, from EP, Seq. 51, from E2BF20, Seq. 8)

P (from S, Seq. 35, from E, Seq. 51, from E2BF20, Seq. 5, 6)

Human Error Events:

		Mean HEPs	EF	Code#
*	OPIS	1.0		HEP 41
	OPSTH	0.025	5	HEP 42

An loss of SDC(B) is the initiator. OPSDC succeeds or fails, but SDC is lost. The operators fail to initiate ECCS water solid operation per the IDHR ONEP (OPECS fails). The operators then fail to steam at low pressure (OPSTM fails) and the P tree is entered. OPIS is the operator action to isolate the SDC low pressure piping if the auto-isolation at 135 psi fails. OPIS must occur in the same time period as OPSTM. If OPECS fails in the current context, something is wrong and it is difficult to give credit for OPSTM or OPIS in the time available. If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get low level isolations (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct dignosis and perform the necessary actions.

* If SDC does not need to be isolated because of the initiator, then OPIS should be set to 0 (success).

HRA

File Name: OPSTHSTM.E2D

Initiator: E2DF93

Event Tree: P (from S, Seq. 35, from EA, Seq. 81,
from E2DF93, Seq. 6)

P (from S, Seq. 35, from EA, Seq. 81,
from LA, Seq. 38, from E2DF93, Seq. 4)

Human Error Events:

		Mean HEPs	EF	Code#
*	OPIS	1.0		HEP 41
	OPSTH	0.025	5	HEP 42

An complete loss of ADHR is the initiator. SDC(B) is started or it fails to starts. For sequences where SDC(B) is started, the operators fail to control level after a loss of CRD. In either case, the operators fail to initiate ECCS water solid operation per the IDHR ONEP (OPECS fails). The operators then fail to steam at low pressure (OPSTM fails) and the P tree is entered. OPIS is the operator action to isolate the SDC low pressure piping if the auto-isolation at 135 psi fails. OPIS must occur in the same time period as OPSTM. If OPECS fails in the current context, something is wrong and it is difficult to give credit for OPSTM or OPIS in the time available. If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get low level isolations (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct dignosis and perform the necessary actions.

* If SDC does not need to be isolated because of the initiator, then OPIS should be set to 0 (success).

File Name: OPSTHSTM.TAB

Initiator: TAB

Event Tree: P (from S, Seq. 35, from EA, Seq. 81, from ADH, Seq. 4, from TAB39, Seq. 5)

P (from S, Seq. 35, from E, Seq. 51, from SDC, Seq. 3, from TAB39, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	1.0		HEP 41
OPSTH	0.025	5	HEP 42

A loss of AC bus is the initiator. ADHR or SDC(B) fails. OPSDC succeeds, SDC is lost. The operators fail to initiate ECCS water solid operation per the IDHR ONEP (OPECS fails). The operators then fail to steam at low pressure (OPSTM fails) and the P tree is entered. OPIS is the operator action to isolate the SDC low pressure piping if the auto-isolation at 135 psi fails. OPIS must occur in the same time period as OPSTM. If OPECS fails in the current context, something is wrong and it is difficult to give credit for OPSTM or OPIS in the time available. If the auto-isolation logic (RHRIP) and the operators fail to isolate the low pressure piping, then when something breaks, drain down will occur and they should get low level isolations (RHRIL and SDCIL). As long as SDC is isolated in some way, the operators could steam the vessel at high pressure on the safety set point of 1SRV. OPSTH is the operator action to steam the vessel at high pressure (CRD or HPCS) to prevent uncovering the core. They have 4 hours to make the correct dignosis and perform the necessary actions.

File Name: OPSTHE2B.FLD

Initiator: E2BF20

Event Tree: P (from S, Seq. 35, from E, Seq. 51,
from E2BF20, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTH	0.025	5	HEP 42
OPIS	1.0		HEP 41

Complete loss of SDC common suction line (RHR/SDC and ADHRS completely lost). The operators either initially fail to detect the loss of SDC or they do detect the loss (OPSDC succeeds or fails). Regardless, OPECS fails (E, Seq.51, and EP, Seq, 51). 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. Thus, in these scenarios, OPSTM (which is a non-proceduralized action) is assumed to fail. At this point, with no SRVs open and SDC isolated, pressure and temperature will have increased significantly. Many indicators (including alarms) should be available. To successfully steam at high pressure, the operators need only add some form of makeup. The operators have four hours to detect the problem and steam at high pressure (on safety set point of 1SRV). CRD available, HPCS lost due to flood. If operators have failed in OPECS and OPSTM, no reason to expect them to isolate low pressure piping if the auto isolation fails. Thus. OPIS is ste to 1.0.

File Name: OPSTMFD2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from F, Seq. 21, from EA, Seq. 5, 10, 11, 22, from LA, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	0.106	10	HEP 29
*	OPMSV	1.0		HEP 82

Loss of IA is the initiator. ADHR is lost and the operators successfully start SDC(B). The operators then fail to control level given the loss of CRD, forced recirculation, and RWCU (OPDHR fails). The operators eventually recognize the problem and initiate ECCS water solid operation (OPECS successful). ECCS fails and the operators fail to decide to flood or cannot flood in the time available with the systems available (e.g., SSWXT gone in these sequences for one of the flooding scenarios). The operators will steam the core by default if they open at least 1 SRV and eventually get some form of injection. The operators have at least FW available for steaming. Unfortunately, FW will fail due to insufficient time, even if they started FW during the time for OPFLD. MSIVs are closed in these sequences.

* According to operators at GGNS, they would not open MSIVs unless a vacuum was present in the condenser. Cannot assume a vacuum during POS 5.

File Name: OPSTHR74.FLD

Initiator: RWC74

Event Tree: P (from S, Seq. 35, from E, Seq. 51,
from RRW, Seq. 32, from RWC74, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTH	0.025	5	HEP 42
OPIS	1.0		HEP 41

The initiator is a break in the RWCU line. Depending on where the break is located in the line, the GPM lost will vary, as will the amount of time the operators have to respond. OPDHR1 in this case is the operator action to isolate letdown (RWCU) before level 3 is reached and SDC auto-isolates. In these sequences, OPDHR1 succeeds. However, the operators initially fail to bring level back up (OPLEC fails) and they then fail to initiate ECCS water solid operation per the IDHR ONEP (failure of OPECS). Since these activities are clearly called out by the IDHR procedure given the loss of SDC, the lack of action by the operators indicates no reason to expect the control room to consciously decide to steam (a non-proceduralized action). Thus, OPSTM fails for these scenarios.

At this point, with no SRVs open, pressure and temperature will have increased significantly. Many indicators (including alarms) should be available. To successfully steam at high pressure, the operators need only add some form of makeup. The operators have four hours to detect the problem and steam at high pressure (on safety set point of 1SRV). CRD or HPCS could be available. If operators have failed in OPLEC and OPECS, no reason to expect them to isolate low pressure piping if the auto isolation fails. Thus. OPIS is set to 1.0.

File Name: OPSTHT5A.FLD

Initiator: T5AF19

Event Tree: P (from S, Seq. 35, from F, Seq. 21,
from E, Seq. 4, 9, 11, 20, 22,
from T5AF19, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPIS	0.063	10	HEP 57
OPSTH	1.0		

In the context of a flooding scenario, the initiator is similar to a loss of SSW along with a LOSP. Because of the flood, SWLOS and IALOS are assumed (see T5AF19 initiator). As a result of IALOS CRD is lost. OPECS succeeds, but HPCS fails for any of several reasons, e.g., no water in SP. Operators either fail to decide to flood or fail because inadequate time available to align FW. They then fail to decide to steam (OPSTM fails). SRVs are closed and the operators should be aware of the fact that pressure will be going up. By Tech. Specs. the low pressure piping needs to be isolated at 135 psi (auto isolation at 135 psi) and othe operators should recieve alarm prior to 135. In addition, if auto isolation fails, the operators should get isolation failure signal. Thus, in this scenario where the operators are initially attempting to follow procedure (OPECS succeeds), whether or not the ops consciously decide to flood or steam (OPSTM and OPFLD succeeds or fails), they should have some probabilty of realizing the need to manually isolate the low pressure piping (OPIS) if the auto isolation signal fails (RHRIP). OPIS must be done in the same time frame as OPSTM (23 min.). Given the success of OPECS and the signals the operators would receive in regards to the low pressure isolation, diagnosing the need to perform the isolation was assumed in this case to be independent of the decision concerning steaming. That is, their decision regarding steaming will not influence their decison to manually perform the failed auto-isolation if it is indicated.

OPSTH is steaming at high pressure and as long as letdown is isolated, have 4 hours for this task. However, with CRD and HPCS unavailable, their are no high pressure systems available for makeup.

File Name: OPSTMFD3.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from F, Seq. 21, from EA, Seq. 5, 10, 11, 22, from TIAF16 or TIAF40 or TIAF93, Seq. 20)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	0.106	10	HEP 29
*	OPOMS	1.0		HEP 82

Loss of IA is the initiator. The operators recognize the loss of ADHR and attempt to start SDC(B) (OPSDC succeeds), but the system fails to start. The operators attempt to initiate ECCS water soild operation (OPECS successful), but ECCS fails. The operators fail to decide to flood or cannot flood with the systems available in the time available. Regardless, on the basis of past actions, they will be aware of the need to get water into the vessel and they will steam by default if they just get some water in and open at least 1 SRV. Oerators have at least FW available for steaming. Unfortunately, FW will fail due to insufficient time, even if they started FW in OPFLD. MSIVs are closed.

* According to ops at GGNS, would not open MSIVs unless had a vacuum in the condenser. Cannot assume vacuum during POS 5.

File Name: OPSTMFS2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from F, Seq, 3, from EA, Seq. 5, 10, 11,
from TIAF16 or TIAF40 or TIAF93, Seq. 20)

SP (from FP, Seq, 3, from EP, Seq. 5, 10, 11,
from TIAF16 or TIAF40 or TIAF93, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of IA is the initiator. If a LOSP occurs, the diesels start and load. SDC is lost. OPECS is successful, but ECCS fails for some reason (LPCI fails on demand or no SP level). The operators decide to flood the vessel/containment. Flooding fails due to SSWXT failure or unavailability. Operators have the option of steaming the vessel.

File Name: OPSTMFWF.TAB

Initiator: TAB39

Event Tree: S (from F, Seq 3, 6, 11
from (E, Seq. 4, 15, 20) or (EA, Seq. 4, 9, 11)
from (SDC, Seq. 3) or (ADH, Seq. 4)
from TAB39, Seq. 3 or 5)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	1.0		HEP 49
*	OPOMS	1.0		HEP 82

A loss of AC bus is the initiator. No LOSP. The operators attempt to initiate ECCS water solid operation (OPECS successful), but HPCS fails or there is no water in the SP. CRD,CDS, and SSWXT are lost with the loss of the bus and IA. Operators then attempt to flood the vessel/containment with FW, but FW fails. With SSWXT and FW unavailable, the operators do not have any systems avialable for steaming.

Note. An error was made in determing the HEP for OPFLD in these sequences. The operators should not have received credit for OPFLD when only FW was available, because there is insufficient time available in OPFLD to accomplish the alignment. Thus, credit was not given for OPSTM at this point simply because with FW failed, no sytems would be available for steaming. In cutsets where FW fails for reasons other than hardware failure, where appropriate, credit will be taken during "recovery" for the operators attempting to aligning FW for injection.

* According to the operators at GGNS, they would not open MSIVs unless had a vacuum was present in the condenser. Cannot assume a vacuum during POS 5.

File Name: OPSTMMK2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from EC, Seq. 68, 69, from EA, Seq. 2, 7, from TIAF16 or TIAF40 or TIAF93, Seq. 20)

S (from EC, Seq. 12, 13, 18, 14, 40, 41, 42, 68, 69, 70, from EA, Seq. 2, 7, from LA, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

SP (from ECP, Seq. 68, 69, from EP Seq. 2, 7, from TIAF16 or TIAF40 or TIAF93, Seq. 9)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	0.106	10	HEP 29
*	OPOMS	1.0		HEP 82

Loss of IA is the initiator. If a LOSP occurs, the diesels start and load (DV1-2 OK). SDC(B) fails or contuniues to run, but the operators initially fail to control level (OPDHR fails). OPECS is successful and LPCI runs. Either SPMU fails, the operators fail to provide SPMU (OPSPM), or the operators fail to provide makeup to the makeup (SPMKP) or to the SP. Therefore, LPCI fails. Operators have the option of steaming the vessel. At this point they are functionally steaming (SRVs open) and need only eventually initiate an available system. Per discussions with operators, this is a very viable option at this point.

* According to operators at GGNS, they would not open MSIVs unless had a vacuum in the condenser. Cannot assume vacuum during POS 5.

File Name: OPSTMMKH.TAB

Initiator: TAB39

Event Tree: S (from EC, Seq 13, 41, 69,
from E or EA, Seq. 3, 8, 14, 19,
from (SDC, Seq. 3 or 4) or (ADH, Seq. 4)
from TAB39, Seq. 3 or 5)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	0.106	10	HEP 29
*	OPOMS	1.0		HEP 82

A loss of AC bus is the initiator. No LOSP. OPECS is successful and HPCS runs for ECCS water solid operation. SPMU hardware (SPMU1) prevents SPMU dump. With no water available for HPCS, the operators have the option of steaming with FW (CRD,CDS,SSWX gone on loss of bus).

* According to operators at GGNS, they would not open any MSIVs unless they had a vacuum in the condenser. Cannot assume a vacuum exists during POS 5.

File Name: OPSTMMKO.TAB

Initiator: TAB39

Event Tree: S (from EC, Seq 12, 14, 40, 42, 68, 70
from E or EA, Seq. 3, 8,
from (SDC, Seq. 3) or (ADH, Seq. 4)
from TAB39, Seq. 3 or 5)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	0.106	10	HEP 29
*	OPOMS	1.0		HEP 82

A loss of AC bus is the initiator. No LOSP. OPECS is successful and HPCS runs for ECCS water solid operation. SPMU hardware (SPMU1) prevents SPMU dump. With no water available for HPCS, the operators have the option of steaming with FW (CRD,CDS,SSWX gone on loss of bus and IA.

* According to operators at GGNS, they would not open any MSIVs unless they had a vacuum in the condenser. Cannot assume a vacuum exists during POS 5.

