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BYRON GENERATING STATION
LIMITING CONDITIONS FOR OPERATION
RELAXATION PROGRAM

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EXECUTIVE SUMMARY

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I. LIMITING CONDITION FOR OPERATION RELAXATION STUDY

Commonwealth Edison, Byron Station met with the NRC, Division of Licensing, Nuclear Reactor Regulation on May 18, 1983 to discuss equipment outage times in the Byron Station Technical Specifications. The present Proof and Review copy of the Technical Specification enables equipment to be in an inoperable status for 72 hours before the plant is taken to Hot Shutdown. Since that time, Commonwealth Edison and Westinghouse have conducted a Probabilistic Risk Assessment (PRA) study which justifies extending the allowed outage period from 72 hours to 7 days. This increase from 72 hours to 7 days is demonstrated to result in no significant increase in plant risk.

An outage time of seven days is reflected in numerous Sections of the Technical Specification within the Action Statements for the Limiting Conditions for Operation. An example Action Statement is:

> "With one ECCS subsystem operable, restore the inoperable subsystem to OPERABLE status with 7 days or be in at least HOT STANDBY within the next 6 hours and in HOT SHUTDOWN within the following 6 hours."

The proposed seven day outage time applies to the following systems:

EMERGENCY CORE COOLING SYSTEM

- o CHARGING PUMPS
- o SAFETY INJECTION PUMPS
- o RESIDUAL HEAT REMOVAL PUMPS

CONTAINMENT SYSTEMS

- o CONTAINMENT SPRAY PUMPS
- o REACTOR CONTAINMENT FAN COOLERS

ELECTRICAL POWER SYSTEMS

- o DIESEL GENERATORS

PLANT SYSTEMS

- o COMPONENT COOLING WATER PUMPS
- o ESSENTIAL SERVICE WATER PUMPS
- o MOTOR DRIVEN AUXILIARY FEEDWATER PUMPS
- o DIESEL DRIVEN AUXILIARY FEEDWATER PUMPS

II. PURPOSE OF THE PROPOSED CHANGES

The primary purpose of the relaxation program is to allow for more thorough equipment maintenance. It is not expected that the accumulated system outage time will increase. A potential increase in out-of-service time for a particular outage caused by the performance of more effective repairs will be counter-balanced by a probable decrease in the frequency in the outage rate of a component. The modeling of the maintenance of equipment is described in Section III-B, below.

Benefits resulting from an increase in allowed outage time include: 1) A potential reduction in total system out-of-service time as described above; 2) A minimization of challenges to plant systems; and 3) A reduction in the number of emergency Technical Specification change requests. This program therefore offers an opportunity to more effectively manage plant maintenance and operation.

III. SCOPE AND METHODOLOGY

A. Scope

The scope of the present work is to perform a limited probabilistic safety study to show that an increase in the allowed maintenance outage time of fluid system components, the Limiting Conditions for Operation, results in no significant increase in plant risk. This effort was centered on the proper modeling of maintenance unavailability of components to assess the impact of maintenance on system unreliability. These resultant changes in system reliability were then carried through a risk model to evaluate the impact on core melt frequency and on several off-site consequences. Maintenance was modeled explicitly in the fault trees developed for each safeguards system. The unavailability due to test or maintenance for each component or train of components that would be unavailable for accident mitigation was placed in the fault tree as a mode of component or train failure, as appropriate. An example of this type of modeling is presented for the RHR system in Figure III-1.

Fault trees were developed for all safeguards systems of the Byron plant, utilizing the failure rate data base compiled for the Zion study. The use of the Zion data was justified due to design and operational similarities with the Byron facility. In addition, the plant event trees and models of the containment and the site were taken from the Zion report, and modified to reflect differences in the Byron design and site configuration. However, the important parameter for this study is the relative change caused by increases in allowed maintenance times, which is not highly dependent on the absolute value of the risk indices. The flow of the work throughout this effort and a guide to the report is presented in Section III-C, below.

III-B. Analysis of Maintenance Unavailability

Several assumptions were made regarding the analysis of maintenance unavailability of components: a) since there is no present data accumulated on the operation of the Byron Station; and b) to maintain consistency in the application of the model. The first assumption was that the maintenance frequency of given components was the same as similar components in the Zion Station, and that this frequency is constant, independent of relatively small variations in the mean time to restore the equipment to service. Intuitively, frequency would vary indirectly with average repair time. Frequency of maintenance could not be derived as a function of repair duration due to a lack of data and inconsistency in plant management schema. Therefore, the use of a constant frequency and increasing Mean Time To Repair (MTTR) is conservatively bounding the component unavailabilities modeled. The maintenance frequencies for different plant components are presented in Table III-1. The second assumption is that the times to restore components will follow a log-normal distribution, as assumed for a prior distribution in the Zion study. This results in the use of the mean times to restore components in maintenance as derived on Tables III-2 (3 day LCO) and III-3 (7 day LCO). These values are kept constant between systems, since this is the most direct and comprehensible means available for measuring the increase in Mean Time To Repair (MTTR) as a function of LCO. Any deviation that may exist between different systems can only be addressed as plant operating experience is gained, where the average time of maintenance for a specific component may be compared to that analyzed. It follows that the unavailability of a component

or train is the maintenance frequency (hr^{-1}) multiplied by the mean time to repair (hr). While these mean restoration times and frequencies of maintenance are just estimates, the model exists in a form that allows updating of the results as plant data is accumulated.

III-C. Methodology and Guide to the Study

The probabilistic risk assessment technique utilized in this study has three areas of primary emphasis: the plant; it's containment; and it's site. The study basically involves quantification in terms of frequency of occurrence of sequences of events that can impact public health. Thus, the PRA task is one of developing a complete set of scenarios for each of the three major study components, appropriately matching the sequences and finally assembling the outputs from the various components into a statement of risk. The result is a set of risk curves for each health effect. The risk curves are decomposed to reveal such details as individual systems, initiating events, key phenomena, and functions contributing to risk. In this study, the analysis of key plant systems was performed to assess the impact on system reliability of possible increases in component unavailability due to maintenance.

The flow of the study is depicted in Figure III-2, showing the separate tasks and production of results. The different steps followed are described below:

Initiating Event Analysis

The initial task in the plant analysis is the determination of a complete set of initiating events. These events are those that have the potential of triggering a sequence of following events that could lead to abnormal plant behavior. These initiators can be derived from operating experience, such as the losses of main feedwater and reactor trips, or from deductive engineering analysis, such as large LOCA and steamline breaks, or by a combination of these methods. The initiating events and their associated yearly frequency of occurrence for this study, presented in Section 1 of the main report, were taken from Zion Probabilistic Safety Study and modified to reflect Byron plant design differences. Figure III-3 is a diagramatic representation of the

initiating event set for the Byron study, showing the relationships between different type transient events and design basis events. The result of this analysis is the ø (phi) matrix, which is each analyzed initiating event's yearly frequency.

Plant Event Tree Analysis

The initiating events or initiating event categories provide the basis for constructing event trees, or sequences of events or system failures leading to different plant states. The course of the sequences depend on the availability and performance of plant systems, both safety and non-safety grade. The end point of a given sequence is the representation of the status of the plant, or the core, given the chain of failures and successes leading to it. Thus, successful mitigation of the initiating event results in success, i.e., no core melt. Depending on what systems fail and when, and on the event path, other categories of sequence endpoints are identified. These are identified by: (1) LOCA (L), transient (T), or small LOCA (S) initiator or sequence behavior; 2) early (E) or LATE (L) melting of the core; 3) containment spray or not (S); and 4) containment fan coolers or not (C). The systems reliabilities are calculated utilizing fault tree analysis as described below. These system probabilities are used in the event trees, enabling the quantification of the specific event sequences. The individual sequences are grouped into plant states and serve as the entry points for the containment analysis.

The event tree analysis for this study was largely derived from the Zion report, with slight modifications made to maintain consistency in our methodology. The Steam Generator Tube Rupture tree was also redone as part of the Byron Risk Study, reflecting more detail in the mitigation and phenomenology of the event. This analysis is presented in Section 2 of the main report.

Fault Tree Analysis

The plant analysis is dependent on a data base, or accumulation and assimilation of operating experience with in-plant equipment. The data base

developed for the Zion study, which was derived from such sources as plant specific failure rate data, WASH-1400, and IEEE-STD-500, is used in this study. The data base is presented in Appendix 3D. The data base provides a baseline to which the system's fault trees are developed, in effect limiting the component failure analysis within a system to those components for which failure data is maintained. The fault trees are developed for all modes of system operation given different requirements on the system placed by different events. For example, two of four high head safety injection pumps are required for medium LOCA mitigation while only one is required for small break events. These models describe the ways a given system can fail to accomplish its mission when demanded because of hardware failures, test, maintenance, human errors, and common cause failures. The fault tree analysis for all systems is presented in Section 3 of the main report.

Part of the plant analysis was the development of the support state model, which bounds the quantification of the event trees. Six states were identified in this study: 1) both AC busses energized with Essential Service Water (ESW) available; 2) both busses energized with no ESW available; 3) bus 142 energized with ESW; 4) bus 141 energized with ESW; 5) neither AC bus energized and ESW available (when Unit 2 is available, only); and 6) neither AC bus energized and no ESW available. These support states are described in Appendix 2C and quantified in Sections 4.1.2 (3 day LCO) and 4.2.2 (7 day LCO).

The Byron Station was also analyzed for single unit operation, which will occur in the interim period while Unit 2 construction is completed. The only difference in analysis is the quantification of the reliability of the shared systems, i.e., Essential Service Water and Component Cooling Water. These in turn affect the quantification of the support state split fractions and the reliability of the low pressure recirculation and high pressure recirculation functions, due to the need for pump and heat exchanger cooling. Refer to Section 6 of the main report.

Quantification of the plant systems analysis is summarized in terms of the plant matrix whose elements represent the conditional probabilities of core melt, given the occurrence of an initiating event, 23 core melt states are defined and their frequencies per reactor year of operation are calculated.

Containment Analysis

The containment analysis models accident progression phenomena and the physical processes involved in core melt and containment attack and breach. The analysis reaches deep into the plant activities, particularly with respect to core behavior and the role of the containment engineered safeguards systems following an accident. Many studies, experiments, and analyses have been done to provide a stronger technical basis for quantifying containment response. Central to the analysis is the development of a detailed containment event tree which permits tracking of containment response to the progression of a degraded core accident. Supporting the event tree are numerous other analyses and studies of physical processes. For example, an analysis was made of degraded core phenomena including in-vessel effects, vessel failure, and ex-vessel effects. Extensive transient analysis was performed for a variety of core melt sequences. Supporting these analyses are experiments and studies on steam explosions and hydrogen generation and combustion. A containment capability assessment was made for determining the ultimate strength of the containment. Finally, source term categories were developed and quantified for input to the site analysis. The results of this analysis are in the form of the "C" matrix, presented in Appendix 4A of the report. 11 fission product release categories are defined and their frequency of occurrence is quantified by using the C-matrix.

Site Analysis

The objective of the site analysis is to estimate the potential for health effect impact in the surrounding population due to the releases assigned to the containment release categories. To determine the health effects from a release, it is necessary to define the distribution of airborne and deposited radioactive material in the environment as a function of time. There are many factors that determine the nature and extent of the health effects. The most important are related to the weather conditions that exist during the release. The approach is to study a large number of individual weather scenarios. Any plume that is projected to leave the site area is assumed to

be influenced according to weather data taken from the nearest measurement station (i.e., data was taken from multiple sites for hourly scenarios). The models employed permit the plume to vary in direction according to the weather. Another important factor is the population distribution and evacuation conditions. A variable direction evacuation scheme was employed to depict actual emergency planning. These analyses were accomplished with the CRACIT code, a variant of CRAC, which was developed for the Reactor Safety Study. The output of this analysis is the "S" matrices which are the conditional probabilities of certain levels of damage given a type of release. The site specific consequence analysis is given by Appendix 48 of the report.

Assembly of Results

A matrix approach is used to summarize and quantify the results of the plant, containment and consequence analyses. This approach is explained in Appendix 4C.

The results are presented in Sections 4.1.3 (3 day LCO, two unit operation), 4.2.3 (7 day LCO, two unit operation), 6.2.2 (3 day LCO, single unit operation), and 6.3.2 (7 day LCO, single unit operation). The results are attained by multiplication of the four matrices developed in each part of the study, as shown by Figure III-2.

TABLE III-1

SPECIALIZED COMPONENT MAINTENANCE FREQUENCY DATA

	Site-Specific Data		Specialized Frequency Distribution*	
Component	Events	Service Hours	Mean (Events/Hour)	Variance
Motor-Driven Auxiliary Feedwater Pumps	26	1.24×10^{5}	1.87×10^{-4}	1.24×10^{-9}
Turbine-Driven Auxiliary Feedwater Pumps	41	6.20×10^{4}	5.33×10^{-4}	1.54×10^{-8}
Centrifugal Charging Pumps	17	1.24×10^{5}	1.45×10^{-4}	1.07×10^{-9}
Component Cooling/Essential Service Water Pumps	46	1.90×10^{5}	2.36×10^{-4}	9.29×10^{-10}
Containment Spray Pumps	11	1.86×10^{5}	6.54×10^{-5}	2.44×10^{-10}
Residual Heat Removal Pumps	6	1.24×10^{5}	6.12×10^{-5}	2.87×10^{-10}
Safety Injection Pumps	1	1.24×10^{5}	4.04×10^{-5}	1.50×10^{-10}
Fan Cooler Units	14	3.10×10^{5}	5.85×10^{-5}	1.57×10^{-10}
Diesel Generators	137	1.62×10^{5}	8.09×10^{-4}	3.76×10^{-9}

*Distributions are lognormal.

PRIOR DISTRIBUTION FOR MEAN DURATION OF MAINTENANCE

Component Inoperability Limit: 72 hours
Parameters characterizing range of lognormal duration distributions:

5th Percentile (hours/event)	Probability	95th Percentile (hours/event)	Probability
1.0	.05		
2.0	.50	24	.05
3.0	.15	36	.05
4.0	.10	48	.15
5.0	.05	60	.50
6.0	.05	72	.15
7.0	.05	84	.05
8.0	.05	96	.05

Distribution: Lognormal
5th percentile: 2 hours/event
95th percentile: 60 hours/event
Mean: 18.7 hours/event
Variance: 668

Basis: Only the most routine maintenance can be performed with a component unavailability time (including removal and return to service operations) of less than two hours. The 72-hour time limit for operation dictates that major maintenance and repair activities be performed during cold shutdown periods. The majority of relatively routine maintenance and some extensive repairs will be completed within two and one-half days, given the high priority assigned to returning the equipment to service within the LCO limit.

Resulting Prior Distribution of Mean Duration of Maintenance:

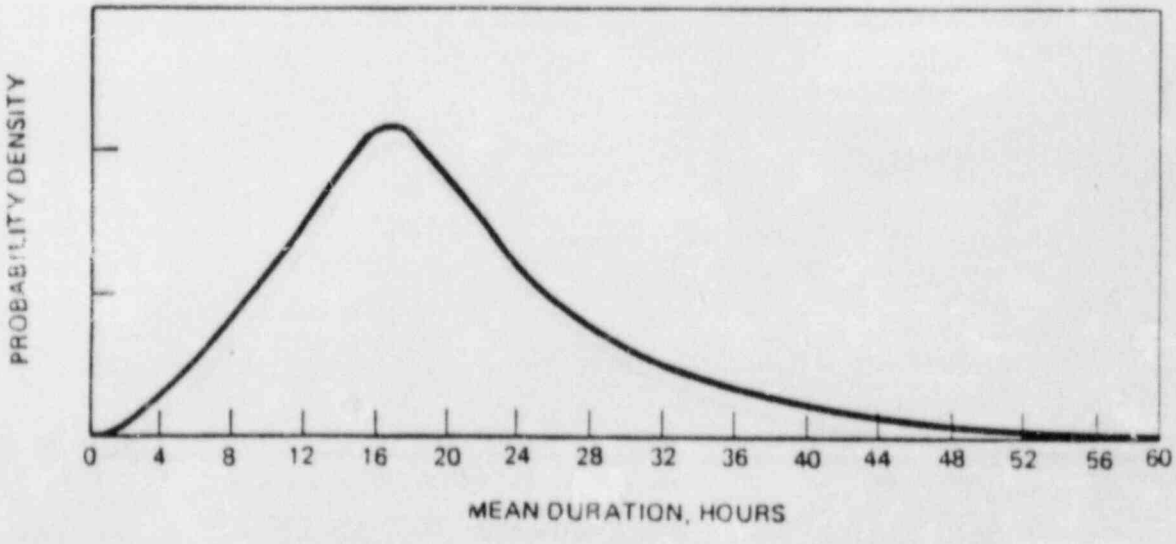


Table III-2

PRIOR DISTRIBUTION FOR MEAN DURATION OF MAINTENANCE

Component Inoperability Time Limit: 7 days
Parameters characterizing range of lognormal duration distributions:

5th Percentile (hours/event)	Probability	95th Percentile (hours/event)	Probability
1	.05	48	.05
2	.50	72	.10
4	.15	96	.10
8	.10	120	.50
12	.10	144	.15
16	.05	168	.05
24	.05	240	.05

Distribution: lognormal
5th percentile: 2 hours/event
95th percentile: 120 hours/event
Mean: 33.6 hours/event
Variance: 4180

Basis: Only the most routine maintenance can be performed with a component unavailability time (including removal and return to service operations) of less than two hours. The 7 day time limit for unit operation dictates that most maintenance will be prioritized to be completed within approximately 5 days to allow for possible unforeseen delays. Furthermore, since most scheduled major maintenance and equipment overhaul is performed during the Monday-Friday work week, the 5 day time limit applies to most of these planned activities as well.

Resulting Prior Distribution of Mean Duration of Maintenance:

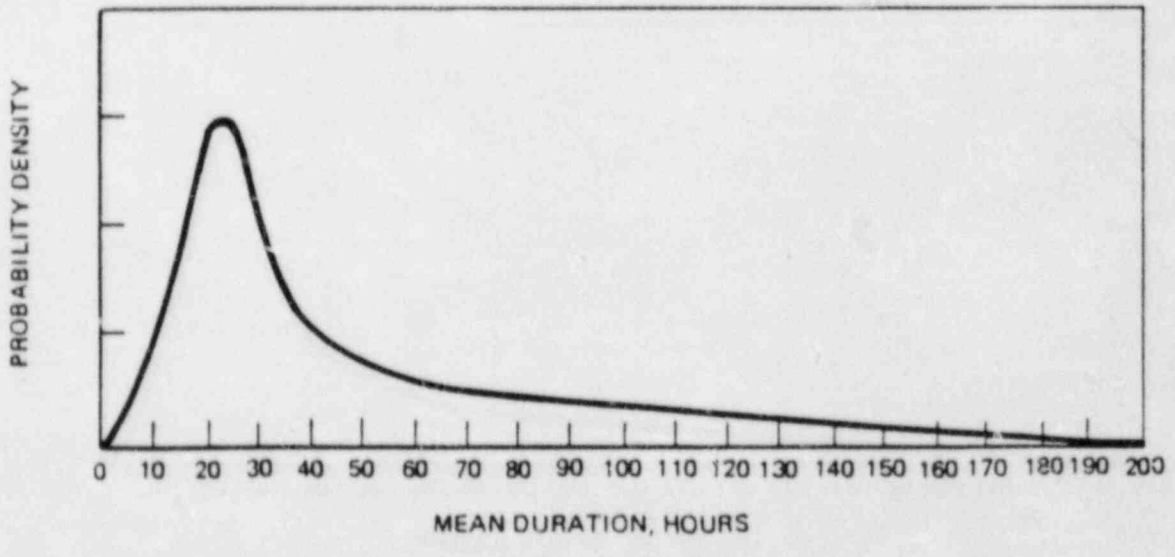
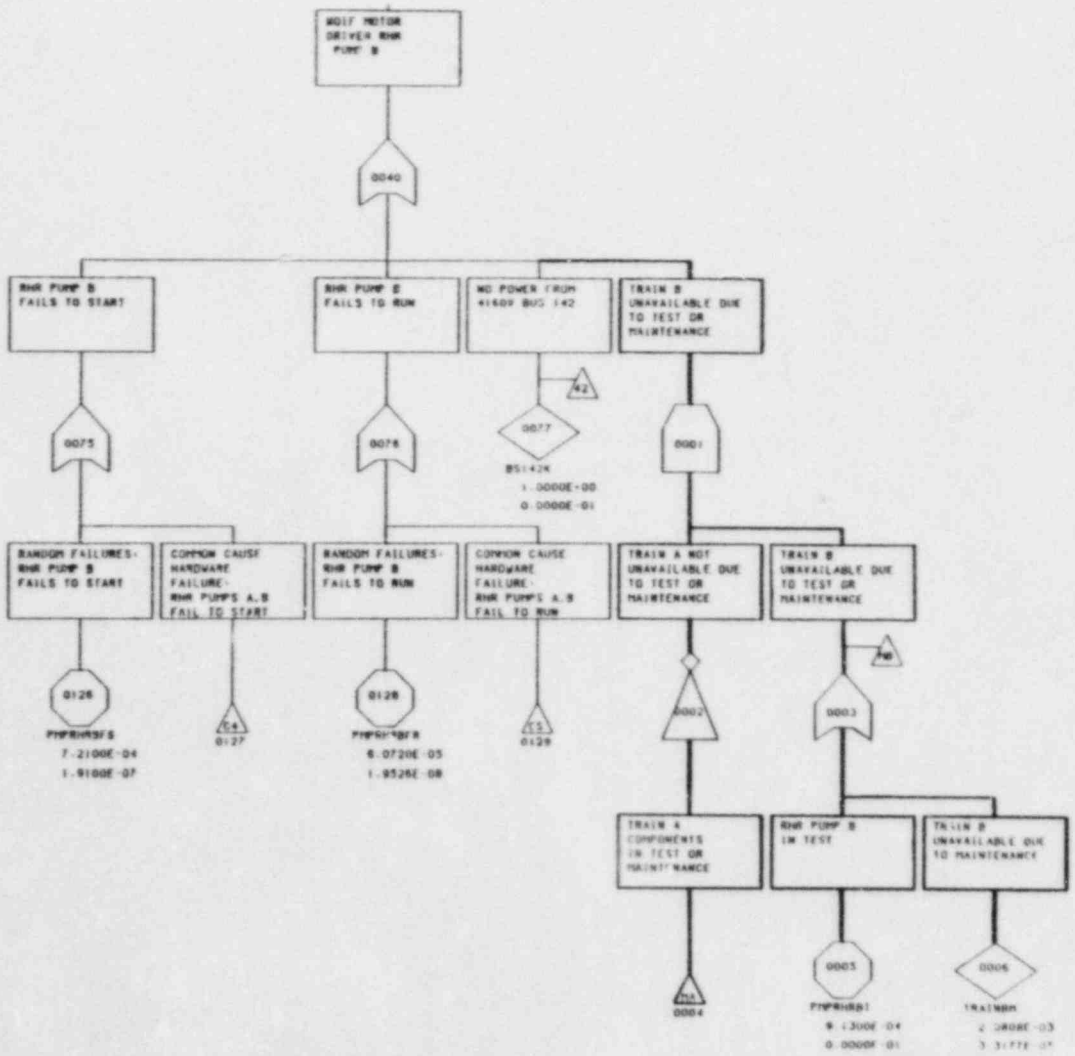


Table III-3

FIGURE III-1

EXAMPLE TEST AND MAINTENANCE MODEL IN FAULT TREE



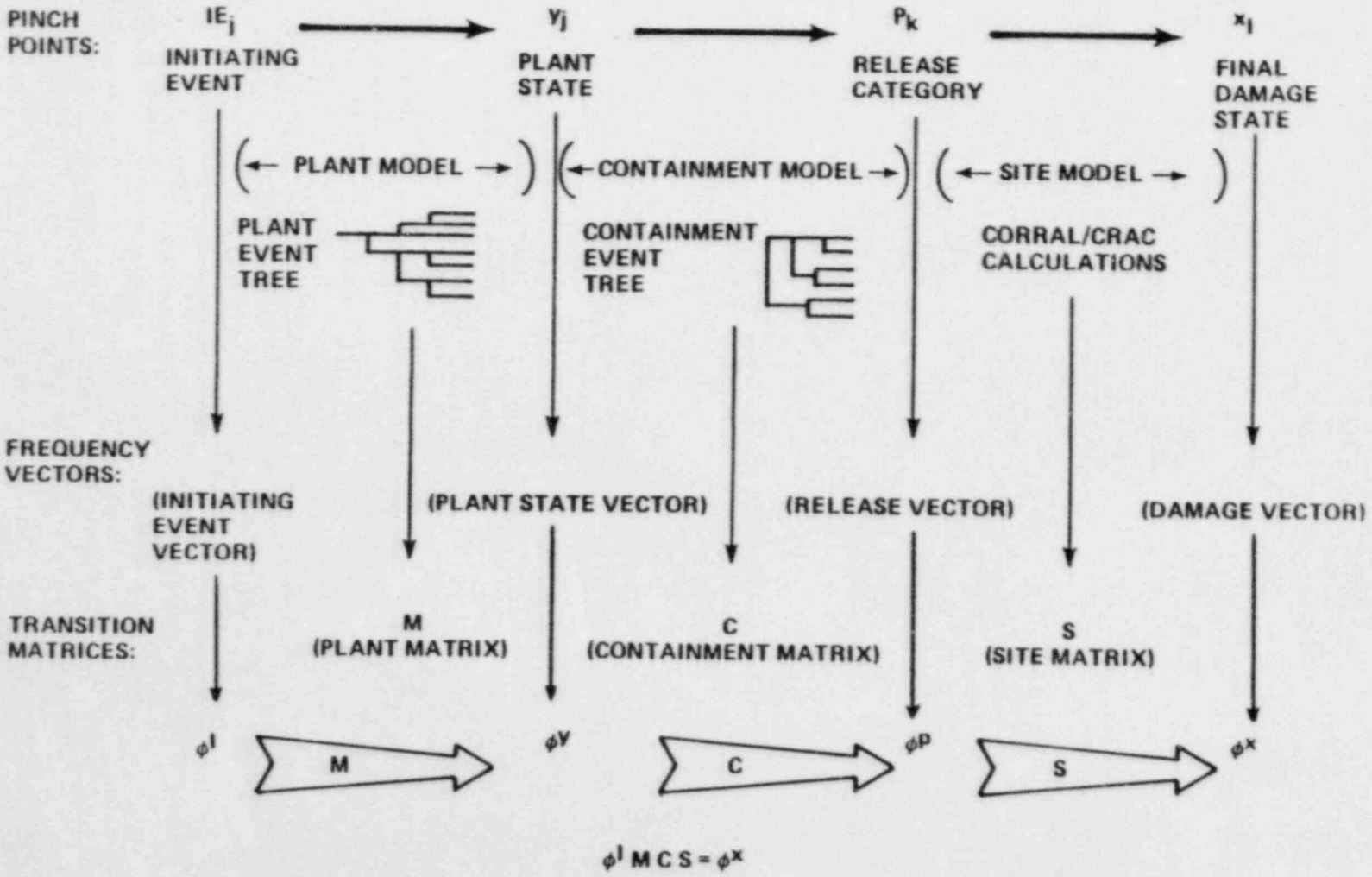


Figure III-2

Overall View of the Assembly Process Showing Relationships of Pinch Points, Event Trees, Frequency Vectors, and Transition Matrices

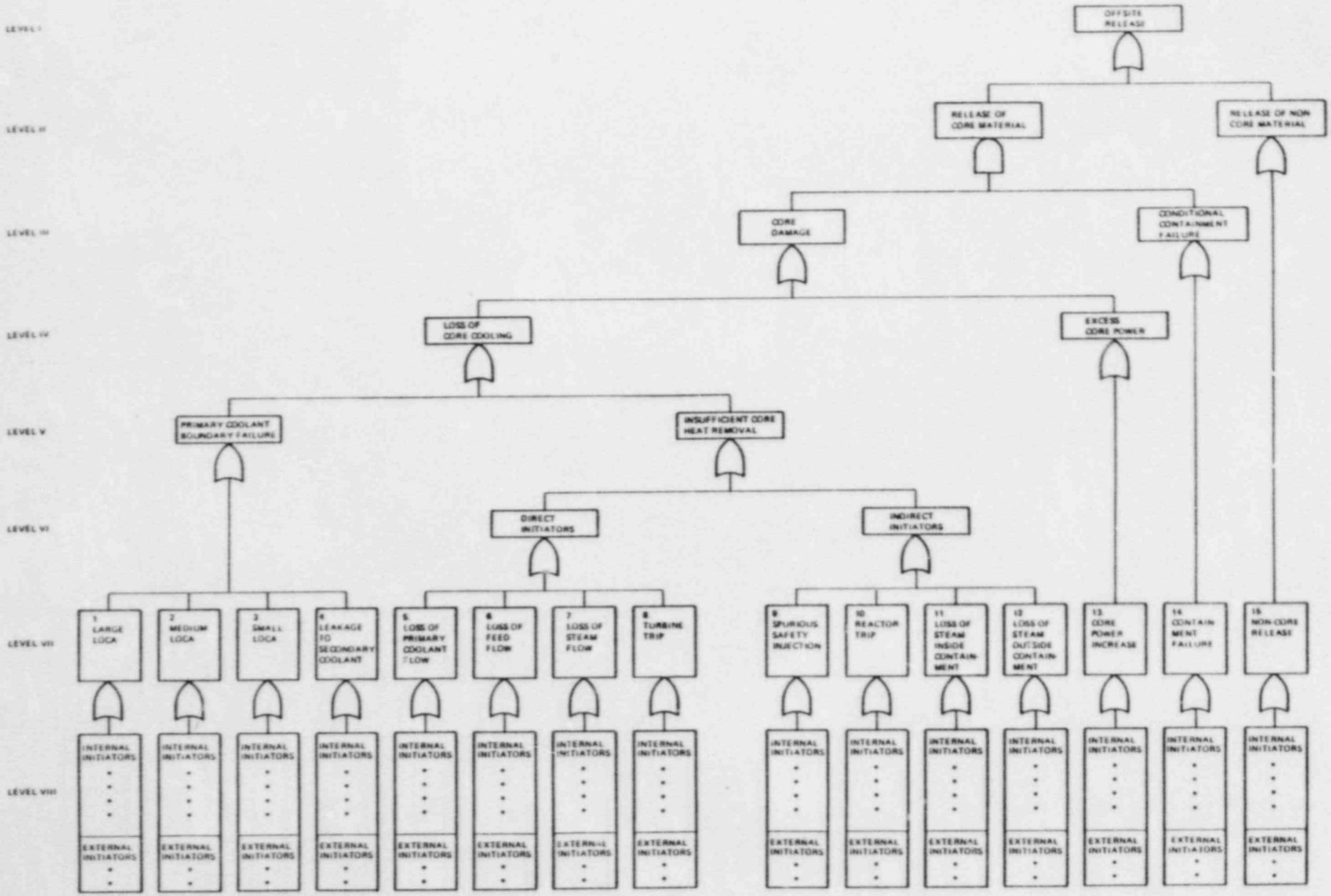


Figure III-3

MASTER LOGIC TREE

IV. SUMMARY OF RESULTS

The major objectives of this study were to: 1) obtain a quantitative characterization of the risk of the Byron plant as functions of 3-day and 7-day Limiting Conditions for Operations for two unit operation; and 2) obtain similar results for Unit 1 single unit operation. The summary of the results of this analysis are presented below.

A. Two Unit Operation

The results of this analysis are presented as a set of risk curves, as done for the Reactor Safety Study and the Zion Probabilistic Safety Study. The results for double unit operation are presented in Figures IV-1 through IV-4, showing the difference in each plant damage indice expected due to an increase in the mean duration of maintenance. The indices presented are:

i. Early fatalities;
ii. Injuries (excluding cancer);
iii. Thyroid cancer cases; and
iv. Cancer fatalities (other than those from thyroid cancer).

Each diagram shows the frequency of exceeding any given level of the damage index. The differences noted on these figures are well within the log-normal 10 and 90 percent confidence limits about the means found in the uncertainty analyses done for the Reactor Safety Study, Zion Probabilistic Safety Study, Indian Point Probabilistic Safety Study, Millstone-3 Probabilistic Safety Study, and others. In addition, the relative risk of the facility is comparable to that for other plants, as found in the above reports.

B. Single Unit Operation

The analysis of Unit 1 in operation alone was performed since Unit 1 will be operational for a short period of time while Unit 2 construction is completed, and certain shared systems, the Component Cooling Water System and the Essential Service Water System, whose availability impacts the risk of the

plant have not been finished. The results of this analysis are presented in Figures IV-5 through IV-8, showing the same risk parameters as discussed in A. above.

C. Conclusions and Recommendations

The results of the analysis show a statistically insignificant increase in the relative risk of the Byron facility due to the projected increase in the LCO for all fluid systems. It is noted that the increase is well within the 10 and 90 percent confidence limits of previous risk assessments performed with the same techniques on similar Westinghouse NSSS reactors. The largest impact on plant risk from a change in the LCO is noted, as expected, in the support systems, especially the diesel generators and the Essential Service Water System. The Component Cooling Water System is not important due to the inclusion of a maintenance spare pump in the design. Analysis performed with no increase in the mean time to restore following maintenance of both the diesel generators and the ESWS showed no increase in plant risk, see Section 5.2 of the main report. The increased outage time of the Auxiliary Feedwater System pumps does not contribute to a noticeable increase in plant risk due to the overall reliability of the system and of backup feed and bleed functions, see Section 5.2. Likewise, the reliability of the high pressure safety injection function, due to the design of four pumps (two HPSI and two charging), is not impacted by the change. The Residual Heat Removal System reliability is impacted by the proposed change, but there is a negligible total impact on plant risk.

Special consideration to the Diesel Generators and the Essential Service Water System are being given. An analysis of past diesel generator maintenance events, presented in NUREG/CR-1362, (1980) with an assumption of a log-normal distribution and categorical mean times to restore of 1, 4, 8, 24 and 72 hours for the discrete distributions of reported maintenance times, yields a mean time to restore of about 7 hours, much less than the analyzed 19 and 34 hours. While not specifically addressing the frequency of this data set, the frequency used in this study is justified in the Zion study. Some plant flexibility in control of the frequency of maintenance is noted, such that significant variation from the unavailability analyzed would be an indicator of skewed component behavior, flagging the equipment for management attention.

The ESWS susceptibility to maintenance is caused by the design of one pump per train, combined with the normally operating status of the system. In single unit operation, this becomes more dominant with the presence of only two (of two necessary) ultimate heat sink forced draft cooling tower fans, where the construction of the Unit 2 components have not been completed. Due to the shared nature of this system and the CCWS, the completion of the Unit 2 portion of the system will yield a noticeable increase in overall system reliability, with concommitant decrease in plant risk.