File Name: OPSTMMKU.E2B

Initiator: E2BF20

Event Tree: S (from EC, Seq. 4, 5, 6, 8, 9, 10 12, 40, 41, 42, 68, 69, 70, from E, Seq. 2, 7, 13, 18, from E2BF20, Seq. 5, 6)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	0.106	10	HEP 29
*	OPOMS	1.0		HEP 82

An loss of SDC(B) is the initiator. No LOSP. OPECS is successful and ECCS is initially OK. Makeup not provided to SP or SPMU dump prevented for some reason. Therefore ECCS will fail in the long term. In some scenarios, SSWXT is available for steaming, but in others only FW is available. OPSTM is operator action to diagnose the need to steam and check open at least 1 SRV.

* According to ops at GGNS, would not open MSIVs unless had a vacuum in the condenser. Cannot assume vacuum during POS 5.

File Name: OPSTMMKU.T5A

Initiator: T5AF19

Event Tree: S (from EC, Seq. 4, 5, 6, 8, 9, 10, 12, 13, 14, 40, 41, 42, 68, 69, 70, from E, Seq. 3, 8, 14, 19, from T5AF19, Seq. 3, 4)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	0.106	10	HEP 29
*	OPOMS	1.0		HEP 82

A loss of SSW is the initiator. No LOSP. OPECS is successful and ECCS is initially OK. Makeup is not provided to SP and therefore ECCS will fail. Operators will have the option to steam the vessel.

* According to the operators at GGNS, they would not open MSIVs unless had a vacuum in the condenser. Cannot assume vacuum during POS 5.

Per rationale for HEP 29 (OPSTM.SP), OPSTM computed.

Also see OPSTEMMKO.TAB and OPSTMMKH.TAB

File Name: OPSTMMKU.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from EC, Seq. 13, 14, 68, 69, 70,
from E, Seq. 2, 7,
from TIAF16 or TIAF40 or TIAF93, Seq. 5)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	0.106	10	HEP 29
*	OPOMS	1.0		HEP 82

Loss of IA is the initiator. No LOSP. SDC(B) fails and OPSDC succeeds. OPECS is successful and LPCI runs. Operators either fail to provide SPMU (OPSPM) or fail to provide makeup to the makeup (SPMKP) or to the SP. Therefore, LPCI will fail. Operators have the option of steaming the vessel. At this point they are functionally steaming (SRVs open) and need only eventually initiate an available system. Per discussions with operators, this is a very viable option at this point.

* According to operators at GGNS, they would not open MSIVs unless had a vacuum in the condenser. Cannot assume vacuum during POS 5.

File Name: OPSTMNFD.E2B

Initiator: E2BF20

Event Tree: S (from F, Seq. 21, from E, Seq. 5, 10, 11, 22, from E2BF20, Seq. 5, 6)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of SDC(B) occurs. No LOSP. OPECS is successful, but ECCS fails. Operators fail to decide to flood or cannot flood with the systems available in the time available. Regardless, they will steam by default if they ensure at least 1 SRV is open. Operators will eventually have to provide makeup.

File Name: OPSTMNFD.T5A

Initiator: T5AF19

Event Tree: S (from F, Seq 21
from E, Seq. 4, 9, 11, 15, 20, 22
from T5AF19, Seq. 3, 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of SSW is the initiator. No LOSP. OPECS is successful, but ECCS fails. Operators fail to decide to flood or cannot flood with the systems available in the time available. Regardless, they will steam by default if they ensure at least 1 SRV is open. Operators will eventually have to provide makeup.

File Name: OPSTMNFD.TAB

Initiator: TAB39

Event Tree: S (from F, Seq 21
from E, Seq. 4, 9,
from (SDC, Seq. 3) or (ADH, Seq. 4)
from TAB39, Seq. 3 or 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of AC bus is the initiator. SDC(B) or ADHR is lost. No LOSP. OPECS is successful, but ECCS fails. Operators fail to decide to flood or cannot flood with the systems available in the time available. Regardless, they will steam by default if they ensure at least 1 SRV is open. Operators will eventually have to provide makeup.

File Name: OPSTMNFD.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from F, Seq. 21, from E, Seq. 5, 10, 11, 22,
from TIAF16 or TIAF40 or TIAF93, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of IA is the initiator. No LOSP. OPECS is successful, but ECCS fails. Operators fail to decide to flood or cannot flood with the systems available in the time available. Regardless, they will steam by default if they ensure at least 1 SRV open and eventually provide makeup. Operators have at least FW available for steaming. Unfortunately, FW will fail due to insufficient time, even if they started FW in OPFLD.

Per rationale for HEP 29 (OPSTM.SP), OPSTM computed.

Also see OPSTMNFD.TAB and***OPSTMNFD.SP***

File Name: OPFLDRM4.FLD

Initiator: RWC74

Event Tree: F (from RRW, Seq. 13, 26, from RWC74, Seq. 2)

F (from RARW, Seq. 13, 26, from RWC74, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	0.138	10	HEP 28
OPMSV	0.01	5	HEP 90
OP1SV	0.302	10	HEP 5

The initiator is a break in the RWCU line. In this scenario, the operators successfully isolate RWCU before level 3 is reached and therefore SDC does not auto-isolate. The operators attempt to provide makeup with an ECCS system to bring level up to where it should be (OPLEC succeeds), but ECCS fails. Operators must diagnose the need to flood the vessel/containment. SSWXT is available.

File Name: OPFLDRM6.FLD

Initiator: RWC26

Event Tree: F (from RRW, Seq. 13, 26, from RWC26, Seq. 2)

F (from RARW, Seq. 13, 26, from RWC26, Seq. 9)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	0.138	10	HEP 28
OPMSV	0.01	5	HEP 90
OP1SV	0.302	10	HEP 5

The initiator is a break in the RWCU line. In this scenario, the operators successfully isolate RWCU before level 3 is reached and therefore SDC does not auto-isolate. The operators attempt to provide makeup with an ECCS system to bring level up to where it should be (OPLEC succeeds), but ECCS fails. Operators must diagnose the need to flood the vessel/containment. SSWXT is available.

File Name: OPFLDTIA.FLD

Initiator: TIAF40, TIAF93

Event Tree: F (from EA, Seq. 5, 10, from L, Seq. 32, 48, from TIAF40, Seq. 18)

F (from EA, Seq. 5, 10, from L, Seq. 32, 48, from TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPFLD	1.0		HEP 33

In this flooding scenario, the impact of the break in the PSW piping is similar to the loss of IA initiator except that SSWXT would not be available due to the flooding. In the present sequences, ADHR is lost, but SDC(B) is successfully started. At some later point, CRD, forced recirculation, and RWCU are lost. The operators initially fail to control level (OPDHR fails) to prevent a "functional" loss of SDC, but eventually recognize the need for decay heat removal and attempt to initiate ECCS water solid operation (OPECS succeeds). However, ECCS fails (either systems or no SP level). Without SSWXT available, the operators would be unable to flood. There is insufficient time available to align the FW system for flooding.

File Name: OPSTMNFS.E2D

Initiator: E2DF93

Event Tree: S (from F, Seq, 3, from EA, Seq. 4, 9, from E2DF93, Seq. 6)

S (from F, Seq, 3, from EA, Seq. 4, 9, from LA, Seq. 38, from E2DF93, Seq. 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A conplete loss of ADHR is the initiator and it is not restored. In some sequences, SDC(B) is started, but the operators fail to control level after a loss of CRD. Eventually, the operators attempt to initiate ECCS water solid with HPCS (OPECS successful), but HPCS fails (LPCI is unavailable from the initiator). The operators decide to flood the vessel/containment. Flooding fails due to SSWXT failure or unavailability. The operators have the option of steaming.

File Name: OPSTMNFS.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from F, Seq, 3, 6, from E, Seq. 5, 10, 11, 16, 21, from TIAF16 or TIAF40 or TIAF93, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of IA is the initiator. No LOSP. OPECS is successful, but ECCS fails for some reason (LPCI fails on demand or no SP level). The operators decide to flood containment. Flooding fails due to SSWXT failure or unavailability. Operators have the option of steaming the vessel.

HRA

File Name: OPSTMOF.E2B

Initiator: E2BF20

Event Tree: S (from OF, Seq. 1, from E, Seq. 50,
from E2BF20, Seq. 5, 6)

Human Error Events:

		Mean HEPs	EF	Code#
	OPSTM	0.106	10	HEP 29
*	OPMSV			
	OPOMS	1.0		HEP 82

A loss of SDC(B) is the initiator. No LOSP. OPECS is successful, but the operators fail to close open MSIVs in time and they have to stop the flooding down open main steam lines (OPSOF). The operator option to steam conservatively assumes ECCS would no longer be available after overfill stopped. With no option for water solid, steaming is viable.

* In this scenario, the operators successfully stopped flooding down MSIVs (OPSOF succeeds), thus MSIVs are closed.

File Name: OPSTMOFP.T5A

Initiator: T5AF19

Event Tree: S (from OF, Seq. 1, from E, Seq. 50,
from T5AF19, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
* OPMSV			
OPOMS	1.0		HEP 82

A loss of SSW is the initiator. No LOSP. OPECS is successful, but the operators fail to close open MSIVs in time and they have to stop the flooding down open main steam lines (OPSOF). The operator option to steam conservatively assumes ECCS would no longer be available after overfill stopped. With no option for water solid, steaming is viable.

* In this scenario, the operators successfully stopped flooding down MSIVs (OPSOF succeeds), thus MSIVs are closed.

HRA

File Name: OPSTMOF.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from OF, Seq. 1, from E, Seq. 50, from TIAF16 or TIAF40 or TIAF93, Seq. 5)

S (from OF, Seq. 1, from EA, Seq. 80, from TIAF16 or TIAF40 or TIAF93, Seq. 20)

SP (from OFP, Seq. 1, from EP, Seq. 50, from TIAF16 or TIAF40 or TIAF93, Seq. 9)

S (from OF, Seq. 1, from EA, Seq. 80, from LA, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
* OPMSV			
OPOMS	1.0		HEP 82

A loss of IA is the initiator. FCIRC, CRD, CDS, and RWCU are lost. If a LOSP occurs, the diesels start and load (DV1-2). IF SDC continues to run, the operators fail to control level (OPDHR fails). Regardless, OPECS is successful, but the operators fail to close open MSIVs in time and they have to stop the flooding down open main steam lines (OPSOF). The operator option to steam conservatively assumes the operating ECCS system would no longer be available after overfill stopped. The operators have the option of steaming the vessel.

* In this scenario, the operators successfully stopped flooding down MSIVs (OPSOF succeeds), thus the MSIVs are closed.

File Name: OPSTMSNP.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: SNP (from HPSWR, Seq. 52, from TIAF16 or TIAF40 or TIAF93, Seq. 11)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0		HEP 49

A loss of IA is the initiator. A LOSP occurs and the diesel fails to start. HPCS is available, but OPECS fails. For this sequence, OPSTM will fail in SNP. If the operators fail to use their only available system and go water solid per procedure (OPECS fails), no reason to expect them to consciously decide to steam (a non-proceduralized action). However, credit for HPCS will be applied during recovery

File Name: OPSTMSRV.E2B

Initiator: E2BF20

Event Tree: S (from E, Seq 23 or 24, from E2BF20, Seq. 5)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of SDC(B) is the initiator. OPSDC succeeds, but all RHR gone due to the initiator. OPECS succeeds, but the operators fail to proceed with only 1SRV (OP1SV fails) or 1 SRV will not open (1SRVB fails). The operators have the option of steaming (consciously or unconsciously) the vessel, but will eventually need to get 1 SRV open. If they don't, will have the option of steaming at high pressure.

File Name: OPSTMSRV.J2

Initiator: J2F48

Event Tree: S (from E, Seq. 23, 24, from A5ISJ, Seq. 1, from J2F48, Seq. 1)

S (from E, Seq. 23, 24, from A5ISJ, Seq. 6, from J2F48, Seq. 1)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A break in the SDC line outside containment is the initiator. The break is isolated with closure of MV 8 or MV 9. SDC and RHR(B) train is lost. Isolation of 8\9 valves occurs with level 3 signal. If a LOSP occurs, the diesels start and load (DV1-2 OK). Operators attempt to go ECCS water solid (OPECS succeeds), but 2SRVs fail to open and either the operators fail to proceed with one SRV or one fails to oper. Operators may decide to steam the vessel.

File Name: OPSTMSRV.T5A

Initiator: T5A

Event Tree: S (from E, Seq 23 or 24, from T5AF19, Seq. 3, 4)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of SSW is the initiator. Eventually, OPECS succeeds, but the operators fail to proceed with only 1SRV (OP1SV fails) or 1 SRV will not open (1SRVB fails). The operators have the option of steaming the vessel (consciously or unconsciously), but they will eventually need to get 1 SRV open. If they don't, they will have the option of steaming at high pressure.

File Name: OPSTMSRV.TAB

Initiator: TAB39

Event Tree: S (from E, Seq. 23, 24, from SDC, Seq. 3, 4,
from TAB39, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of AC bus is the initiator. SDCB fails. OPSDC succeeds or fails, but no SDC is obtained. OPECS succeeds, but the operators fail to proceed with only 1SRV (OP1SV fails) or 1 SRV will not open (1SRVB fails). The operators have the option of steaming the vessel (consciously or unconsciously), but they will eventually need to get 1 SRV open. If they don't, they will have the option of steaming at high pressure.

File Name: OPSTMSRV.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from E, Seq 23 or 24, from L, Seq. 32, 48,
from TIAF16 or TIAF40 or TIAF93, Seq. 3)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of IA is the initiator. SDC(B). SDC(B) continues to run. RWCU isolates and CDR gone with the initaitor. OPDHR fails, but OPECS succeeds. However, the operators fail to proceed wuth ECCS water solid with only 1SRV (OP1SV fails) or 1 SRV will not open (1SRVB fails). The operators have the option of steaming the vessel (consciously or unconsciously), but they will eventually need to get 1 SRV open. If they don't, they will have the option of steaming at high pressure.

File Name: OPSTMSV2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from EA, Seq 23, 24, 39, from LA, Seq. 32, 48, from TIAF16 or TIAF40 or TIAF93, Seq. 18)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of IA is the initiator. ADHR is lost and SDC(B) is started. RWCU isolates and FCIRC, CRD, and CDS are lost with the initaitor. OPDHR fails, but OPECS succeeds. However, the operators fail to proceed wuth ECCS water solid with only 1SRV (OP1SV fails) or 1 SRV will not open (1SRVB fails). The operators have the option of steaming the vessel (consciously or unconsciously), but they will eventually need to get 1 SRV open. If they don't, they will have the option of steaming at high pressure.

File Name: OPSTMYD.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from E, Seq. 51, from L, Seq. 32,
from ADEP, Seq. 3, from OVPR, Seq. 4,
from HYDRO, Seq. 5, from TIAF16 or TIAF40 or TIAF93, Seq. 33)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	1.0	10	HEP 49

A loss of IA during HYDRO is the initiator. FCIRC, CRD, and RWCU are lost. RWCU in the recirculation mode fails to continue to run. No LOSP. The SRVs open on safety set point and fail to close (SAFEC). Depressurization occurs. In ADEP tree SDCUI succeeds and SDC(B) runs. The operators fail to control level (OPDHR fails) and they fail to initiate ECCS water solid operation (OPECS fails). The operators have the option of steaming at low pressure. However, this is a non-proceduralized action and given their pattern of failures, no credit given for steaming. Credit is given for deciding to steam at high pressure in P tree, where substantially more time is available.

File Name: OPSTMYD2.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: S (from F, Seq. 3, from E, Seq. 5, 10, from ADEP, Seq. 6, from OVPR, Seq. 4, from HYDRO, Seq. 5, from TIAF16 or TIAF40 or TIAF93, Seq. 33)

Human Error Events:

	Mean HEPs	EF	Code#
OPSTM	0.106	10	HEP 29
OPOMS	1.0		HEP 82

A loss of IA during HYDRO is the initiator. FCIRC, CRD, CDS, and RWCU are lost. RWCU in the recirculation mode fails to continue to run. No LOSP. The SRVs open on safety setpoint and fail to close (SAFEC). Depressurization occurs. In ADEP tree SDCUI succeeds, but SDC(B) and ADHR1 fail or are unavaiable. Thus, enter the E tree and OPECS. OPECS is successful, but ECCS fails on demand and the operators decide to flood the vessel/containment. Flooding fails due to SSWXT failure or unavailability. The operators have the option of steaming.

File Name: OPXTIE.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: TIAF16 or TIAF40 or TIAF93

Human Error Events:

		Mean HEPs	EF	Code#
	XTIEB	0.073	10	HEP 19
*	OPSDC	0.6	10	HEP 20

In this scenario, a loss of IA and a LOSP has occurred and the diesel generator has failed to start. HPCS is determined to be unavailable, which indicates the need to cross-tie the HPCS DG to train 2 (XTIEB). OPSDC involves diagnosing the likelihood that SDC(B) will isolate on 135 PSI when the cross-tie is completed (and thus not be available) and then entering the IDHR ONEP to prepare for initiating ECCS water solid operation per procedure (OPECS). If the control room fails to make this diagnosis in the time allowed for OPSDC, the time available for OPECS might not be used appropriately. That is, the operators could simply waste the time for OPSDC and OPECS with the notion that they will restart SDC(B) when they get the cross-tie completed and then not have any time for diagnosing and carrying-out the actions related to OPECS (starting an ECCS system (LPCI (C)) and opening SRVs etc). As indicated by the HEP for OPSDC, the correct diagnosis is non-trivial.

* Use this value for OPSDC only in sequences where XTIEB is asked.

File Name: SDCUI.TAB

Initiator: TAB39

Event Tree: ADEP (from OVPR, Seq. 4, from HYDRO, Seq. 5, from TAB39, Seq. 7)

Human Error Events:

	Mean HEPs	EF	Code#
SDCUI	0.04	5	HEP 48

A loss of AC bus during HYDRO occurs. No LOSP, but IA isolates. RWCU (letdown) and CRD (makeup) are lost, as is recirculation. SRVs open on safety set point and fail to close. Thus, the vessel depressurizes. Some form of SDC is needed. SDCUI is operator action to unisolate several systems and initiate ADHR. RHR is unavailable. While ADHR is available, several actions are required before it can be started. The operators must unisolate IA and PSW, and restore TBCW. The necessary actions are indicated in the ONEPs for the loss of AC power and for IDHR. The operators have 8.7 hrs. available for the diagnosis and actions. During HYDRO, water level is high enough for natural recirculation, so they just need to initiate ADHR.

File Name: SDCUI.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: ADEP (from OVPR, Seq. 4, from HYDRO, Seq. 5, from TIAF16 or TIAF40 or TIAF93, Seq 33)

Human Error Events:

	Mean HEPs	EF	Code#
SDCUI	3.5E-3	5	HEP 52

A loss of IA occurs during a HYDRO test. FCIRC, CRD, and RWCU are lost. RWCU (letdown) isolates and recirculation mode is lost. SRVs open on safety set point and fail to close. Thus, depressurization occurs. A normal means of SDC is needed. SDCUI is the operator action to initiate RHR/SDC or ADHR. RHR is available and can be aligned from the control room . The operators have 8.7 hrs. to diagnose need for some form of SDC and initiate the system. During HYDRO, water level is high enough for natural recirculation, so they just need to initiate RHR/SDC(B).

File Name: SDCUI.TIO

Initiator: TIOPF65

Event Tree: ADEP (from OVPR, Seq. 4, from TIOPF65, Seq 19)

Human Error Events:

	Mean HEPs	EF	Code#
SDCUI	3.5E-3	5	HEP 52

A mismatch between letdown and makeup occurs during a HYDRO test. SRVs open on safety set point and fail to close. Thus, depressurization occurs. A normal means of SDC is needed. SDCUI is the operator action to initiate RHR/SDC or ADHR. RHR is available and can be aligned from the control room. The operators have 8.7 hrs. available for the diagnosis and actions. During HYDRO, water level is high enough for natural recirculation, so they just need to initiate RHR or ADHR.

File Name: SPMUN.T5A

Initiator: T5AF19

Event Tree: ECNP (from HPSWR, Seqs. 1, 4, 8, 11, 34, 37,
from T5AF19, Seq. 6)

Human Error Events:

	Mean HEPs	EF	Code#
SPMUN	0.011	5	HEP 26
SPMKN	0.032	5	HEP 27

A loss of SSW is the initiator. LOSP is lost and the diesels fail to start. HPCSA is successful and OPECS succeeds in HPSWR. That is, the operators initiate ECCS water solid operation. Given HPCS is injecting, the operators must diagnose the need to makeup water to the SP with SPMU (SPMUN) and provide additional makeup (SPMKN).

File Name: SPMUNECN.E2B

Initiator: E2BF20

Event Tree: ECNP (from HPSWR, Seqs. 1, 4, 8, 11, 34, 37, 41, 44)
from E2BF20, Seq. 10)

Human Error Events:

	Mean HEPs	EF	Code#
SPMUN	0.011	5	HEP 26
SPMKN	0.032	5	HEP 27

From E1B5H or E2BF20, HPCSA is OK and OPECS succeeds in HPSWR. Given HPCS is injecting, the operators must diagnose the need to makeup water to the SP with SPMU (SPMUN) and provide additional makeup (SPMKN).

File Name: SPMUNECN.T5A

Initiator: T5AF19

Event Tree: ECNP (from HPSWR, Seqs. 1, 4, from T5AF19, Seq. 6)

Human Error Events:

	Mean HEPs	EF	Code#
SPMUN	0.011	5	HEP 26
SPMKN	0.032	5	HEP 27

From T5AF19, HPCSA is successful and OPECS succeeds in HPSWR.
Given HPCS is injecting, the operators must diagnose the need to makeup water to the SP with SPMU (SPMUN) and provide additional makeup (SPMKN).

File Name: SPMUNECN.TIA

Initiator: TIAF16 or TIAF40 or TIAF93

Event Tree: ECNP (from HPSWR, Seqs. 1, 4, 8, 11, 34, 37,
from TIAF16 or TIAF40 or TIAF93, Seq. 11)

Human Error Events:

	Mean HEPs	EF	Code#
SPMUN	0.011	5	HEP 26
SPMKN	0.032	5	HEP 27

A loss of IA is the initiator and a LOSP also occurs. The diesels fail to start, but HPCSA is successful and OPECS succeeds in HPSWR.
Given HPCS is injecting, the operators must diagnose the need to makeup water to the SP with SPMU (SPMUN) and provide additional makeup (SPMKN).

Appendix H

Flood Specific Event Trees and Top Event Definitions

Contents

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Appendix H - Flood Specific Event Trees and Top Event Definitions

H.1 Event Trees

As discussed in the body of the report and Appendix F, initiating event trees for flood-induced initiators were, in most cases, identical to the corresponding non-flood initiating events. In these cases, for the sake of clarity, the initiating event names were changed to those of flood-induced initiators and run with the flood initiator frequency and other top event frequencies changed as appropriate. These event trees are given in Figures H.1 through H.16.

The RWC26 and RWC74 events required the development of new initiating event trees. These trees are given in Figures H.17 and H.18. The RWC initiators also required the development of three transfer trees for the second level of analysis, the RRW, RARW, and RWCHI trees. These trees are given in Figures H.19 through H.21. For other event trees, the reader is referred to Whitehead et al., BWR Low Power and Shutdown Accident Frequencies, Phase 2, Volume 1, Part 1.

H.2 Flood Specific Top Events

The top events in the flood analyses are the same as those in the report referenced in Section H.1. Five additional top events were required to address flood-induced initiators. These are defined in Table H.1.

Table H.1
Flood Specific Top Events

OPDHR1	Operator fails to isolate RWCU before level 2 is reached (applies to break in RWCU pump suction or pump outlet line).
OPSDC1	Operator fails to recognize loss of operating SDC system due to RWCU pipe break.
RWAIS	RWCU auto-isolates on level 3 after RWCU pipe break
OPADH	Operator action to configure system to run on ADHRS from HYDRO
NOACDC	Developed event for loss of all AC and DC power except for Balance of Plant (BOP) power.