FIGURE IV-1

POINT ESTIMATE RISK CURVE FOR EARLY FATALITIES
SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED
INTERNAL RISK ONLY

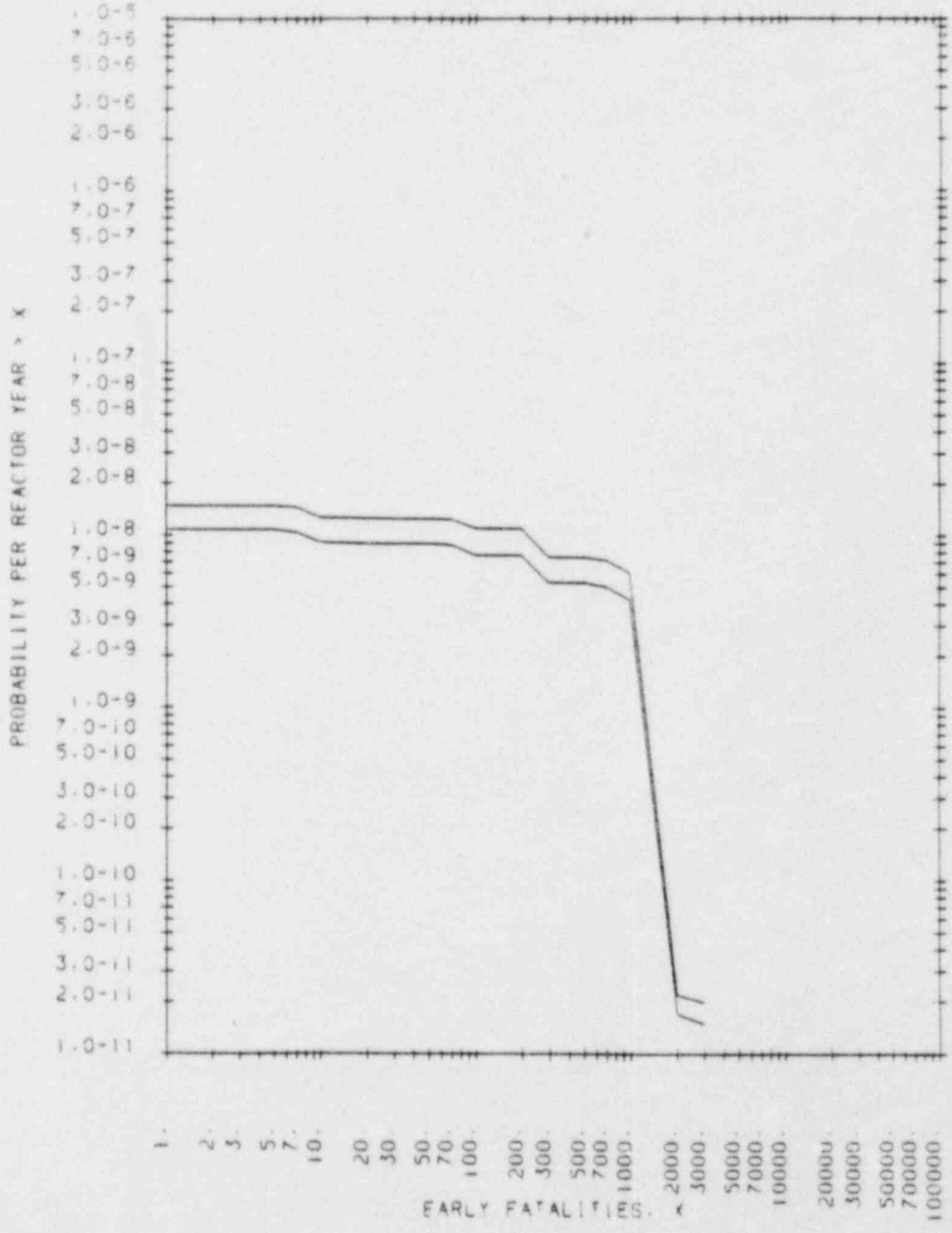


FIGURE IV-2

POINT ESTIMATE RISK CURVE FOR LATENT CANCERS

SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED

INTERNAL RISK ONLY

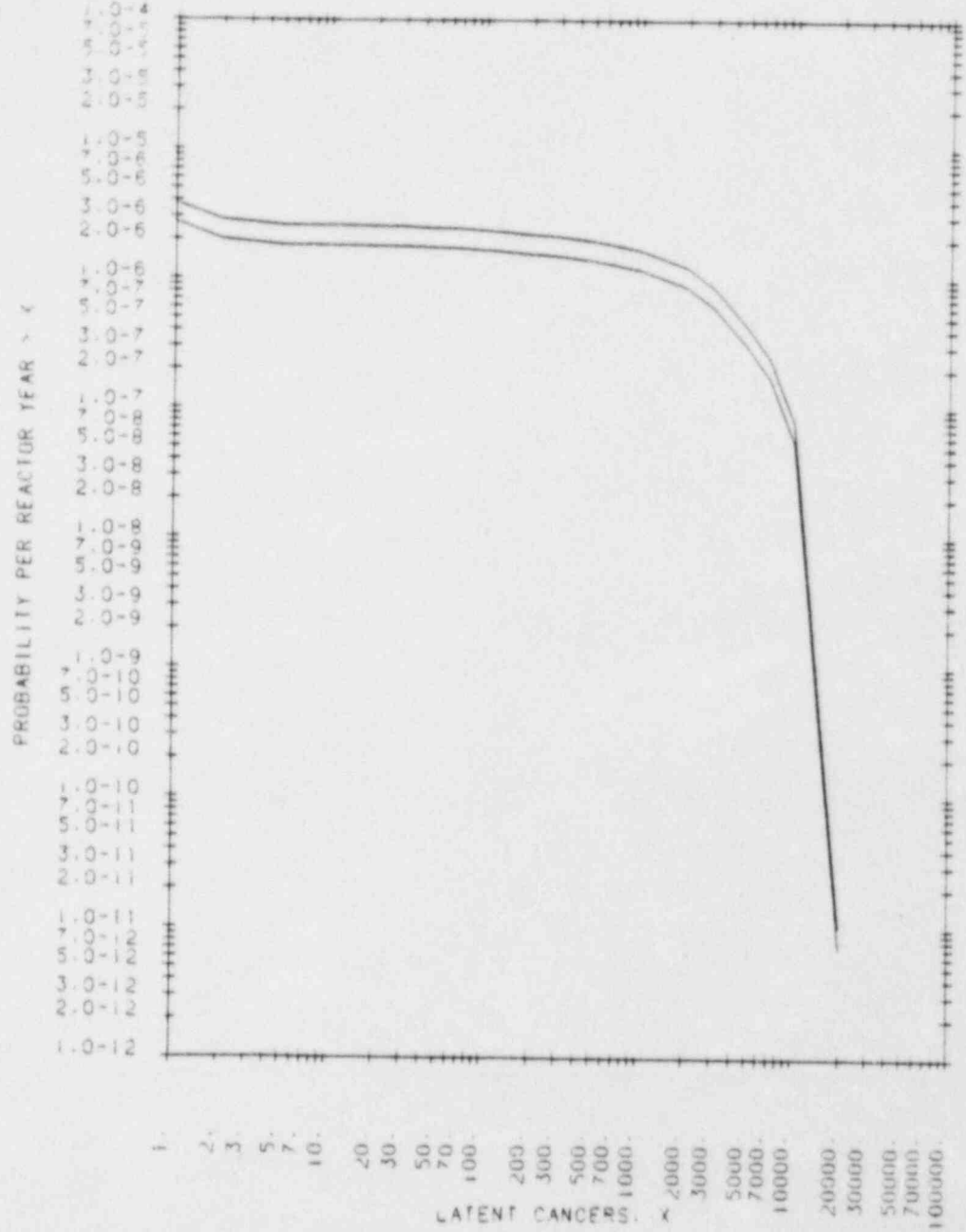


FIGURE IV-3

POINT ESTIMATE RISK CURVE FOR THYROID CANCERS
SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED
INTERNAL RISK ONLY

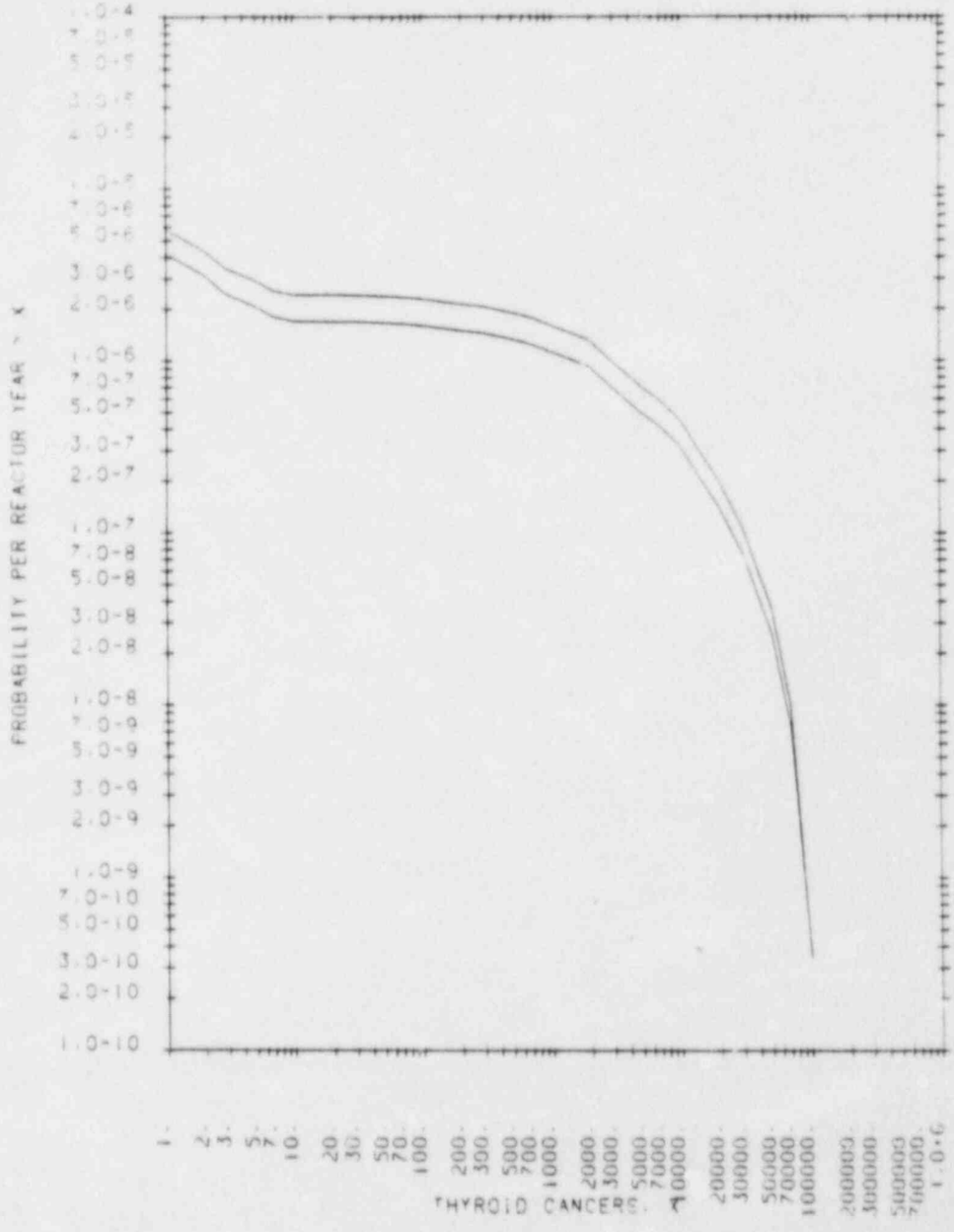
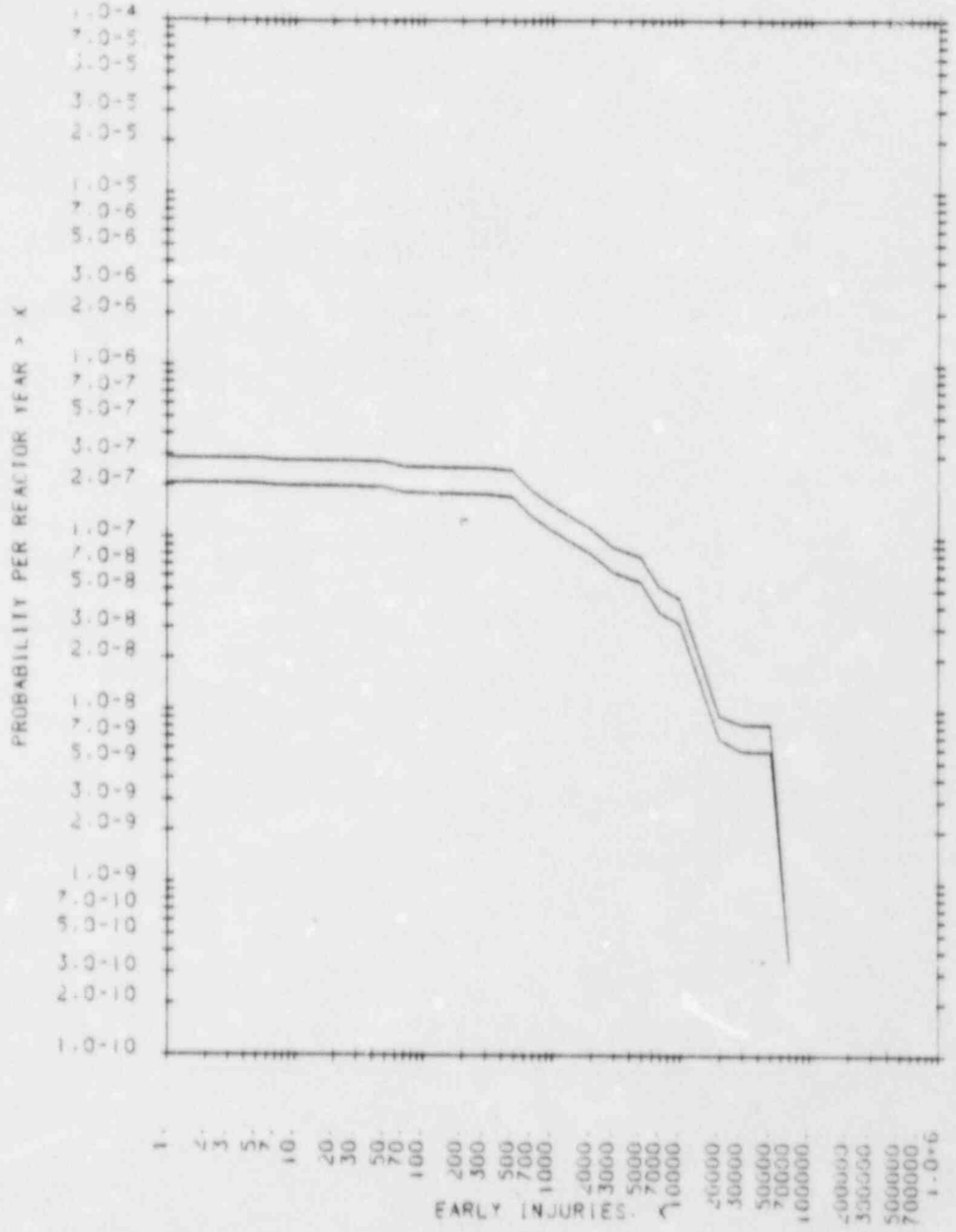


FIGURE IV-4

POINT ESTIMATE RISK CURVE FOR EARLY INJURIES
SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED
INTERNAL RISK ONLY



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1.0 INTERNAL INITIATING EVENTS

The purpose of this section is to present each internal initiating event class employed in the Byron/Braidwood LCO Relaxation Study. These classes were developed and employed in the previous probabilistic safety studies (references 1, 2, 3). The Zion Probabilistic Safety Study (ZPSS) contains an extensive evaluation of generic and plant specific initiating events. It grouped these into a smaller number of initiating event classes which serve as the basis for event tree development in this report. Each of the initiating event classes and their applicability to the Byron plant is discussed below. Since there are no significant plant variations between Byron and Zion, the Zion initiating event class and frequency are employed. The internal initiating event categories and their frequencies are summarized in Table 1-1.

1. Large LOCA:

This event class includes reactor coolant system pipe breaks greater than a 6 inch diameter equivalent and reactor vessel failures of similar size or functional effect. The mean frequency for such events at Zion is 9.4×10^{-4} per reactor year. The frequency of pipe breaks overwhelmingly dominates this class of events. The Zion and Byron reactor coolant systems are nearly identical in configuration. The Byron system is designed to a more rigorous code than Zion and was installed under the auspices of a more sophisticated Q.A. program than Zion's. Also, although of trivial effect, the reactor vessel material at Byron is less susceptible to radiation embrittlement than the Zion vessel material. It is judged that the Zion mean initiating event frequency of 9.4×10^{-4} per reactor year can be applied to Byron with a resulting introduction of only minor conservatisms.

2. Medium LOCA:

This event class includes reactor coolant system pipe breaks greater than 2 inches and less than 6 inches diameter equivalent. The mean frequency for such events at Zion is 9.4×10^{-4} per reactor year. Using the same rationale for the large LOCA event, the Zion frequency is applied to Byron.

3. Small LOCA:

This event class includes reactor coolant system pipe breaks or equivalent functional losses of integrity of less than 2 inches diameter equivalent. The mean frequency for such events at Zion is 3.54×10^{-2} per reactor year. This frequency is slightly above the PWR generic mean as a result of Zion specific data being combined with the generic data using Bayesian techniques. (Zion had an incident involving a drain valve being inadvertantly left open.) It can be argued that Byron should not be penalized for the Zion incident since Byron will have learned from Zion's problems. Conversely, one can argue that the Zion data reflects Edison operational characteristics and should be included. In reality, one should resolve this issue by employing a somewhat larger uncertainty than

was used for Zion with the distribution centered on the generic data. It is judged that such an approach might well result in a mean value similar to Zion's. In view of this and the relatively small difference in Zion and generic means, the Zion value of 3.54×10^{-4} is employed for Byron.

4. Steam Generator Tube Rupture:

The steam generator tube rupture (SGTR) applies to the rupture of one or more steam generator tubes resulting in a loss of primary coolant into the secondary system. The experienced frequency of a tube rupture event is approximately $\lambda = 2 \times 10^{-6}$ per tube year of operation. This is based on 5 events in ~2.5 million tube years of experience. There are 4578 tubes in each of Byron's four steam generators. The frequency of tube ruptures based on this historical data is 3.7×10^{-2} per year of plant operation. It is judged that frequency is a conservative estimate because the failure data is from operating plants which, in many cases, operated for extended periods using water chemistry controls now recognized to be less than optimum. Byron has extensive water chemistry control programs planned and has design features aimed at minimizing these problems. These features include secondary cleanup demineralizers, increased blowdown capacity, and extensive use of stainless steel in the secondary system. However, Byron will require modifications to eliminate flow induced tube vibrations. The Byron SGTR mean frequency is judged to be 3.70×10^{-2} per reactor year which is slightly greater than the Zion SGTR frequency due to the recent Ginna SGTR event which was included in the data base.

5. Secondary Break Inside Containment:

This class of events includes all steamline and feedwater line breaks upstream of the main steam isolation valves (MSIVs) and downstream of the main feedwater isolation valves (MFIVs), respectively, that are large enough to actuate safety injection. The mean frequency for such events at Zion is 9.4×10^{-4} per reactor year. The steamline configurations of Zion and Byron are nearly identical. Therefore, the Byron mean frequency is judged to be 9.4×10^{-4} per reactor year.

6. Secondary Break Outside Containment:

This class of events includes all excessive steamline and feedwater line demands or breaks downstream of the MSIVs and upstream of the MFIVs respectively that actuate safety injection. The mean frequency for such events at Zion is 9.4×10^{-4} per reactor year. No significant steamline or feedwater line configuration changes exist between Byron and Zion. Therefore, the Byron mean frequency is judged to be 9.4×10^{-4} per reactor year.

7. Loss of Main Feedwater:

The loss of main feedwater event class is initiated by a loss of feedwater to one or more steam generators from causes outside containment such as loss of condensate pumps, feedwater pumps, loss of feedwater line break upstream of the MFIVs, etc. The mean frequency for such events at Zion is 5.2 per reactor year. The generic mean is slightly above 3 per reactor year. Both the generic and Zion data are highly biased by loss of feedwater events that occur during unit startup and power ascent. Byron has incorporated extensive design revisions, including a startup feedwater pump, to reduce these problems. As a result, it is judged reasonable to use a generic mean frequency of 3 per reactor year for Byron.

8. MSIV Trip (One Valve):

This event class is initiated by closure of one of the four main steam isolation valves. Simultaneous multiple MSIV trips, 2 or 3 closures, are bounded by this event class and closure of all MSIVs is bounded by the turbine trip event class. The mean frequency of such events at Zion is 2.52×10^{-1} per reactor year. The Byron valve design is different from that of Zion but is not unique in the industry. The Byron mean frequency is selected as 2.52×10^{-1} per reactor year which is more representative of modern plants than the generic mean of about 6.0×10^{-1} per reactor year.

9. Loss of RCS Flow:

The loss of RCS flow includes any event that causes loss of flow in any or multiple reactor coolant loops. The mean frequency of such events at Zion

is 3.58×10^{-1} per reactor year. The generic mean is slightly lower. Most of the Zion events involved testing which tripped a bus or a reactor coolant pump. The mean frequency for Byron is selected as 3.58×10^{-1} per reactor year since similar testing would be expected at Byron. No significant design or system differences exist between Zion and Byron that would influence the event frequency.

10. Core Power Excursion:

This event class covers a large number of infrequent events that could cause the core power to increase while the plant is in hot shutdown, hot standby or at power. The mean frequency for such events at Zion is 2.28×10^{-2} per reactor year. This is based largely upon generic data. The mean frequency for Byron is also judged to be 2.28×10^{-2} per reactor year. As with the above event class, no significant design or system differences exist between Zion and Byron that would influence this event class.

11. Turbine Trip:

The turbine trip event class bounds all events which are initiated by a turbine trip such as loss of condenser vacuum or loss of circulating water. The mean frequency for such events at Zion is 3.7 per reactor year. The generic mean is ~4 per reactor year. Byron may be expected to experience such events more frequently than that of Zion due to the operation of main cooling towers at Byron. The Byron mean frequency is judged to be closer to the generic experience and a value of 4.0 per reactor year is selected.

12. Loss of Offsite Power:

This event class covers all initiating event resulting in a loss of offsite power. These events may be internal or external to Byron. The mean frequency of such events at Zion is 5.76×10^{-2} per reactor year. This is considerably lower than the generic mean of 1×10^{-1} per reactor year. Largely, this is due to the strong Edison grid and its interties

coupled with the multiple, multi-directional transmission corridors leading from the Zion site. The Byron situation is similar to Zion in these respects. The mean frequency for Byron is therefore judged to be 5.76×10^{-2} per reactor year.

13. Spurious Safety Injection:

This event class covers events initiated by any actual safety injection that from a safety standpoint is not required. The mean frequency of such events at Zion is 6.4×10^{-1} per reactor year. The generic mean is 1.6×10^{-1} per reactor year. Both values are strongly biased by human interactions with complex relay systems in close working spaces during periodic test and calibration work. The Byron systems for SI actuation are largely solid state with improved testability. The frequency of such events is expected to decline. The mean frequency for Byron is expected to be 8.00×10^{-2} per reactor year.

14. Reactor Trip:

The reactor trip event class considers events that are initiated by a reactor trip. The mean frequency of this event at Zion is 3.00 per reactor year. The contributors at Zion were reviewed to ascertain the percentage of such trips which could be eliminated from Byron by virtue of the solid state logic features and testing. As a result, the mean frequency at Bryon is estimated to be 3 per reactor year.

15. Interfacing Systems LOCA (V-Sequence):

This event class covers possible interfacing systems LOCAs between the reactor coolant systems and supporting systems. This event is treated as a separate subset of large LOCA. The Zion mean frequency is 1.05×10^{-7} per reactor year with broad uncertainty. Close examination of the Byron design reveals that the RHR pump discharge check valve configuration is the same as Zion. However, in the important suction valve area, Byron has 2 parallel strings of 2 series MOVs. This doubles the frequency. As a result, the mean frequency at Byron is 2.10×10^{-7} per reactor year.

TABLE 1-1

INITIATING EVENT DEFINITIONS AND MEAN FREQUENCIES
(Internal Events Only)

Event Symbol	Event Description	Frequency/ Reactor Year
1	Large LOCA	9.40E-04
2	Medium LOCA	9.40E-04
3	Small LOCA	3.54E-02
4	Steam Generator Tube Rupture	3.70E-02
5	Secondary Break Inside Containment	9.40E-04
6	Secondary Break Outside Containment	9.40E-04
7	Loss of Main Feedwater	3.00E+00
8	Closure of One MSIV	2.52E-01
9	Loss of RCS Flow	3.58E-01
10	Core Power Excursion	2.28E-02
11	Turbine Trip	4.00E+00
12	Loss of Offsite Power	5.76E-02
13	Spurious Safety Injection	8.00E-02
14	Reactor Trip	3.00E+00
15	Interfacing Systems LOCA	2.10E-07

2.0 EVENT TREE STRUCTURE

This section presents each of the event trees employed in the Byron LCO Relaxation Study. It identifies the top events or nodal questions asked for each tree. A detailed description of the event tree nodes are provided in Appendix 2A. Top event success criteria are the same as those of the Byron Risk Study unless specifically noted to the contrary.

System dependencies that are explicit in the tree are discussed if they vary from the dependencies discussed in the Byron Risk Study. Detailed dependencies are also discussed on a systems level in section 3.0 for each system analyzed for Byron.

2.1 EVENT TREE 1, LARGE LOCA

The top events or nodal questions for this event tree are :

SYMBOL	DESCRIPTION
TK:	Availability of the refueling water storage tanks (RWST) as a source of ECCS injection water.
TR1:	Consequential multiple steam generator tube rupture event.
SA1:	Generation of a safeguards actuation signal.
LP:	Operation of the low pressure ECCS injection systems.
CS:	Operation of the containment spray system in the injection phase. One-out-of-two pumps are required.
NA:	Containment spray system sodium hydroxide addition.
CF:	Operation of the containment fan coolers in an accident mitigation mode. Two-out-of-four units are required.
CC:	Operation of the component cooling water system supply to the residual heat removal (RHR) heat exchangers and other vital components.
R-1:	Operation of the low pressure ECCS in the long term recirculation mode.

The basic systemic dependencies explicitly displayed in this event tree, Figure 2-1, are the described above. Support state dependencies are explicitly treated for each node. These support states include dependencies on electric power and essential service water for a total of 6 support states.

2.2 EVENT TREE 2, MEDIUM LOCA

The top events or nodal questions for this event tree are:

SYMBOL	DESCRIPTION
TK:	Availability of the refueling water storge tank (RWST) as a source of ECCS injection water.
TR1:	Consequential multiple steam generator tube rupture event.
SA1:	Generation of safeguards actuation signal.
LP:	Operation of the low pressure ECCS injection systems.
HH1:	Operation of the high-head ECCS injection systems.
CS:	Operation of the containment spray system in the injection phase. One-out-of-two pumps are required.
NA:	Containment spray sodium hydroxide addition
CF:	Operation of the containment fan coolers in an accident mitigation mode. Two-out-of-four units are required.
CC:	Operation of the component cooling water system supply to the residual heat removal (RHR) heat exchangers and other vital components.
R-1:	Operation of the low pressure ECCS in the long term recirculation mode.

The basic systemic dependencies explicitly displayed in this event tree, Figure 2-2, are described above. Support state dependencies are explicitly treated for each node. These support states include dependencies on electric power and essential service water for a total of 6 support states.

2.3 EVENT TREE 3, SMALL LOCA

The top events or nodal questions for this event tree are described below. The small LOCA tree does not include a TR1 (steam generator tube rupture) node. The reason for not adding such a node centers around the fact that a small LOCA does not result in significant steam generator tube loadings. Therefore, consequential tube failures are judged to be very unlikely and would not be capable of contributing significantly to risk.

SYMBOL	DESCRIPTION
TK:	Availability of the refueling water storge tank (RWST) as a source of ECCS injection water.
K-3:	Automatic reactor trip and reactor trip signal.
SA1:	Generation of a safeguards actuation signal.
HH2:	Operation of the high head ECCS injection systems.
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP1:	Operator action of primary bleed through the pressurizer power operated relief valves (PORV's). Operation of one-out-of-two PORVs is required.
CF:	Operation of the containment fan coolers in an accident mitigation mode. Two-out-of-four units are required.
CC:	Operation of the component cooling water system supply to the residual heat removal (RHR) heat exchangers and other vital components.

R-2: Operation of the high head ECCS systems in the recirculation mode.

CS: Operation of the containment spray system in the injection phase. One-out-of-two pumps are required.

NA: Containment spray sodium hydroxide addition.

The basic system dependencies explicitly displayed in this event tree, Figure 2-3, are described above. Support state dependencies are treated as noted for event trees 1 and 2.

2.4 EVENT TREE 4, STEAM GENERATOR TUBE RUPTURE

Event tree 4 in this study is extensive since many modifications have been made to facilitate the assessment of tube rupture impact on risk.

The steam generator tube rupture (SGTR) event tree, Figure 2-4, applies to the rupture of one or more steam generator tubes causing primary coolant to leak to the secondary system. The event tree model is used to calculate the conditional probability of various core melt states and release states following a SGTR. The event tree uses the following symbols to identify system and operator functions modeled within the tree as top events.

SA2: Generation of safeguards actuation signal and operation of the high head ECCS pumps in the injection mode.

K-3: Automatic reactor trip and reactor trip signal

L-1: Auxiliary feedwater actuation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.

MT: Multiple Tube Ruptures

OP5: Operator Controls Rupture Flow

LK: Steam Leak Associated with the Faulted Steam Generator

OP8: Operator Controls Depressurization and Make-up

R-2: Operation of the high head ECCS systems in the recirculation mode.

A brief discussion for each of these systems and operator actions including success criteria and system interaction is provided in the following subsections.

ACCIDENT PROGRESSION

This is a description of a typical response to a steam generator tube rupture accident and the potential actions, manual or automatic, that may occur. This description is provided to permit an understanding of a typical tube rupture event and the plant response thereto. The trends described are only representative responses expected during the accident since variations in manual actions or operable equipment, as well as tube rupture size, will result in different plant behavior. For this reason, this discussion is limited to the expected plant response following a SGTR accident if the top events modeled within the event tree succeed according to their success criteria. The representative nature of this description does not influence the event tree structure or quantification.

The SGTR is initiated by random or consequential rupture of the steam generator tubes ranging from a single split tube up to 10 equivalent double ended tube ruptures.

Initially, RCS pressure will decrease as flow through the tube rupture, in excess of charging pump capacity, depletes the primary coolant inventory. The rate of RCS pressure drop will increase with tube rupture size and decrease with increased charging pump flow.

For the accident presented, reactor trip could occur on either low pressurizer pressure or overtemperature delta-T. In some instances, the operator may only receive an alarm indicating the close proximity of the reactor coolant average temperature to the trip. This depends on the relationship between the alarm and actual trip setpoint. Due to this relationship, reactor trip may occur on low pressurizer pressure. For smaller tube ruptures, the operator may trip the reactor manually prior to automatic trip.

Following reactor trip the primary pressure decreases more rapidly as sensible energy transfer to the secondary rapidly cools the RCS and tube rupture flow continues to deplete primary inventory. This decrease in RCS pressure results

in a low pressure safety injection signal soon after reactor trip. For smaller tube ruptures the operator may manually initiate safety injection prior to automatic actuation. Normal feedwater flow is automatically terminated on safety injection and auxiliary feedwater is actuated to deliver flow to all steam generators. Eventually, operator action is required to adjust auxiliary feedwater flow to maintain water level in the unfaulted steam generators and terminate flow to the faulted generator.

Secondary pressure will increase due to automatic turbine trip upon reactor trip. Normally, automatic steam dump to the condenser would be expected to dissipate energy transferred from the primary, thereby limiting the secondary pressure increase and maintaining programmed no-load RCS temperature. In some cases, the steam dump may not adequately control the rapid increase in pressure, which may cause the steam generator relief valves or the steam generator safety valves to lift, releasing steam to the atmosphere. If offsite power is unavailable, automatic steam dump to condenser will not occur resulting in an increase in secondary pressure to the safety valve setpoint pressure. The relief capacity of the safety valves is sufficient to maintain secondary pressure approximately constant. In the event of an uncontrolled secondary steam release, such as a stuck open safety valve or steamline fracture, secondary pressure and RCS temperature will continue to decrease below no-load pressure.

Automatic steam dump control is expected to establish and maintain programmed no-load RCS temperature after reactor trip. If a reactor coolant pump continues running, only a small core delta-T will exist. Consequently, the core inlet and core outlet temperatures will tend to stabilize at no-load temperature until manual cooldown of the RCS is initiated. Safety injection and auxiliary feedwater flow eventually reduce the RCS average temperature to near no-load until auxiliary feedwater is manually controlled to maintain steam generator level.

When the post-trip RCS cooldown subsides, safety injection is expected to begin refilling the pressurizer and increase RCS pressure until injection flow equals break flow, thus maintaining primary inventory constant. This equilibrium pressure is dependent on the size of the tube rupture and

injection capacity. For multiple tube ruptures or reduced injection capacity, RCS pressure may continue to decrease toward the ruptured steam generator pressure until equilibrium is established. Manual actions may reduce RCS pressure and safety injection flow prior to reaching equilibrium.

Operator action is required to mitigate the steam generator tube rupture accident. The optimum recovery guidelines, which form the basis for the actions modeled have been developed through a comprehensive analysis program that investigates the sensitivity of system response to potential operator actions. The operator identifies the ruptured steam generator by a high steam generator water level. For a double ended tube rupture, significantly more coolant mass exists in the ruptured steam generator early in the transient so that identification on high water level is expected. For smaller tube ruptures, high radiation indications may be necessary for positive identification of the ruptured steam generator. However, in such instances, the break flow would be less and, consequently, more time exists to recover.

Once identified, the ruptured steam generator is manually isolated to maintain the ruptured steam generator pressure above the non-ruptured and to minimize activity releases. Auxiliary feedwater flow is terminated to the ruptured steam generator to prevent steam release from the faulted steam generator. Steam dump from the non-ruptured steam generators to the condenser, via the steam dump system or to the atmosphere through the atmospheric relief valves, is initiated to reduce the RCS temperature to 50°F below the saturation temperature at the ruptured steam generator pressure. This assures adequate subcooling of the RCS after depressurization to the ruptured steam generator pressure.

After the primary temperature is reduced, the RCS is depressurized to the ruptured steam generator pressure to terminate break flow. The preferred method of depressurization is the normal pressurizer spray system. When this is not available or not effective, the primary pressure is reduced by opening one pressurizer PORV. This method will cause release to the Pressurizer Relief Tank (PRT), possibly failing the rupture disk, and results in additional primary inventory loss. Consequently, it is presented as an alternative method in the event that normal pressurizer spray does not function.

When the RCS pressure is equal to the ruptured steam generator pressure, the PORV (or spray valve) is closed. In some cases, depressurization of the RCS may be terminated on high pressurizer level to prevent filling of the pressurizer. Pressurizer level and, consequently, RCS pressure continue to increase until safety injection is terminated, after primary pressure increases 200 psi. The 200 psi termination criteria is required to verify the integrity of the pressurizer vapor space and to collapse any voids in the RCS which may have been generated as a result of the depressurization phase.

Cooldown of the RCS is initiated by dumping steam from the non-ruptured steam generators until the Residual Heat Removal System (RHR) can be placed in service. The ruptured steam generator is slowly depressurized via steam dump to condenser or through a steam generator PORV. The RCS pressure is simultaneously reduced using pressurizer spray to maintain RCS/ruptured steam generator pressure equilibrium.

2.5 EVENT TREE 5, SECONDARY BREAK INSIDE THE CONTAINMENT

The top events or nodal questions for this event tree are:

SYMBOL	DESCRIPTION
TR3:	Consequential multiple steam generator tube rupture event.
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
SA2:	Generation of safeguards actuation signal and operation of the high head ECCS pumps in the injection mode.
K-3:	Automatic reactor trip and reactor trip signal.
MS1:	Trip of the main steam isolation valves
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP3:	Operator controls safety injection and feed and bleed. Success involves operation of one high head ECCS pump and one PORV.
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.
CS:	Operation of the containment spray system in the injection phase.
NA:	Containment spray sodium hydroxide addition.

The basic systems dependencies displayed in this event tree, Figure 2-5, are described above. Support state electric power dependencies are treated as discussed in event trees 1 and 2.

2.6 EVENT TREE 6, SECONDARY BREAK OUTSIDE CONTAINMENT

The top events or nodal questions for this event tree are:

SYMBOL	DESCRIPTION
TR3:	Consequential multiple steam generator tube rupture event.
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
SA2:	Operation of the ESF actuation signal and the high-head ECCS pumps in the injection mode.
K-3:	Automatic reactor trip and reactor trip signal.
MS1:	Trip of the main steam isolation valves.
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP3:	Operator controls safety injection and feed and bleed. Success involves operation of one high head ECCS pump and one PORV.
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.
CS:	Operation of the containment spray system in the injection phase.
NA:	Containment spray sodium hydroxide addition.

The basic systems dependencies displayed in this event tree, Figure 2-6, are described above. Support state electric power dependencies are treated as discussed in event trees 1 and 2.

2.7 EVENT TREE 7, LOSS OF MAIN FEEDWATER

The top events or nodal questions for this event tree are:

SYMBOL	DESCRIPTION
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
TR2:	Single steam generator tube rupture event feeding event tree 4.
K-3:	Automatic reactor trip and reactor trip signal.
TT1:	Turbine trip
MS2:	Trip of the main steam isolation valves
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP2:	Operator action of primary bleed and feed cooling using one high head ECCS pump and one PORV
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.
CS:	Operation of the containment spray system in the injection phase.
NA:	Containment spray sodium hydroxide addition.

The basic systems dependencies displayed in this tree, Figure 2-7, are described above. Support state dependencies are treated as discussed in event trees 1 and 2.

2.8 EVENT TREE 8, CLOSURE OF ONE MSIV

The top events or nodal questions for this event tree are:

SYMBOL	DESCRIPTION
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
TR2:	Single steam generator tube rupture event feeding event tree 4.
K-3:	Automatic reactor trip and reactor trip signal.
OP4:	Operator action to stabilize the transient using the 3 unaffected secondary loops
TT1:	Turbine trip
MS2:	Trip of the main steam isolation valves.
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP2:	Operator action of primary bleed and feed cooling using one high head ECCS pump and one PORV
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.
CS:	Operation of the containment spray system in the injection phase.
NA:	Containment spray sodium hydroxide addition.

The basic systems dependencies displayed in this event tree, Figure 2-8, are described above. Support state dependencies are treated as discussed in event trees 1 and 2.

2.9 EVENT TREE 9, LOSS OF REACTOR COOLANT FLOW

The top events or nodal questions for this event tree are:

SYMBOL	DESCRIPTION
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
TR2:	Single steam generator tube rupture event feeding event tree 4.
K-3:	Automatic reactor trip and reactor trip signal.
TT1:	Turbine trip
MS2:	Trip of the main steam isolation valves
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP2:	Operator action of primary bleed and feed cooling using one high head ECCS pump and one PORV
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.
CS:	Operation of the containment spray system in the injection phase.
NA:	Containment spray sodium hydroxide addition.

The basic system dependencies displayed in this event tree, Figure 2-9, are described above. The treatment of support state dependencies is discussed in event trees 1 and 2.

2.10 EVENT TREE 10, CORE POWER EXCURSION

The top events or nodal questions for this tree are:

OP9: Operation action to identify and terminate the excursion

K-5: Turbine runback to reduce power without a reactor trip

S2: Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.

TR2: Single steam generator tube rupture event feeding event tree 4.

K-3: Automatic reactor trip and reactor trip signal.

L-1: Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.

OP2: Operator action of primary bleed and feed cooling using one high head ECCS pump and one PORV

R-2: Operation of the high head ECCS systems in the recirculation mode.

CF: Containment fan coolers.

CS: Operation of the containment spray system in the injection phase.

NA: Containment spray sodium hydroxide addition.

The basic system dependencies displayed in this event tree, Figure 2-10, are described above. The treatment of support state dependencies is discussed in event trees 1 and 2.

2.11 EVENT TREE 11, TURBINE TRIP:

The top events or nodal questions for this event tree are described below. This tree covers the cases of a turbine trip and a turbine trip-loss of service water.

SYMBOL	DESCRIPTION
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
TR2:	Single steam generator tube rupture event feeding event tree 4.
K-3:	Automatic reactor trip and reactor trip signal.
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP2:	Operator action of primary bleed and feed cooling using one high head ECCS pump and one PORV.
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.
CS:	Operation of the containment spray system in the injection phase.
NA:	Containment spray sodium hydroxide addition.

The basic system dependencies displayed in this event tree, Figure 2-11, are described above. The treatment of support state dependencies is discussed in event trees 1 and 2.

2.12.1 EVENT TREE 12, LOSS OF OFFSITE POWER WITH ONSITE AC POWER AVAILABLE

This description applies to support states 1, 2, 3, and 4 which have onsite power available. The top events for this event tree are:

SYMBOL	DESCRIPTION
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
TR2:	Single steam generator tube rupture event feeding event tree 4.
K-3:	Automatic reactor trip and reactor trip signal.
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP2:	Operator action of primary bleed and feed cooling using one high head ECCS pump and one PORV
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.
CS:	Operation of the containment spray system in the injection phase.
NA:	Containment spray sodium hydroxide addition.

The basic system dependencies displayed in this event tree, Figure 2-12, are described above. The treatment of support state dependencies is discussed in event trees 1 and 2.

2.12.2 EVENT TREE 12a, LOSS OF OFFSITE POWER WITH NO ONSITE AC POWER AVAILABLE

This event tree is a special sub-tree of event tree 12 and applies to support states 5 and 6 which have no electric power available. It has been specifically constructed to explicitly model the electric power recover points in the event tree. As a result, it adds 2 nodes (E60 and 120) to event tree 12. These nodes represent the frequency of electric power recovery at 60 and 120 minutes into the event. Other than these additions, event tree 12A is the same as event tree 12. The top events for this event tree are:

SYMBOL	DESCRIPTION
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
K-3:	Automatic reactor trip and reactor trip signal.
E60:	Onsite/Offsite AC electrical power is recovered to one ESF bus in less than 60 minutes.
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
120:	Onsite/Offsite AC electrical power is recovered to one ESF bus in less than 120 minutes.
OP2:	Operator action of primary bleed and feed cooling using one high head ECCS pump and one PORV
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.

CS: Operation of the containment spray system in the injection phase.

NA: Containment spray sodium hydroxide addition.

The basic system dependencies displayed in this event tree, Figure 2-12A, are described above. The treatment of support state dependencies is discussed in event trees 1 and 2.

2.13 EVENT TREE 13, SPURIOUS SAFETY INJECTION

The top events or nodal questions for this event tree are:

SYMBOL	DESCRIPTION
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
TR2:	Single steam generator tube rupture event feeding event tree 4.
K-3:	Automatic reactor trip and reactor trip signal.
TT1:	Turbine trip
MS2:	Trip of the main steam isolation valves
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP3:	Operator controls safety injection and feed and bleed. Success involves operation of one high head ECCS pump and one PORV.
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.
CS:	Operation of the containment spray system in the injection phase.
NA:	Containment spray sodium hydroxide addition.

The basic system dependencies displayed in this event tree, Figure 2-13, are described above. The treatment of support states is discussed in event trees 1 and 2.

2.14 EVENT TREE 14, REACTOR TRIP

The top events or nodal questions for this event tree are:

SYMBOL	DESCRIPTION
S2:	Small primary system break. This node was added, and feeds event tree 3, to account for the possibility of a stuck open PORV and block valve.
TR2:	Single steam generator tube rupture event feeding event tree 4.
K-2:	The insertion of reactor control rods into the core given that the trip breakers have actuated as the initiating event. This was added to clarify any possible ATWS interface.
TT1:	Turbine trip
MS2:	Trip of the main steam isolation valves
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
OP2:	Operator action of primary bleed and feed cooling using one high head ECCS pump and one PORV.
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.
CS:	Operation of the containment spray system in the injection phase.
NA:	Containment spray sodium hydroxide addition.

The basic system dependencies displayed in this event tree, Figure 2-14, are described above. The treatment of support states is discussed in event trees 1 and 2.

2.15 EVENT TREE 15, INTERFACING SYSTEMS LOCA

This event tree covers potential interfacing systems LOCAs between the reactor coolant system and supporting systems. The top events are:

SYMBOL	DESCRIPTION
V:	Interfacing systems LOCA leads to core melt.

This event tree is depicted in Figure 2-15.

2.16 EVENT TREE 16, ATWS

The top events or nodal questions for this event tree are:

SYMBOL	DESCRIPTION
PL:	Initial power level > 80 percent
TT2:	Turbine trip or MSIV closure
L-1:	Auxiliary feedwater operation and secondary cooling. Operation of either auxiliary feedwater pump or the startup pump is required.
L-2:	Auxiliary feedwater operation and secondary cooling for ATWS events. One auxiliary feedwater pump is required to supply all four steam generators.
OP6:	Operator manually drives control rods in within 1 minute.
PR1:	ATWS primary system pressure relief
SO:	Safety injection system operable
OP7:	Operator manually deenergizes and RCCAs fall into the core
PR2:	ATWS primary system pressure relief secured.
OP2:	Operation action of primary bleed and feed cooling using one high head ECCS pump and one PORV.
R-2:	Operation of the high head ECCS systems in the recirculation mode.
CF:	Containment fan coolers.

CS: Operation of the containment spray system in the injection phase.

NA: Containment spray sodium hydroxide addition.

The basic system dependencies are presented in Figure 2-16. Support states are treated as discussed in event trees 1 and 2.