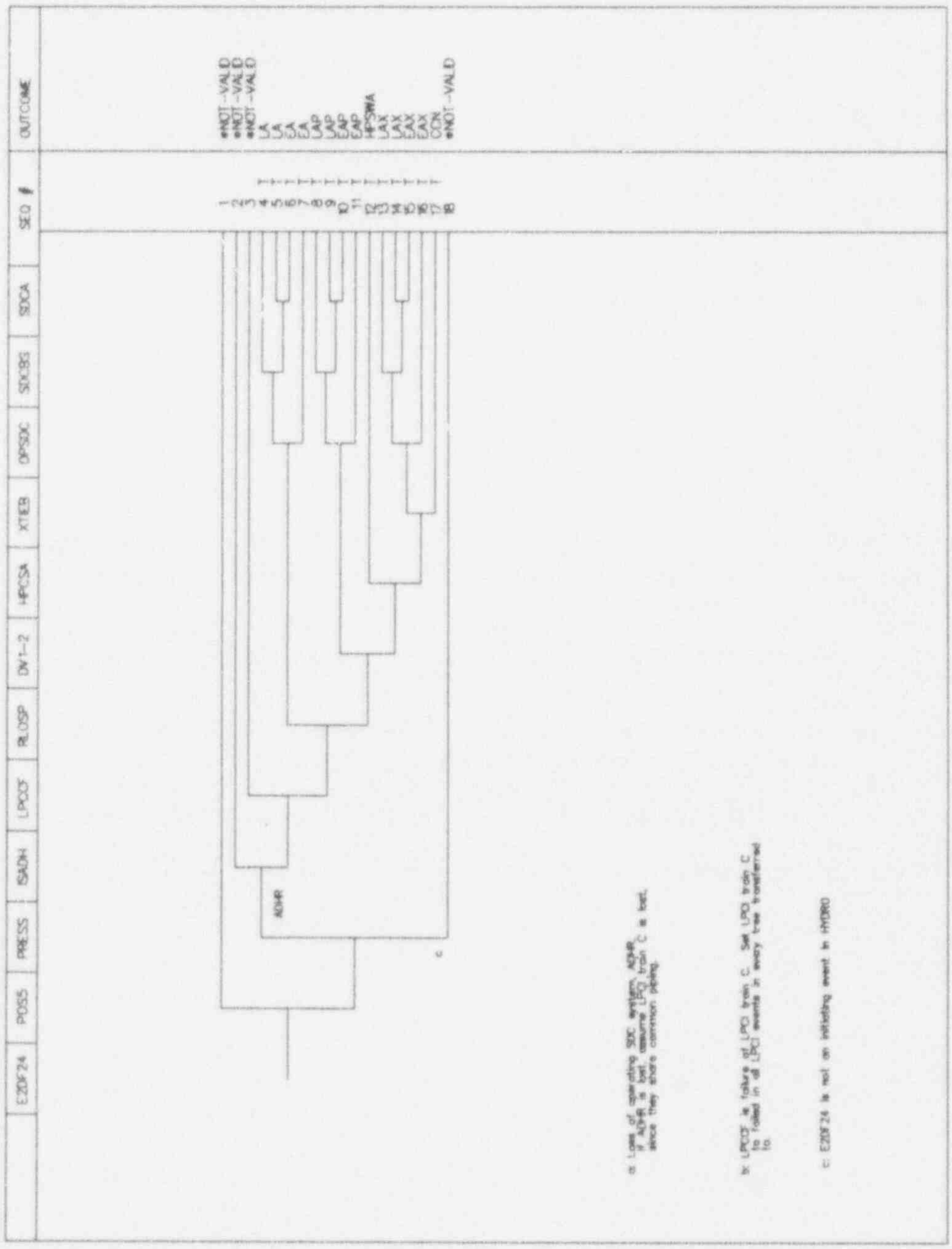

Figure H.1 E2DF24 Event Tree

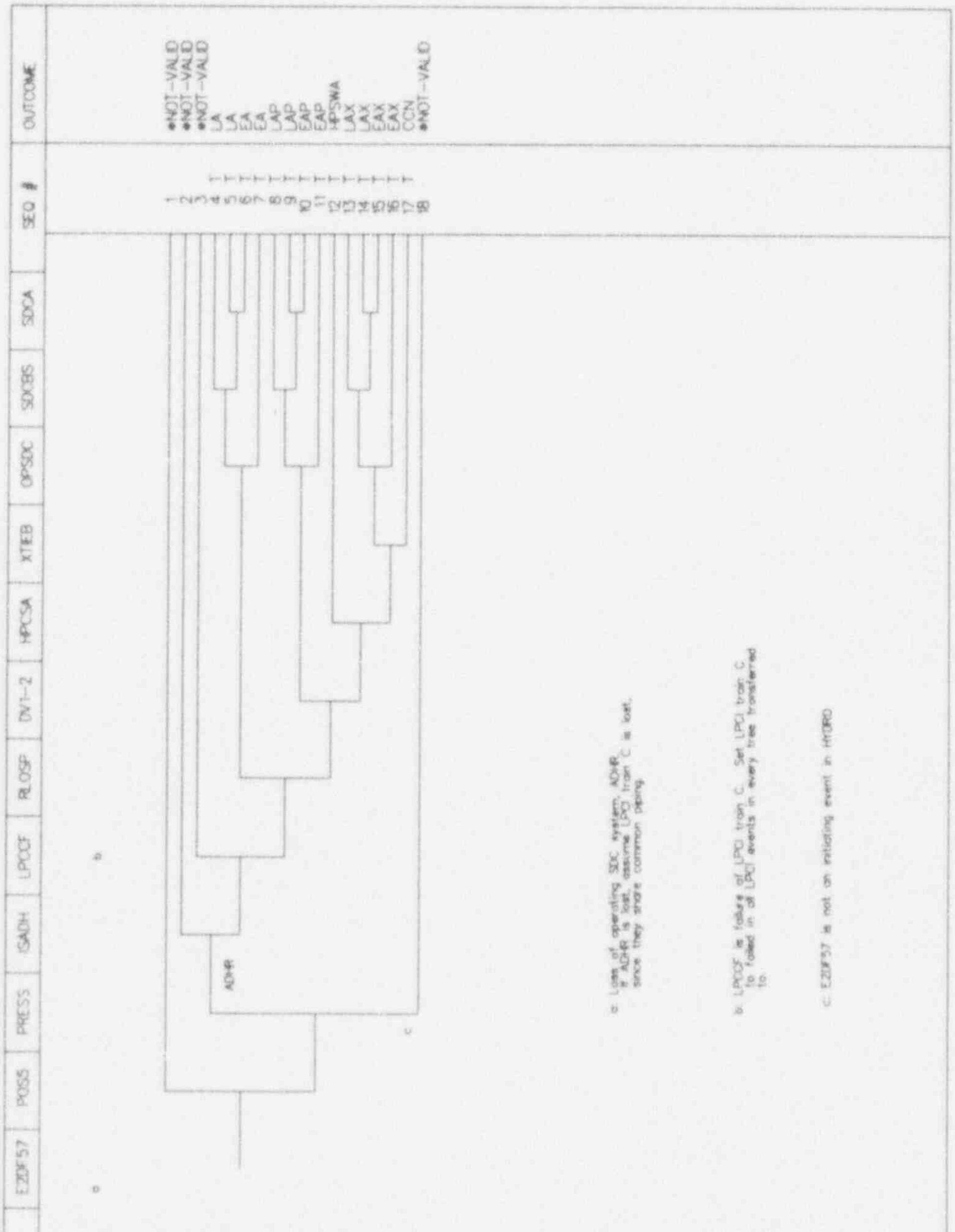

Figure H.2 E2DF57 Event Tree

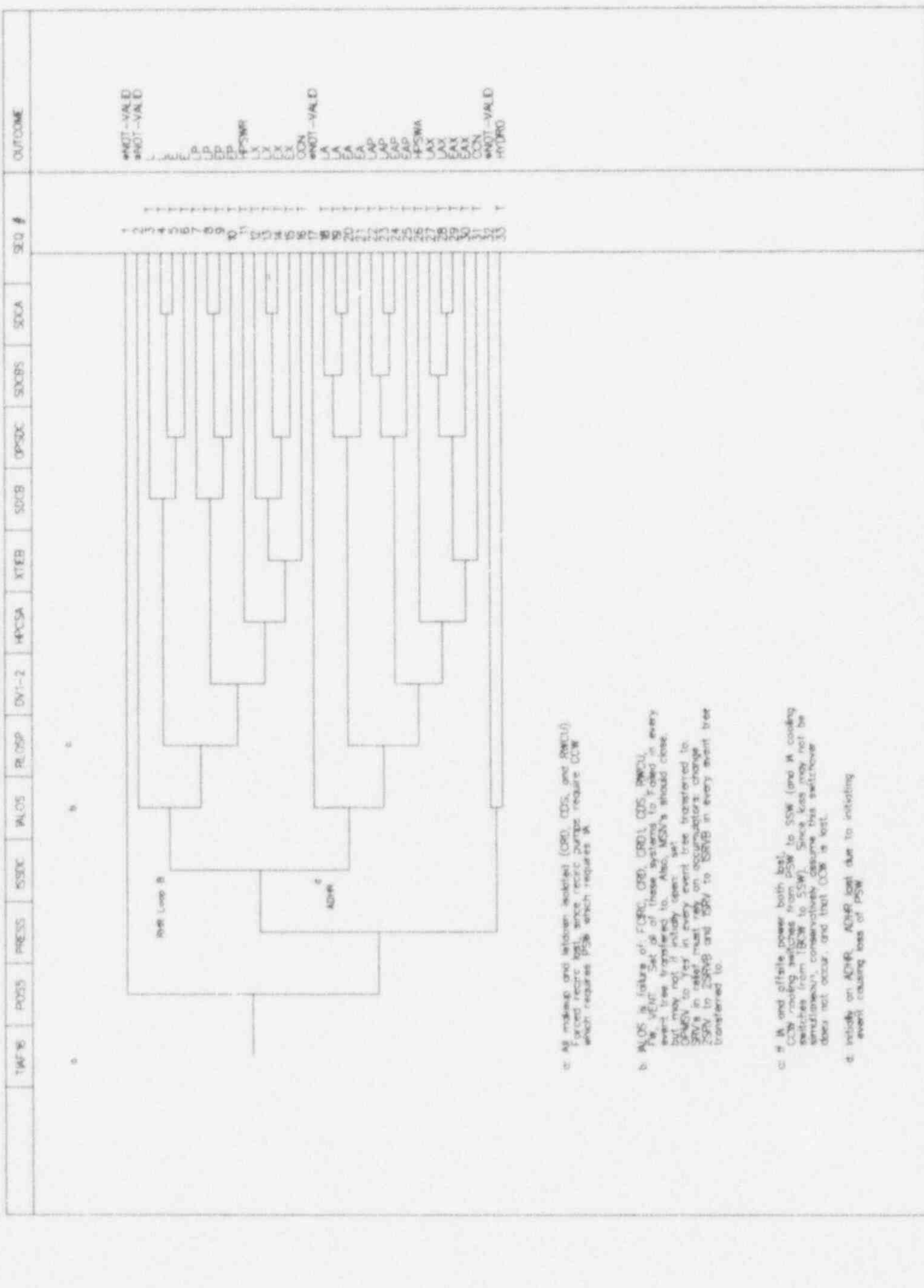

Figure H.3 TIAF16 Event Tree

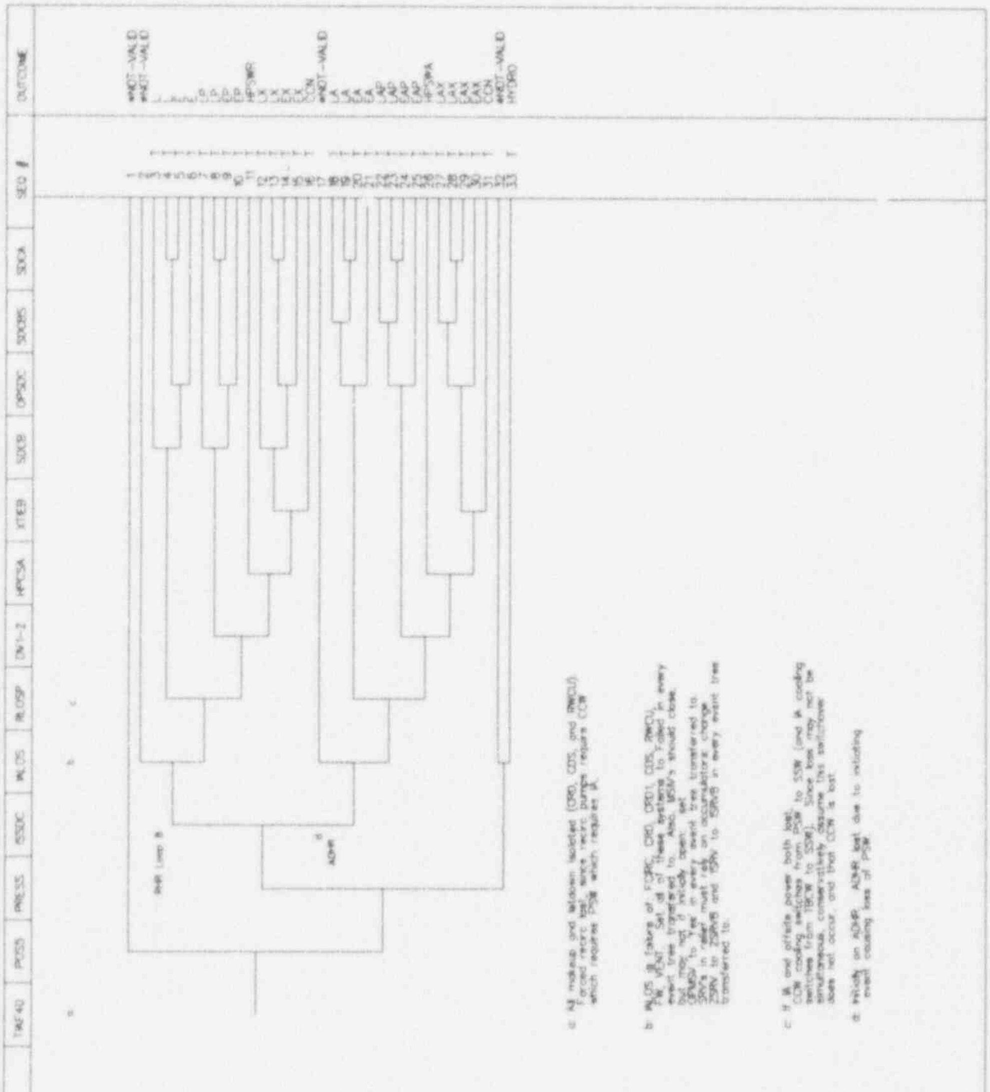

Figure H.4 TIAF40 Event Tree

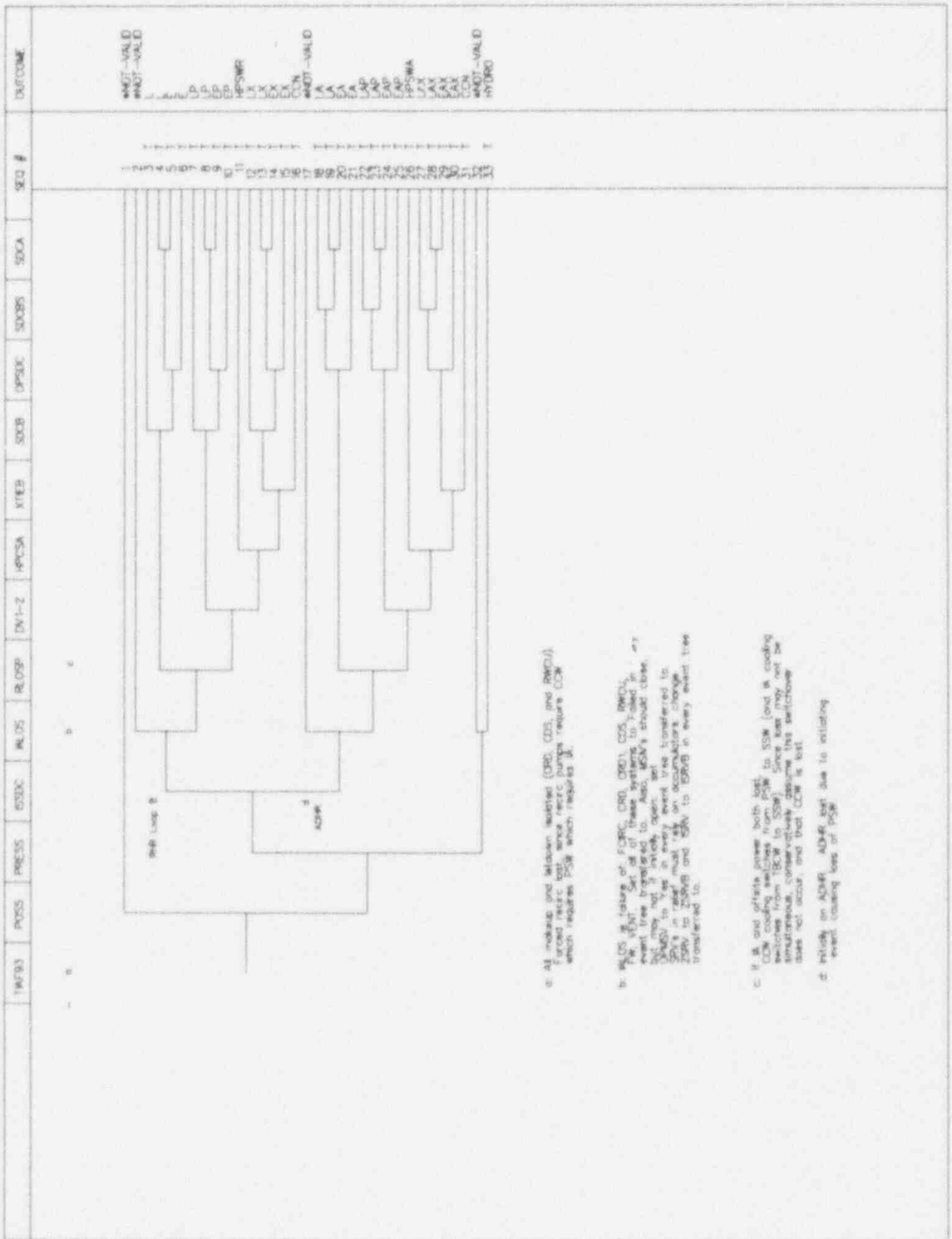

Figure H.5 TIAF93 Event Tree

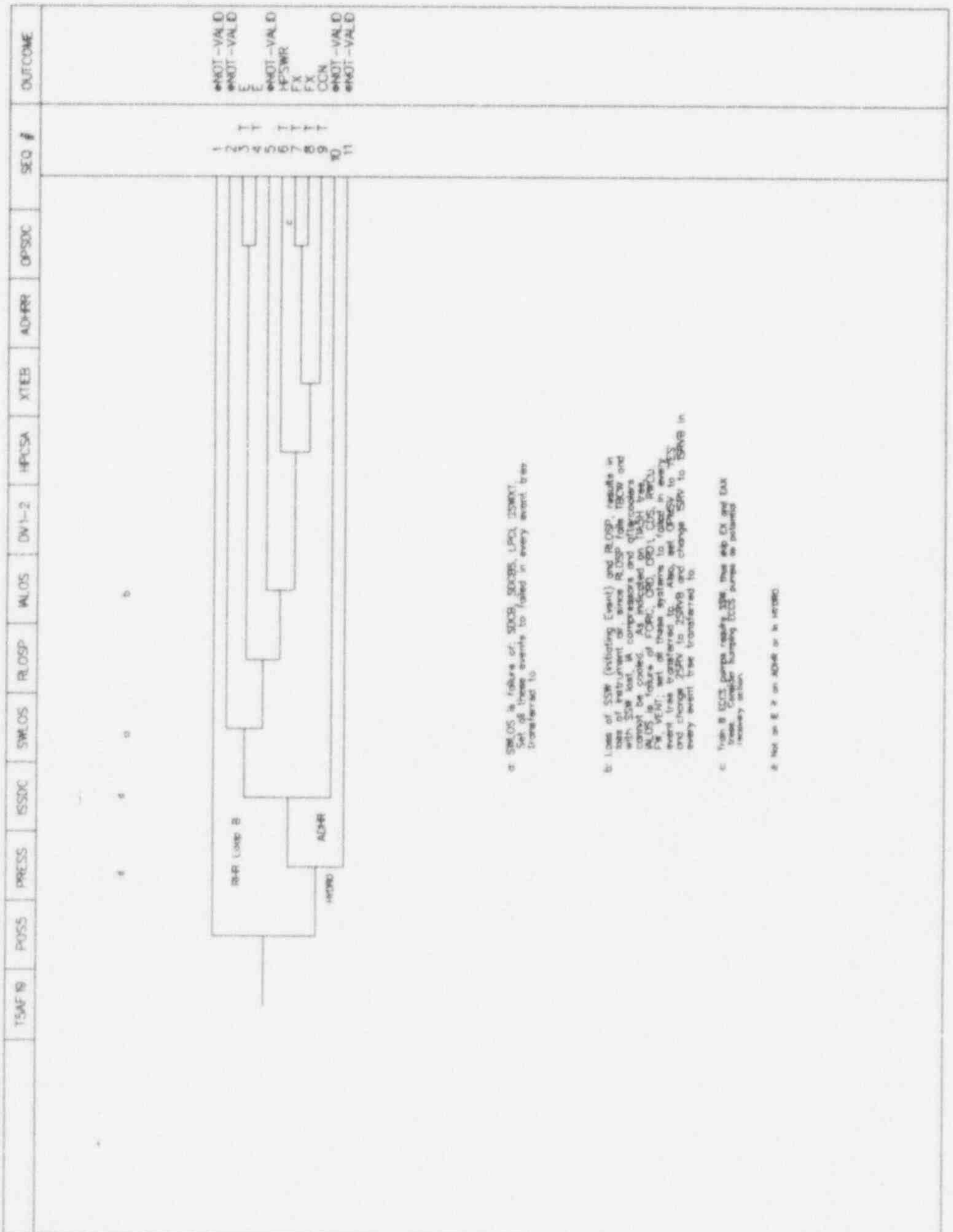

Figure H.6 T5AF19 Event Tree

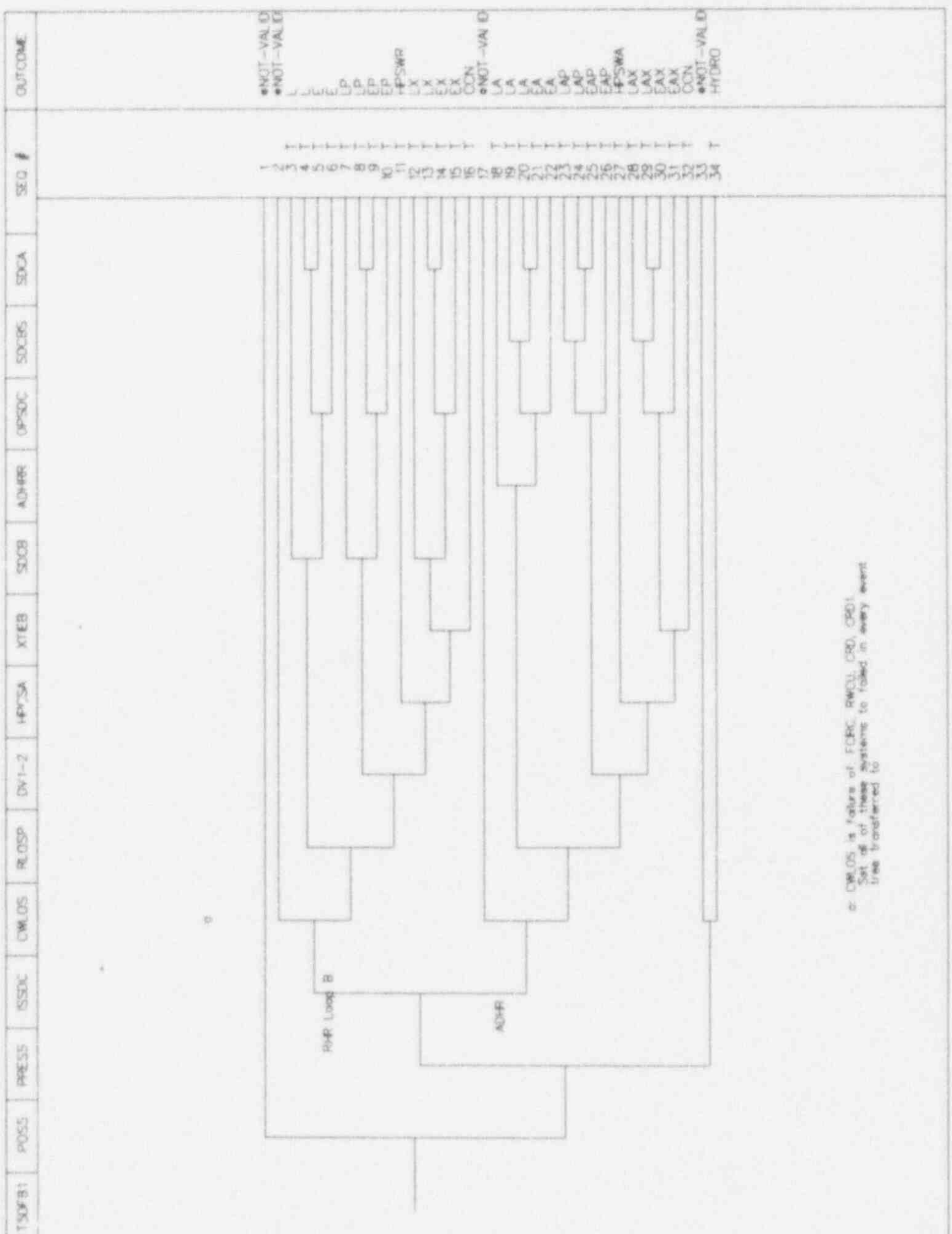

Figure H.7 T5DF81 Event Tree

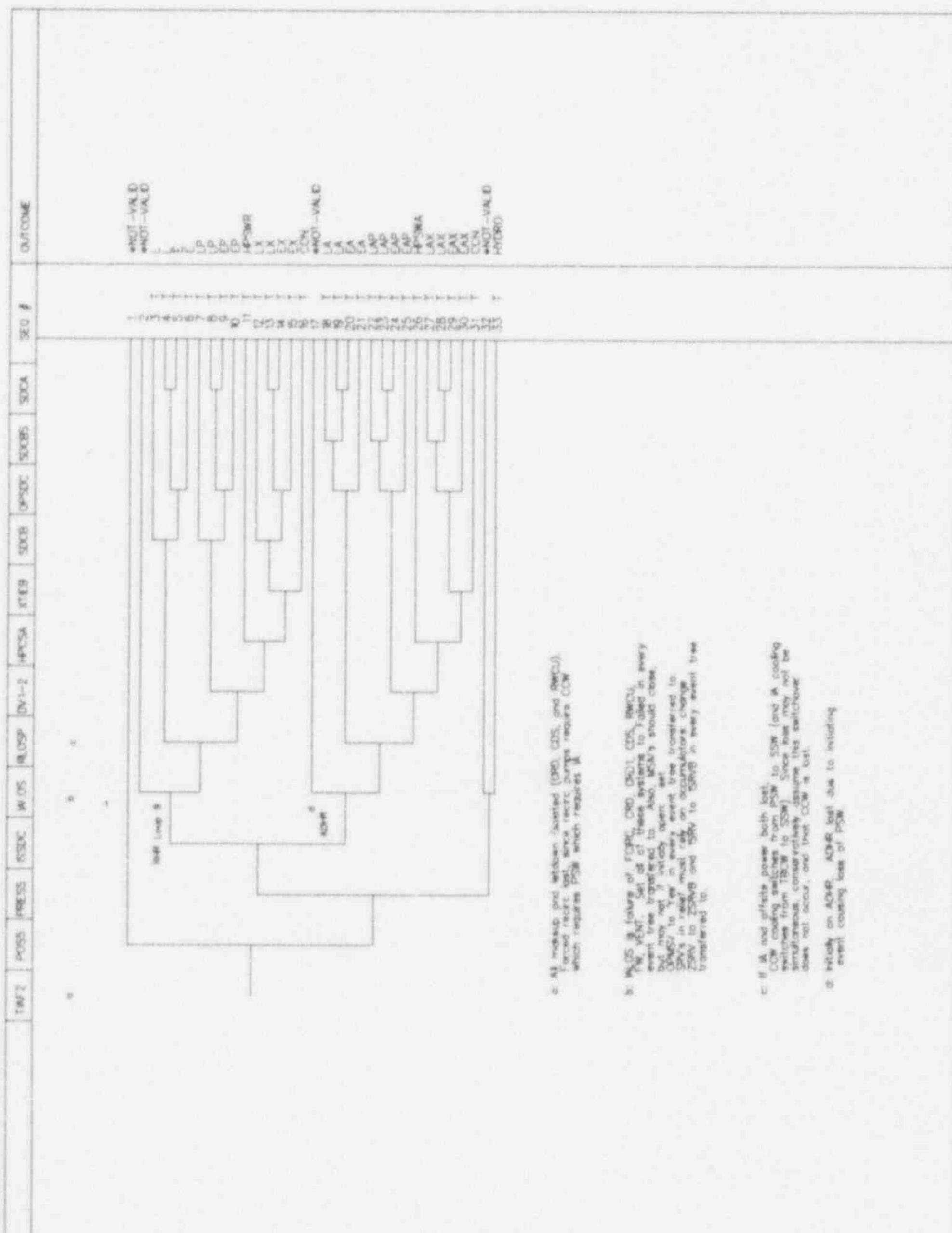

Figure H.8 TIAF22 Event Tree

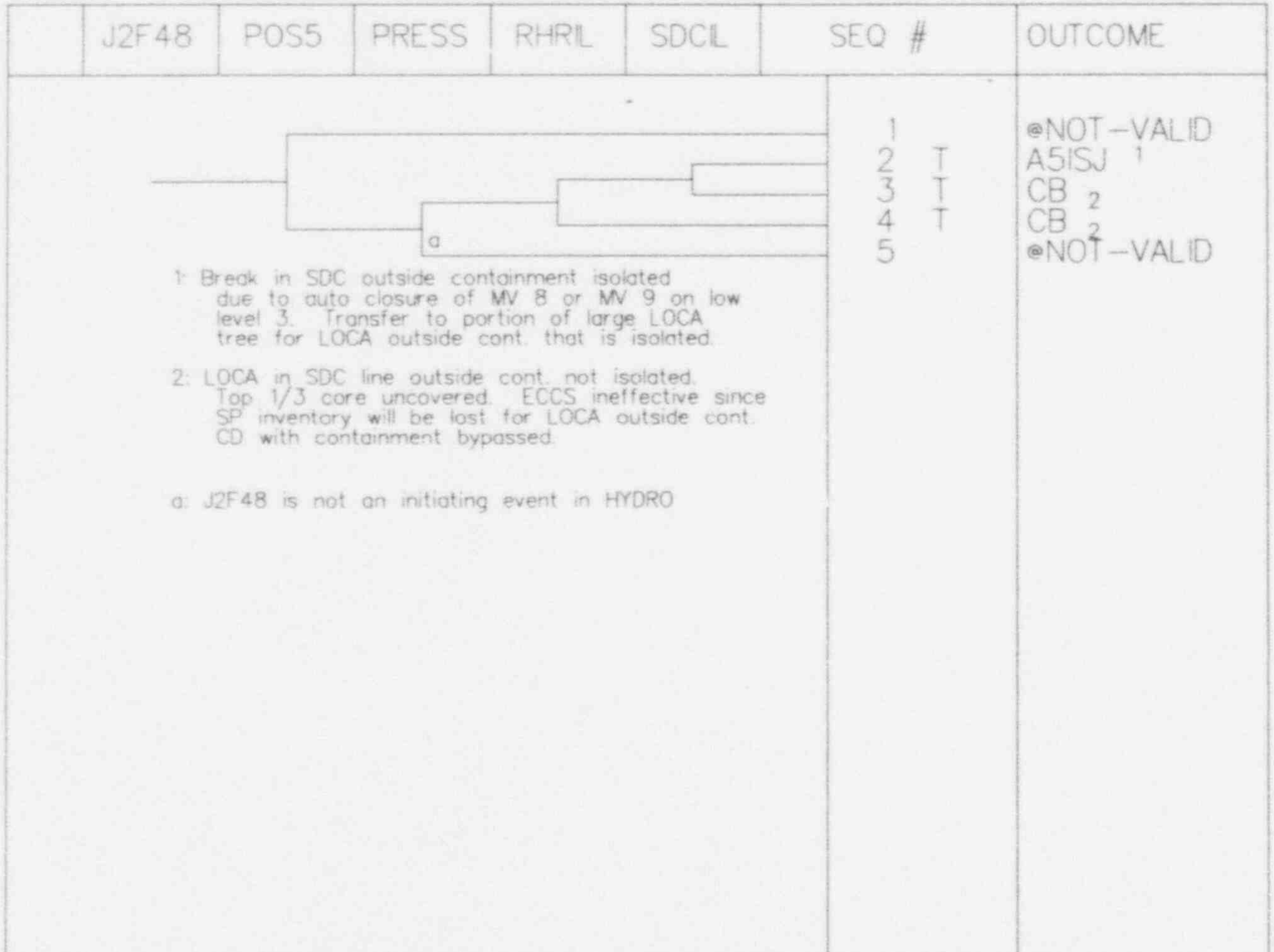

Figure H.9 J2F48 Event Tree

Figure H.10 E2DF92 Event Tree