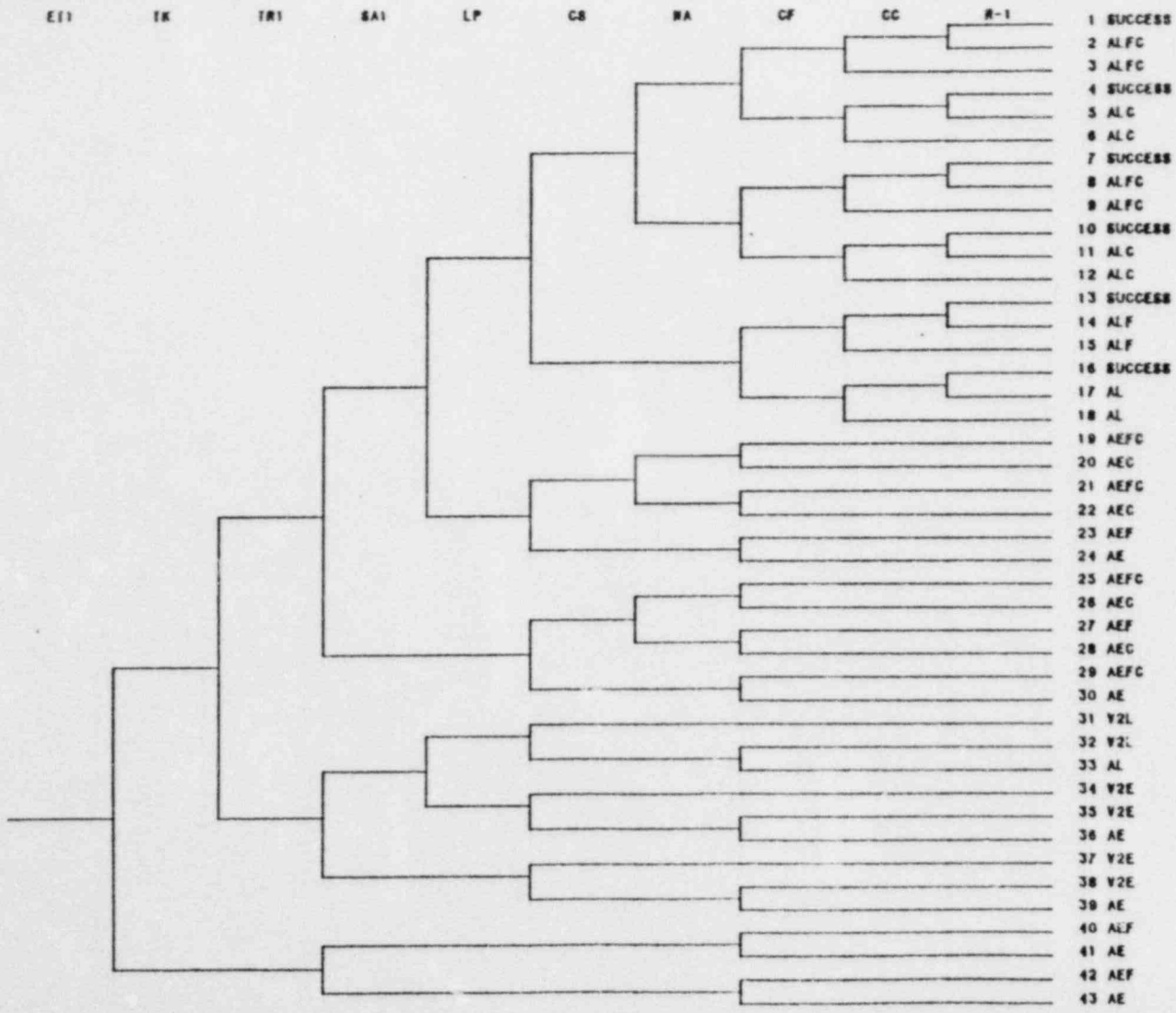


Figure 2-1 Large LOCA

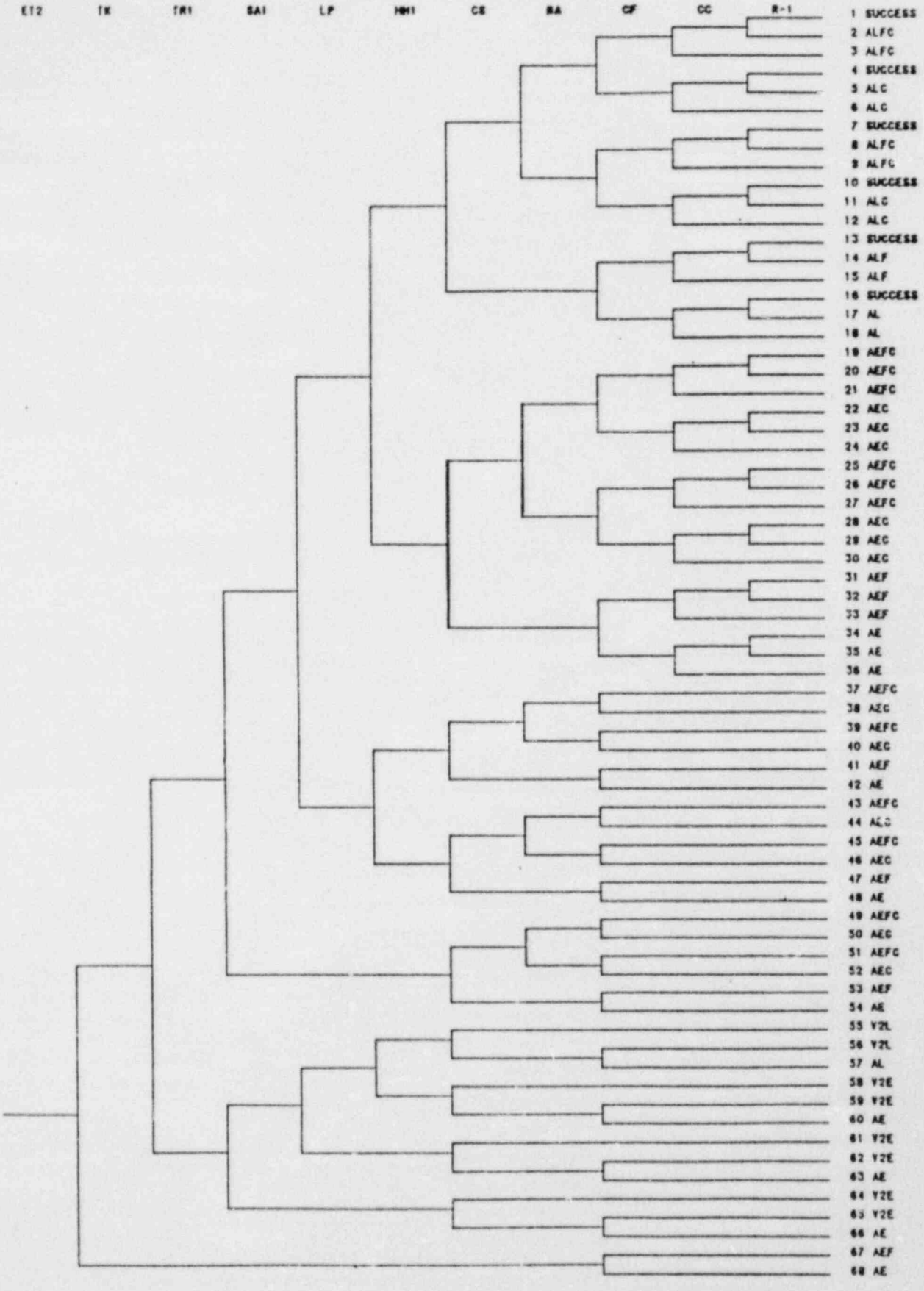


Figure 2-2 Medium LOCA

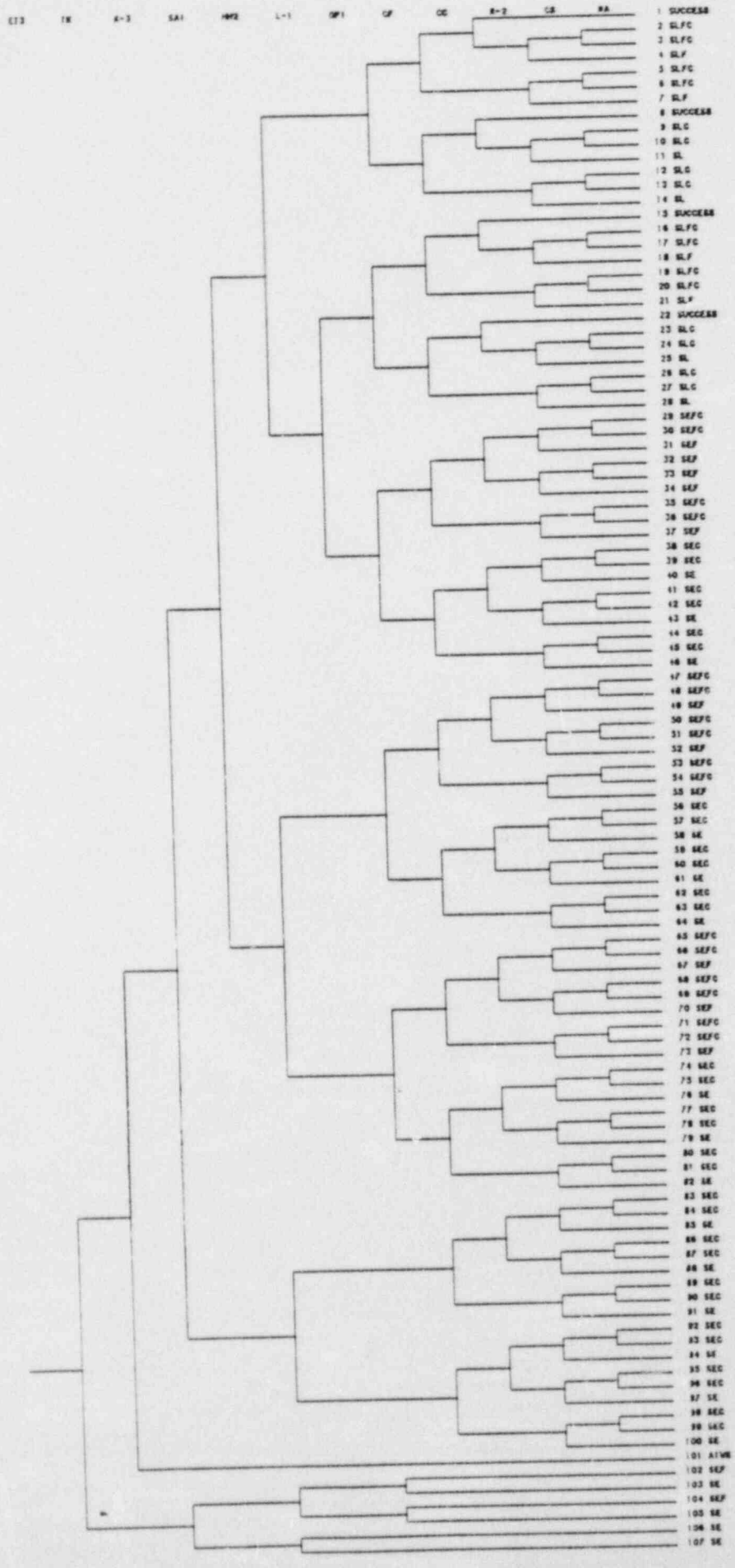


Figure 2-3 Small LOCA

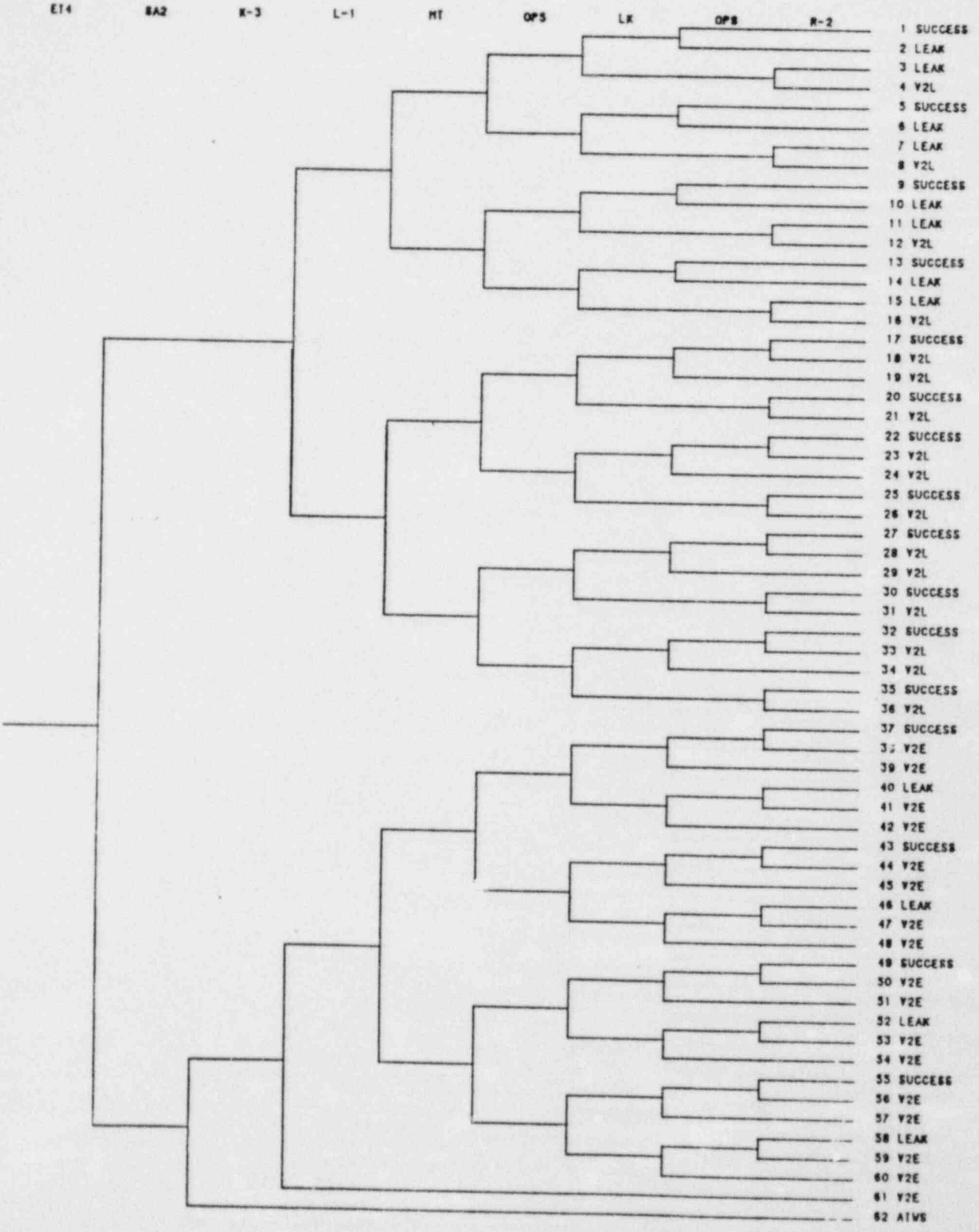


Figure 2-4 Steam Generator Tube Rupture

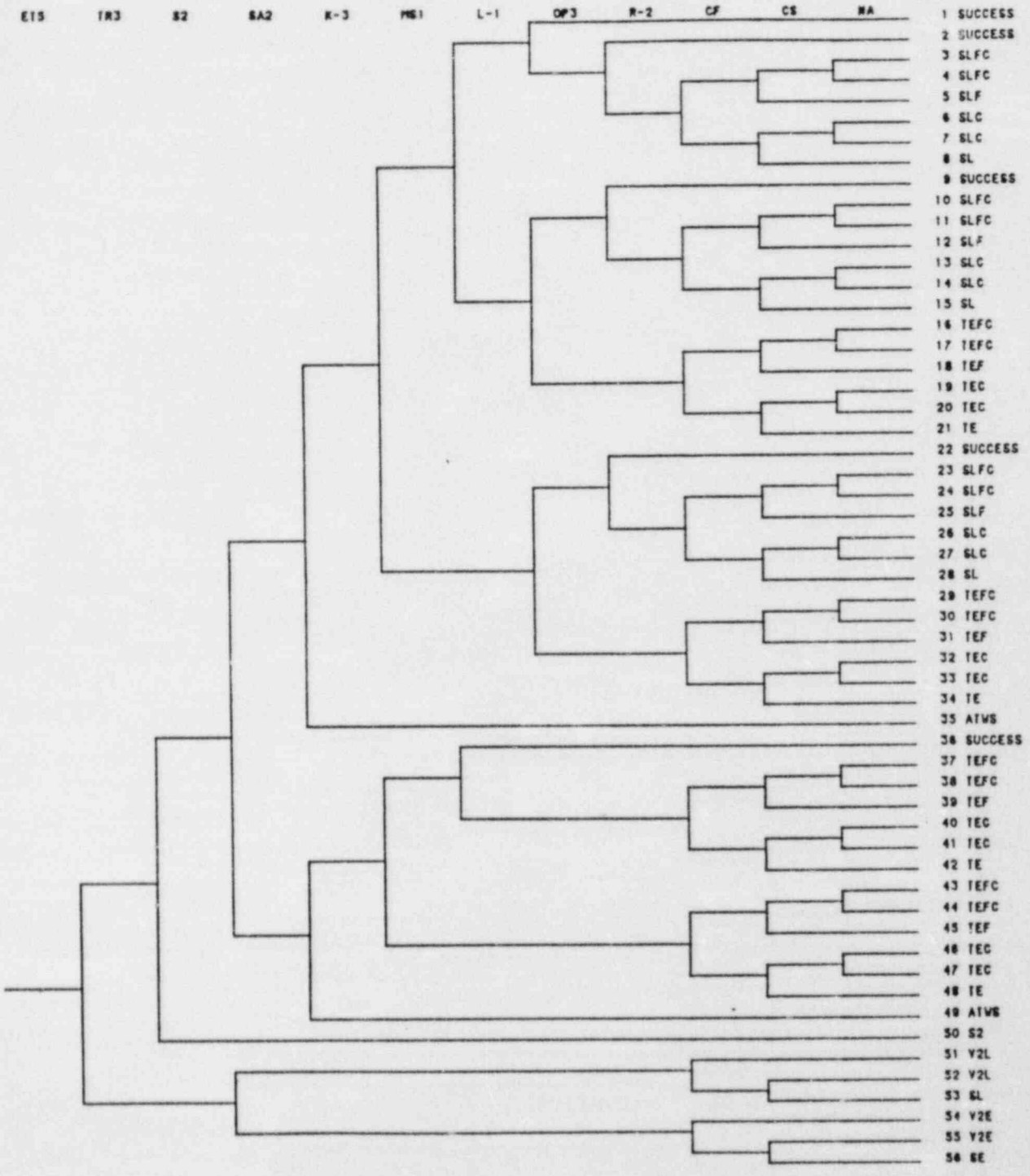


Figure 2-5 Secondary Break Inside Containment

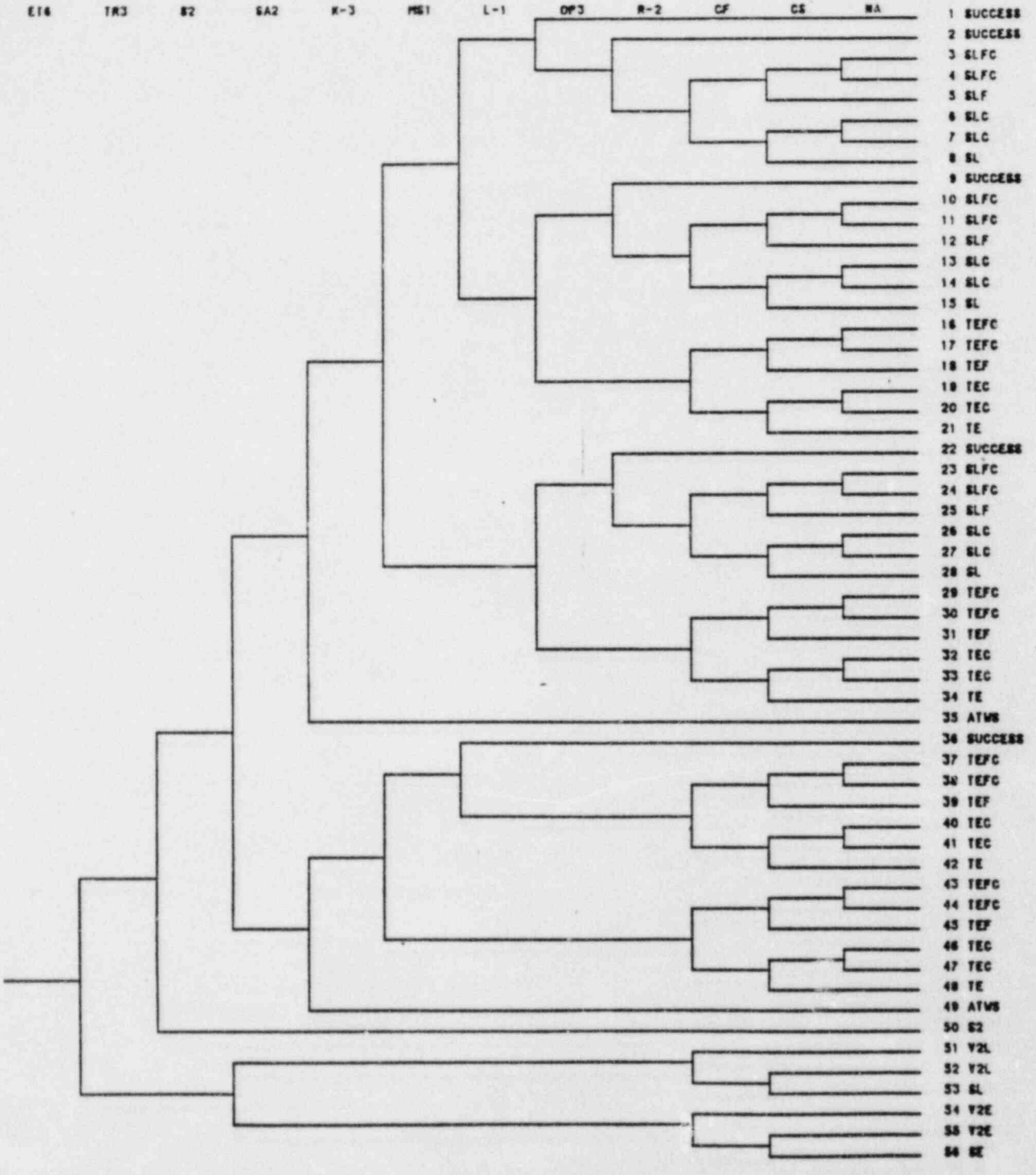


Figure 2-6 Secondary Break Outside Containment

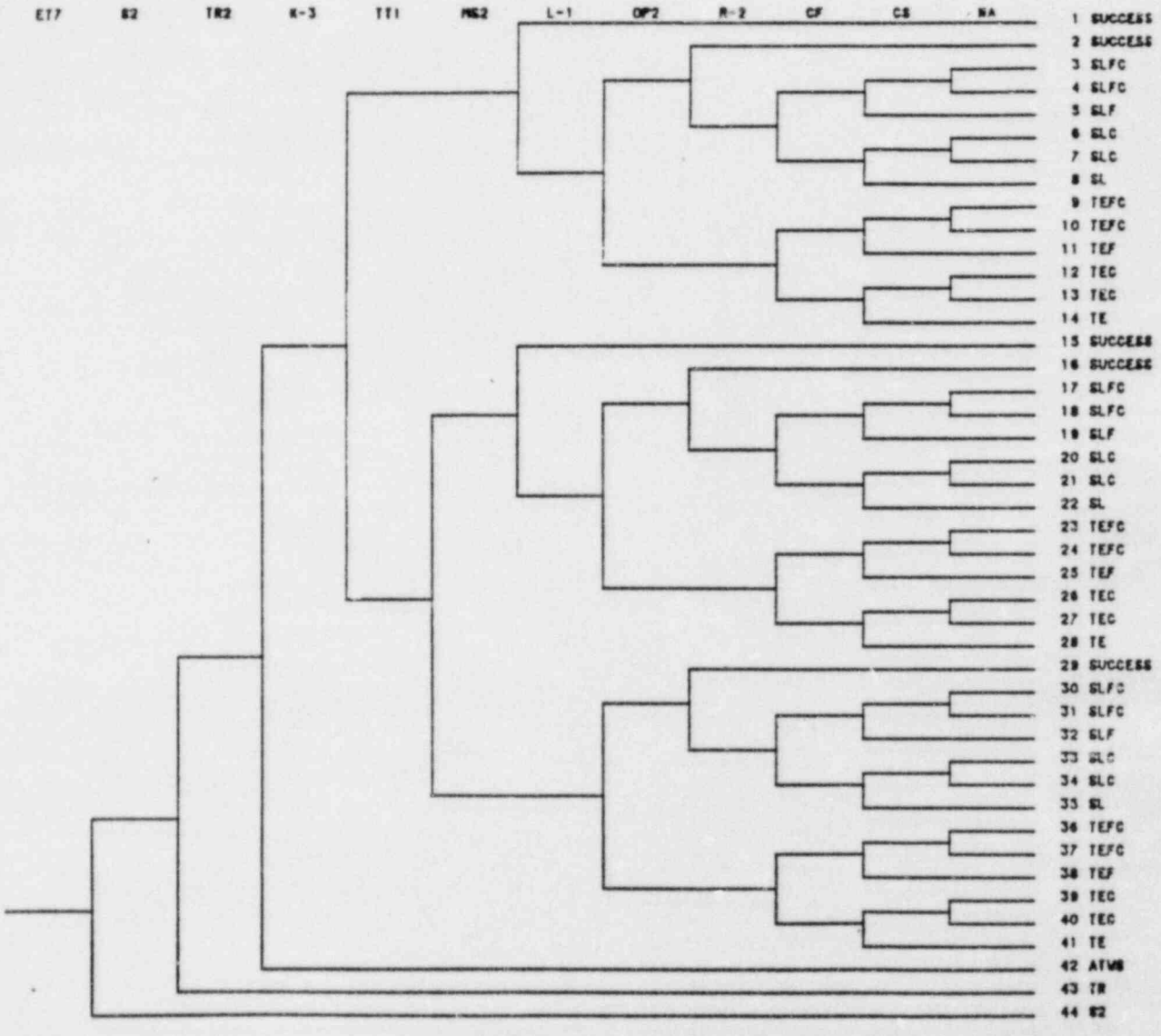


Figure 2-7 Loss of Main Feedwater

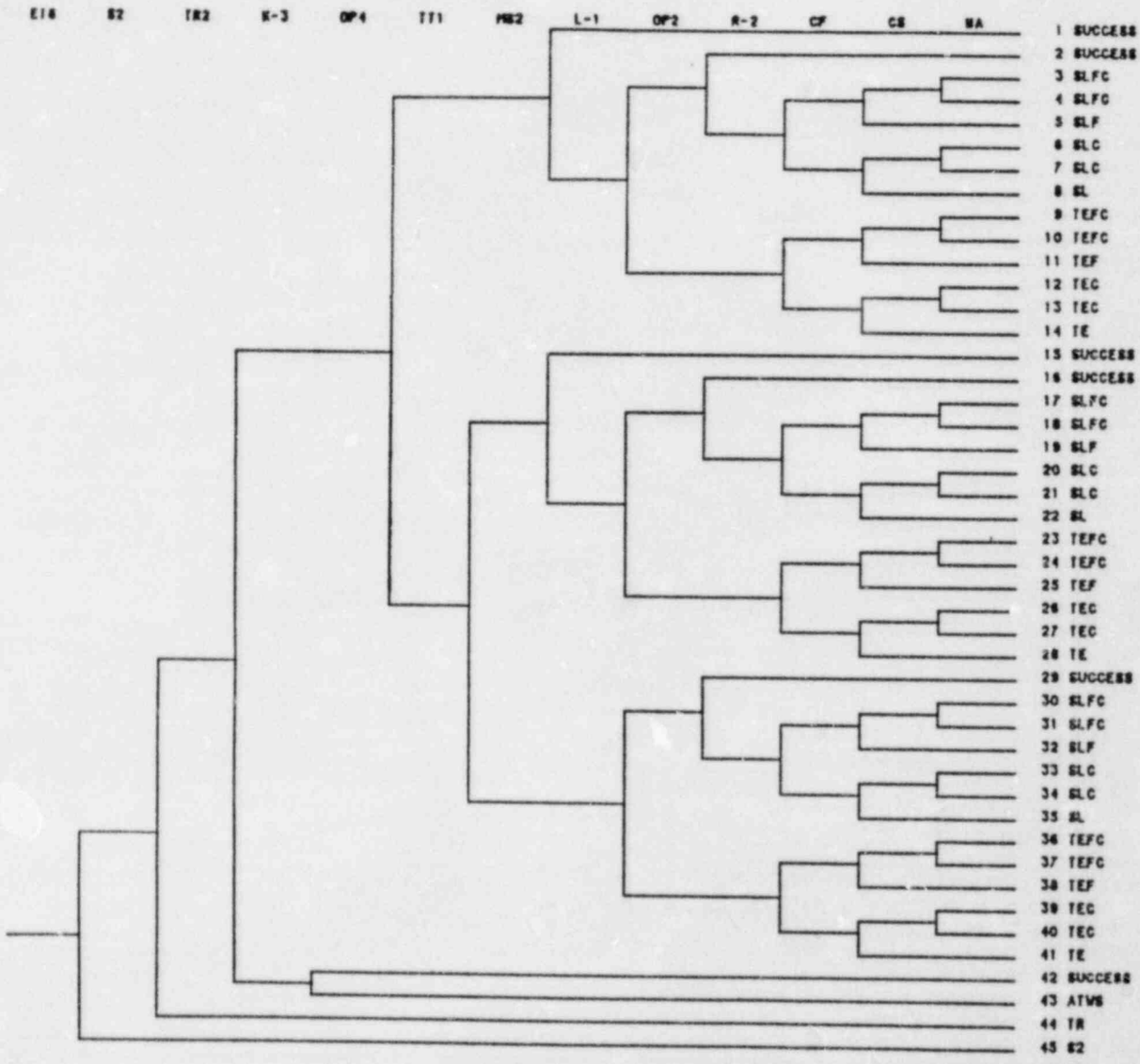


Figure 2-8 Closure of One MSIV

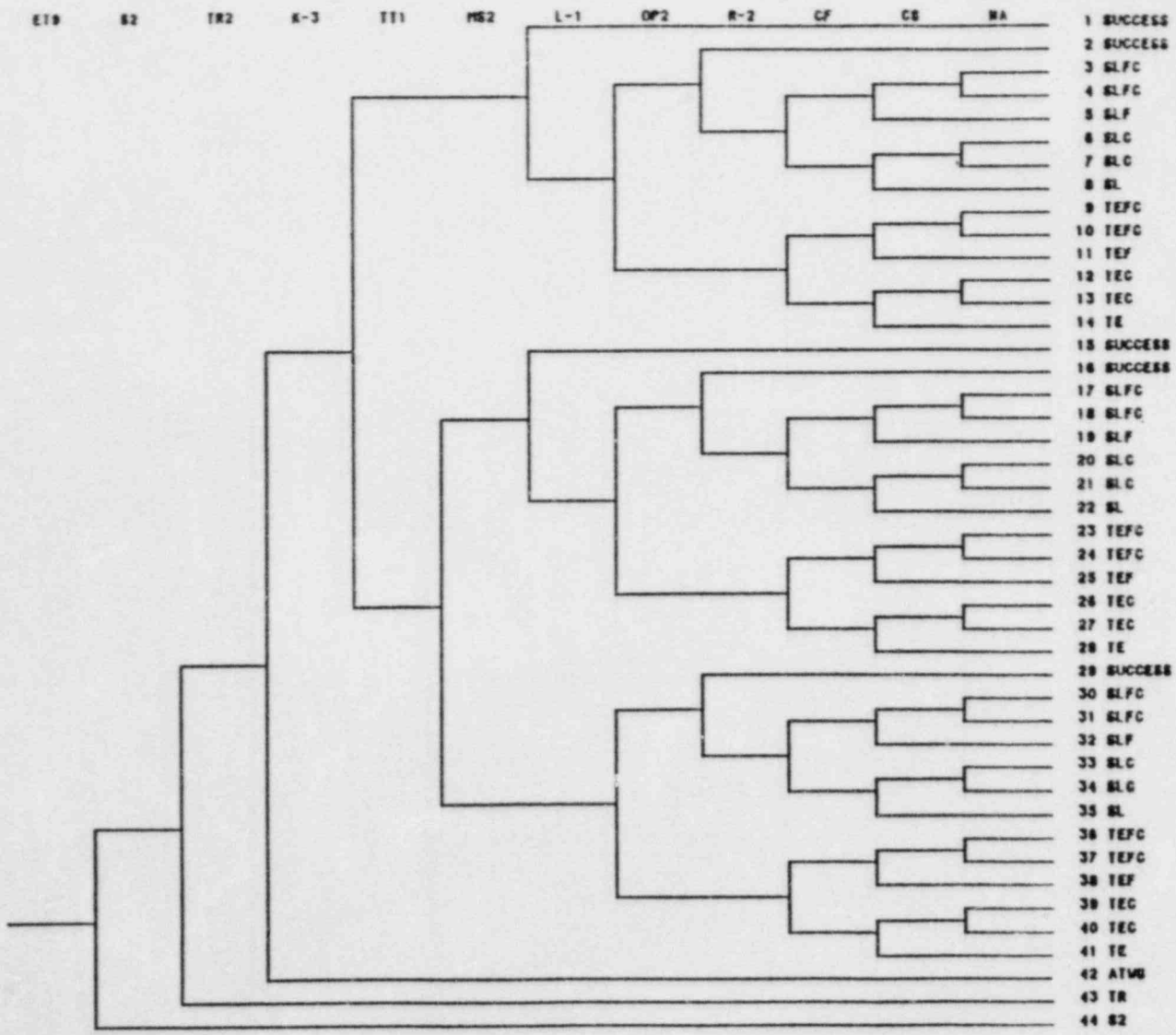


Figure 2-9 Loss of Reactor Coolant System Flow

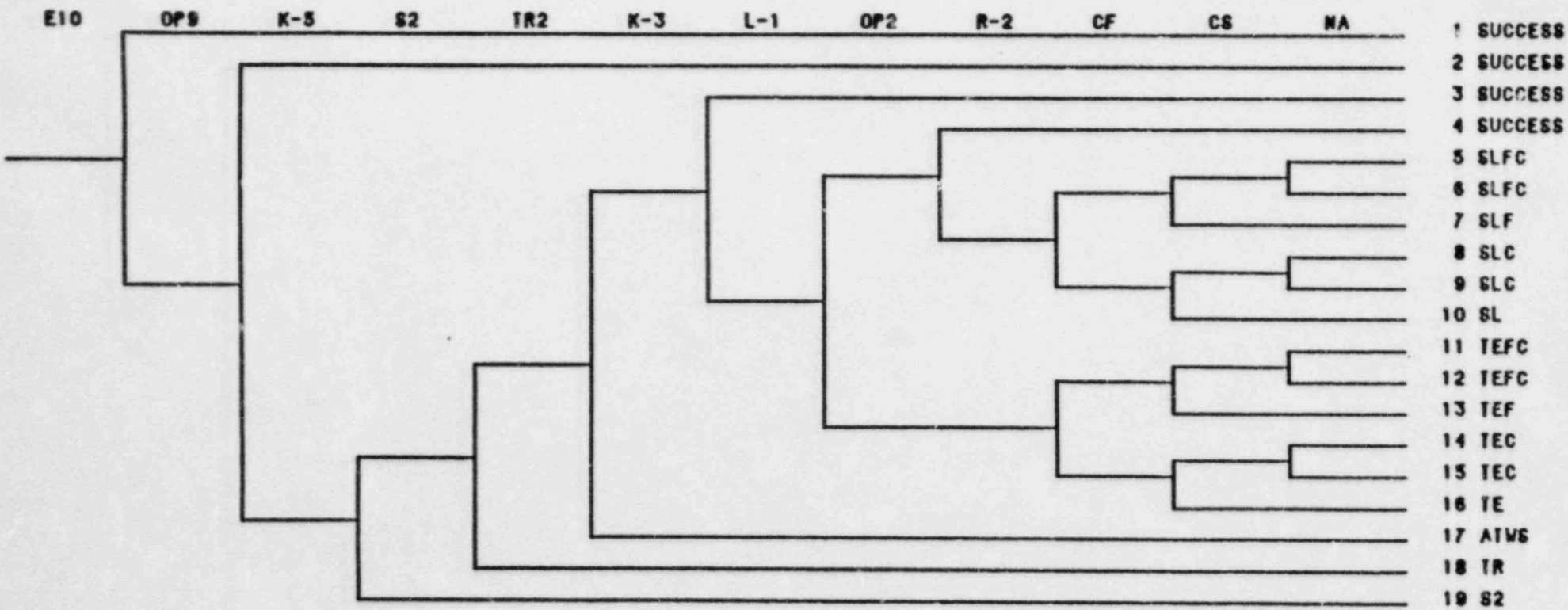


Figure 2-10 Core Power Excursion

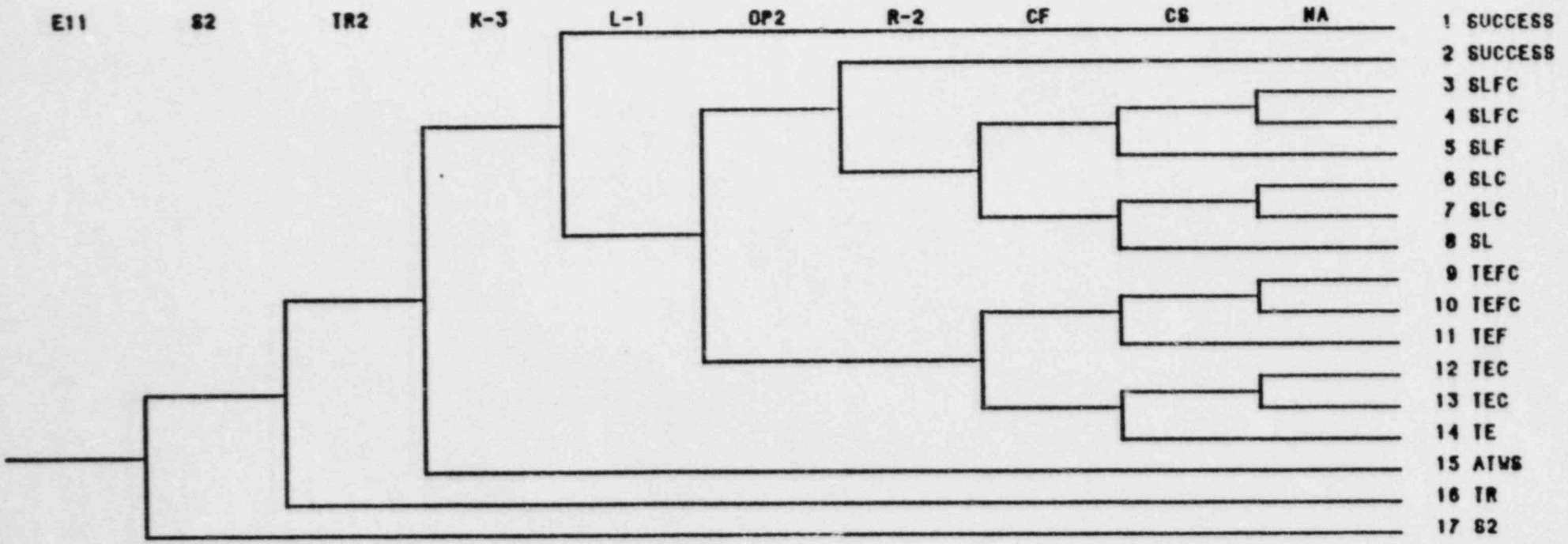


Figure 2-11 Turbine Trip

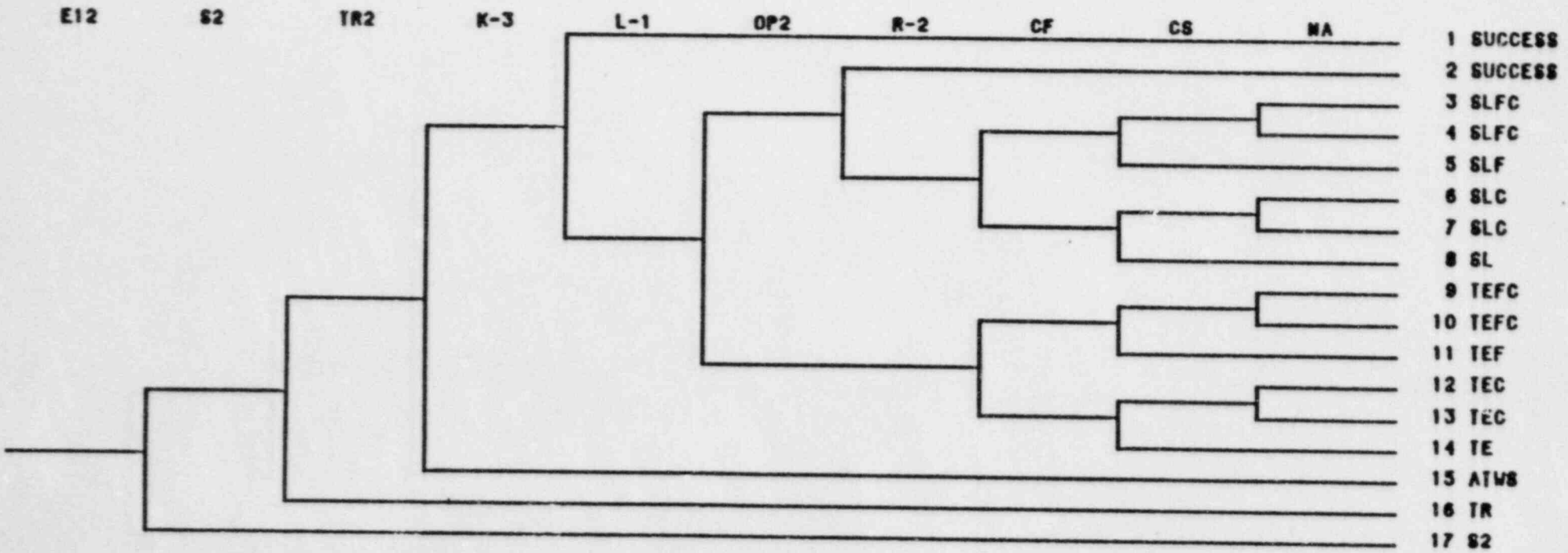


Figure 2-12 Loss of Offsite Power with Onsite Power Available

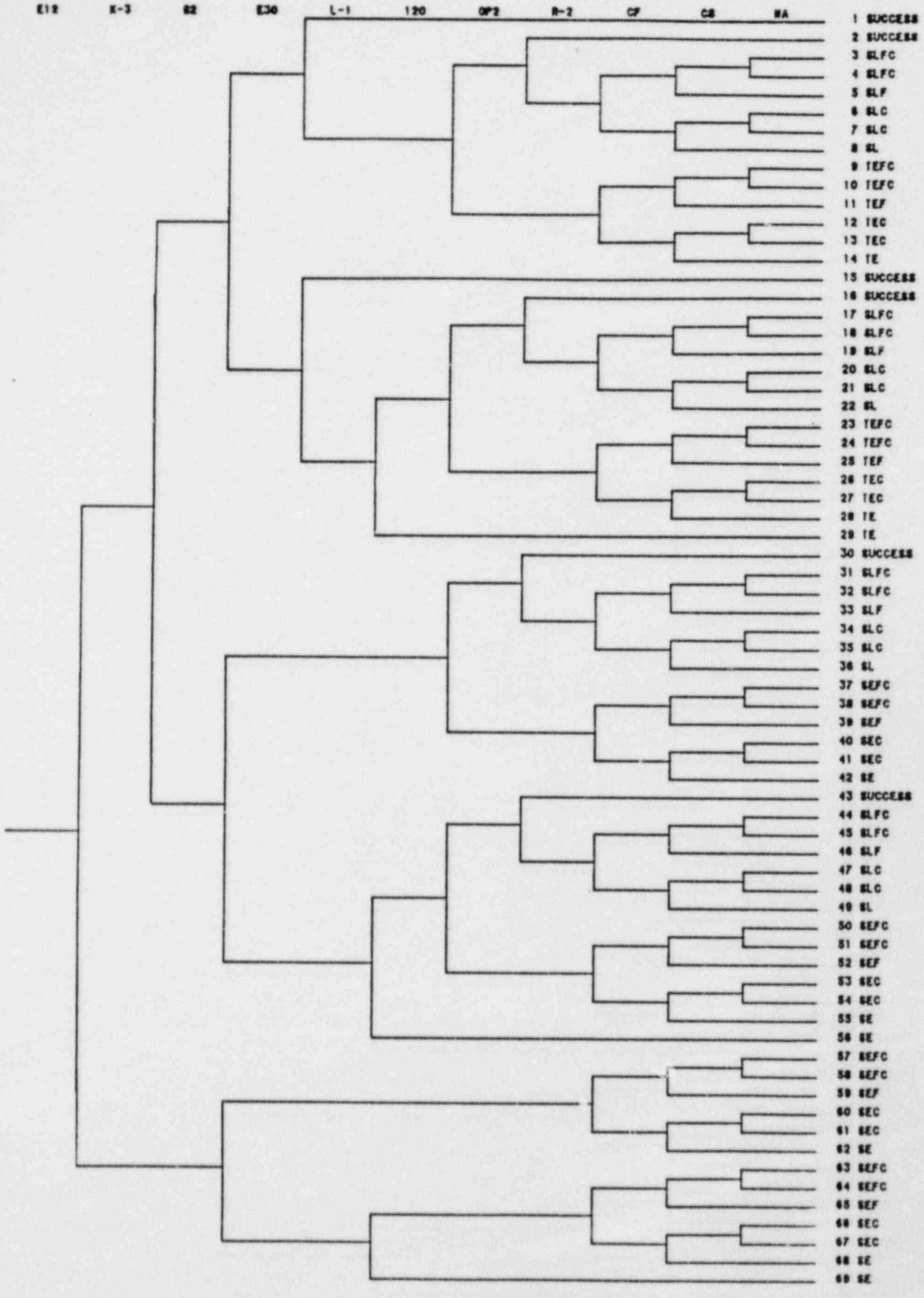


Figure 2-12A Loss of Offsite Power
with No Onsite AC Power Available

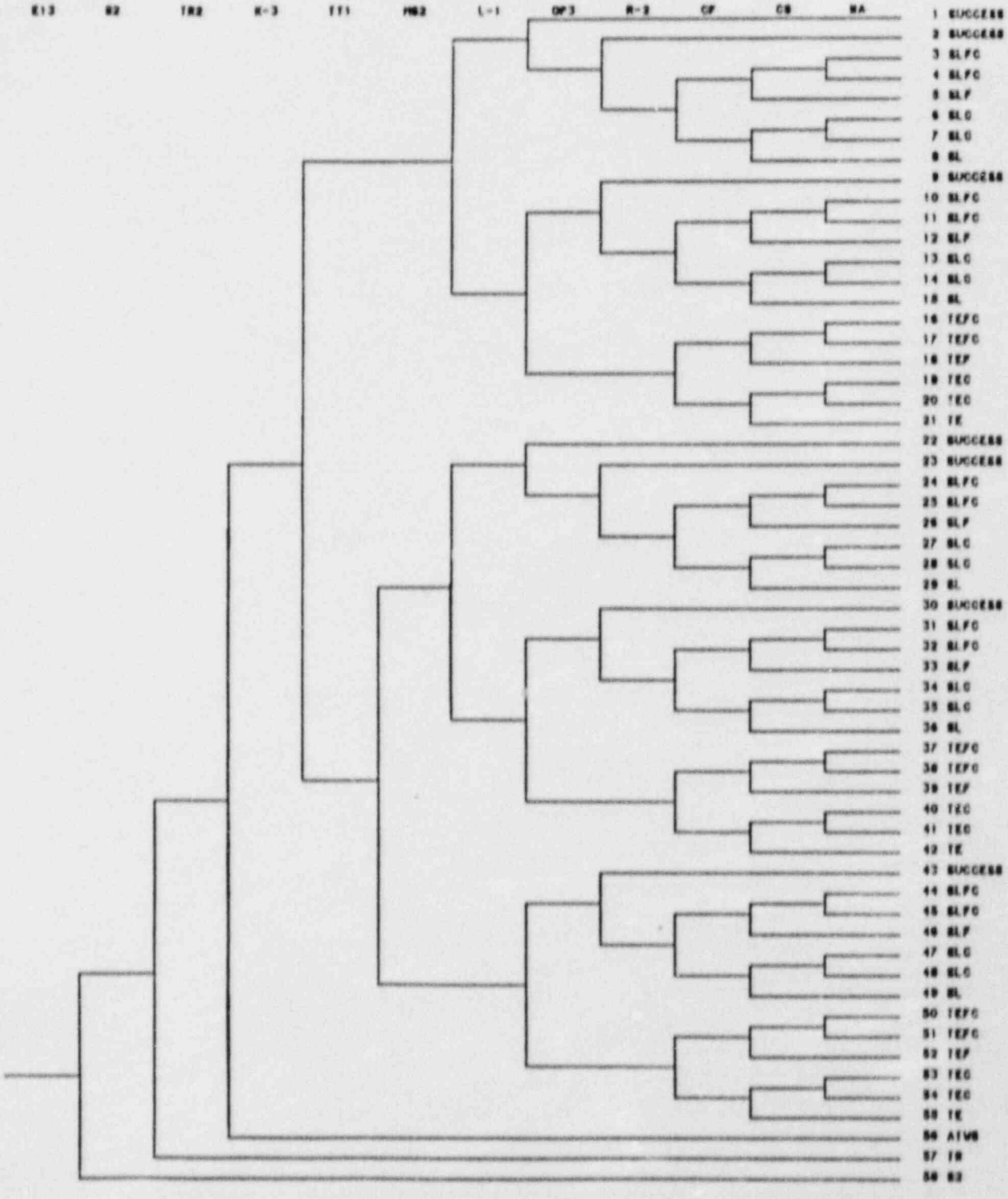


Figure 2-13 Spurious Safety Injection

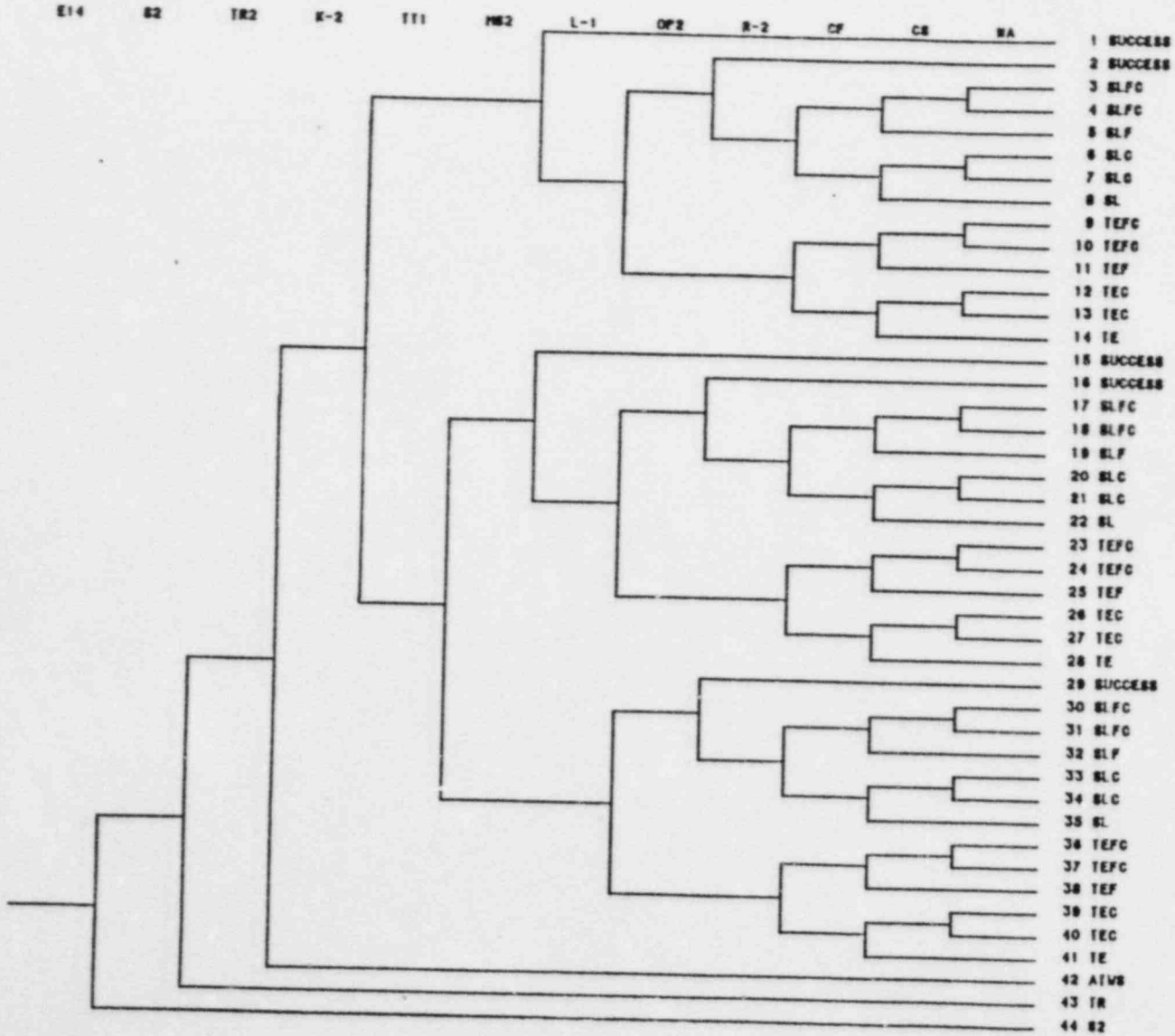


Figure 2-14 Reactor Trip

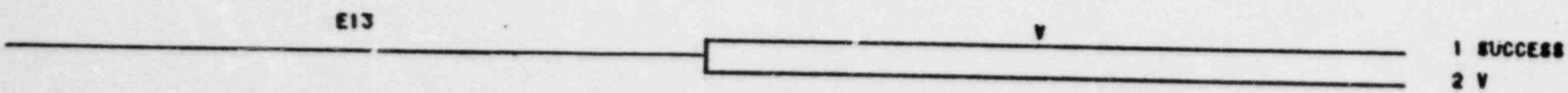


Figure 2-15 Interfacing Systems LOCA-V Sequence

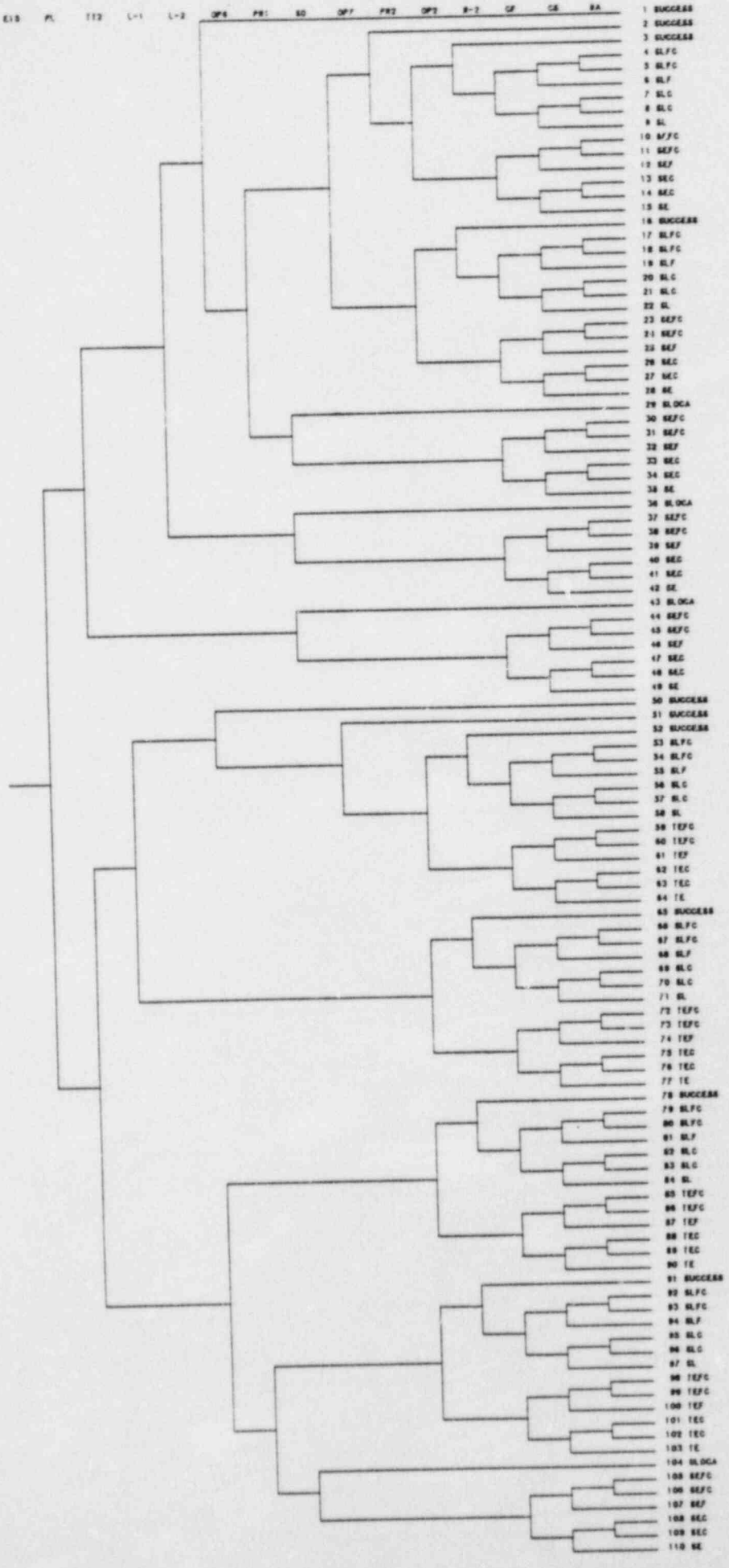


Figure 2-16 ATWS

APPENDIX 2A

EVENT TREE NODE DESCRIPTIONS

This appendix contains the top level event descriptions for both the event tree and fault tree analysis used in the present study. The node descriptions are arranged according to node type.

1. Component Cooling Water (CC)

This system is needed for long-term cooling. During the recirculation cooling mode, it provides cooling for the RHR pump and the RHR heat exchangers which cool the recirculation water from the containment sump. One component cooling water pump per unit can supply sufficient water for safeguards requirements. This system is shared between Units 1 and 2 and has great flexibility.

2. Containment Fan Coolers (CF)

Containment fan coolers provide long-term cooling for the containment atmosphere. They prevent overpressure and can effectively cool recirculation water from the containment sump. The success criterion for the fan coolers is three-out-of-five fan coolers operating in the emergency low speed mode. Because the heat sink for the fan coolers is the service water system, CF is analyzed conditional on success of the service water system. Note that, as the heat load is reduced after several hours, this criterion becomes quite conservative. Because of the shift to low speed, fan coolers at Byron station provide cooling for all conceivable pressures and temperatures within the containment.

3. Containment Spray (CS)

Containment spray protects the containment from overpressure failure and scrubs the containment atmosphere of radionuclides. These functions are important if core melt occurs because they reduce the chance of severity of releases. Event CS includes successful generation of an automatic or manual actuation signal. Automatic actuation occurs on high-high containment pressure, coincident with an SI signal. One-out-of-three pumps is required for success. Intermittent manual operation can be effective as long as water is available in the RWST.

4. High Head Injection (HH1)

Success requires that two-out-of-four high head pumps deliver water to the two-out-of-three intact header paths to the reactor coolant system.

5. High Head Injection (HH2)

Success requires that any one-out-of-four high head pumps deliver water to two-out-of-four header paths of the reactor coolant system.

6. AFWS Actuation and Secondary Cooling (L-1)

The auxiliary feedwater system success requires the start of one motor driven pump or the turbine driven pump in response to an automatic actuation signal or in response to operator action. The automatic signals to start the auxiliary feedwater pumps for this event tree come from low-low steam generator level.

Secondary cooling is achieved by removal of heat from the steam generator by the automatic or manual opening of a relief valve(s) associated with a steam generator(s) receiving auxiliary feedwater. Additional heat removal means are safety valves, steam dumps to the main condenser, or blowdown. Only the steam reliefs and safeties are modeled for secondary cooling as there is adequate cooling provided by this means alone.

Heat removal is only required from one steam generator to provide required cooling to the primary system. Given these conditions, the reactor core will be cooled by single-phase or two-phase natural circulation to the steaming steam generator.

7. AFWS Actuation and Secondary Cooling (L-2)

Success of this function involves providing feedwater flow to all steam generators from one turbine or two motor driven auxiliary feedwater pumps. Success may also be achieved by providing the equivalent flow from the main

feedwater system, however, no flow from this source is modeled. Success of this function also requires that there is an adequate heat transport mechanism from the reactor core to the steam generators. Thus, overpressurizations which result in loss of significant primary inventory or loss of natural circulation will fail this function even with the auxiliary feedwater system functional.

8. Low Pressure Injection and Accumulator Injection (LP)

For injection cooling to be successful, one-out-of-two RHR pumps and three-out-of-four accumulators must deliver flow to the reactor coolant system. Because delivery of accumulator flow into the ruptured loop would be ineffective, three-out-of-three accumulators must deliver flow to the three good legs. Core geometry must not have been so deformed by the blowdown forces that successful cooling is impossible. Although manual actuation of the LP system is possible, only starting due to an SA-1 signal is modeled.

9. Sodium Hydroxide Addition (NA)

Success involves proper lineup of the sodium hydroxide tank with the containment spray system to provide a high pH containment spray. Basic spray improves scrubbing of radioactive nuclides from the containment atmosphere. If the containment fails following core melt, improved scrubbing reduces the severity of any release.

10. Recirculation Cooling (R-1)

Following injection of the RWST water into the reactor coolant system, operators must realign the suction of at least one RHR pump from RWST to the containment sump. Success of this switchover operation involves both equipment success and human action success in a limited time frame. Time is a most important factor as difficulties in switchover from injection to recirculation can cause rapid fuel degradation. A great deal of care is given in procedures and training for plant operators in this area. This subsystem includes the containment sumps and the valves to the RHR pumps, and success includes the continued operability of the RHR pumps. In the recirculation

mode, with hot water flowing through the system, component cooling is necessary for the RHR pumps. The system is modeled conditional on the success of component cooling. When cooling is required via the RHR heat exchanger, the operator must successfully establish component cooling water flow to the RHR heat exchanger.

11. Recirculation Cooling (R-2)

Following the injection of the RWST water into the reactor coolant system, operators must realign the suction of the RHR pumps from the RWST to the containment sump, and realign the discharge of the RHR pumps to the charging pump suction or the safety injection pump suction to provide high pressure recirculation. Success of this switchover operation involves both equipment success and human action success; however, there is a less limiting time period involved here than for the large or medium LOCAs. The operator must also successfully establish component cooling flow to the RHR heat exchanger for continued core cooling.

12. Automatic Reactor Trip Given a Reactor Trip Signal (K-2)

The unavailability of K-2 is that of the scram breakers, wiring, and the CRDMs themselves.

13. Automatic Reactor Trip and RT Signal (K-3)

Failure of K-3 is simply failure of the signal from the appropriate protection system instrumentation to the reactor protection logic trains or K-2.

14. Automatic Runback (K-5)

Automatic runback is grouped with K-3, reactor trip, since, if rod control is in AUTO, the control rods will insert following turbine runback. The runback is generated from the overpower ΔT circuitry. If the runback is not successful, a reactor trip should develop.

15. MSIV Trip (MS-1)

The success of MS-1 requires closure of the steamline check valve, or trip of the MSIV, by either automatic or manual actuation. Automatic isolation of the MSIVs results from a high-high containment pressure signal. The operator is directed by the emergency operating procedures to manually close the MSIV for the faulted steam generator.

16. MSIV Trip (MS-2)

If TT does not occur, given that a reactor trip occurred, the operator can close the MSIVs manually to terminate the cooldown. As one MSIV is already closed, the steam generator associated with that MSIV can be used to provide secondary cooling.

17. Initial Power Level > 80 Percent (PL)

An upward event tree branch (PL>80 percent) means that the ATWS event can potentially lead to reactor coolant system pressures large enough to induce a LOCA and even disable safety injection. A downward branch (PL<80 percent) means that large pressure spikes cannot occur for all events with the exception of those scenarios which also include failure of TT-2. For these scenarios, OP-2 or OP-6 will be required; however, the challenge to the system is significantly less than for the scenarios in the upward branch of PL. This conclusion is based on very conservative assumptions with respect to component stress limits. In addition, since a large number of transient initiators are grouped together, transient progression (pressure rises) are substantially overpredicted.

18. ATWS Pressure Relief (PR-1)

When PL>80 percent, reactor coolant system relief is required to prevent exceeding 3,200 psia. Depending on the value of the moderator temperature coefficient, such capability

- Can be supplied by three pressurizer safety valves
- Can be supplied by three safety valves and one power-operated relief valve
- May not be possible.

The 3,200 psia criterion is a conservative lower bound on the pressure at which the reactor coolant system could fail with loss of safety injection function. Failure of a relief valve to reclose is not considered at this node (See PR-2).

19. Secure PR (PR-2)

When auxiliary feedwater is successful and the reactor is shut down, the transient can be terminated by securing the blowdown. This requires reseating of all three safety valves and reseating of the PORVs or manual closure of their block valves.

20. Safety Injection Actuation (SA-1)

The input signals which are generated are:

a. Low pressurizer pressure, less than 1,815 psig.
b. High containment pressure, greater than 4.5 psig.
c. Manual activation of the safety injection signal.

Success of SA-1 requires a safety injection (SI) signal resulting from any one of the three listed input sources. Startup of the equipment is included with the respective systems.

21. Safety Injection Actuation (SA-2)

The input signals which are generated are:

a. Low pressurizer pressure, less than 1,815 psig.
b. Manual actuation of the safety injection signal.

Success of SA-2 requires a safety injection signal resulting from any one of the two listed input signals and the startup of at least one-out-of-four high-head safety injection pumps. Any one charging or safety injection pump will satisfy this criteria. High pressure safety injection provides borated water to the RCS to maintain inventory and provides the boration necessary to establish adequate shutdown margin in the absence of a reactor trip.

22. Safety Injection System Operable (SO)

The chance of failing the safety injection system, given RCS pressure exceeding 3,200 psia.

23. Refueling Water Storage Tank (TK)

The refueling water storage tank provides the source of borated ($\geq$ 2,000 ppm) water necessary for low pressure injection and recirculation cooling of the core as well as containment spray following the large LOCA event. To be

successful, the tank must be available for use with a water level equal to greater than that required by the technical specifications, i.e., 350,000 gallons. Normal inventory is approximately 390,000 gallons. The system consists of the stainless steel-lined concrete tank and its water but no valves.

The RWST is alarmed in the control room to assist in detection of deviations from desired level. Each of the following components have a suction line from the RWST:

a. Each Containment Spray Pump
b. Centrifugal Charging Pumps (shared suction line)
c. Safety Injection Pumps (shared suction line)
d. Residual Heat Removal (RHS) Pumps (shared suction line).

24. Turbine Trip (TT-1)

Success of TT includes generation of automatic or manual turbine trip signals and actual trip of the turbine stop valves. The trip signal to the turbine is generated from the reactor protection circuitry given a reactor trip signal has been generated.

25. Turbine Trip/MSIV Closure (TT-2)

Success of this function involves rapid interruption of steam flow through the turbine via closure of the turbine throttle valve or main steamline isolation valve closure. The purpose of this function is to minimize steam generator water losses during the early phases of the transient, thus providing for a longer time before significant reductions occur in steam generator tube heat transfer. This will reduce pressurizer insurges which would reduce the potential for significant overpressures during the early phases of the transient. Failure to stop turbine steam load is assumed to result in severe overpressurization of the reactor coolant system.

26. E60 AC Power Recovery Within 60 Minutes

The modeling of E60 is implicit in the support states. If electric power is recovered, support states 5 and 6 for event tree 12 do not apply. If electric power is not recovered, E60 unavailability must be equal to 1.0.

27. 120 AC Power Recovery Between 60 - 120 Minutes

AC Power recovery up to 60 minutes is considered in the support state model. If the power is not recovered within 60 minutes, in the Loss of Offsite Power event, the node 120 is introduced to take credit for the use of containment safeguards functions to retain containment integrity core damage is conservatively postulated.

28. Primary Bleed (OP-1)

Primary Bleed is used in event tree small loss of coolant accident. The sequence of interest for this event is for the operator to establish primary feed and bleed given that the secondary cooling capability is failed and a high-head charging or safety injection pump has been successful. The operator must do the following:

1. Recognize that secondary cooling is lost.

2. Recognize that the size of the break is too small to allow adequate cooling with current injection flow.

3. Open either power-operated relief valve (PORV).

4. Verify that the primary system is stabilized with heat removal being equal to or greater than heat generation rate.

29. Primary Bleed and Feed (OP-2)

Primary bleed and feed is used in several of the transient event trees. The sequence of interest is for the operator to establish primary feed and bleed given that a reactor trip has occurred and secondary cooling has failed. The operator must do the following:

1. Recognize that auxiliary feedwater and secondary heat removal has failed.

2. Start a charging pump or safety injection pump (if pressure is low enough) and establish valve lineup if needed.

3. Open either power-operated relief valve (PORV).

4. Verify that adequate heat removal is taking place.

30. Control Primary Bleed and Feed (OP-3)

This action is used in the following event trees: Steam Break Inside Containment, Steam Break Outside Containment, and Spurious Safety Injection. The sequence of interest for these events is for the operator to: 1) control and stabilize the safety injection per his emergency operating procedures given that secondary heat removal is successful, and 2) bleed and feed given that secondary heat removal has failed and safety injection has occurred. When secondary cooling is failed, the event simplifies to OP-1.

31. Stabilize Transient (OP-4)

Operator stabilizing the transient is assumed in the Closure of One MSIV, and Core Power Excursion event trees. The sequence of interest is for the operator to stabilize the reactor coolant system given the initiating event, thereby terminating the transient. These actions taken by the operator are actions taken without tripping the plant and result in a controlled plant shutdown.

The action of the operator stabilizing the transient is included, for cases where it could be effective. In the case of Closure of One MSIV, it results in the plant operating in a three-loop mode until the plant is shut down in a controlled manner per normal operating procedures. The situation is possible if the plant was at low power levels when the MSIV was closed.

32. Control Rupture Flow (OP-5)

This action is used in the SGTR event tree. The success of this action depends on the operator(s) depressurizing and stabilizing the reactor coolant system at a pressure below that of the ruptured steam generator prior to filling the steam generator. This is done using the auxiliary feedwater system and steam reliefs or dumps and through the use of pressurizer sprays or pressurizer PORVs to cool and depressurize the primary system below the ruptured S/G pressure. After depressurization, the operators stabilize the RCS by terminating safety injection, controlling charging flow to maintain system inventory, and continued cooldown through the non-ruptured steam generators.

These operations are fully described in the emergency operating procedures for SGTR.

To meet the success criteria for OP-5, the operators must terminate rupture flow using the measures described above before significant carryover of liquid into the ruptured steam generator steamlines can occur. This significantly reduces the probability of challenging the ruptured steam generator relief valves with two phase flows. The time available for the operators to perform actions described for OP-5 depends on the size and number of tube ruptures. The time available is also dependent on safety injection flow since high safety injection capacity can hold the primary system pressure above the ruptured steam generator pressure.

33. Manual Reactor Trip (OP-6)

This action is used in the ATWS event tree. Should automatic reactor trip fail, many important failure modes are bypassed when the manual trip button is pressed. Also, unless the rods are physically hung up in the core, they can be driven using the rod control system. Success of OP-6 requires that the operator trip a manual trip and if it fails, that he try to drive rods.

34. Manual Deenergize to Drop RCCAs (OP-7)

This action is used in the ATWS event tree. Success at this action involves the operator manually tripping the reactor within 10 minutes of transient initiation by opening the control rod power supply motor-generator set supply breakers.

35. Depressurization and Makeup (OP-8)

This action is used in the SGTR tree. Several different actions are represented by operator control depressurization and makeup depending on the preceeding sequence of events.

1. Following successful actuation of safety injection (SA-2) and auxiliary feedwater (L-1) OP-8 requires continued cooldown of the RCS through the

use of the non-ruptured steam generators to the point where long-term cooling measures are employed (350°F and 400 psia). Inventory makeup is supplied by safety injection, charging, or backfilling the RCS through the ruptured steam generator. Coincident with this cooldown of the RCS the ruptured steam generator must be depressurized. This is accomplished by controlled blowdown of the ruptured S/G to the blowdown condenser, backfilling the RCS, or by steaming the S/G to the condenser or atmosphere.

2. Without auxiliary feedwater to the non-faulted steam generators continued cooldown of the RCS requires bleed and feed operation to be employed to the point where long-term cooling measures are employed.

3. The operators can only control the depressurization upon failure of safety injection. Hence, success of OP-8 requires cooldown to the point where long-term cooling measures are employed without severe inventory losses.

4. If high pressure safety injection has failed and a steam leak is present on the ruptured steam generator, the operator must establish some means of replenishing RCS inventory. Following the emergency procedures, the operator is advised to blowdown the unfaulted steam generators to atmospheric pressure. This may be accomplished by either blowing down the steam generators through the condenser (main steamline isolation or a loss of offsite power cannot be present) or through the steam generator PORVs to the atmosphere. Secondary depressurization can only be accomplished if auxiliary feedwater is available. Performing secondary depressurization concurrent with a SGTR and no high pressure safety injection will cause rapid depressurization of the primary system.

   In addition to secondary depressurization, low pressure safety injection must be available. Success of low pressure injection requires that one-out-of-two low pressure safety injection (RHR) pumps function. Complete success requires that the operator realize that high pressure safety injection has failed, RCS inventory is being lost out the steam leak, and low pressure safety injection is necessary to maintain RCS inventory and core coolability.

36. Stabilize Transient (OP-9)

Operator stabilizing the transient is assumed in the Closure of One MSIV, and Core Power Excursion event trees. The sequence of interest is for the operator to stabilize the reactor coolant system given the initiating event, thereby terminating the transient. These actions taken by the operator are actions taken without tripping the plant and result in a controlled plant shutdown.

For the Core Power Excursion event tree, it is possible for the operator to take action by emergency boratng or manually inserting control rods or changing power level on the turbine-generator. Here, positive action ends the transient while failure simply calls upon the next level of protection. While the time to act can be fairly short before backup measures are encountered (less than 15 minutes), the stress is low and the backup systems actuation serve to alert the operators.

37. Steam Leak Associated With Ruptured Steam Generator (LK)

This event considers a possible uncontrolled steam leak associated with the ruptured steam generator. The LK event examines the possible modes for steam leaks to occur; these include failure of main steam isolation valve together with turbine stop or steam dump valves, failure of the steam generator atmospheric relief valve and block valve, failure of steam generator safety valve, and failure of main steamline.

38. Multiple Tube Ruptures (MT)

This event considers the probability that more than one equivalent double-ended tube rupture occurs. The multiple tube ruptures may occur as the initiating event or as a consequential result of the initiating tube rupture. Success is defined as a tube rupture accident with equivalent rupture size less than or equivalent to one double-ended tube rupture. Separation of SGTR accidents into single and multiple ruptures enables approximate time windows for operator action to be developed.

39. Consequential Small LOCA Following Non-LOCA Initiating Events (S2)

The small LOCA consequential failures are defined as unisolated small breaks which are bounded by the small LOCA initiating event category defined in Section 1. Consequential small LOCAs are modeled as arising from three possible failures: first, passive failures such as ruptures in piping networks, second, active failures such as relief valves, and last, truly consequential failures due to the initiating event and support state condition such as degradation of reactor coolant pump seals.

Consequential small LOCA failures are considered in all transient event trees. In the loss of offsite power event tree, the impact of a small LOCA consequential failure for support states 5 and 6, which is defined as a total station blackout, is modeled within the event tree structure so that power recovery during the accident sequence can be included. Small LOCA

consequential failures are not considered in any LOCA event trees as either the LOCA break size bounds the event or to avoid infinite loops.

40. Consequential Multiple Tube Ruptures Following a LOCA (TR1)

This event considers the probability that three or more equivalent double-ended tube ruptures occur. The multiple tube ruptures may occur as a consequential result of the initiating event which in this case is specific to LOCA events. For a LOCA event the pressure differential is in a direction opposite to that of a feedwater or steamline break and the loading in case of a LOCA would be in a direction to seal off leaks or collapse tubes rather than cause a large leakage path. Extensive testing has shown that the strength requirement to guard against tube rupture during a postulated feedwater line or steamline break is always more limiting in terms of tube wall thickness than for a tube collapse for a postulated LOCA. Therefore, the unavailability of this node is bounded by that of TR3.

41. Consequential Single Tube Rupture Following a Non-LOCA Event (TR2)

This event considers the possibility that one or more double-ended tube rupture occur as a consequential result of a non-LOCA event other than a steamline or feedline break. The pressure differential and tube loadings are only slightly higher than nominal. Therefore, the unavailability of this node is consistent with the probability of a tube rupture event during normal operating conditions.

42. Consequential Multiple Tube Rupture Following a Secondary Line Break (TR3)

This event considers the possibility that three or more equivalent double-ended tube ruptures occur as a consequential result of a steamline or feedline break. This is the most limiting initiating event for a consequential tube rupture due to the very large primary to secondary differential pressures experienced by the steam generator tubes of the faulted steam generator.

APPENDIX 2B

SUCCESS CRITERIA

Once the preliminary plant system event trees have been developed, success criteria for each event tree system must be defined. The system success criteria are then translated to statements defining the criteria for system failures which then become the top level events in the development of system fault trees. The fault tree analysts can then determine system unavailabilities which will be fed into the event tree quantification. Finally, by sorting all the event tree accident sequences in terms of success or failure based on event tree success criteria, the conditional probability of success or failure is obtained.

The fault tree models require exactly defined failure criteria which are translated from the success criteria for each event tree system. However, failure and success criteria can not always be considered as logic opposites of each other, since previous system failures in the accident sequence may dictate that either some system equipment is unavailable or that other equipment within the system must operate. Each system success criterion must be defined in respect to particular accident sequences or to particular system event trees. Bounding the success criteria in such a manner affects the fault tree top events and thus the fault tree logic. However, by careful accident sequence modeling and use of the support state model, only a limited number of these type of effects had to be considered. The success criteria defined for the systems notes used in the event tree nodes is given by Table 2B-1. The event tree success criteria is given by Table 2B-2.

TABLE 2B-1

SYSTEM SUCCESS CRITERIA

SYSTEM	EVENT TREES	SUCCESS CRITERIA	OPERATOR ACTIONS	DEPENDENCIES	RUN TIME
Auxiliary Feedwater L-1	1) All except medium LOCA and large LOCA	Either auxiliary feedwater pump feeding at least one steam generator	Confirm operation of system	1) Condensate storage tank 2) Electric power (141) 3) Actuation signal	Must start within 30 minutes and run for 5 hours
L-2	1) ATWS	Either auxiliary feedwater pump feeding all four steam generators	Confirm operation of system	1) Condensate storage tank 2) Electric power (141) 3) Actuation signal	Run for 5 hours
Low Pressure Recirculation Cooling (RHR) R-1	1) Large LOCA 2) Medium LOCA	One-out-of-two RHR pumps delivering flow into at least one available cold leg of the reactor coolant system.	1) Confirm operation of system 2) Close flow path to RWST 3) Open flowpaths to CCW system	1) Electric power 2) Service water 3) Actuation signal 4) Water in sump 5) Component Cooling Water	Run for 23 hours following low pressure injection
High Pressure Recirculation Cooling R-2	1) All event trees except large and medium LOCA	One-out-of-two RHR pumps delivering flow to the suction of the high pressure injection pumps.	1) Realign system 2) Confirm operation of system	1) Electric power 2) Service water 3) Actuation signal 4) Water in sump 5) Component Cooling Water	Run for 23 hours following high pressure injection
Containment Spray CS	1) All event trees except steam generator tube rupture	1 containment spray pump delivering flow to one containment spray header	1) Confirm operation of system	1) Electric power 2) Actuation signal 3) RWST	Run for 2 hours
High Pressure Safety Injection HH1	1) Medium LOCA	Two-out-of-four high pressure pumps delivering flow to 2 of 3 intact header paths of the reactor coolant system	1) Confirm operation of system	1) Electric power 2) Service water 3) Actuation signal 4) RWST	Run for 1 hour followed by high pressure recirculation
HH2	1) Small LOCA	1 out 4 high pressure pumps delivering flow to 2 of 4 header paths of the reactor coolant system	1) Confirm operation of system	1) Electric power 2) Service water 3) Actuation signal 4) RWST	Run for 1 hour followed by high pressure recirculation

TABLE 2B-1 (Continued)

SYSTEM SUCCESS CRITERIA

SYSTEM	EVENT TREES	SUCCESS CRITERIA	OPERATOR ACTIONS	DEPENDENCIES	RUN TIME
Low Pressure Injection System LP	1) Large LOCA 2) Medium LOCA	One-out-of-two low pressure safety injection pumps delivering flow into at least one available cold leg of the reactor coolant system along with the successful discharge of 3 accumulators into 3 intact RCS loops.	1) Confirm operation of system	1) Electric power 2) Actuation signal 3) RWST	Run for 1 hour followed by low pressure recirculation
Service Water ESW	1) All event trees	1) Two service water trains in operation 2) One service water train in operation	1) Confirm operation of system 2) Align common CCW heat exchanger	1) Electric power	Run for 24 hours
Component Cooling Water CC	1) All LOCA trees	1) Two CCW trains in operation 2) One CCW train in operation	1) Confirm operation of system 2) Align common CCW heat exchanger	1) Electric power	Run for 24 hours
Electrical Power	1) All event trees	1) Two ESF buses energized 2) One ESF bus energized	1) Confirm operation of system	1) Offsite Power 2) Diesel generators and actuation signal	Available for 24 hours
Refueling Water Storage Tank TK	1) All event trees	Available with inventory equal to or greater than technical specification	None	1) Chilled water system	Not applicable
Main Steam Isolation MS-1	1) Secondary line break	Isolation of faulted steam generator - closure of either one-out-of-one main steam isolation valve (MSIV) or closure of three-out-of-three MSIVs	Confirm closure	1) Signal actuation	Not applicable
MS-2	1) Loss of Feed 2) Single MSIV Closure 3) Low RCS Flow 4) Spurious SI 5) Reactor Trip	Closure of all MSIV's	Initiate steam line isolation	None	Not applicable

TABLE 2B-1 (Continued)

SYSTEM SUCCESS CRITERIA

SYSTEM	EVENT TREES	SUCCESS CRITERIA	OPERATOR ACTIONS	DEPENDENCIES	RUN TIME
Reactor Protection System K-3	1) All event trees except reactor trip ATWS and the large and medium LOCA event trees	Generation of reactor trip signal and insertion of reactor control rods	Confirm trip	1) Signal actuation	Not applicable
K-2	1) Reactor trip	Insertion of reactor control rods	Confirm trip	None	Not applicable
Turbine Trip TT-1	1) Loss of Feed 2) Single MSIV Closure 3) Low RCS Flow 4) Spurious SI 5) Reactor Trip	Closure of all turbine stop or control valves	Confirm trip	None	Not applicable
Turbine Trip TT-2	1) Anticipated transients without scram	Closure of all turbine stop or control valves	Confirm trip	None	Not applicable
Containment Fan Coolers CF	1) All event trees	Two out of four fan coolers available	Confirm operation of system	1) Electric power 2) Actuation signal	Run for 24 hours
Sodium Hydroxide Addition NA	1) All event trees except steam generator tube rupture	Sodium hydroxide addition to containment spray system	Confirm operation of system	1) Electric power 2) Actuation signal 3) Containment spray	Run for 2 hours

TABLE 2B-2

EVENT TREE SUCCESS CRITERIA[1]

EVENT TREE	SYSTEMS REQUIRED	OPERATOR ACTIONS	PLANT FUNCTIONS OR EQUIPMENT REQUIRED
Large LOCA	1) Low pressure injection system (LP) 2) Low pressure recirculation cooling (R-1)	None	1) Safety injection actuation signal 2) Refueling water storage
Medium LOCA	1) High pressure safety injection (HH1) 2) Low pressure injection system (LP) 3) Low pressure recirculation cooling (R-1)	None	1) Safety injection actuation signal 2) Refueling water storage
Small LOCA	1) High pressure safety injection (HH-2) 2) Auxiliary feedwater (L-1) 3) High pressure recirculation cooling (R-2)	1) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Safety injection actuation signal 3) Refueling water storage tank
	1) High pressure safety injection (HH-2) 2) High pressure recirculation cooling (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Safety injection actuation signal 3) Refueling water storage tank 4) Pressurizer PORVs

Note 1 The table only gives the success criteria in terms of front line event tree systems; support systems are not shown.

TABLE 2B-2 (Continued)

EVENT TREE SUCCESS CRITERIA

EVENT TREE	SYSTEMS REQUIRED	OPERATOR ACTIONS	PLANT FUNCTIONS OR EQUIPMENT REQUIRED
Steam Generator Tube Rupture	1) High pressure safety injection (HH-2) 2) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-3) 2) Safety injection actuation signal 3) Refueling water storage tank 4) Assumes no leak
	1) High pressure safety injection (HH-2) 2) High pressure recirculation cooling (R-2)	1) Initiate bleed and feed cooling (if no leak) 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Safety injection actuation signal 3) Refueling water storage tank 4) Pressurizer POKVs
	1) Auxiliary feedwater (L-1) 2) High pressure recirculation cooling (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Safety injection actuation signal 2) Refueling water storage tank 3) Steam relief valves 4) Pressurizer PORVs 5) Reactor Trip (K-3)
	1) Auxiliary feedwater (L-1) 2) High pressure injection system (HH-2) 3) High pressure recirculation cooling (R-2)	1) Depressurize primary system using auxiliary feedwater and steam relief valves 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Safety injection actuation signal 3) Refueling water storage tank 4) Steam relief valves 5) Assumes secondary leak

TABLE 2B-2 (Continued)

EVENT TREE SUCCESS CRITERIA

EVENT TREE	SYSTEMS REQUIRED	OPERATOR ACTIONS	PLANT FUNCTIONS OR EQUIPMENT REQUIRED
Steamline Break Inside Containment	1) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-3) 2) Safety injection actuation signal 3) Main steam isolation (MS-1)
	1) High pressure safety injection (SA-2) 2) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Safety injection actuation signal 3) Refueling water storage tank 4) Pressurizer PORVs
	1) High pressure safety injection (SA-2) 2) High pressure recirculation (R-2) 3) Auxiliary Feedwater (L-1)	1) Realign containment recirculation spray system to RCS recirculation	1) Safety injection actuation signal 2) Reactor trip (K-3) 3) Refueling water storage tank 4) Main steam isolation (MS-1)
	1) High pressure safety injection (SA-2) 2) Auxiliary Feedwater (L-1)	1) Initiate feed and bleed cooling	1) Safety injection actuation signal 2) Reactor trip (K-3) 3) Refueling water storage tank 4) Main steam isolation (MS-1) 5) Pressurizer PORVs

TABLE 2B-2 (Continued)

EVENT TREE SUCCESS CRITERIA

EVENT TREE	SYSTEMS REQUIRED	OPERATOR ACTIONS	PLANT FUNCTIONS OR EQUIPMENT REQUIRED
Steamline Break Outside Containment	1) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-3) 2) Safety injection actuation signal 3) Main steam isolation (MS-1)
	1) High pressure safety injection (SA-2) 2) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Safety injection actuation signal 3) Refueling water storage tank 4) Pressurizer PORVs
	1) High pressure safety injection (SA-2) 2) High pressure recirculation (R-2) 3) Auxiliary Feedwater (L-1)	1) Realign containment recirculation spray system to RCS recirculation	1) Safety injection actuation signal 2) Reactor trip (K-3) 3) Refueling water storage tank 4) Main steam isolation (MS-1)
	1) High pressure safety injection (SA-2) 2) Auxiliary Feedwater (L-1)	1) Initiate feed and bleed cooling	1) Safety injection actuation signal 2) Reactor trip (K-3) 3) Refueling water storage tank 4) Main steam isolation (MS-1) 5) Pressurizer PORVs

TABLE 2B-2 (Continued)

EVENT TREE SUCCESS CRITERIA

EVENT TREE	SYSTEMS REQUIRED	OPERATOR ACTIONS	PLANT FUNCTIONS OR EQUIPMENT REQUIRED
Loss of Main Feedwater	1) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-3) 2) Turbine trip (TT-1) or MSIV Closure (MS-2)
	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Pressurizer PORVs
Loss of Reactor Coolant Flow	1) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-3) 2) Turbine trip (TT-1) or MSIV closure (MS-2)
	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Pressurizer PORVs
Closure of One MSIV	1) None	1) Operator stabalizes transient	Not applicable.
	1) Auxiliary Feedwater (L-1)	None	1) Reactor trip (K-3) 2) Turbine trip (TT-1) or MSIV closure (MS-2)

TABLE 2B-2 (Continued)

EVENT TREE SUCCESS CRITERIA

EVENT TREE	SYSTEMS REQUIRED	OPERATOR ACTIONS	PLANT FUNCTIONS OR EQUIPMENT REQUIRED
Closure of One MSIV (Cont.)	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Pressurizer PORVs
Turbine Trip	1) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-3)
	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Pressurizer PORVs
Reactor Trip	1) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-2) 2) Turbine trip (TT-1) or MSIV closure (MS-2)
	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-2) 2) Pressurizer PORVs

TABLE 2B-2 (Continued)

EVENT TREE SUCCESS CRITERIA

EVENT TREE	SYSTEMS REQUIRED	OPERATOR ACTIONS	PLANT FUNCTIONS OR EQUIPMENT REQUIRED
Core Power Excursion	1) None	1) Operator stabalizes transient	Not applicable
	1) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-3)
	1) Turbine runback	None	Not applicable
	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Pressurizer PORVs
Spurious Safety Injection	1) Auxiliary feedwater (L-1)	1) Initiate bleed and feed cooling	1) Reactor trip (K-3) 2) Pressurizer PORVs 3) Turbine trip (TT-1) or MSIV closure (MS-2)
	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Pressurizer PORVs
	1) Auxiliary feedwater (L-1) 2) High pressure recirculation (R-2)	1) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Turbine trip (TT-1) or MSIV closure (MS-2)

TABLE 2B-2 (Continued)

EVENT TREE SUCCESS CRITERIA

EVENT TREE	SYSTEMS REQUIRED	OPERATOR ACTIONS	PLANT FUNCTIONS OR EQUIPMENT REQUIRED
Loss of Offsite Power-Support States 1,2,3,4	1) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-3)
	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Pressurizer PORVs
Loss of Offsite Power-Support States 5,6	1) Auxiliary feedwater (L-1)	None	1) Reactor trip (K-3) 2) Power recovery 3) No reactor coolant pump seal LOCA
	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation	1) Reactor trip (K-3) 2) Power recovery 3) Pressurizer PORVs
Interfacing Systems LOCA	None	None	None

TABLE 2B-2 (Continued)

EVENT TREE SUCCESS CRITERIA

EVENT TREE	SYSTEMS REQUIRED	OPERATOR ACTIONS	PLANT FUNCTIONS OR EQUIPMENT REQUIRED
Anticipated Transients Without Scram	1) Auxiliary feedwater (L-2)	1) Initiate reactor trip (OP7)	1) Turbine trip (TT-2) 2) Power level $\leq$ 80 percent (PL $\leq$ 80 percent) 3) ATWS pressure relief (PR1 and PR2)
	1) High pressure recirculation (R-2)	1) Initiate bleed and feed cooling 2) Realign containment recirculation spray system to RCS recirculation 3) Initiate reactor trip (OP6)	1) Pressurizer PORVs
	1) Auxiliary feedwater (L-1 or L-2)	1) Initiate reactor trip (OP6 or OP7)	1) Turbine trip (TT2) 2) Power level $\leq$ 80 percent (PL $\leq$ 80 percent)
	1) High pressure recirculation (R-2)	1) Realign containment recirculation spray system to RCS recirculation	1) Turbine trip (TT2) or ATWS pressure relief (PR1) 2) Pressurizer PORVs

APPENDIX 2C

SUPPORT STATE MODEL

The availability of AC power on the ESF buses 141 and 142 affects the response of the plant systems during event sequences and the success of the outcome. Loss of power on one of these two buses will disable one train of the many engineered safety systems, thus, reducing them effectively to one train systems. Also the emergency service water system affects the success of many front line systems. The dependence of front line systems on the two major support systems is given by Table 2C-1. To treat this important effect (the dependence of the front line systems in these two major support systems), the following six support states are defined:

Support State	Systems Available	Probability (Split Fraction)
1	141, 142 and ESW	S_1
2	141 and 142, no ESW	S_2
3	142 and ESW	S_3
4	141 and ESW	S_4
5	ESW only	S_5
6	None	S_6

The sum of the split fractions for each of these states add up to 1:

$$1 = S_1 + S_2 + S_3 + S_4 + S_5 + S_6.$$

During each accident sequence, the plant is modeled to be in each of the six support states, with a probability of S_i ($i = 1, 2, 3, 4, 5, 6$). The split fractions for support states are modeled (see Figure 2C-1) and calculated in Section 4.1 and 4.2. Power recovery is taken into account in transients and also in the loss of offsite power initiating event.

When the plant is in a support state, each event tree node probability is calculated, given the support system availabilities associated with that power state. For example, if the plant is in the third power state (142 is available, 141 is lost), the low pressure injection reliability is calculated based on availability of one RHR pump, the one that is powered from the 142 ESF bus. If that pump is in maintenance, then low pressure safety injection function will be unavailable.

TABLE 2C-1

DEPENDENCE OF FRONT LINE SYSTEMS ON SUPPORT SYSTEMS

Event Tree Node	Front Line Systems	ESF Buses 141 and 142	ESW
LP	Low Pressure Injection	X	-
R-1	Low Pressure Recirculation	X	X
HH1/HH2	High Pressure Injection	X	X
	High Pressure Recirculation	X	X
L-1/L-2	Auxiliary Feedwater System	X	X
CF	Containment Fan Coolers	X	X
CS	Containment Spray System	X	-
NA	Sodium Hydroxide Addition System	X	-
-	Emergency AC System	-	X
-	Component Cooling System	X	X
-	Service Water System	X	X
-	Offsite AC Power System	-	-

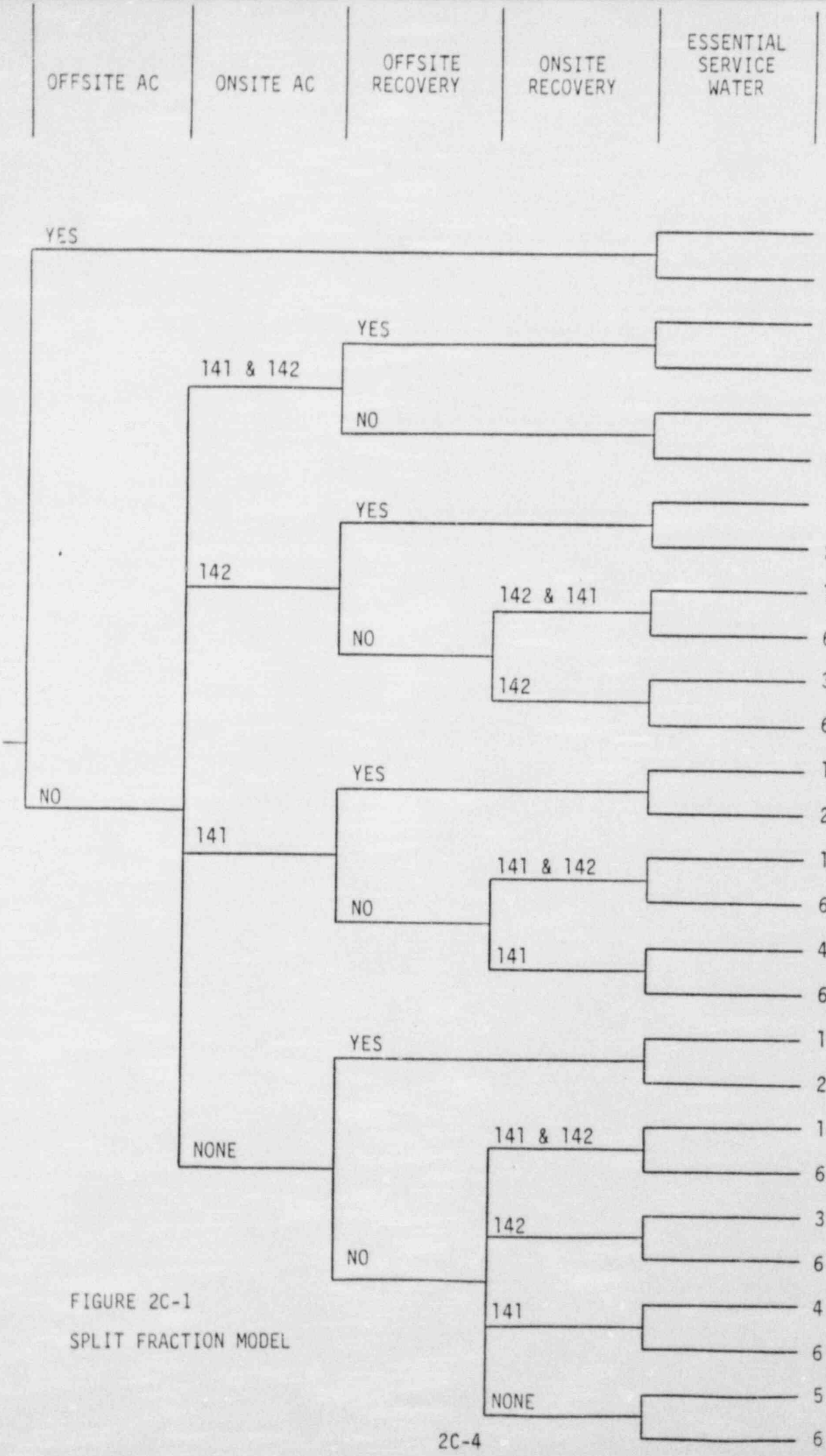


FIGURE 2C-1

SPLIT FRACTION MODEL

APPENDIX 2D

PLANT DAMAGE STATE CLASSIFICATION

The plant system event tree models display the possible accident scenarios following a given initiating event. These accident scenarios are sorted into either plant damage states or success states. This sorting process between plant damage states and success is based on analytical analysis and response of mitigating systems. The accident success criteria which provides the basis for sorting between damage states and success is given in Appendix 2B.