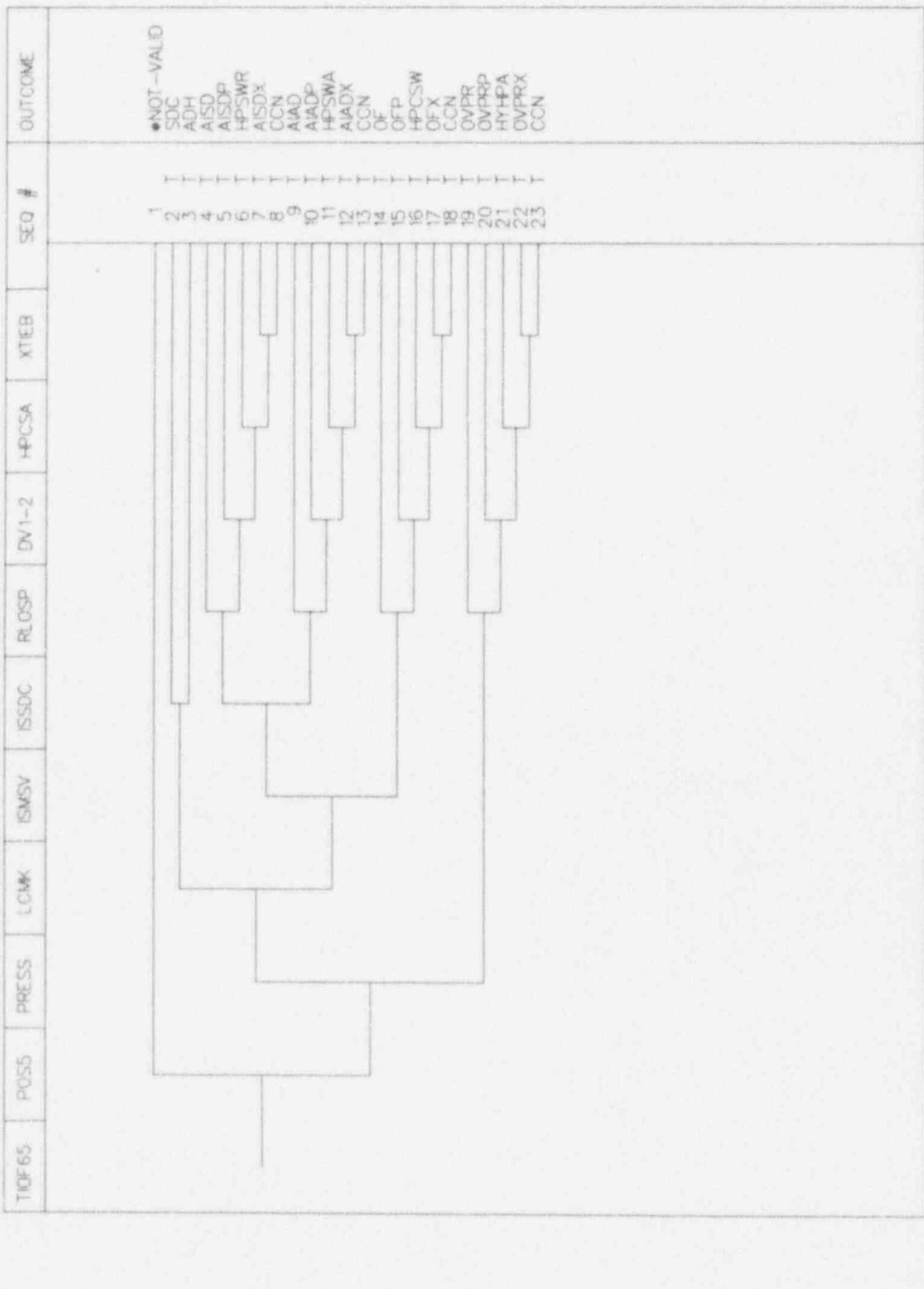

Figure H.11 TIOF65 Event Tree

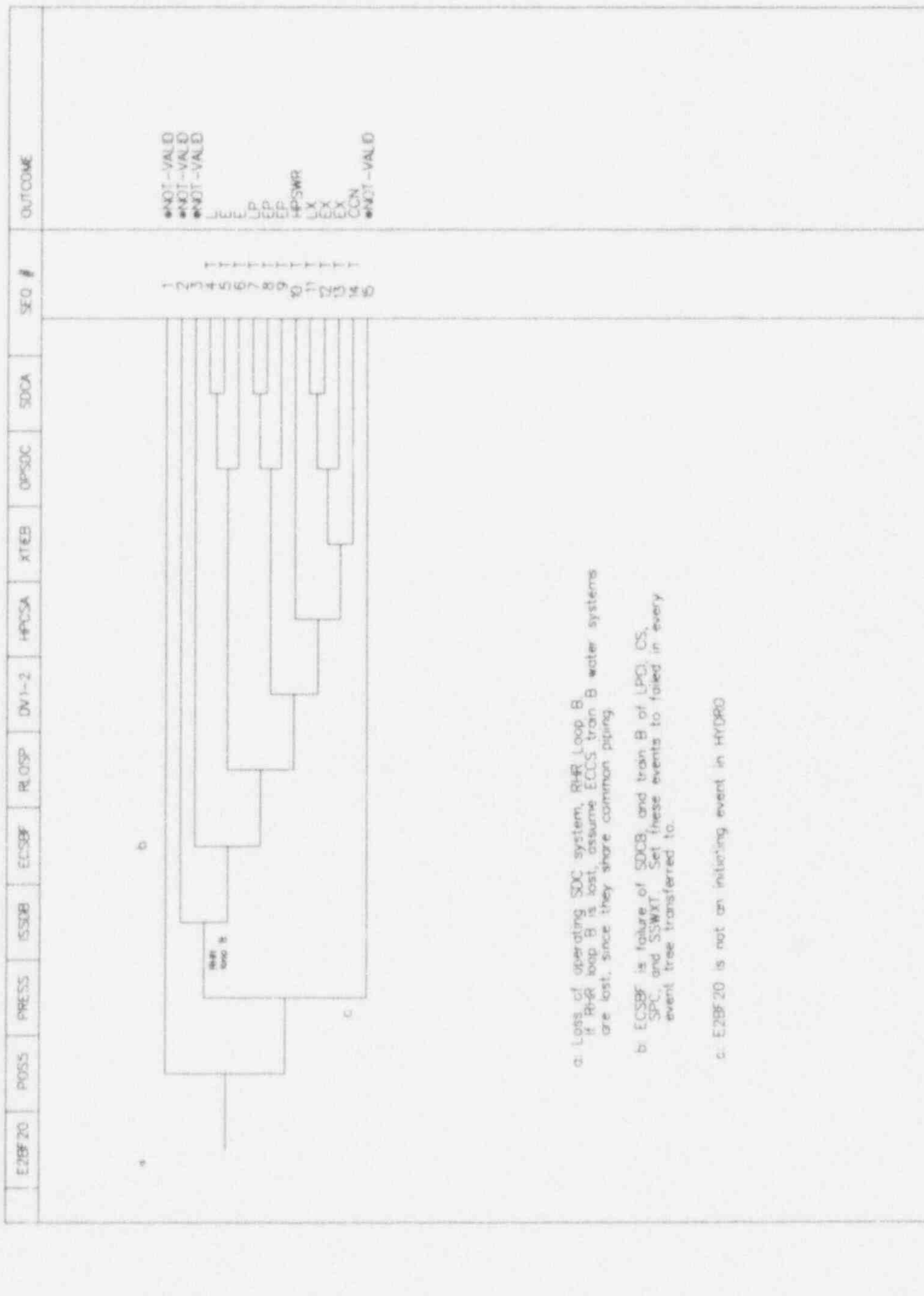

Figure H.12 E2BF20 Event Tree

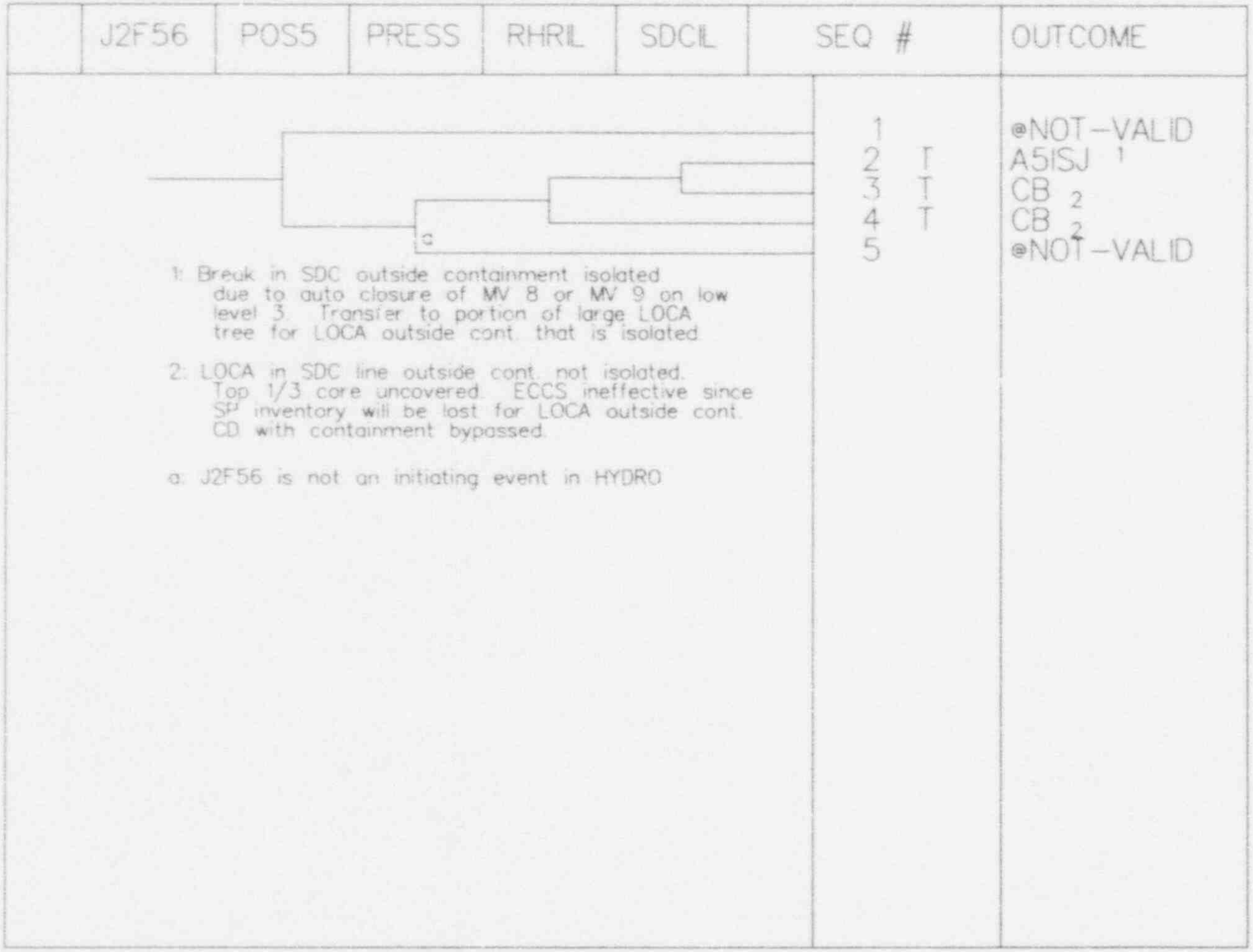

Figure H.13 J2F56 Event Tree

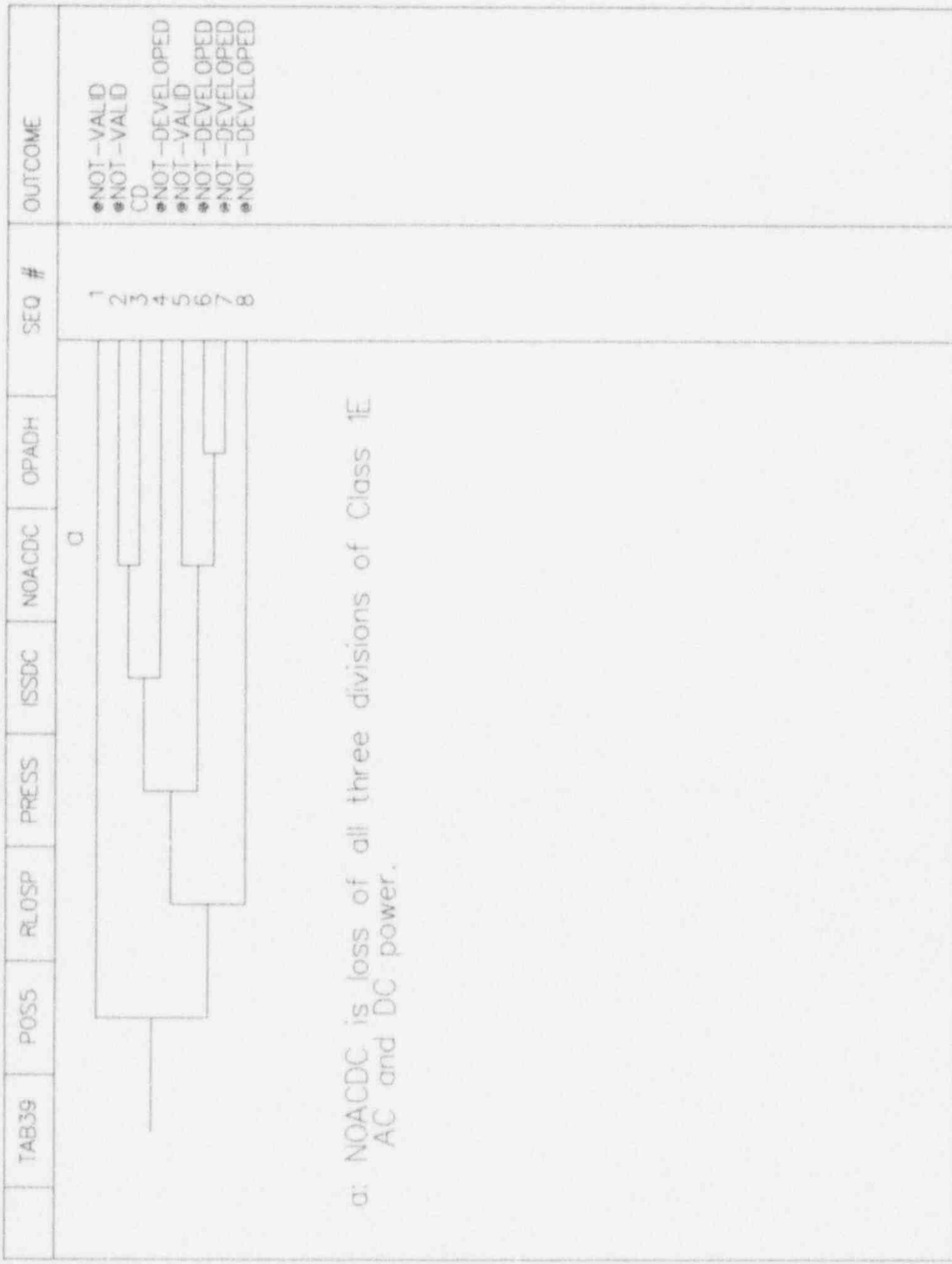

Figure H.14 TAB39 Event Tree

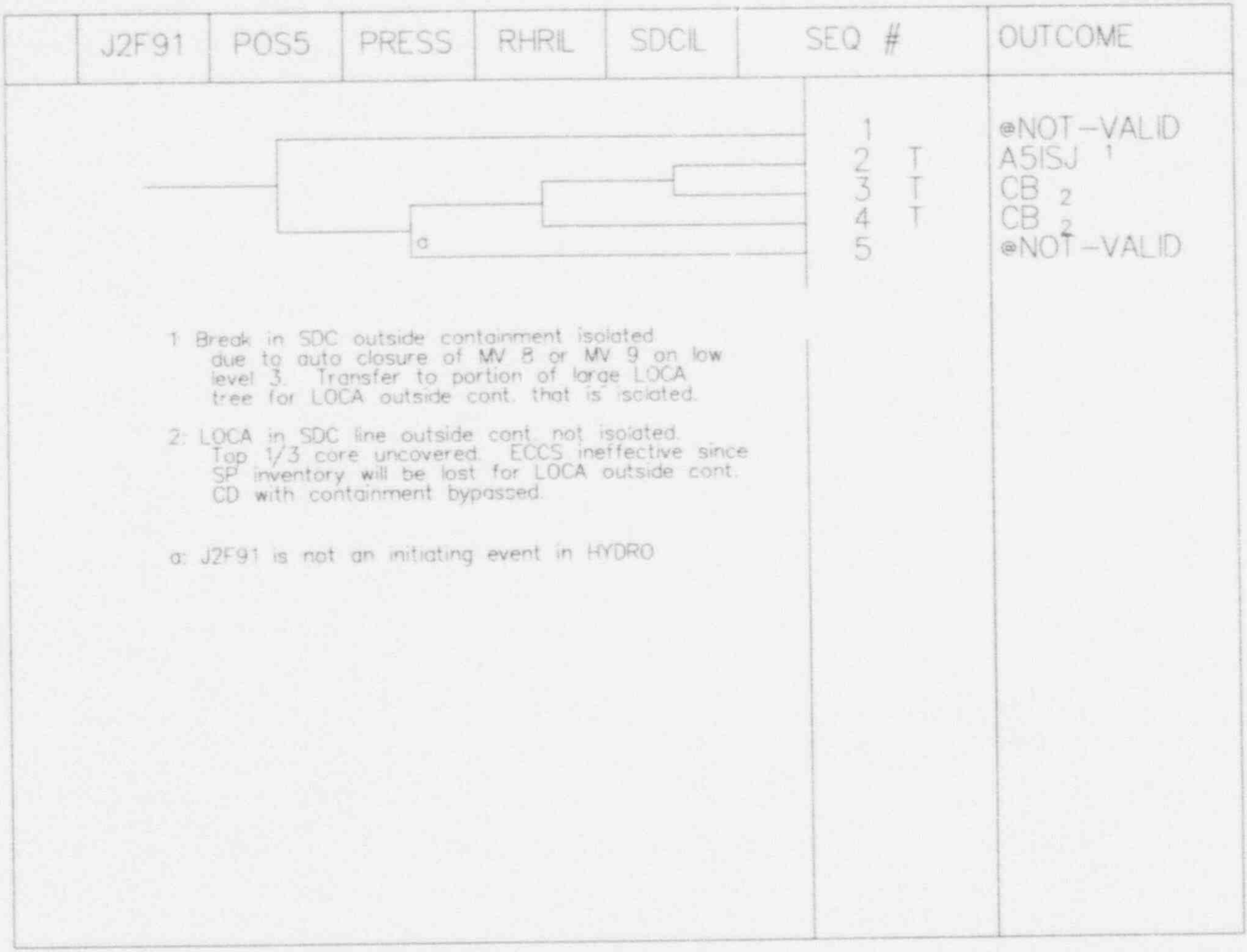

Figure H.15 J2F91 Event Tree

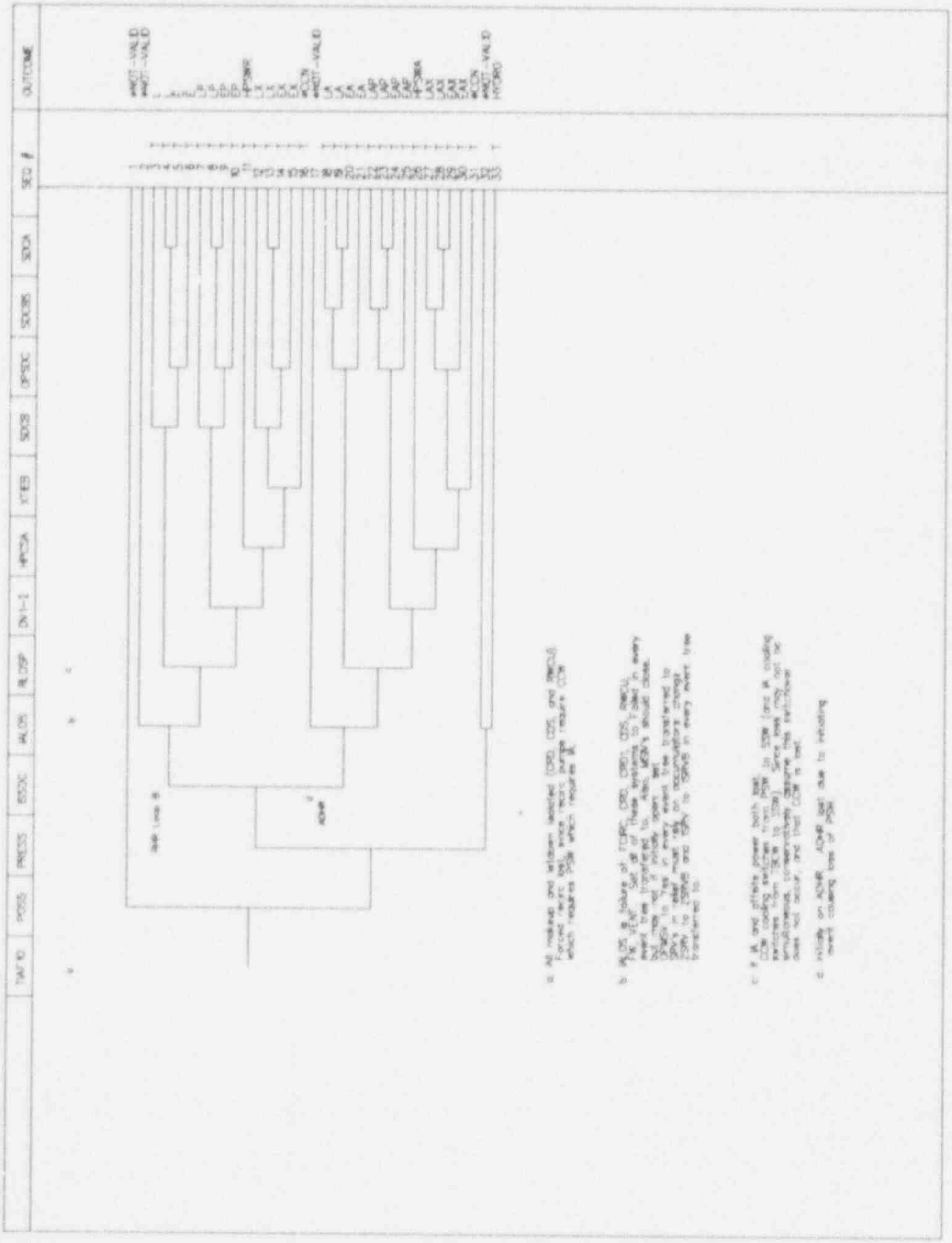

Figure H.16 TIAF10 Event Tree

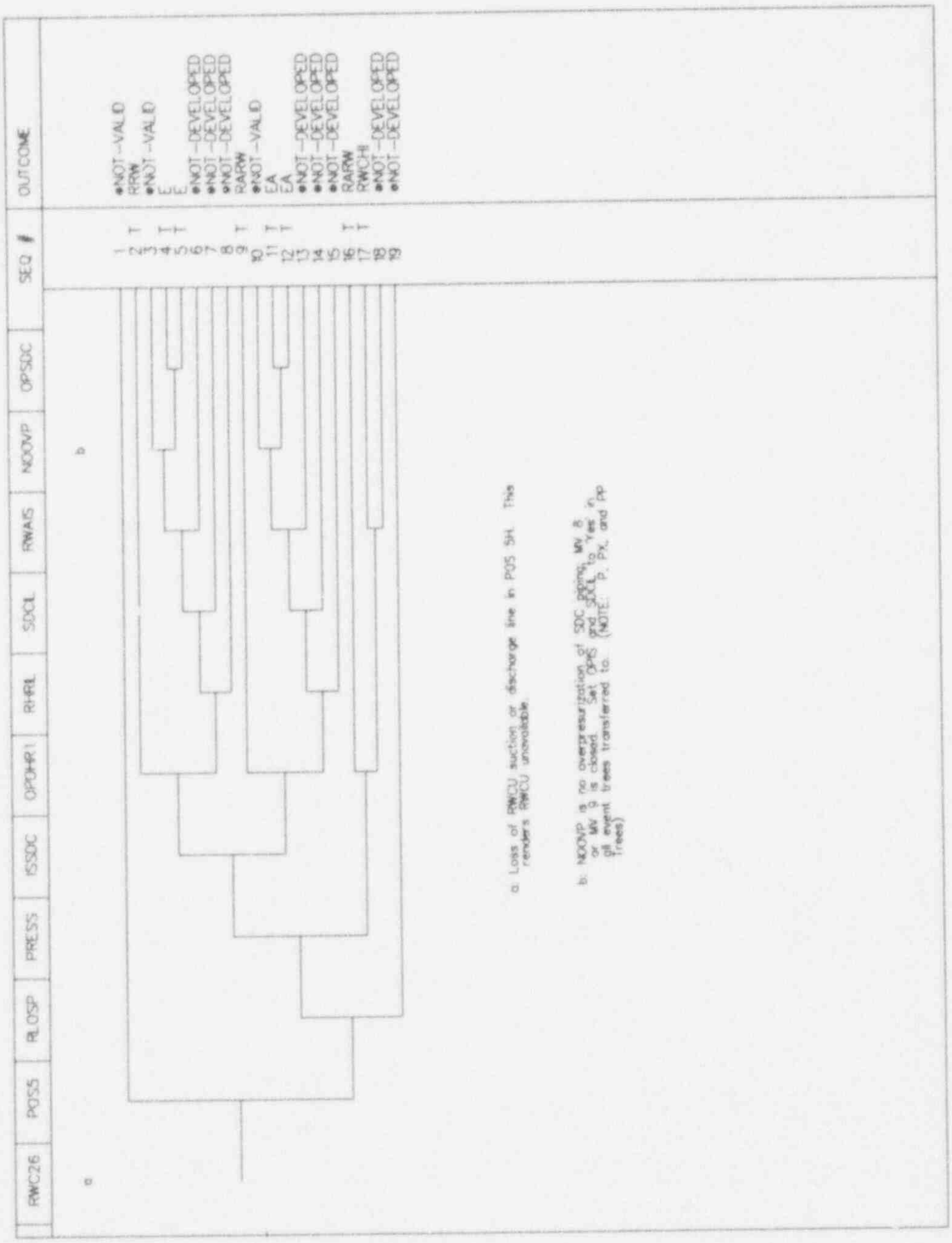

Figure H.17 RWC26 Event Tree

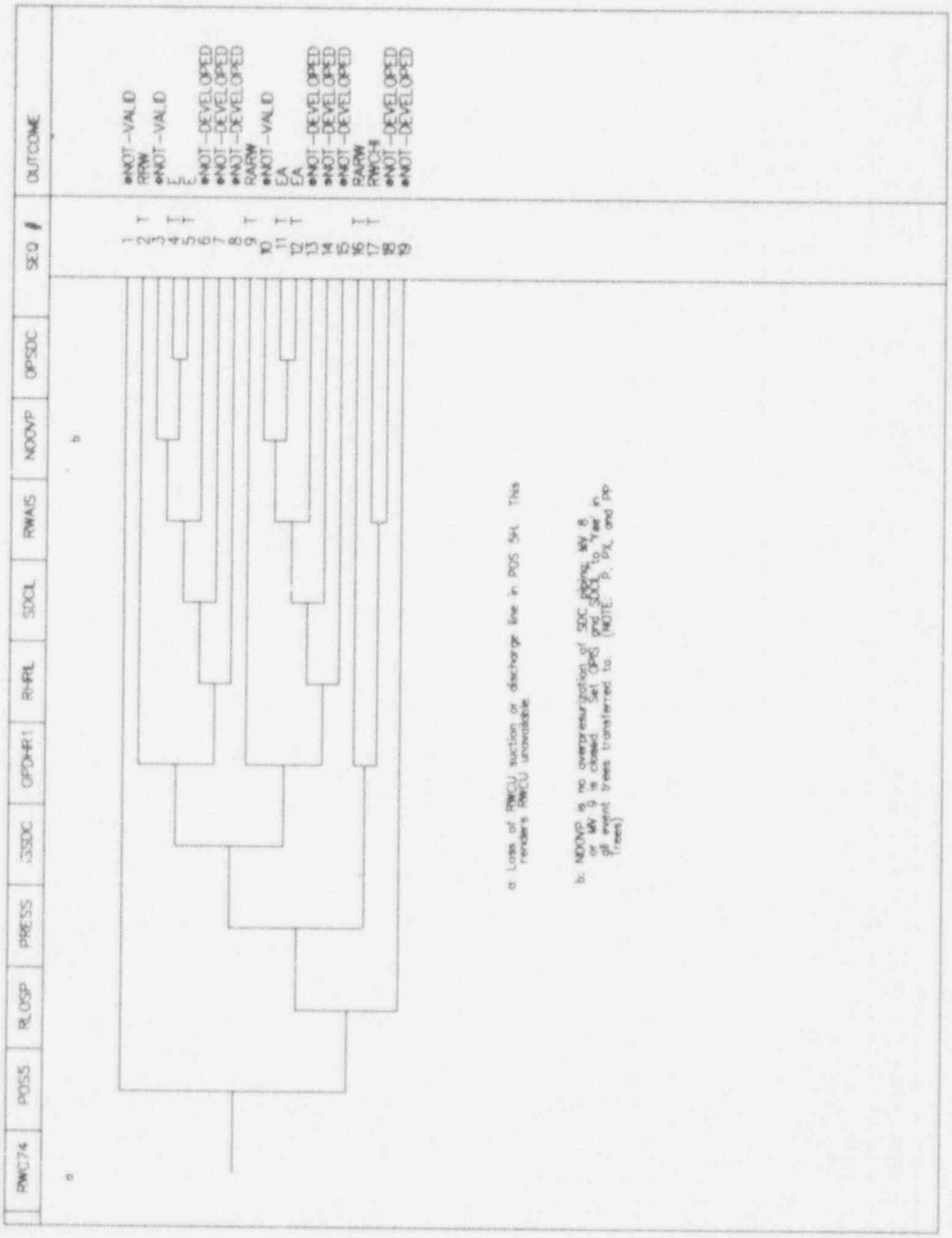

Figure H.18 RWC74 Event Tree

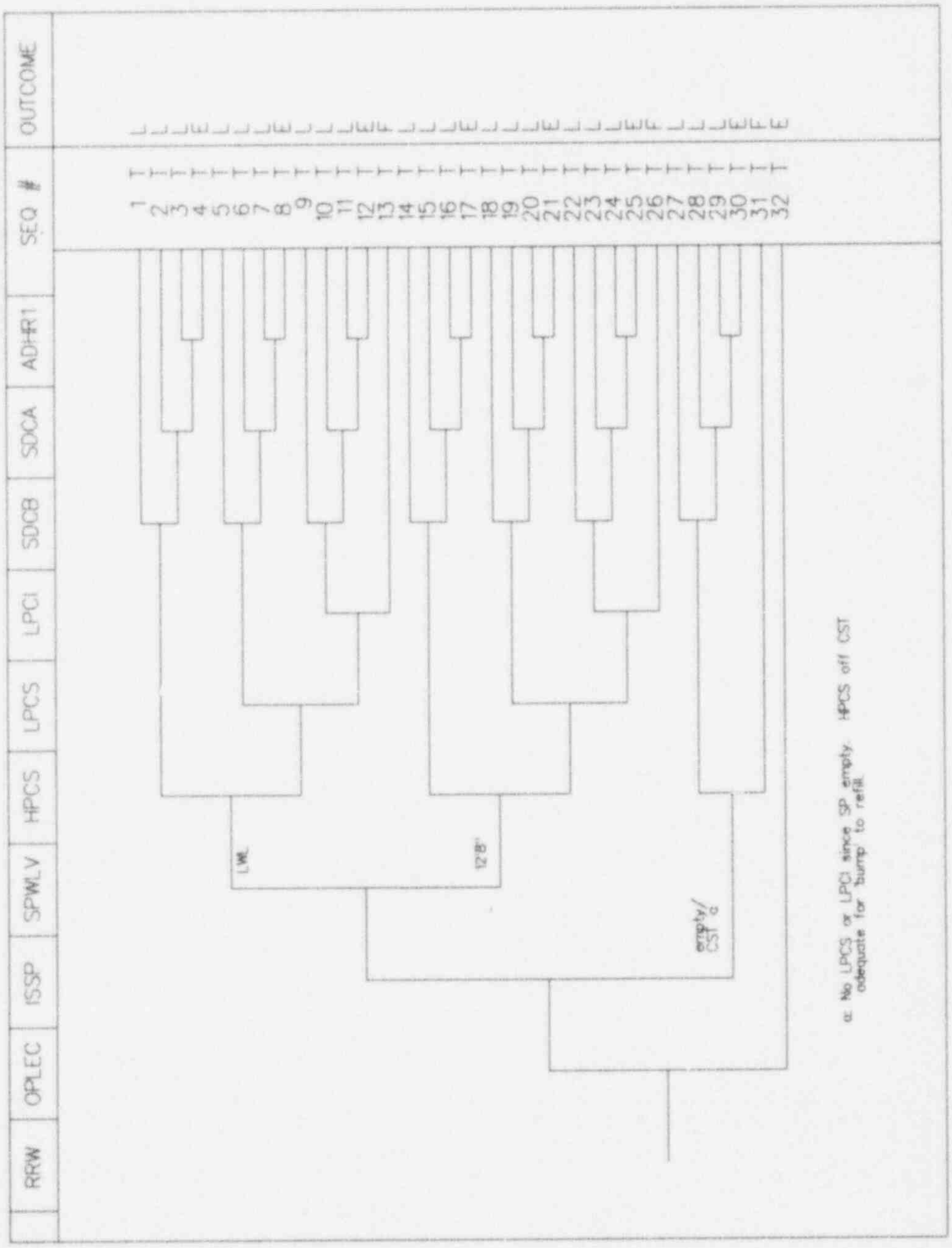

Figure H.19 RRW Event Tree

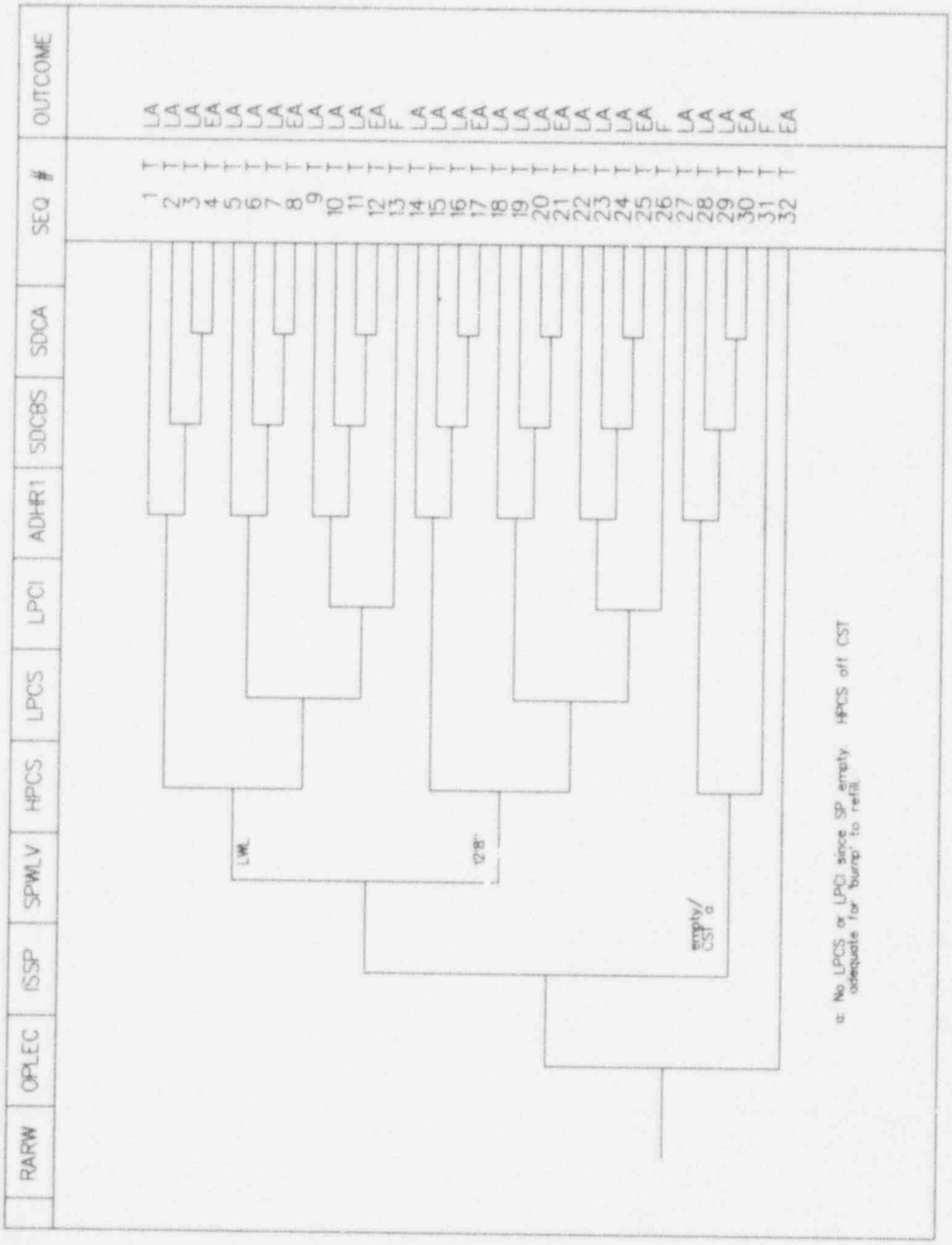