Plant damage states represent groups of possible accident sequences classified by a discrete set of accident conditions that describe the type of accident, the timing of core melt, and operational status of the safeguard features. This selection of classification is based on preserving relevent information on each sequence and to ensure that the plant analysis results can be organized in a manageable form. The definition and nomenclature for each plant damage state was kept as consistent as possible to recent comprehensive PRA studies for comparative purposes.

Table 2E-1, Definition and Nomenclature of Plant Damage States, explains and defines each of the damage states. Each plant damage state title is composed of a single letter identifier for type of accident, timing of core melt and containment safeguards operation status. For example:

The ALC plant damage state is composed of the following letter identifiers that describe the conditions of all accident sequences that are represented by ALC:

A - Type of Accident, Large LOCA
L - Time of Core Melt, Late
C - Containment Safeguards Operational Status; Containment Sprays Operational. (Containment Fan Coolers Failed).

The SEF plant damage state:

S - Type of Accident, Small LOCA
E - Time of Core Melt, Early
F - Containment Safeguards Operational Status; Containment Fan Coolers Operational. (Containment Sprays Failed).

The TECF plant damage state:

T - Type of Accident, Transient
E - Time of Core Melt, Early
FC - Containment Safeguards Operational Status; Both Containment Fans and Fan Coolers operational.

The SE plant damage status:

S - Type of Accident, Small LOCA
E - Time of Core Melt, Early
(Absence of the containment safeguards operational status identifier implies failure of containment fan coolers and sprays).

In all, 23 plant damage states represent the hundreds of possible accident sequences modeled by the system event trees. These damage states present the plant analysis results in a manageable form, but yet, pass on sufficient information about each accident sequence they represent to permit a meaningful analysis of the containment response.

Two success states are defined as "SUCCESS" and "LEAK". "LEAK" state refers to conditional success in the SGTR event where the leakage through the breaks into the secondary system cannot be reduced, but core integrity and cooling is achieved.

TABLE 2D-1

DEFINITION AND NOMENCLATURE OF PLANT DAMAGE STATES

TYPE OF ACCIDENT	APPLICABLE EVENT TREES	TIMING OF CORE MELT	PHYSICAL DESCRIPTION OF ACCIDENT SEQUENCE	PLANT CONDITION	CONTAINMENT SAFEGUARDS OPERATIONAL STATUS FAN COOLERS	SPRAYS	PLANT DAMAGE STATE
A-Large LOCA	1) Large LOCA 2) Medium LOCA	E-Early	Large LOCA behavior with failure of safety injection	Safety Injection Failure	Yes	Yes	AEFC
					Yes	No	AEF
					No	Yes	AEC
					No	No	AE
A-Large LOCA	1) Large LOCA 2) Medium LOCA	L-Late	Large LOCA behavior with failure of recirculation cooling	Safety Injection Success AND Recirculation Cooling Failure	Yes	Yes	ALFC
					Yes	No	ALF
					No	Yes	ALC
					No	No	AL
S-Small LOCA	1) Small LOCA 2) Steam Generator Tube Rupture 3) Loss of Offsite Power 4) Anticipated Transients Without Scram	E-Early	Small LOCA behavior with failure of safety injection or core heat removal functions which cause the reactor coolant system to remain pressurized Loss of Offsite Power Reactor Coolant Pump Seal LOCA Sequences	Safety Injection Failure OR Core Heat Removal Failure OR ATWS Pressure Spikes OR Loss of Offsite Power Induced Reactor Coolant Pump Seal LOCA	Yes	Yes	SEFC
					Yes	No	SEF
					No	Yes	SEC
					No	No	SE
S-Small LOCA	1) Small LOCA 2) Steam Generator Tube Rupture	L-Late	Small LOCA behavior with failure of recirculation cooling	Safety Injection Success AND Recirculation Cooling Failure	Yes	Yes	SLFC
					Yes	No	SLF
					No	Yes	SLC
					No	No	SL

TABLE 2D-1 (Continued)

DEFINITION AND NOMENCLATURE OF PLANT DAMAGE STATES

TYPE OF ACCIDENT	APPLICABLE EVENT TREES	TIMING OF CORE MELT	PHYSICAL DESCRIPTION OF ACCIDENT SEQUENCE	PLANT CONDITION	CONTAINMENT SAFEGUARDS OPERATIONAL STATUS FAN COOLERS	SPRAYS	PLANT DAMAGE STATE
T-Transient	1) All Transient Event Trees 2) Steam Generator Tube Rupture 3) Anticipated Transient Without Scram	E-Early	Transient behavior with failure of core heat removal which causes the reactor coolant system to remain highly pressurized	Core Heat Removal Failure	Yes	Yes	TEFF
					Yes	No	TEF
					No	Yes	TEC
					No	No	TE
T-Transient	1) All Transient Event Trees 2) Anticipated Transient Without Scram	L-Late	These transient behave like small LOCAs with failure of recirculation cooling	Core Heat Removal Success AND Recirculation Cooling Failure	Yes	Yes	SLFC
					Yes	No	SLF
					No	Yes	SLC
					No	No	SL
V2-Steam Generator Tube Rupture	1) Steam Generator Tube	E-Early	Steam generator tube rupture behavior with failure of safety injection or core heat removal functions which cause the reactor coolant system to remain pressurized	Safety Injection Failure OR Core Heat Removal Failure	Not Applicable	Not Applicable	V2E
V2-Steam Generator Tube Rupture	1) Steam Generator Tube	L-Late	Small LOCA behavior with failure of recirculation cooling	Safety Injection Success AND Recirculation Cooling Failure	Not Applicable	Not Applicable	V2L
V-Interfacing Systems LOCA	1) Interfacing Systems LOCA	E-Early	Large LOCA behavior with containment bypass	Not Applicable	Not Applicable	Not Applicable	V

APPENDIX 2E

CONSEQUENTIAL FAILURE MODEL

One of the requirements of a comprehensive PRA analysis is to address the possibility of consequential failures. This requirement is more than adequately justified based on past consequential and possible consequential events at Three Mile Island (feedwater transient-small LOCA), Ginna (steam generator tube rupture-lifting of secondary steam relief valves) and Salem (feedwater transient-anticipated transient without scram). Due to this requirement, the consequential failure model was employed in the development of the plant system event trees. During the initial event tree development process it was decided that consequential failures such as small LOCAs, steamline breaks, and Anticipated Transients Without Scram (ATWS) events would be transferred to the appropriate event tree models. For example, should a small LOCA occur during the normal progression of a transient event, due to a malfunction of primary relief valve, then this particular accident sequence would be transferred to the small LOCA event tree and subsequently analyzed there. Were such a transfer not made, then an event tree structure similar to the small LOCA event tree would have to be included in the transient event tree. Four possible consequential failures were postulated, they are:

1. Small LOCA (S2)
2. Anticipated Transient Without Scram (ATWS)
3. Steam Generator Tube Rupture (TR)

Each of these consequential failures were then considered in the construction of each plant system event tree. In addition, the consequential failures were ordered in each event tree so that no infinite loops could develop. The following subsections describe each consequential failure and the applicable event trees for each failure. The initiating event categories that contain the consequential failures are shown in Table 2E-1

1. Small LOCA (S2)

   The small LOCA consequential failures are defined as unisolated small breaks which are bounded by the small LOCA initiating event category defined in Section 1. Consequential small LOCAs are modeled as arising

from three possible failures: first, passive failures such as ruptures in piping networks, second, active failures such as relief valves, and last, truly consequential failures due to the initiating event and support state condition such as degradation of reactor coolant pump seals.

Consequential small LOCA failures are considered in all transient event trees. In the loss of offsite power event tree, the impact of a small LOCA consequential failure for support states 5 and 6, which is defined as a total station blackout, is modeled within the event tree structure so that power recovery during the accident sequence can be included. Small LOCA consequential failures are not considered in any LOCA event trees as either the LOCA break size bounds the event or to avoid infinite loops.

2. Anticipated Transients Without Scram

Anticipated Transients Without Scram (ATWS) consequential failures are defined as failures to insert sufficient Reactor Control Rod Cluster Assemblies (RCCAs) into the core such that it is subcritical. Consequential ATWS failures are considered in any accident sequence in which the operating boundary of any plant parameter that is used to generate a reactor trip signal is exceeded.

Consequential ATWS failures are modeled in all the plant system event trees except the large and medium LOCA event trees. For these LOCA trees reactor shutdown is modeled as part of the safety injection function in which borated water is injected into the reactor coolant system. In addition, possible steam voids in the core during the very early stages of these accidents would tend to control reactivity until the reactor coolant inventory is sufficiently borated. Consequential ATWS failures led to the development of an ATWS event tree so that all ATWS sequences could be modeled and quantified.

3. Steam Generator Tube Rupture

The consequential steam generator tube rupture applies to the rupture of one or more steam generator tubes resulting in a loss of primary coolant

into the secondary system. The initiating events that degenerate into consequential SGTR events are looped into event tree 4, the SGTR event tree, except in Large LOCA, Medium LOCA and Steamline Break events where they are treated within the original event tree. Three consequential SGTR nodes are defined within the event trees (other than SGTR event tree):

TR-1: Multiple SGTR in medium and large LOCA events

TR-2: Single SGTR in transients

TR-3: Multiple SGTR in Secondary Line Breaks

In addition to the above, two more consequential failures are considered within the SGTR event tree. These are described below.

Multiple Tube Ruptures (MT)

This top event considers the probability that more than one equivalent double-ended tube rupture occurs. The multiple tube ruptures may occur as the initiating event or as a consequential result of the initiating tube rupture. Success is defined as a tube rupture accident with equivalent rupture size less than or equivalent to one double-ended tube rupture. Separation of SGTR accidents into single and multiple ruptures enables approximate time windows for operator action to be developed.

Steam Leak Associated With Ruptured Steam Generator (LK)

This top event considers a possible uncontrolled steam leak associated with the ruptured steam generator. The LK top event examines the possible modes for steam leaks to occur; these include failure of main steam isolation valve together with turbine stop or steam dump valves, failure of the steam generator atmospheric relief valve and block valve, failure of steam generator safety valve, and failure of main steamline.

TABLE 2E-1

CONSEQUENTIAL FAILURES IN EVENT TREES

	Looping Functions			Other Consequential Failures			
Initiating Event	ATWS	S2	TR2	TR1	TR3	MT	LK
1				X			
2				X			
3	X						
4	X					X	X
5	X	X			X		
6	X	X			X		
7	X	X	X				
8	X	X	X				
9	X	X	X				
10	X	X	X				
11	X	X	X				
12	X	X	X				
12a		X					
13		X	X				
14		X	X				
V							

3.0 PLANT SYSTEMS ANALYSIS

3.1 INTRODUCTION

This section presents the quantitative fault tree analysis of the Byron Station safeguards systems. The analysis was based upon the Zion Probabilistic Safety Study (ZPSS). The fault trees in this study reflect the same level of detail as the ZPSS but have been changed to: 1) reflect system design differences; 2) explicitly model testing and maintenance of components; 3) explicitly model human errors and common cause failures; and 4) fully utilize the computer based fault tree tools available.

The data base for this study was derived mainly from the ZPSS, with exceptions for common cause analysis, human errors, and certain components unique to the Byron plant. Appropriate reference to the source of data is made in the calculations and in the data base. The Data Base is presented in Appendix 3D.

General analysis techniques and assumptions are presented in Appendix 3A, BYRON LCORP GUIDE TO FAULT TREE DEVELOPMENT. Common cause and human error modeling and calculations are presented in Appendices 3B and 3C, respectively. System descriptions, success criteria, and modeling assumptions specific to a particular analysis are presented in the following subsections.

3.1.1 MAINTENANCE MODELING

Maintenance of system components is modeled explicitly in the fault tree developed for each system. The frequency of maintenance for each component or train was taken from the Zion Probabilistic Safety Study, Reference 7.1, Table 1.5.1-29. Several assumptions were made regarding the analysis of maintenance unavailability of components: a) since there is no present data accumulated on the operation of the Byron Station; and b) to maintain consistency in the application of the model. The first assumption was that the maintenance frequency of given components was the same as similar components in the Zion Station, and that this frequency is constant, independent of relatively small variations in the mean time to restore the equipment to service. Intuitively, frequency would vary indirectly with the average repair time. Frequency of

maintenance could not be derived as a function of repair donation due to a lack of data and inconsistency in plant management schema. Therefore, the use of a constant frequency and increasing Mean Time To Repair (MTTR) is conservatively bounding the component unavailabilities modeled. The maintenance frequencies for different plant components are presented in Table 3.1-1. The second assumption is that the times to restore components will follow a log-normal distribution, as assumed for a prior distribution in the Zion study. This results in the use of the mean times to restore components in maintenance as derived on Tables 3.1-2 (3 day LCO) and 3.1-3 (7 day LCO). These values are kept constant between systems, since this is the most direct and comprehensible means available for measuring the increase in Mean Time To Repair (MTTR) as a function of LCO. Any deviation that may exist between different systems can only be addressed as plant operating experience is gained, where the average time of maintenance for a specific component may be compared to that analyzed. It follows that the unavailability of a component or train is the maintenance frequency (hr^{-1}) multiplied by the mean time to restore (hr). While these mean restoration times and frequencies of maintenance are just estimates, the model exists in a form that allows updating of the results as plant data is accumulated.

TABLE 3.1-1

SPECIALIZED COMPONENT MAINTENANCE FREQUENCY DATA

	Site-Specific Data		Specialized Frequency Distribution*	
Component	Events	Service Hours	Mean (Events/Hour)	Variance
Motor-Driven Auxiliary Feedwater Pumps	26	1.24×10^{5}	1.87×10^{-4}	1.24×10^{-9}
Turbine-Driven Auxiliary Feedwater Pumps	41	6.20×10^{4}	5.33×10^{-4}	1.54×10^{-8}
Centrifugal Charging Pumps	17	1.24×10^{5}	1.45×10^{-4}	1.07×10^{-9}
Component Cooling/Essential Service Water Pumps	46	1.90×10^{5}	2.36×10^{-4}	9.29×10^{-10}
Containment Spray Pumps	11	1.86×10^{5}	6.54×10^{-5}	2.44×10^{-10}
Residual Heat Removal Pumps	6	1.24×10^{5}	6.12×10^{-5}	2.87×10^{-10}
Safety Injection Pumps	1	1.24×10^{5}	4.04×10^{-5}	1.50×10^{-10}
Fan Cooler Units	14	3.10×10^{5}	5.85×10^{-5}	1.57×10^{-10}
Diesel Generators	137	1.62×10^{5}	8.09×10^{-4}	3.76×10^{-9}

*Distributions are lognormal.

TABLE 3.1-2

PRIOR DISTRIBUTION FOR MEAN DURATION OF MAINTENANCE

Component Inoperability Limit: 72 hours
Parameters characterizing range of lognormal duration distributions:

5th Percentile (hours/event)	Probability	95th Percentile (hours/event)	Probability
1.0	.05		
2.0	.50	24	.05
3.0	.15	36	.05
4.0	.10	48	.15
5.0	.05	60	.50
6.0	.05	72	.15
7.0	.05	84	.05
8.0	.05	96	.05

Distribution: Lognormal
5th percentile: 2 hours/event
95th percentile: 60 hours/event
Mean: 18.7 hours/event
Variance: 668

Basis: Only the most routine maintenance can be performed with a component unavailability time (including removal and return to service operations) of less than two hours. The 72-hour time limit for operation dictates that major maintenance and repair activities be performed during cold shutdown periods. The majority of relatively routine maintenance and some extensive repairs will be completed within two and one-half days, given the high priority assigned to returning the equipment to service within the LCO limit.

Resulting Prior Distribution of Mean Duration of Maintenance:

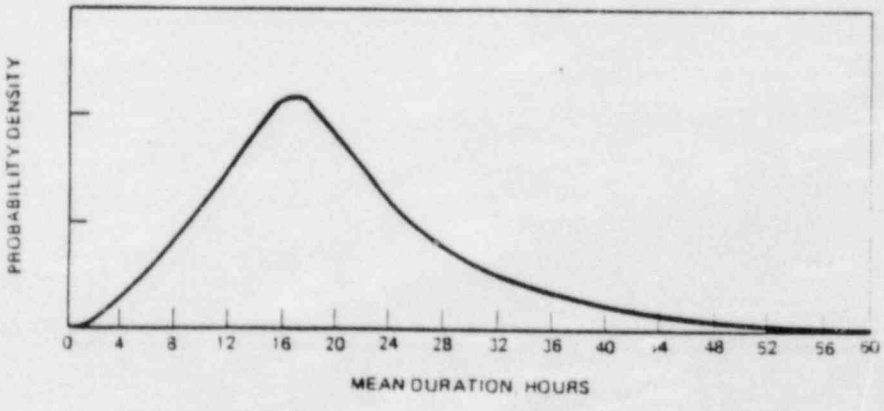


TABLE 3.1-3

PRIOR DISTRIBUTION FOR MEAN DURATION OF MAINTENANCE

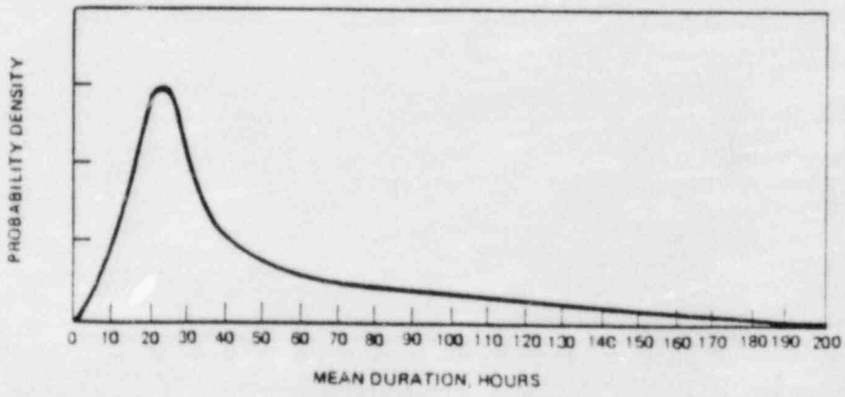
Component Inoperability Time Limit: 7 days
Parameters characterizing range of lognormal duration distributions:

5th Percentile (hours/event)	Probability	95th Percentile (hours/event)	Probability
1	.05	48	.05
2	.50	72	.10
4	.15	96	.10
8	.10	120	.50
12	.10	144	.15
16	.05	168	.05
24	.05	240	.05

Distribution: lognormal
5th percentile: 2 hours/event
95th percentile: 120 hours/event
Mean: 33.6 hours/event
Variance: 4180

Basis: Only the most routine maintenance can be performed with a component unavailability time (including removal and return to service operations) of less than two hours. The 7 day time limit for unit operation dictates that most maintenance will be prioritized to be completed within approximately 5 days to allow for possible unforeseen delays. Furthermore, since most scheduled major maintenance and equipment overhaul is performed during the Monday-Friday work week, the 5 day time limit applies to most of these planned activities as well.

Resulting Prior Distribution of Mean Duration of Maintenance:



3.2 ONSITE AC POWER SYSTEM

3.2.1 SYSTEM DESCRIPTION

The onsite AC power system has two diesel generators per unit, supplying two redundant 4160 V busses. These busses in turn supply 480 V essential AC to various loads and motor control centers throughout the plant. These vital sources are required for the supply of AC to equipment following design basis accidents and anticipated transients. The diesels auto-start on bus undervoltage, as occurs on a loss of offsite AC power.

The plant support state split fractions are calculated in Section 4.1.2 and 4.2.2. for the 3 day and 7 day LCO applications, respectively. A simplified one line diagram of the AC power distribution system is presented in Figure 3.2-1.

The two diesel generators are physically and functionally separate, having separate start systems, fuel day-tanks, DC bus dependence, and service water cooling dependence.

3.2.2 FAULT TREE ANALYSIS

The fault tree constructed to model the AC power system is presented in Figure 3.2-2. This section describes the analysis supporting the quantification of system unreliability.

3.2.2.1 SUCCESS CRITERIA

Either diesel generator has the capacity to supply all necessary loads for mitigation of all analyzed events. In order to address failures of other systems, this report probabilistically analyzes each state that the electric power system can be in, i.e., both busses energized, either bus 141 or 142 energized, and neither bus energized (failure of both diesel generators).

3.2.2.2 DEPENDENCE ON SUPPORT STATES

The two diesels are supplied with cooling water flow from the Essential Service Water system header, the loss of which will cause a loss of the diesels. This phenomenon is modeled as support state 6, concurrent with loss of offsite power. Refer to Sections 4.1.2 and 4.2.2.

3.2.2.3 RANDOM FAILURE MODEL

The following assumptions were utilized in the development of the fault tree for this analysis:

1. Diesel recovery is addressed in the Support State Model development, see Sections 4.1.2 and 4.2.2.

2. Loss of service water causes a nonrecoverable failure of the diesels. This is conservative due to protective instrumentation on the diesel.

3.2.2.4 COMMON CAUSE ANALYSIS

The common cause of the AC diesel generators is modeled by simple application of the beta factor derived for diesels. The common dependence on ESW is explicitly modeled. Refer to Appendix 3B for derivation of common cause treatment methodology and applicable beta factors.

Calculation:

$$Qcc = \beta_2 \cdot P \text{ (FAIL to start and run)}$$

$$= (.026)[2.42\ (-2)]$$

$$= 6.3\ (-4)$$

3.2.2.5 TEST AND MAINTENANCE MODEL

Testing of the diesel generators does not render them unavailable, and is therefore not modeled. Maintenance, however, is a significant contributor to overall diesel unavailability. The frequency of diesel maintenance is taken from the ZPSS, Reference 7.1 , Table 1.5.1-29; f = 8.09 (-4) event/hour.

3.2.2.6 HUMAN ERROR ANALYSIS

No errors of omission or commission affecting diesel reliability are explicitly modeled due to the frequent testing and stringent requirements guiding diesel maintenance.

3.2.2.7 INPUT DATA

An input listing of component identifiers and associated probabilities for analysis of the AC power system is presented in Table 3.2-1. Both 3 day and 7 day LCO data are listed.

3.2.3 FAULT TREE QUANTIFICATION

The following sections describe the results of the quantification of the AC power state split fractions.

3.2.3.1 SYSTEM UNAVAILABILITY CALCULATIONS

The quantification of the AC power tree was accomplished with the WAMCUT Code. The fractions for the power states are as follows:

Power State	3 Day LCO	7 Day LCO
1	.9221	.9009
2	.038	.048

Power State	3 Day LCO	7 Day LCO
3	.038	.048
4	.0019	.0025

The major contributors to system unreliability are, of course, the diesel generators' failing to start, failing to run, and maintenance. Here, the increase in mean time of maintenance results in a 26 percent increase in each diesel's unreliability.

3.2.3.2 DOMINANT CUTSETS

Diesel unavailability is comprised of the following modes and resulting percentages of overall train unavailability:

Mode	3 Day	7 Day
Diesel Fails to Start and Load	47	35
Diesel Fails to Run (24 hours)	14	11
Diesel Maintenance	39	54

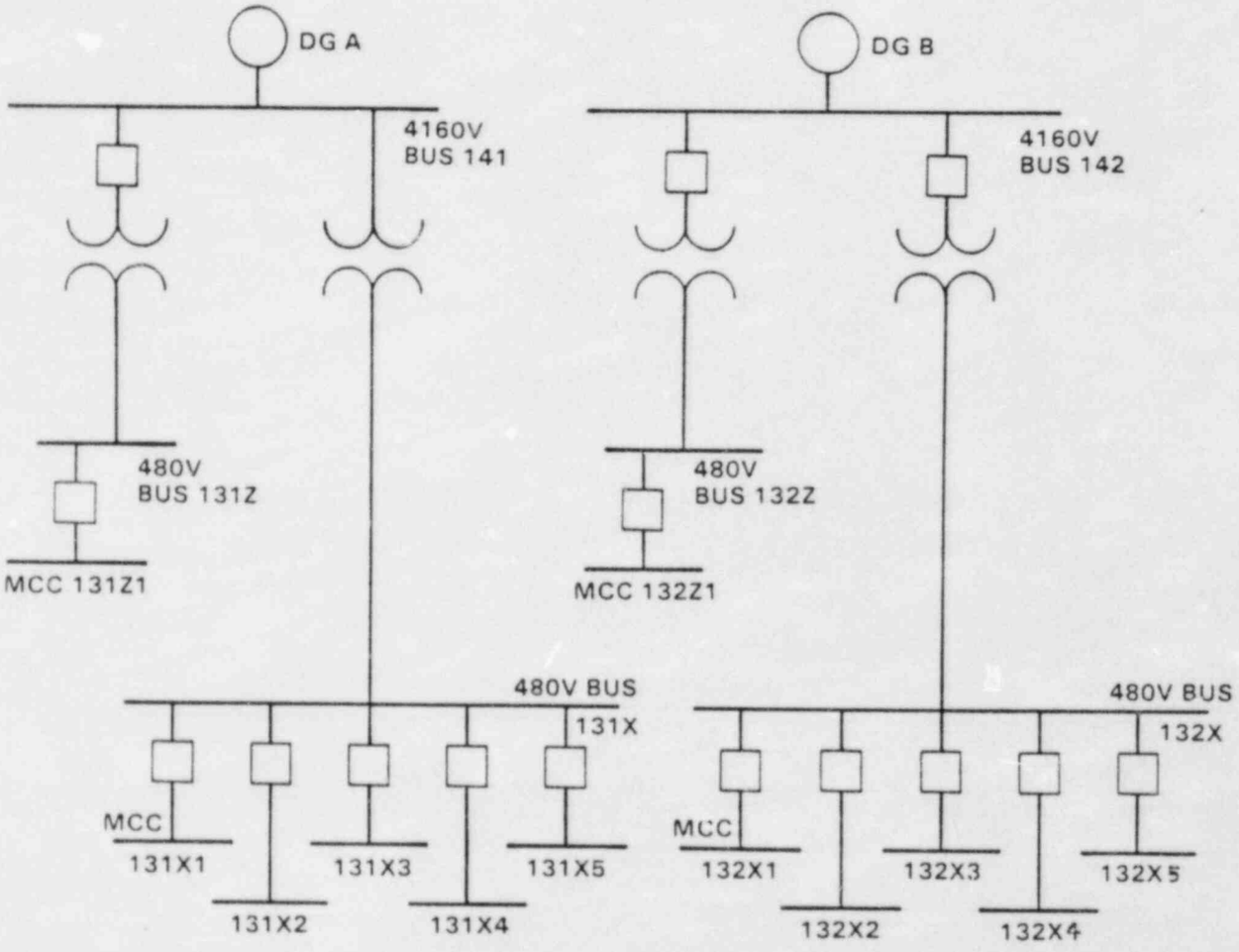
TABLE 3.2-1

AC POWER COMPONENTS 3 DAY LCO

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
BUS141D	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
BUS142D	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
DGAM	DG	DIESEL MAINTENANCE F	8.090E-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	1.54E-02	0.00E-01
DGBM	DG	DIESEL MAINTENANCE F	8.090E-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	1.54E-02	0.00E-01
DGAFS	DG	FAIL TO START	1.820E-02	1.260E-05	ZPSS	0.000E-01	0.000E-01	1.82E-02	1.26E-05
DGBFS	DG	FAIL TO START	1.820E-02	1.260E-05	ZPSS	0.000E-01	0.000E-01	1.82E-02	1.26E-05
DGAFR	DG	FAIL DURING OPERATIO	5.970E-03	4.050E-06	ZPSS	1.000E+00	0.000E-01	5.97E-03	4.05E-06
DGBFR	DG	FAIL DURING OPERATIO	5.970E-03	4.050E-06	ZPSS	1.000E+00	0.000E-01	5.97E-03	4.05E-06
CCAC	CC	COMMON CAUSE FAILURE	6.300E-04	0.000E-01	AC1	0.000E-01	0.000E-01	6.30E-04	0.00E-01

FIGURE 3.2-1

SIMPLIFIED ONE LINE DIAGRAM



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3.3 ESSENTIAL SERVICE WATER SYSTEM

3.3.1 SYSTEM DESCRIPTION

The Essential Service Water System (ESWS) provides cooling water flow from the plant ultimate heat sink (UHS) mechanical draft cooling towers to various plant safeguards equipment and the component cooling water heat exchangers. The system is comprised of two pumps per unit, divided into two trains, where the common trains (i.e., trains A and B) of the two units share a UHS cooling tower. Each cooling tower has four (4) 480 V AC fans, two of which are loaded on each unit's associated safeguards bus, thereby maintaining train separation. Each pump is provided with suction and discharge block valves and a service water strainer. The pumps feed a header, which feeds lines to the various equipment and the A train component cooling water (CCW) heat exchanger. Both unit one and two service water headers may be aligned to the common CCW heat exchanger, as well as aligning flow through the crosstie to other components in the event of a loss of one unit's pumps, by operator action to open both valves (1SX005 and 2SX005). This may be a manual action if the associated B train 480 V bus in each unit is deenergized.

The valves associated with the CCW and other equipment heat exchangers are modeled in each respective system's fault tree analysis.

A simplified flow diagram of the Essential Service Water System is presented in Figure 3.3-1.

3.3.2 FAULT TREE ANALYSIS

The fault tree analysis of the ESWS was performed in accordance with the BYRON LCORP Guide to Fault Tree Development, Appendix 3A. The fault tree logic for this analysis is shown in Figure 3.3-2, and the entire fault tree developed is presented in Figure 3.3-3. In addition, the system components are listed in Table 3.3-1. This section addresses the methods and calculations utilized in the analysis of the Essential Service Water System.

3.3.2.1 SUCCESS CRITERIA

The success of the Essential Service Water System is comprised of the successful operation of one pump and two fans in the UHS dedicated to the unit 1 heat load via the unit 1 header. This means that either of the unit 1 pumps or both of the unit 2 pumps and associated UHS fans must function. However, no credit is taken for the second unit in sequences requiring safety injection, since SI pump trip on high temperature is assumed to occur before alignment of the crosstie valves is accomplished.

3.3.2.2 DEPENDENCE ON SUPPORT STATES

The Essential Service Water System depends only on AC power for system operation. The ESWS is modeled and utilized as a support system. Refer to Sections 4.1.2 and 4.2.2 for the calculation of support state split fractions.

3.3.2.3 RANDOM FAILURE MODEL

The following assumptions were utilized in the development of the fault tree for this analysis:

1. As a normally operating system, at least two pumps will be operating at any time. It is assumed for the analysis that both A train pumps are running and all four fans on the A train Ultimate Heat Sink (UHS) are operating.

2. The heat exchanger and component block valves throughout the system are included in the analysis of systems which depend on essential service water flow for operation.

3. If both unit 1 pump trains fail, both unit 2 pump trains must operate to remove station heat loads, and the crosstie must be opened by the operators. This will be a remote manual operation if 480 V bus 132 Z is deenergized (e.g., loss of diesel generator B following a Loss of Offsite AC Power).

4. No credit is taken for the latent heat capacity of the system except for the Auxiliary Feedwater diesel-driven pumps' capability to operate without flow. Therefore, the failure of both hot water bypass valves (open) will fail that loop due to high temperature.

5. No credit is taken for unit 2 availability following LOCA and other events which require Safety Injection. The high head pumps will not operate for more than several minutes without cooling flow, and the capability of the operators to recognize the loss of service water on unit 1 and align both valves in the crosstie, given the high stress event, is ignored.

6. The availability of service water flow to the unit 2 Train A CCW heat exchanger is not explicity modeled, but assumed to be concurrent with flow to the unit 1 Train A CCW heat exchanger. Refer to Section 3.4 for the analysis of the CCW system.

3.3.2.4 COMMON CAUSE ANALYSIS

The common cause analysis of the ESW system addresses potential common cause failures between the a) UHS fans; b) standby pumps; c) normally running pumps; and d) pumps located in a specific unit. The first three calculations below present the component failure due to all modes affected by common cause. The common cause calculations follow the component failure calculations.

Probability of Failure of Cooling Tower

Fan fails to start	1.17(-3)
Fan fails to run	8.47(-5)
No power to MCC	5.35(-7)
Tower inlet valve transfers closed	1.27(-6)
	1.26(-3)

Probability of Failure of Standby Pump Trains

Pump discharge valve transfers closed	5.78(-5)
ESW Strainer Plug/Failure	2.40(-4)
Pump discharge check valve fails to open	4.32(-5)
Pump suction valve transfers closed	5.78(-5)
Pump suction header valve transfers closed	1.27(-6)
ESW pump fails to start	7.21(-4)
ESW pump fails to run	3.17(-5)
P (start and run)	1.2 (-3)

$\therefore$ P (start) = 7.2(-4)

P (run) = 4.8(-4)

Probability of Failure of Normally Operating Pumps

Pump suction valve transfers closed	1.27(-6)
Pump suction header valve transfers closed	1.27(-6)
ESW strainer plug/failure	2.40(-4)
Pump discharge valve transfers closed	1.27(-6)
Pump fails to run	3.17(-5)
P (Run)	2.76(-4)

a) Common Cause Failure of UHS heat exchangers

$$Qcc = 6\,\beta_2\,P^2_{\text{cooling tower}} + 3\,\beta_3\,P_{ct} + \beta_4\,P_{ct}$$

$$= 6\,(.1)[1.26(-3)]^2 + 3\,(.02)[1.26(-3)] + (.01)[1.26(-3)]$$

$$= 9.5(-7) + 7.6(-5) + 1.3(-5)$$

$$= 8.9(-5)$$

b) Common Cause Failure of Standby Pumps

$$Qcc = \beta_{run} \cdot P_{run} + \beta_{start} \cdot P_{start}$$

$$= (.041)[4.80(-4)] + (.093)[7.2(-4)]$$

$$= 1.97(-5) + 6.7(-5)$$

$$= 8.7(-5)$$

c) Common Cause Failure of Normally Operating Pumps

$$Qcc = \beta_2 \cdot P_{run}$$

$$= (.041)[2.76(-4)]$$

$$= 1.13(-5)$$

d) Common Cause Failure of Either Unit's Trains

The analysis assumes a beta of 1.0 percent since it is felt that the beta addressed by the analysis above implicitly includes any contribution arising from causes peculiar to a single unit. Specifically, the coupling between pumps due to physical and functional location in unit 1 or unit 2 is small, if not non-existent.

$$Qcc = \beta \cdot P_{(train)}$$

$$= (.01)[1.2\ (-3)]$$

$$= 1.2\ (-5)$$

The common cause methodology used above and the development of beta factors are described in Appendix 3B.

3.3.2.5 TEST AND MAINTENANCE MODEL

Testing of components is not addressed for this system, since any test start of a component does not render it unavailable. Maintenance of the pumps, strainer, and UHS fans is modeled.

a. Pump maintenance.

The frequency of pump maintenance is taken from the Zion PSS, Reference 7.1, Table 1.5.1-29. Due to the difference in pump types, however, the service water pump frequency is set equal to that of the component cooling water pumps, or $f_{(maintenance)} = 2.36\ (-4)$ event/hour.

b. Strainer maintenance.

Due to the passive nature of the strainers, it is assumed that strainer maintenance is performed with pump maintenance. For conservatism, however, and with the recognition that the strainer may force a train outage, the frequency is set at 1.0(-5) event/hour. This corresponds with the hourly failure rate of the strainer used in the Byron Risk Study, Reference 7.4, Section 4.6.5.

c. Ultimate heat sink fan maintenance.

The maintenance frequency for these components is taken from the ZPSS, Reference 7.1, Table 1.5.1-29, and is set equal to the maintenance frequency of the Containment Fan Coolers. Recognizing the differences in type and service of fans, it is felt that both are low maintenance items. Therefore, the frequency of maintenance equals 5.85(-5) event/hour.

3.3.2.6 HUMAN ERROR MODEL

The Essential Service Water System, as a normally operating system, is not subject to human errors of omission and commission since any failures of these types are immediately noticeable by flow and temperature alarms on affected equipment. Due to the necessity for operator action to align flow paths to

alleviate a degraded flow condition, such as might arise from multiple 4160 V bus loss, the failure of this action is modeled. In this instance, the operator must open both crosstie valves (1SX005 and 2SX005) to align flow from the unit 2 header to the unit 1 header. This will be a remote manual action if 480 V bus 132 Z or 4160 V bus 142 is deenergized (Train B). Alignment of both CCW heat exchanger outlet header valves is not necessary due to the overflow capability of the UHS basins.

The development of the probability of failure of this action is calculated in Appendix 3C.

3.3.2.7 INPUT DATA

An input listing of component identifiers and associated probabilities for analysis of the ESWS with no Loss of Offsite Power is presented in Table 3.3-2. Three different sets of input data were utilized for quantification, assuming system symmetry on AC busses. The variables were the availability of 4160 V AC busses as follows: 1) all busses available; 2) bus 142 deenergized; and 3) busses 141 and 142 deenergized.

3.3.3 FAULT TREE QUANTIFICATION

The following sections describe the results of the quantification of ESWS unavailability.

3.3.3.1 SYSTEM UNAVAILABILITY CALCULATIONS

The quantification of the ESWS fault tree was accomplished with the WAMBAM code. Results are presented in Tables 3.3-3, 4 and 5. Tables 3.3-3 and 3.3-4 present the calculation of Non-LOCA unavailabilities for 3 Day and 7 Day LCO, respectively. The 2 unit conditional probabilities of electric power are those derived for the Component Cooling Water System unavailability calculation, Section 3.4.3.1. The LOCA unavailability is taken directly from quantification output, comprising the failure of both Unit 1 ESW trains. The results are summarized in Table 3.3-5.

3.3.3.2 DOMINANT CUTSETS

The common cause and random failures of active components and maintenance of system components totally dominate failure of the ESWS. This is expected due to the normal operating condition of the system. Quantification was made to find the contribution of system maintenance to overall unavailability. The major cutsets derived for system failure and relative probabilities are presented in Table 3.3-6. Overall maintenance contribution to system unavailability is presented in Table 3.3-7 as relative percentages.

TABLE 3.3-1

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error (See Note)
1SX01PA	X			X	X	
1SX01PB		X		X	X	
2SX01PA	X			X	X	
2SX01PB		X		X	X	
1SX01FA					X	
1SX01FB					X	
2SX01FA					X	
2SX01FB					X	
SX03CA	X				X	
SX03CB	X				X	
SX03CC	Unit 2				X	
SX03CD	Unit 2				X	
SX03CE		X			X	
SX03CF		X			X	
SX03CG		Unit 2			X	
SX03CH		Unit 2			X	
1SX005		X				FO
2SX005		Unit 2				FO
OSX162A	X					
OSX162C	Unit 2					
OSX162B		X				
OSX162D		Unit 2				
OSX163A	X					
OSX163B	X					
OSX163C	Unit 2					
OSX163D	Unit 2					
OSX163E		X				
OSX163F		X				
OSX163G		Unit 2				

TABLE 3.3-1 (Continued)

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error (See Note)
OSX163H		Unit 2				
OSX138A						
OSX138B						
1SX001A						
1SX001B						
2SX001A						
2SX001B						
1SX002A						
1SX002B						
2SX002A						
2SX002B						
1SX143A						
1SX143B						
2SX143A						
2SX143B						

Notes:

Operator Error Symbols

FR = Fails to restore following (T, M or R)
T = Test
M = Maintenance
R = Refueling
FO = Fails to open
FC = Fails to close

TABLE 3.3-2

ESSENTIAL SERVICE WATER COMPONENT FAULTS

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
OMVSX162AO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	2.400E+01	0.000E-01	7.54E-07	8.99E-12
OMVSX162CO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	2.400E+01	0.000E-01	7.54E-07	8.99E-12
OMVSX162BO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	2.400E+01	0.000E-01	7.54E-07	8.99E-12
OMVSX162DO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	2.400E+01	0.000E-01	7.54E-07	8.99E-12
OMVSX163AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163EC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163FC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163GC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163HC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
FSXO3CAFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
FSXO3CBFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
FSXO3CCFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FSXO3CDFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FSXO3CEFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
FSXO3CFFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
FSXO3CGFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07

TABLE 3.3-2 (Cont.)

ESSENTIAL SERVICE WATER COMPONENT FAULTS

FSXO3CHFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FSXO3CAFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CBFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CCFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CDFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CEFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CFFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CGFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CHFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
BUS131ZD	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
BUS132ZD	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
BUS231ZD	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
BUS232ZD	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
BUS132D	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
BUS232D	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS241D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS242D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
OXVSX138AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OXVSX138BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
1MVSX001AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12

TABLE 3.3-2 (Cont.)

ESSENTIAL SERVICE WATER COMPONENT FAULTS

2MVSX001AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
1MVSX001BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
2MVSX001BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
1CVSX002AC	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
1CVSX002BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
2CVSX002AC	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
2CVSX002BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
1SSX01FAQ	STR	STRAINER FAILURE	2.400E-04	1.400E-05	BRS	0.000E-01	0.000E-01	2.40E-04	1.40E-05
1SSX01FBQ	STR	STRAINER FAILURE	2.400E-04	1.400E-05	BRS	0.000E-01	0.000E-01	2.40E-04	1.40E-05
2SSX01FAQ	STR	STRAINER FAILURE	2.400E-04	1.400E-05	BRS	0.000E-01	0.000E-01	2.40E-04	1.40E-05
2SSX01FBQ	STR	STRAINER FAILURE	2.400E-04	1.400E-05	BRS	0.000E-01	0.000E-01	2.40E-04	1.40E-05
1XVSX143AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
2XVSX143AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
1XVSX143BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
2XVSX143BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
1PSX01PAFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
1PSX01PBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
2PSX01PBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
2PSX01PAFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
1PSX01PAFR	MDP	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.400E+01	0.000E-01	3.17E-05	2.15E-09
1PSX01PBFR	MDP	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.400E+01	0.000E-01	3.17E-05	2.15E-09
2PSX01PAFR	MDP	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.400E+01	0.000E-01	3.17E-05	2.15E-09

TABLE 3.3-2 (Cont.)

ESSENTIAL SERVICE WATER COMPONENT FAULTS

2PSXO1PBFR	MDP	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.400E+01	0.000E-01	3.17E-05	2.15E-09
1SSXO1FAM	STR	STRAINER MAINT. FREQ	1.000E-05	0.000E-01	ES1	1.900E+01	0.000E-01	1.90E-04	0.00E-01
1SSXO1FBM	STR	STRAINER MAINT. FREQ	1.000E-05	0.000E-01	ES1	1.900E+01	0.000E-01	1.90E-04	0.00E-01
2SSXO1FAM	STR	STRAINER MAINT. FREQ	1.000E-05	0.000E-01	ES1	1.900E+01	0.000E-01	1.90E-04	0.00E-01
2SSXO1FBM	STR	STRAINER MAINT. FREQ	1.000E-05	0.000E-01	ES1	1.900E+01	0.000E-01	1.90E-04	0.00E-01
1PSXO1PAM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
1PSXO1PBM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
2PSXO1PAM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
2PSXO1PBM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
1SXOO5D	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
2SXOO5D	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
OPERROR	HE	OPERATOR FAILS TO AL	2.000E-03	0.000E-01	HE3	0.000E-01	0.000E-01	2.00E-03	0.00E-01
CCESWPA	ESWP	CC RUNNING ESW TRAIN	1.130E-05	0.000E-01	ES3	0.000E-01	0.000E-01	1.13E-05	0.00E-01
CCESWPB	ESWP	CC STANDBY ESW TRAIN	8.700E-05	0.000E-01	ES4	0.000E-01	0.000E-01	8.70E-05	0.00E-01
CCESWHXA	ESWH	COMMON CAUSE HEAT EX	8.920E-05	0.000E-01	ES2	0.000E-01	0.000E-01	8.92E-05	0.00E-01
CCESWHXB	ESWH	COMMON CAUSE HEAT EX	8.920E-05	0.000E-01	ES2	0.000E-01	0.000E-01	8.92E-05	0.00E-01
CCESWU1	ESWU	CC ESW BETWEEN UNITS	1.200E-05	0.000E-01	ES5	0.000E-01	0.000E-01	1.20E-05	0.00E-01
CCESWU2	ESWU	CC ESW BETWEEN UNITS	1.200E-05	0.000E-01	ES5	0.000E-01	0.000E-01	1.20E-05	0.00E-01
FSXO3CAM	FANS	UHS FAN MAINT. FREQ.	5.850E-05	0.000E-01	ESW	1.900E+01	0.000E-01	1.11E-03	0.00E-01
FSXO3CBM	FANS	UHS FAN MAINT. FREQ.	5.850E-05	0.000E-01	ESW	1.900E+01	0.000E-01	1.11E-03	0.00E-01
FSXO3CCM	FANS	UHS FAN MAINT. FREQ.	5.850E-05	0.000E-01	ESW	1.900E+01	0.000E-01	1.11E-03	0.00E-01
FSXO3CDM	FANS	UHS FAN MAINT. FREQ.	5.850E-05	0.000E-01	ESW	1.900E+01	0.000E-01	1.11E-03	0.00E-01

TABLE 3.3-3

CALCULATION OF ESSENTIAL SERVICE WATER SYSTEM - NON-LOCA UNAVAILABILITY

3 DAY LCO

Power State	Split Fraction	Probability	Product	Sum
1	.9221	1.8(-6)	1.7(-6)	3.2(-6)
2	.0375	2.0(-5)	7.5(-7)	
3	.0375	2.0(-5)	7.5(-7)	
4	.0019	2.0(-5)	3.8(-8)	
5	.882	2.9(-4)	2.6(-4)	9.6(-4)
6	.051	6.0(-3)	3.1(-4)	
7	.051	6.0(-3)	3.1(-4)	
8	.016	6.0(-3)	9.6(-5)	
9	.882	2.9(-4)	2.6(-4)	9.6(-4)
10	.051	6.0(-3)	3.1(-4)	
11	.051	6.0(-3)	3.1(-4)	
12	.016	6.0(-3)	9.6(-5)	
13	.345	1.9(-2)	6.6(-3)	0.66
14	.31	1.0	.31	
15	.31	1.0	.31	
16	.035	1.0	.035	

TABLE 3.3-4

CALCULATION OF ESSENTIAL SERVICE WATER SYSTEM - NON-LOCA UNAVAILABILITY

7 DAY LCO

Power State	Split Fraction	Probability	Product	Sum
1	.9009	3.1(-6)	2.8(-6)	5.5(-6)
2	.048	2.7(-5)	1.3(-6)	
3	.048	2.7(-5)	1.3(-6)	
4	.0025	2.7(-5)	6.8(-8)	
5	.892	4.3(-4)	3.8(-4)	1.4(-3)
6	.052	9.6(-3)	5.0(-4)	
7	.052	9.6(-3)	5.0(-4)	
8	.0037	9.6(-3)	3.6(-5)	
9	.892	4.3(-4)	3.8(-4)	1.4(-3)
10	.052	9.6(-3)	5.0(-4)	
11	.052	9.6(-3)	5.0(-4)	
12	.0037	9.6(-3)	3.6(-5)	
13	.843	2.8(-2)	2.4(-2)	0.18
14	.072	1.0	.072	
15	.072	1.0	.072	
16	.013	1.0	.013	

TABLE 3.3-5

SUMMARY OF RESULTS

Electrical Power State	Transient/LOCA	3 Day LCO	7 Day LCO
1	T	3.2(-6)	5.5(-6)
	L	2.0(-5)	2.7(-5)
2	T	9.6(-4)	1.4(-3)
	L	6.0(-3)	9.6(-3)
3	T	9.6(-4)	1.4(-3)
	L	6.0(-3)	9.6(-3)
4	T	0.66	0.18
	L	1.0	1.0

TABLE 3.3-6

DOMINANT CUTSETS - ALL ELECTRIC POWER

Component Failures and Modes	Relative Contribution (%) 3 Day	7 Day
1. Train A Maintenance and Train B Common Cause Failure	22	23
2. Train A Maintenance and Train B UHS Common Cause Failure	22	23
3. Train B Maintenance and Train A UHS Common Cause Failure	22	23

TABLE 3.3-7

RELATIVE MAINTENANCE CONTRIBUTION TO SYSTEM
UNAVAILABILITY - ALL ELECTRIC POWER

ESW Failure Mode	Maintenance Contribution (%) 3 Day	7 Day
Non-LOCA	85	91
LOCA	38	54

FIGURE 3.3-1

SIMPLIFIED FLOW - ESSENTIAL SERVICE WATER SYSTEM

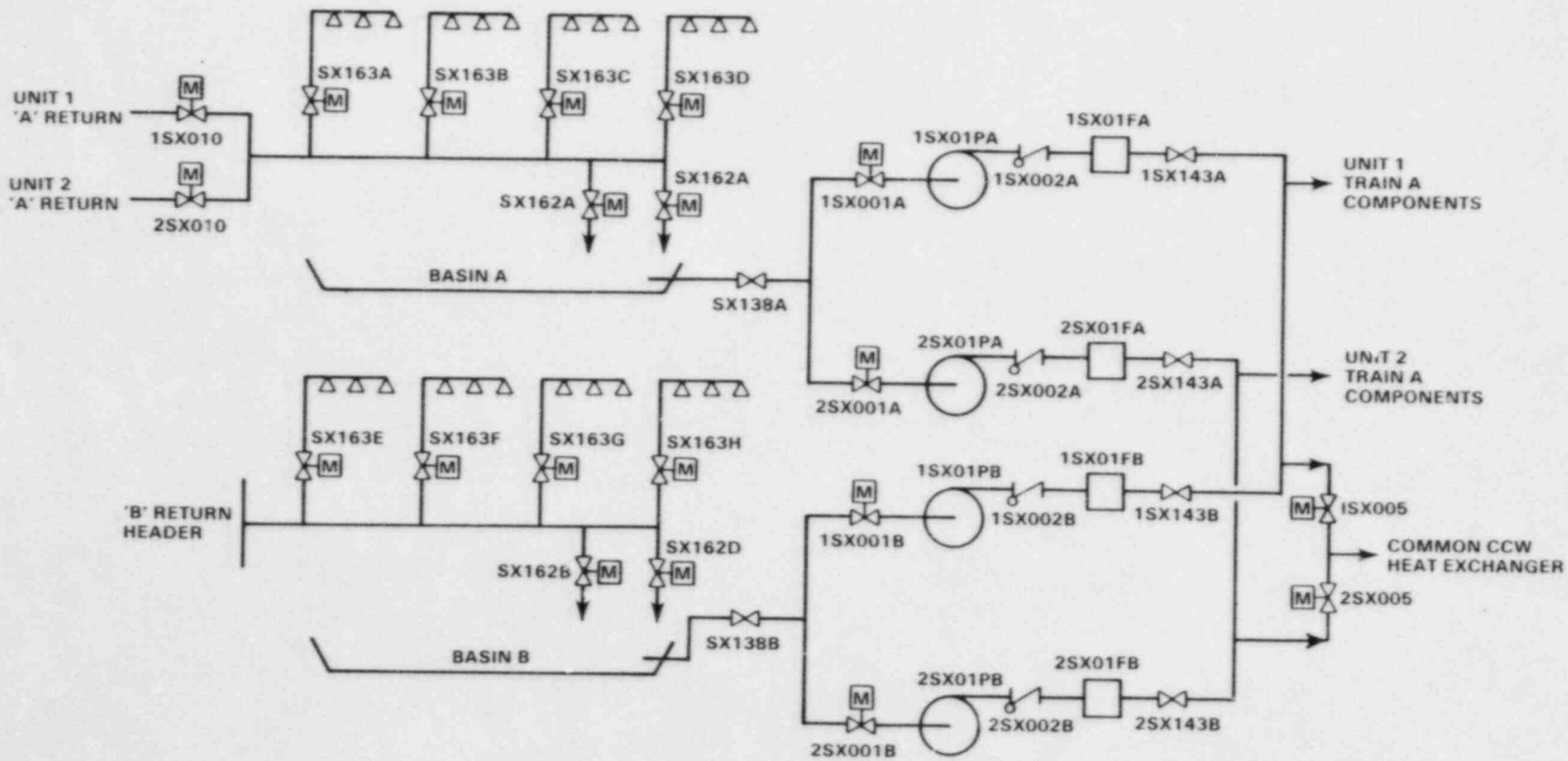
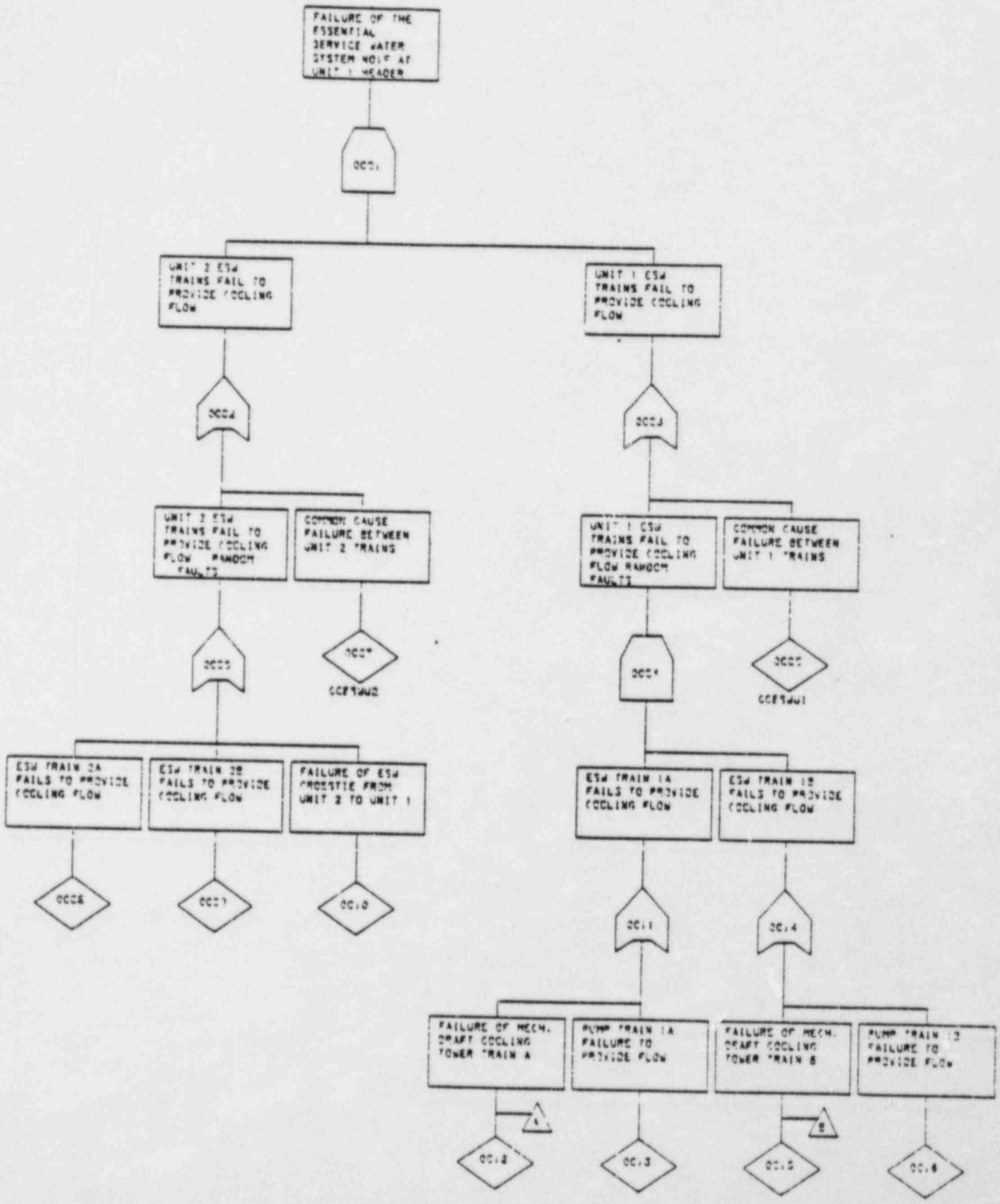


FIGURE 3.3-2

ESWS FAULT TREE TOP LOGIC



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3.4 COMPONENT COOLING WATER SYSTEM

3.4.1 SYSTEM DESCRIPTION

The Component Cooling Water System (CCWS) is provided to remove residual heat via the residual heat exchangers of the Residual Heat Removal System (RHR) and supply cooling to the RHR pump seal. The system is comprised of five pumps, one of which, a maintenance spare, is capable of functionally and electrically replacing any other pump when removed for service. The pumps feed a ring header which directs flow through the three (1A, 2A, and common) CCW heat exchangers, which are cooled by Essential Service Water. A simplified flow diagram of the CCWS is presented in Figure 3.4-1.

3.4.2 FAULT TREE ANALYSIS

The fault tree developed for this analysis is presented as Figure 3.4-3. For a simplified view of the top logic of this fault tree, refer to Figure 3.4-2. The component list for this analysis is presented in Table 3.4-1. The tree explicitly models the two flow paths to the A and B train RHR heat exchangers, showing how flow can be interrupted to each line from each CCW pump through each CCW heat exchanger. To enable easier comprehension of the fault tree, the circled numbers on the simplified flow diagram of this system, Figure 3.4-1, represent the transfer identifiers of the ring header valves in the fault tree.

3.4.2.1 SUCCESS CRITERIA

The success of the CCWS is the successful operation of one pump feeding one heat exchanger that is being fed by the Essential Service Water System, with flow to each RHR heat exchanger. RHR dependence on CCW is explicitly modeled in the Low Pressure and High Pressure Recirculation fault tree unalysis, refer to Sections 3.6.2 and 3.7, respectively.

3.4.2.2 DEPENDENCE ON SUPPORT STATES

The Component Cooling Water System depends on AC Power and the Essential Service Water Systems for successful operation.

3.4.2.3 RANDOM FAILURE MODEL

The following assumptions were utilized in the development of the fault tree for this analysis:

1. Given a reduced flow of CCW, the operators will be guided by procedures in the proper alignment of manual and motor operated valves, both in the ring header and in the pump suction and CCW heat exchanger discharge headers.

2. The window for proper system alignment is on the order of thirty minutes, thereby allowing time for remote manual operation of valves, given the realization of the need for such action. Operator action is explicitly modeled.

3. The maintenance spare pump (OC) is capable of electrical and functional replacement of any other pump. Therefore, the LCO does not take effect until at least two pumps are removed from service.

4. It is assumed that the A train pumps in each unit are normally working and the B pumps are in standby. Additionally, the common heat exchanger (O) is isolated on the essential service water side.

3.4.2.4 COMMON CAUSE ANALYSIS

The common cause analysis of the CCW system addresses potential common cause failures between the a) normally running pumps; and b) standby pumps. The common cause calculations follow.

a. Common Cause Affecting Normally Running Pumps

$$Q_{cc} = \beta_{Run} \cdot P_{Fail\ to\ Run}$$
$$= (.041)[1.12(-4)]$$
$$= 4.6(-6)$$

b. Common Cause Affecting Standby Pumps

$$Qcc' = \beta_{Run} \cdot P_{Run} + \beta_{Start} \cdot P_{Start}$$
$$= (.041)[1.12(-4)] + (.093)[7.21(-4)]$$
$$= 4.59(-6) + 6.71(-5)$$
$$= 7.2(-5)$$

The methodology used and the development of beta factors are described in Appendix 3B.

3.4.2.5 TEST AND MAINTENANCE MODEL

Testing of components modeled in this analysis is not addressed since any test start of a pump does not render it unavailable. Pump maintenance is modeled.

The frequency of pump maintenance is taken from the ZPSS, Table 1.5.1-29; $f_{(maintenance)} = 2.36(-4)$ event/hour.

This analysis assumes the same 19 hr. and 34 hr. mean time to restore for a pump that is replaced in service by the maintenance spare; that is, the presence of the spare pump will not extend the period of time needed for maintenance.

3.4.2.6 HUMAN ERROR MODELING

The Component Cooling Water System, as a normally operating system, is not subject to human errors of omission and commission since any failures of these types are immediately noticeable by flow and temperature alarms on affected equipment. Due to the necessity for operator action to align flow paths to alleviate a degraded flow condition, such as might arise from multiple 4160 V bus loss, the failure of this action is modeled. In this instance, the operators must open either: 1) the normally closed motor operated ring header valves to get flow to a particular heat exchanger; or 2) the heat exchanger discharge header manual block valve. Additionally, the operator MUST open the CCW pump suction header block valve, since flow to the unit one pumps' suction is isolated from the unit two pumps' suction.

The development of the probability of failure of this action is calculated in Appendix 3C.

3.4.2.7 INPUT DATA

An input listing of component identifiers and associated probabilities for analysis of the CCWS with no Loss of Offsite Power is presented in Table 3.4-2. Sixteen different sets of input data were used for quantification, varying power to the four electric busses as follows:

POWER STATE	BUSSES AVAILABLE
1	141, 142, 241, 242
2	141, 142, 242
3	141, 142, 241
4	141, 142
5	142, 231, 242
6	142, 242
7	142, 241
8	142
9	141, 241, 242
10	141, 242
11	141, 241
12	141
13	241, 242
14	242
15	241
16	-

3.4.3 MULTI-UNIT ANALYSIS OF THE COMPONENT COOLING WATER SYSTEM

Due to the alignment of the valves in the pump suction header and discharge header of the heat exchangers, a dependence on unit 2 pumps for flow to the 1A RHR heat exchanger results. It is necessary to calculate the split fraction probabilities of both unit's diesel generators, or power at the busses, as appropriate, in order to properly weight the CCW system in it's two unit

operating configuration. Due to the small difference expected in calculations of CCW System unavailability for the three categories of split fractions (i.e., LOCA, LOC , and Transient, see Sections 4.1.2 and 4.2.2) the two unit operating split fractions (AC power only) have been developed for the LOOP initiator only. This is very conservative, as the failure probability of offsite power given a LOCA or Transient is not included, and the resulting split fractions are higher than actually expected for LOCA and transient events.

3.4.3.1 CALCULATION OF TWO UNIT ELECTRIC POWER SPLIT FRACTIONS

The calculation of the four bus split fractions for two unit operation utilizes beta factors as derived in Appendix 38. The use of these beta factors places less credibility in the possibility of a component success given the prior number of failures in redundant trains. These beta factors represent conditional probabilities as follows: 1) probability that a third component will fail given two previous failures is 0.2; and 2) probability that the fourth component will fail given three previous failures is 0.5. The calculations of the Unit 2 Conditional Probabilities follow, the results of which are presented graphically on Figures 3.4-4 and 3.4-5.

The approach used determines the number of failures in each 2 unit power state and then calculates the frequency (or split fraction) of that state, given a loss of offsite power. The Unit 2 conditional probability is then achieved by separating the contribution of Unit 1 to those frequencies.

The following table presents the two unit power states, showing the status of busses as operating (1) or failed (0), and the total number of diesel failures in that state. This allows for a grouping of states throughout the following calculations.

Power State	Busses 142	141	242	241	Number of Failures 0	1	2	3	4
1		1	1	1	X				
2	1	1	1	0		X			
3	1	1	0	1		X			
4	1	1	0	0			X		
5	1	0	1	1		X			
6	1	0	1	0			X		
7	1	0	0	1			X		
8	1	0	0	0				X	
9	0	1	1	1		X			
10	0	1	1	0			X		
11	0	1	0	1			X		
12	0	1	0	0				X	
13	0	0	1	1			X		
14	0	0	1	0				X	
15	0	0	0	1				X	
16	0	0	0	0					X

CALCULATION OF UNIT 2 CONDITIONAL PROBABILITIES

Definitions

Random Diesel Failure Probability: R = 2.42(-2)

3 Day LCO Maintenance Unavailability: M_3 = 1.54(-2)

7 Day LCO Maintenance Unavailability: M_7 = 2.75(-2)

β_2 = .026 (Refer to Appendix 3B)

β_3 = .2 x .026 = .013

β_4 = .1 x .026 = .0026

CC = β_2 x R = 6.3(-4)

CCC = β_3 x R = 1.26(-4)

CCCC = β_4 x R = 6.3(-4)

Electric Power States 1, 2, 3 and 4

The Unit 2 conditional split fractions are equal to those derived from the fault tree presented in Section 3.2 for Unit 1 diesel generators, therefore the calculation of total two unit split fractions in these states is not necessary. See Figures 3.4-4 and 3.4-5.

For the split fractions of all other states, the probability of the total number of failures in both units is derived from: 1) the fault tree presented in Section 3.2 for one and two failures; and 2) the calculations presented below for three and four failures. The resulting total (2 unit) split fraction is then divided by the Unit 1 split fraction, resulting in the Unit 2 conditional (on Unit 1) split fraction.

3 Failures

Cutsets	Busses		
	1	2	3
2	M	M	R
3	M	R	R
1	R	R	R
3	R	C	C
1	C	C	C
3	M	C	C

where: M is component maintenance
R is component random failure
C is component common cause failure

Equation

$$P_f = 2[M^2 \times R] + 3[M \times R^2] + R^3 + 3[R \times CC] + CCC + 3[M \times CC]$$

3-Day LCO

$$P_f = 2[1.54(-2)^2 \times 2.42(-2)] + 3[1.54(-2) \times 2.42(-2)^2] + 2.42(-2)^3 + \\ + 3[2.42(-2) \times 6.3(-4)] + 1.26(-4) + 3[1.54(-2) \times 6.3(-4)] \\ = 2.53(-4)$$

7-Day LCO

$$P_f = 2[2.75(-2)^2 \times 2.42(-2)] + 3[2.75(-2) \times 2.42(-2)^2] + 2.42(-2)^3 + \\ + 3[2.42(-2) \times 6.3(-4)] + 1.26(-4) + 3[2.75(-2) \times 6.3(-4)] \\ = 3.23(-4)$$

These total split fractions are applicable to states 8, 12, 14 and 15, as shown in the table above. The numbers and results for these states are presented in Figures 3.4-4 and 3.4-5 for 3-Day and 7-Day LCO, respectively.

4 Failures

Cutsets	Busses			
	1	2	3	4
4	M	M	R	R
4	M	R	R	R
1	R	R	R	R
4	M	M	C	C
12	M	R	C	C
4	M	C	C	C
4	R	C	C	C
6	R	R	C	C
1	C	C	C	C

Equation

$$P_f = 4[M^2 \times R^2] + 4[M \times R^3] + R^4 + 4[M^2 \times CC] + 12[M \times R \times CC] + 4[M \times CCC] + 4[R \times CCC] + 6[R^2 \times CC] + CCCC$$

3-Day LCO

$$\begin{aligned} P_f &= 4[1.54(-2)^2 \times 2.42(-2)^2] + 4[1.54(-2) \times 2.42(-2)^3] + 2.42(-2)^4 + \\ &\quad + 4[1.54(-2)^2 \times 6.3(-4)] + 12[1.54(-2) \times 2.42(-2) \times 6.3(-4)] + \\ &\quad + 4[1.54(-2) \times 1.26(-4)] + 4[2.42(-2) \times 1.26(-4)] + 6[2.42(-2)^2 \times 6.3(-4)] + \\ &\quad + 6.3(-5) \\ &= 9.04(-5) \end{aligned}$$

7-Day LCO

$$\begin{aligned} P_f &= 4[2.75(-2)^2 \times 2.42(-2)^2] + 4[2.75(-2) \times 2.42(-2)^3] + 2.42(-2)^4 + \\ &\quad + 4[2.75(-2)^2 \times 6.3(-4)] + 12[2.75(-2) \times 2.42(-2) \times 6.3(-4)] + \\ &\quad + 4[2.75(-2) \times 1.26(-4)] + 4[2.42(-2) \times 1.26(-4)] + 6[2.42(-2)^2 \times 6.3(-4)] + \\ &\quad + 6.3(-5) \\ &= 1.02(-4) \end{aligned}$$

The total split fractions above are applicable to State 16, where all diesels fail. The conditional split fraction of Unit 2 components is equal to the total split fraction divided by the Unit 1 split fraction for each respective LCO outage time. See Figures 3.4-4 and 3.4-5.

The conditional split fraction for States 5, 9, and 13 are the complements of the sum of other Unit 2 conditional split fractions for a given Unit 1 power state, (i.e., 1 - (sum of other conditional split fractions)).

3.4.4 FAULT TREE QUANTIFICATION

The results of this analysis are presented in Table 3.4-3. Due to the presence of the maintenance spare pump, there is negligible difference between the 3 day and 7 day LCO analysis for this system. Dominant contributors to the system failure are active component failures, comprised of the pumps failure to start and run, due to both random and common cause faults. Due to the passive nature of other system components such as valves, heat exchangers, and the surge tanks, this result is expected. A table of relative contributions of dominant cutsets to system failure is not presented, since: 1) with a multitude of support states analyzed, a listing of cut sets would not be meaningful; and 2) common cause failures of pumps is the dominant contributor to system unavailability. Therefore, the results are broken into the following categories of failure.

1. COMMON - represents the probability of failures leading to entire system failure;

2. TRAIN A - represents the probability of failure of flow to the Train A RHR heat exchanger; and

3. TRAIN B - represents the probability of failure of flow to the Train B RHR heat exchanger.

The differences between these categories are due to the alignment of the systems valves, which places the A train component and heat exchanger loads on the Unit 2 CCW pumps, heat exchanger, and essential service water system.

3.4.4.1 SYSTEM UNAVAILAILITY CALCULATIONS

The calculations of system unavailability are presented in Tables 3.4-4 and 3.4-5 for 3 day and 7 day LCO, respectively. These calculations weight the probability of system failure with the Unit 2 conditional split fractions of the AC electric busses which were derived in Section 3.4.3 (see Figures 3.4-4 and 3.4-5). The summary of results is presented in Table 3.4-3.

3.4.4.2 DOMINANT CUTSETS

The dominant contributors to system unavailability are the CCW pumps, which fail due to random and common cause faults. Maintenance contributes a negligible amount of system unavailability due to the presence of the spare pump.