Figure H.20 RARW Event Tree

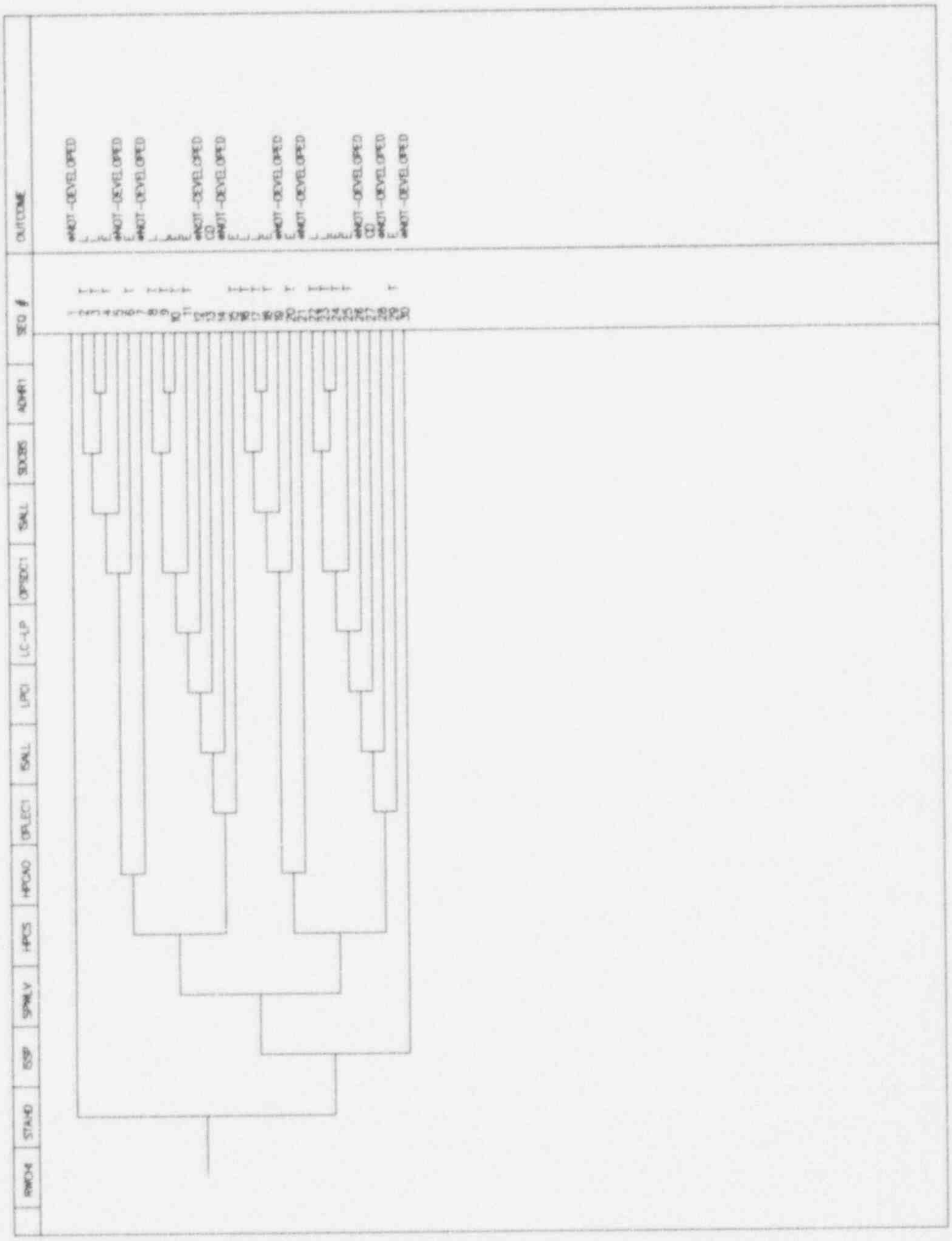

Figure H.21 RWCHI Event Tree

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NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)
NUREG/CR-6143
SAND93-2440
Vol. 4

2. TITLE AND SUBTITLE

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

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

3. DATE REPORT PUBLISHED

MONTH	YEAR
July	1994

4. FIN OR GRANT NUMBER
L1923

5. AUTHOR(S)

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6. TYPE OF REPORT
Technical

7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION – NAME AND ADDRESS (If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)

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9. SPONSORING ORGANIZATION – NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)

Division of Safety Issue Resolution
Office of Nuclear Regulatory Research
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10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

An estimate of the contribution of internal flooding to the mean core damage frequency at the Grand Gulf Nuclear Station was calculated for Plant Operational State 5 during a refueling outage. Pursuant to this objective, flood zones and sources were identified and flood volumes were calculated. Equipment necessary for the maintenance of plant safety was identified and its vulnerability to flooding was determined. Event trees and fault trees were modified or developed as required, and PRA quantification was performed using the IRRAS code. The mean core damage frequency estimate for GGNS during POS 5 was found to be 2.3 E-8 per year.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

PRA, Low Power, Shutdown

13. AVAILABILITY STATEMENT
Unlimited

14. SECURITY CLASSIFICATION
(This Page)
Unclassified
(This Report)
Unclassified

15. NUMBER OF PAGES

16. PRICE

NRC FORM 335 (2-89)

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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