TABLE 3.4-1

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error (see Note)
1CC01PA	X				X	
1CC01PB		X			X	
2CC01PA	Unit 2				X	
2CC01PB		Unit 2			X	
0CC01P	X	X			X	
1CC9463A						
1CC9463B						
2CC9463A						
2CC9463B						
1CC9473A	X					FO
1CC9473B		X				FO
1CC9459A						
1CC9459B						FO
2CC9459A						
2CC9459B						
1CC9467A						
1CC9467B						FO
2CC9467A						
2CC9467B						
1CC9470A						
1CC9470B						
2CC9470A						
2CC9470B						
2CC9473A	Unit 2					
2CC9473B		Unit 2				
1CC9460A						
1CC9460B						
2CC9460A						
2CC9460B						
1CC9466A						
1CC9466B						
2CC9466A						
21CC9470B						
2CC9467C						
1CC9471B						
1CC9471A						
0CC9509						
2CC9458						
1CC9458						
1SX004		X				
2SX004		Unit 2				
1SX007	X					
2SX007	Unit 2					

TABLE 3.4-1 (Continued)

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error (see Note)
OSX007		X				
1SX146		X				
2SX146		Unit 2				
1SX005		X				
2SX005		Unit 2				

Note:

Operator Error Symbols

FR = Fails to restore following (T, M or R)
T = Test
M = Maintenance
R = Refueling
FO = Fails to open
FC = Fails to close

TABLE 3.4-2

CCW SYSTEM COMPONENT FAULTS 1, 3

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
1MOVSX004C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
2MOVSX004C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC94604C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC94608C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVC294604C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVC294608C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC94664C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	.27E-06	1.62E-12
XVC294664C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC94668C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVC294668C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVC194708C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
QXVSX007C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC94718C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
1MOVSX007C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
2MOVSX007C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC94714C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC95008C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.728E+05	0.000E-01	9.12E-03	8.42E-05
XVC294738C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.728E+05	0.000E-01	9.12E-03	8.42E-05
XVC294508C	X_MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.728E+05	0.000E-01	9.12E-03	8.42E-05

TABLE 3.4-2 (Cont.)

CCW SYSTEM COMPONENT FAULTS 1, 3

XWC294677CC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.728E+05	0.000E-01	9.12E-03	8.42E-05
MWC294738C	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.728E+05	0.000E-01	9.12E-03	8.42E-05
XWC194677CC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.728E+05	0.000E-01	9.12E-03	8.42E-05
XWC194758C	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XWC194703AC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC194678BC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC194678BD	OPER	OPERATOR ERROR MANUA	1.10OE-03	0.000E-01	HES	0.000E-01	0.000E-01	1.10E-03	0.00E-01
XWC194758BD	OPER	OPERATOR ERROR MANUA	1.10OE-03	0.000E-01	HES	0.000E-01	0.000E-01	1.10E-03	0.00E-01
XWC294703AC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC294708BC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC194708BC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC194598BC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC194678AC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC294678AC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC294678BC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC294598BC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XWC294594AC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XWC194594AC	X_MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MWC194734D	MOV	FAIL TO OPERATE	1.55OE-03	6.30OE-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MWC194738D	MOV	FAIL TO OPERATE	1.55OE-03	6.30OE-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MWC194738D	OPER	OPERATOR ERROR MOTOR	1.40OE-03	0.000E-01	HEB	0.000E-01	0.000E-01	1.40E-03	0.00E-01
MWC194734D	OPER	OPERATOR ERROR MOTOR	1.40OE-03	0.000E-01	HEB	0.000E-01	0.000E-01	1.40E-03	0.00E-01

TABLE 3.4-2 (Cont.)

CCW SYSTEM COMPONENT FAULTS 1, 3

MOVSX146D	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MOVSX147D	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
1SX005D	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
2SX005D	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVCC9463AC	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
CVCC9463BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVC29463AC	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
CVC29463BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
OCCO1PM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
1CCO1PAM	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
1CCO1PBM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
2CCO1PAM	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
2CCO1PBM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS241D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS242D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BUS132D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
BUS232D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
BUS131X3D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
PCCO2PAFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
PCCO2PBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07

TABLE 3.4-2 (Cont.)

CCW SYSTEM COMPONENT FAULTS 1, 3

PCCO1PBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCCO1PAFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
PCCO1PAFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
PCCO1PBFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
PCCO2PBFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
PCCO2PAFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
CCCCWPA	CC	CC RUNNING CCW TRAIN	4.590E-06	0.000E-01	CCW	0.000E-01	0.000E-01	4.59E-06	0.00E-01
CCCCWPB	CC	COMMON CAUSE STANDBY	7.160E-05	0.000E-01	CC2	0.000E-01	0.000E-01	7.16E-05	0.00E-01

TABLE 3.4-3

SUMMARY OF RESULTS

3 Day LCO

Support State	Common	Train A	Train B
1	4.5(-9)	7.1(-6)	3.8(-8)
2	1.0	0.0	0.0
3	2.6(-5)	5.8(-5)	3.8(-6)
4	1.4(-5)	5.8(-5)	4.6(-6)
5	3.6(-2)	3.0(-10)	3.4(-3)
6	1.0	0.0	0.0

7 Day LCO

Support State	Common	Train A	Train B
1	5.7(-9)	9.4(-6)	3.8(-8)
2	1.0	0.0	0.0
3	7.6(-6)	1.3(-5)	3.8(-6)
4	3.6(-6)	1.3(-5)	4.6(-6)
5	1.3(-2)	2.9(-10)	3.5(-3)
6	1.0	0.0	0.0

TABLE 3.4-4

CALCULATION OF 3 DAY CCW PROBABILITIES

Power State	Split Fraction	CCW Unavailability			Product		
		Common	Tr 'A'	Tr 'B'	Common	Tr 'A'	Tr 'B'
1	.9221	3.0(-10)	5.0(-9)	3.8(-8)	2.8(-10)	4.6(-9)	3.5(-8)
2	.038	6.0(-8)	3.9(-6)	3.8(-8)	2.3(-9)	1.5(-7)	1.4(-9)
3	.038	5.4(-9)	3.4(-6)	3.8(-8)	2.1(-10)	1.3(-7)	1.4(-9)
4	.0019	9.0(-7)	3.6(-3)	1.9(-8)	1.7(-9)	6.8(-6)	3.6(-11)
					4.5 (-9)	7.1(-6)	3.8(-8)
5	.882	6.2(-8)	7.6(-9)	3.8(-6)	5.5(-8)	6.7(-9)	3.4(-6)
6	.051	7.3(-5)	3.7(-6)	3.5(-6)	3.7(-6)	1.9(-7)	1.8(-7)
7	.051	1.2(-6)	4.0(-6)	3.8(-6)	6.1(-6)	2.0(-7)	1.9(-7)
8	.016	1.0(-3)	3.6(-3)	1.0(-8)	1.6(-5)	5.8(-5)	1.6(-10)
					2.6(-5)	5.8(-5)	3.8(-6)
9	.882	6.4(-9)	7.5(-9)	4.6(-6)	5.6(-9)	6.6(-9)	4.1(-6)
10	.051	1.3(-6)	3.9(-6)	4.6(-6)	6.6(-8)	2.0(-7)	2.3(-7)
11	.051	5.7(-6)	4.3(-6)	4.5(-6)	2.9(-7)	2.2(-7)	2.3(-7)
12	.016	8.6(-4)	3.6(-3)	1.5(-6)	1.4(-5)	5.8(-5)	2.4(-8)
					1.4(-5)	5.8(-5)	4.6(-6)
13	.345	2.3(-6)	3.0(-10)	3.6(-3)	7.9(-7)	1.0(-10)	1.2(-3)
14	.31	1.0(-3)	3.0(-10)	3.6(-3)	3.1(-4)	1.0(-10)	1.1(-3)
15	.31	1.0(-3)	3.0(-10)	3.6(-3)	3.1(-4)	1.0(-10)	1.1(-3)
16	.035	1.0	0.0	0.0	.035	0.0	0.0
					3.6(-2)	3.9(-10)	3.4(-3)

TABLE 3.4-5

CALCULATION OF 7 DAY CCW PROBABILITIES

Power State	Split Fraction	CCW Unavailability			Product		
		Common	Tr 'A'	Tr 'B'	Common	Tr 'A'	Tr 'B'
1	.9009	3.0(-10)	5.0(-9)	3.8(-8)	2.7(-10)	4.5(-9)	3.4(-8)
2	.048	6.0(-8)	3.9(-6)	3.8(-8)	2.9(-9)	1.9(-7)	1.8(-9)
3	.048	5.4(-9)	3.4(-6)	3.8(-8)	2.6(-10)	1.6(-7)	1.8(-9)
4	.0025	9.0(-7)	3.6(-3)	1.9(-8)	2.3(-9)	9.0(-6)	4.8(-11)
					5.7 (-9)	9.4(-6)	3.8(-8)
5	.892	6.2(-8)	7.6(-9)	3.8(-6)	5.5(-8)	6.8(-9)	3.4(-6)
6	.052	7.3(-5)	3.7(-6)	3.5(-6)	3.8(-6)	1.9(-7)	1.8(-7)
7	.052	1.2(-6)	4.0(-6)	3.8(-6)	6.2(-8)	2.1(-7)	2.0(-7)
8	.0037	1.0(-3)	3.6(-3)	1.0(-8)	3.7(-7)	1.3(-5)	3.7(-11)
					7.6(-6)	1.3(-5)	3.8(-6)
9	.892	6.4(-9)	7.5(-9)	4.6(-6)	5.7(-9)	6.7(-9)	4.1(-6)
10	.052	1.3(-6)	3.9(-6)	4.6(-6)	6.8(-8)	2.0(-7)	2.4(-7)
11	.052	5.7(-6)	4.3(-6)	4.5(-6)	3.0(-7)	2.2(-7)	2.3(-7)
12	.0037	8.6(-4)	3.6(-3)	1.5(-6)	3.2(-6)	1.3(-5)	5.6(-9)
					1.4(-5)	5.8(-5)	4.6(-6)
13	.843	2.3(-6)	3.0(-10)	3.6(-3)	1.9(-6)	2.5(-10)	3.0(-3)
14	.072	1.0(-3)	3.0(-10)	3.6(-3)	7.2(-5)	2.2(-11)	2.6(-4)
15	.072	1.0(-3)	3.0(-10)	3.6(-3)	7.2(-5)	2.2(-11)	2.6(-4)
16	.013	1.0	0.0	0.0	.013	0	0
					.013	2.9(-10)	3.5(-3)

FIGURE 3.4-1

COMPONENT COOLING WATER SYSTEM

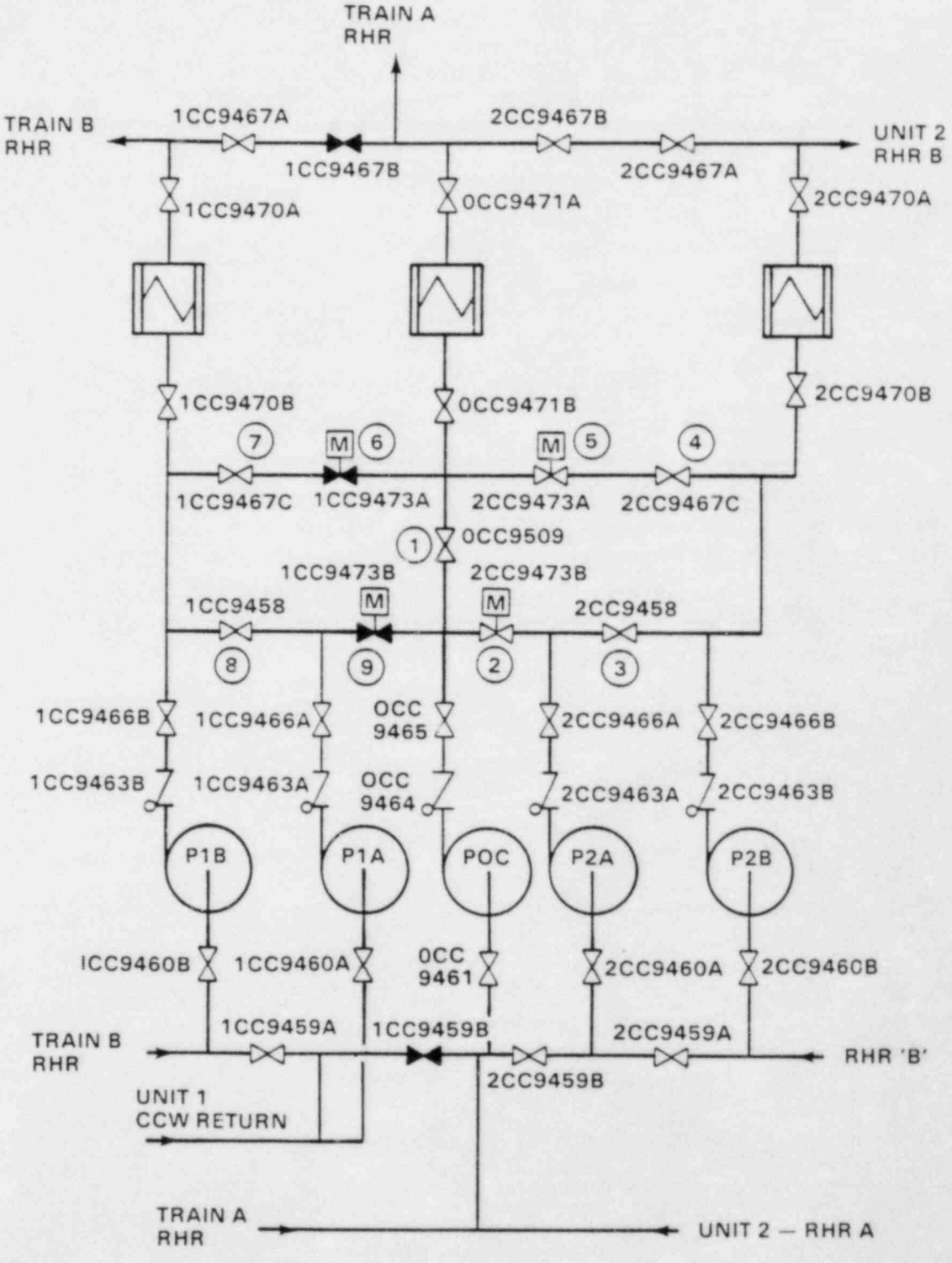

FIGURE 3.4-2

CCW FAULT TREE TOP LOGIC

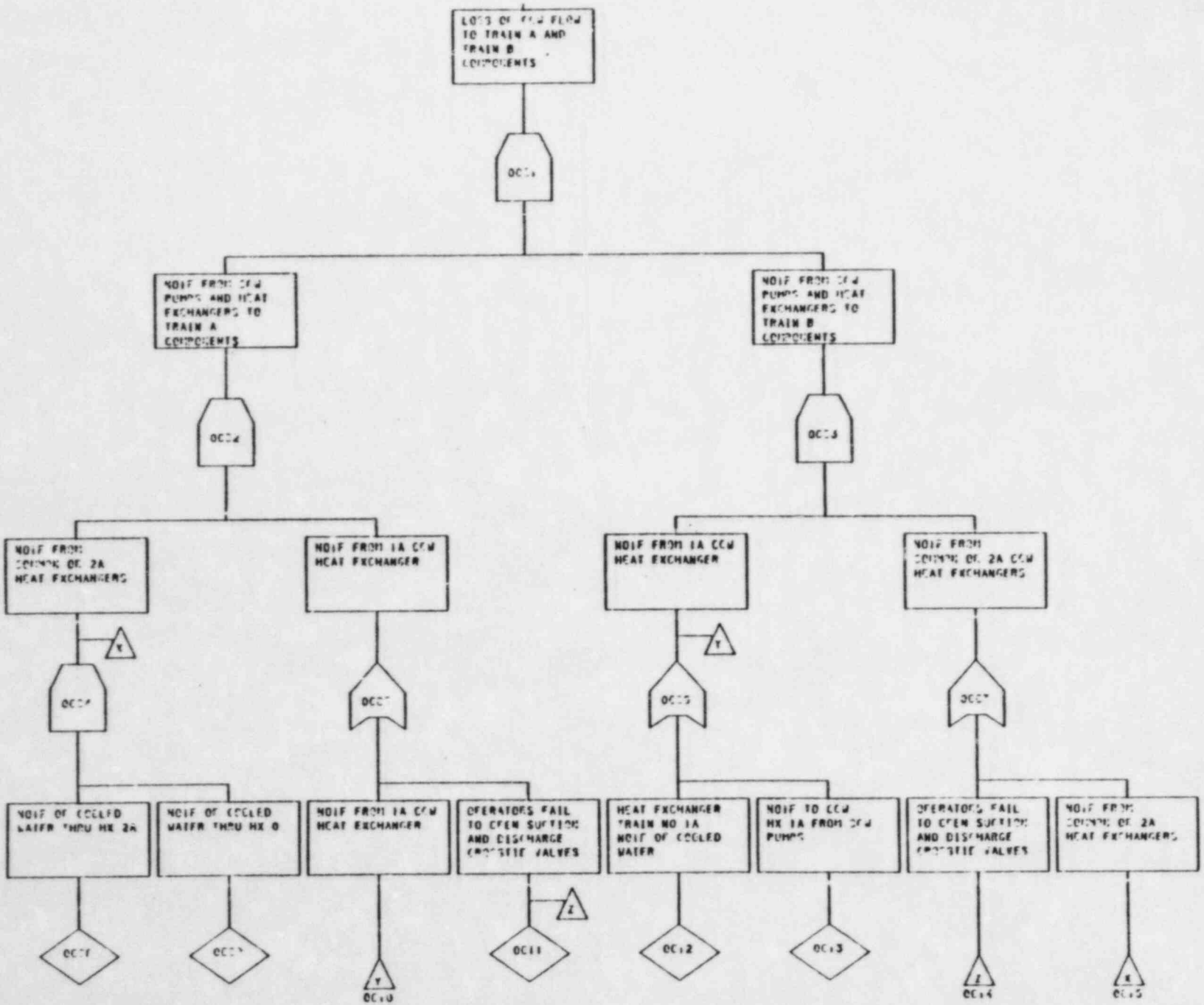

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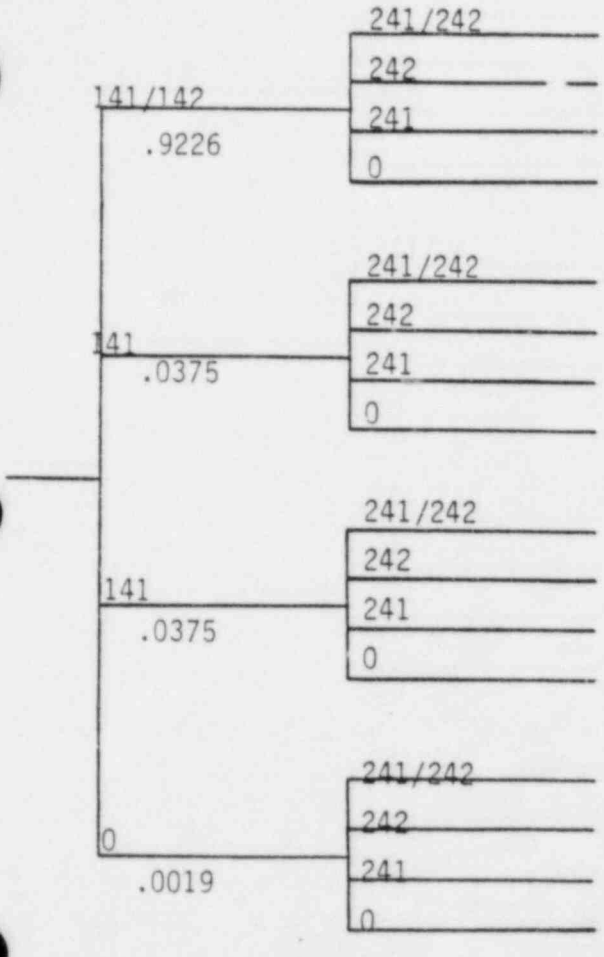
FIGURE 3.4-4

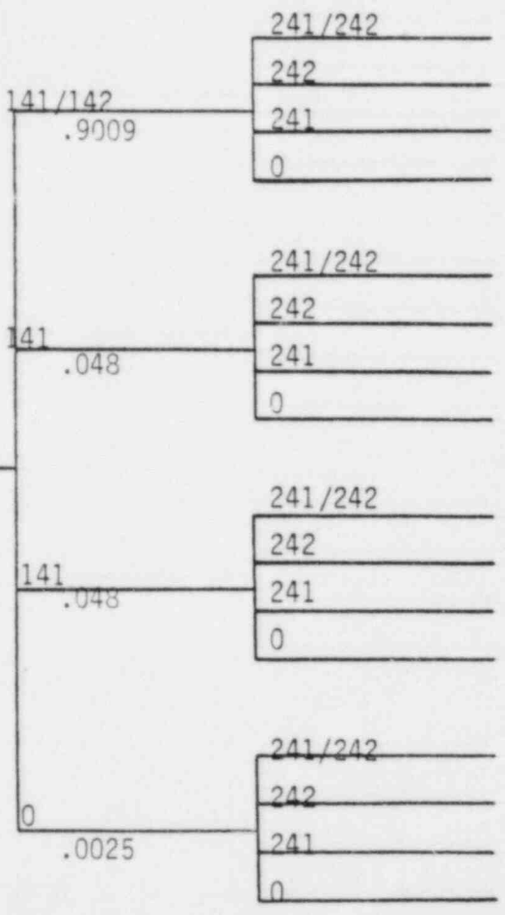
DERIVATION OF 3-DAY TWO UNIT SPLIT FRACTIONS,
CONDITIONAL FRACTIONS OF UNIT 2 BUSSES



STATE	TOTAL # FAILURES	UNIT 2 CONDITIONAL SPLIT FRACTION	TOTAL (2 UNIT) SPLIT FRACTION
1	0	.9226	-
2	1	.0375	-
3	1	.0375	-
4	2	.0019	-
5	1	.8913	-
6	2	.051	.0019
7	2	.051	.0019
8	3	6.7(-3)	2.53(-4)
9	1	.8913	-
10	2	.051	.0019
11	2	.051	.0019
12	3	6.7(-3)	2.53(-4)
13	2	.692	-
14	3	.13	2.53(-4)
15	3	.13	2.53(-4)
16	4	.048	9.04(-5)

FIGURE 3.4-5

DERIVATION OF 7-DAY TWO UNIT SPLIT FRACTIONS,
CONDITIONAL FRACTIONS OF UNIT 2 BUSSES



STATE	TOTAL # FAILURES	UNIT 2 CONDITIONAL SPLIT FRACTION	TOTAL (2 UNIT) SPLIT FRACTION
1	0	.9009	-
2	1	.048	-
3	1	.048	-
4	2	.0025	-
5	1	.8893	-
6	2	.052	.0025
7	2	.052	.0025
8	3	.0067	3.23 (-4)
9	1	.8893	-
10	2	.052	.0025
11	2	.052	.0025
12	3	.0067	3.23(-4)
13	2	.699	-
14	3	.13	3.23(-4)
15	3	.13	3.23(-4)
16	4	.041	1.02(-4)

3.5 AUXILIARY FEEDWATER SYSTEM

3.5.1 SYSTEM DESCRIPTION

The Auxiliary Feedwater System (AFWS) functions as a heat removal system with the steam generator and steam generator relief valves and safety valves. It can operate independently from the main feedwater system for emergencies or as required equipment in startup, shutdown, or hot standby conditions. A simplified flow diagram of the AFWS is shown in Figure 3.5-1.

The auxiliary feedwater pumps are started on either a low-low level in any steam generator, a safety injection signal or a loss of power to the reactor coolant pumps. One motor-driven pump and all motor-operated valves are supplied with emergency power from the diesel generators. The other pump will utilize direct diesel-engine drive so that auxiliary feedwater can be supplied in the event that all onsite and offsite sources of AC power are lost. All electrical equipment in each of the two subsystems is powered from separate diesels. All motor-operated valves are normally open, with the exception of the essential service water suction valves which are normally closed.

A restricting flow orifice is provided in each line so that an auxiliary feedwater pump can deliver adequate flow to each of three unfaulted steam generators within 1 minute following an accident. Consequently, operator action is unnecessary for 30 minutes following an accident.

In addition to the auxiliary feedwater pumps discussed above, the main feedwater startup pump may be activated and valved into the system. Auxiliary feedwater is pumped to the upper nozzles of the steam generators via the tempering flow lines. The feedwater enters the steam generators above the normal water level elevation in the steam generators. Therefore, water hammer is not induced by the admission of unheated auxiliary feedwater to steam generators.

Either of the two auxiliary feedwater pumps or the startup main feedwater pump supplying the four steam generators will provide enough feedwater to cool the unit down safely to the temperature at which the residual heat removal system can be utilized.

The direct diesel engine-driven auxiliary feedwater pump is equipped with two sets of batteries for starting. It requires no supporting services to maintain flow of auxiliary feedwater to two steam generators during loss of onsite and offsite AC power.

A local alarm panel is provided for each direct diesel engine-driven pump to annunciate low lube oil pressure and high jacket water temperature. A single alarm in the main control room will sound when either of these conditions exists. The engine will be automatically tripped in the event of overspeed, high jacket water temperature or low lube oil pressure.

3.5.2 FAULT TREE MODEL OF AUXILIARY FEEDWATER SYSTEM

The auxiliary feedwater system is modeled in two fault trees with different success criteria. Figures 3.5-2 and 3.5-3 show the top logic of these trees and Figures 3.5-4 and 3.5-5 show the trees themselves. Table 3.5-1 lists all the components used in the fault tree model.

3.5.2.1 SUCCESS CRITERIA FOR AUXILIARY FEEDWATER SYSTEM

Two auxiliary feedwater nodes, L-1 and L-2, appear in the event trees. The success criteria for L-1 requires injection from one pump to two of four steam generators. L-2, based on ATWS mitigation, requires injection from one pump to all four steam generators.

3.5.2.2 DEPENDENCE OF AUXILIARY FEEDWATER SYSTEM ON SUPPORT STATES

Train A of the system depends on bus 141 for electric power and on essential service water (ESW) for pump cooling. Train B, however, relies on bus 142 and ESW only if the condensate storage tank fails to supply water. Nothing on train B itself has support state dependencies, but the service water system which backs up the condensate storage supply depends on ESW and bus 142.

3.5.2.3 RANDOM FAILURE MODEL OF AUXILIARY FEEDWATER SYSTEM

The random failure fault tree models were developed according to the LCORP Guide to Fault Tree Development in Appendix 3A with the exception of event identifiers. AOV, MOV, and MV were used as component identifiers rather than AV, MV, and XV, respectively. There is no 'P' preceding pump failure identifiers, but the 'P' at the end of the pump number (i.e., AF01PA for pump A) identifies pump failures. The following assumptions are not addressed in Appendix 3A but apply to the AFWS fault tree:

1) Recirculation flow orifice rupture or excessive flow is negligible. Further, these restrictive openings are sufficient to prevent excessive flow given a) the spurious opening of the service water minimum flow valve 1AF024 while on condensate supply, or b) the failure to close condensate mini-flow valves 1AF022A and B when on service water supply.

2) Success time for the AFW system is five hours, based on Torrey Pines Report Section 3.2.1.1.

3) Diesel pump testing verifies proper cooling valve alignments. All valves must be open for successful pump operation.

The probability of the failure of the diesel pump is not in the Zion data base; therefore, it is calculated using the Torrey Pines Report. The applicable failures from that report are as follows:

35	DC start batteries	3×10^{-4}*
36	Fuel supply failure	3×10^{-3}*
37	Actuation failure	7×10^{-3}*
38	Manual override failure	1×10^{-2}*
39	Engine failure-cooling	1×10^{-3}

40	Pump failure-cooling	1×10^{-3}
41	Engine failure-lube	2×10^{-3}
42	Pump failure-lube	1×10^{-3}
43	Gear box failure (5 hrs)	4.5×10^{-4}
44	Intake blocked-air	2×10^{-3}*
46	Exhaust blocked	1×10^{-3}*
47	Engine breakdown	1×10^{-3}

Asterisked items constitute failure to start, so the probability of failure to start is the sum of these, or 2.33×10^{-2}. The sum of the other failures is 5.45×10^{-3}. Therefore the hourly failure to run rate is $5.45 \times 10^{-3}/5$ hrs, or 1.09×10^{-3}/hr.

3.5.2.4 COMMON CAUSE MODEL OF AUXILIARY FEEDWATER SYSTEM

The only common cause failure considered is that of the pumps. The β factor represents those common things between two components which could cause their failure. Since the pumps themselves are the same but the drivers are different, the β used should include only those things which would fail the pumps. The β's for motor driven and diesel driven pumps both include failures pertaining to the pump and the driver. The smaller of these β's is used as a conservative estimate of the real β. This β is multiplied by the larger of the two random failure probabilities to produce a conservative common cause probability. Common cause failure to start and to run are combined into one failure mode. The calculation of this number is as follows:

$$AF2 = \beta_{start} \times P \text{ (diesel fails to start)} + \beta_{run} \times P \text{ (diesel fails to run)}$$
$$= .008\ (2.33 \times 10^{-2}) + .006\ (1.09 \times 10^{-3}) = 1.93 \times 10^{-4}$$

3.5.2.5 TEST AND MAINTENANCE MODEL OF AUXILIARY FEEDWATER SYSTEM

The test and maintenance of the system is modeled by trains, as explained in Appendix 3A. Table 3.5-1 lists all of the components in the model and if they are tested or maintained. The table also indicates which valves have failure to restore as a failure mode.

The valve and pump tests are done on a staggered test basis, as described in the Byron plant technical specifications. The longest time periods that the trains of the system could operate between test and an event is one month for one train, and 1/2 month for the other. The shortest time periods between test and an event are 1/2 month and no time, when one test has just been finished. As is standard practice, half of the time interval was used: 3/4 month for one train and 1/4 month for the other. Common components such as condensate storage tank outlet valves are tested every two weeks, with each train test.

3.5.2.6 HUMAN ERROR MODEL OF AUXILIARY FEEDWATER SYSTEM

No human errors are modeled in the auxiliary feedwater system fault trees. One valve is closed for test and maintenance but it is flow tested following test and maintenance, which ensures that it is not left closed.

3.5.2.7 INPUT DATA FOR AUXILIARY FEEDWATER SYSTEM

Tables 3.5-2 through 3.5-5 list all event identifiers, brief descriptions of the failure modes they represent, and the number used as input to the fault tree quantification. The first two tables are for 3 day LCO, the last two for 7 day LCO. These numbers are drawn from the data bank in Appendix 3D. The input is the same for both fault trees.

3.5.3 FAULT TREE QUANTIFICATION FOR AUXILIARY FEEDWATER SYSTEM

3.5.3.1 SYSTEM UNAVAILABILITY CALCULATIONS FOR AUXILIARY FEEDWATER SYSTEM

The fault trees were analyzed using the WAMBAM computer code. Figures 3.5-2 and 3.5-3 show the top logic for both fault trees and Tables 3.5-6 and 3.5-7 give the probabilities for the lower nodes of these figures for 3 day and 7 day LCO, respectively. Table 3.5-8 lists the results for both fault trees.

3.5.3.2 DOMINANT CUTSETS FOR AUXILIARY FEEDWATER SYSTEM

The WAMCUT computer code was used to obtain cutsets for both fault tree models. Table 3.5-9 lists the cutsets for the L-1 success criteria. Table 3.5-10 lists the cutsets for the ATWS mitigation, or L-2, success criteria.

TABLE 3.5-1

COMPONENTS IN AUXILIARY FEEDWATER MODEL

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error [1]
MDP AF01PA	X		X	Staggered Monthly	X	
DDP AF01PB			X(2)	Staggered Monthly	X	
MOV AF013A	X			Quarterly		
MOV AF013B	X			Quarterly		
MOV AF013C	X			Quarterly		
MOV AF013D	X			Quarterly		
MOV AF013E		X		Quarterly		
MOV AF013F		X		Quarterly		
MOV AF013G		X		Quarterly		
MOV AF013H		X		Quarterly		
AOV AF005A						
AOV AF005B						
AOV AF005C						
AOV AF005D						
AOV AF005E						
AOV AF005F						
AOV AF005G						
AOV AF005H						
AOV AF004A						
AOV AF004B						
MOV AF017A	X			Quarterly		
MOV AF017B		X		Quarterly		
MOV AF006A	X			Quarterly		
MOV AF006B		X		Quarterly		
XV AF002A						
XV AF002B						
AOV SX173						
AOV SX178						
Condensate Storage Tank						
CV AF001A						
CV AF001B						
CV AF003A						
CV AF003B						
CV AF014A						

TABLE 3.5-1 (Continued)

COMPONENTS IN AUXILIARY FEEDWATER MODEL

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	1 Operator Error
CV AF014B						
CV AF014C						
CV AF014D						
CV AF014E						
CV AF014F						
CV AF014G						
CV AF014H						
CV AF029A						
CV AF029B						
CV CD183						
CV SX174						
XV CD022						
XV CD091						
XV CD149						
XV SX175						
XV SX176						
XV SX177						
SV SX101A						

Notes:

System Component Notes

FR = Fails to restore following (T, M or R)
T = Test
M = Maintenance
R = Refueling
FO = Fails to open
FC = Fails to close

1 - Diesel-driven pump depends on ESW only if condensate
2 - Storage tank supply fails

TABLE 3.5-2

AUX FEED COMPONENT FAILURES-PS. 1, 3 DAY

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
AFO1PBFS	DDP	FAIL TO START	2.330E-02	0.000E-01	TP	0.000E-01	0.000E-01	2.33E-02	0.00E-01
AFO1PFS	MDP	FAIL TO START	5.020E-03	9.260E-06	ZPSS	0.000E-01	0.000E-01	5.02E-03	9.26E-06
AFO1PBFR	DDP	FAIL DURING OPERATIO	1.090E-03	0.000E-01	TP	5.000E+00	0.000E-01	5.45E-03	0.00E-01
AFO1PFR	MDP	FAIL DURING OPERATIO	9.870E-05	1.980E-08	ZPSS	5.000E+00	0.000E-01	4.93E-04	4.95E-07
SVSX101AD	SV	FAIL TO OPERATE	2.000E-06	6.100E-12	NREP	0.000E-01	0.000E-01	2.00E-06	6.10E-12
AOVSX173D	AOV	FAIL TO OPERATE	1.440E-03	7.930E-07	ZPSS	0.000E-01	0.000E-01	1.44E-03	7.93E-07
OVSX178D	AOV	FAIL TO OPERATE	1.440E-03	7.930E-07	ZPSS	0.000E-01	0.000E-01	1.44E-03	7.93E-07
MOVAFO17AD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MOVAFO17BD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MOVAFO06AD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MOVAFO06BD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MOVAFO13AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MOVAFO13BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MOVAFO13CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MOVAFO13DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MOVAFO13EC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
MOVAFO13FC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
MOVAFO13GC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
MOVAFO13HC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10

TABLE 3.5-2 (Continued)

AUX FEED COMPONENT FAILURES-PS. 1, 3 DAY

AOVAF005AC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.83OE+02	0.000E-01	2.05E-05	6.16E-10
AOVAF005BC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.83OE+02	0.000E-01	2.05E-05	6.16E-10
AOVAF005CC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.83OE+02	0.000E-01	2.05E-05	6.16E-10
AOVAF005DC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.83OE+02	0.000E-01	2.05E 05	6.16E-10
AOVAF005EC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	5.48OE+02	0.000E-01	6.14E-05	5.53E-09
AOVAF005FC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	5.48OE+02	0.000E-01	6.14E-05	5.53E-09
AOVAF005GC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	5.48OE+02	0.000E-01	6.14E-05	5.53E-09
AOVAF005HC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	5.48OE+02	0.000E-01	6.14E-05	5.53E-09
CVAFO14AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14CC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14DC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14EC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14FC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14GC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14HC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO29AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO29BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO03AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO03BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO01AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO01BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09

TABLE 3.5-2 (Continued)

AUX FEED COMPONENT FAILURES-PS. 1, 3 DAY

CVSX174C	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSX175C	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	5.48OE+02	0.000E-01	2.89E-05	8.47E-10
MVSX176C	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	5.48OE+02	0.000E-01	2.89E-05	8.47E-10
MVSX177C	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	5.48OE+02	0.000E-01	2.89E-05	8.47E-10
MVAFOO2AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.83OE+02	0.000E-01	9.66E-06	9.44E-11
MVAFOO2BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	5.48OE+02	0.000E-01	2.89E-05	8.47E-10
AOVAFOO4AC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.83OE+02	0.000E-01	2.05E-05	6.16E-10
AOVAFOO4BC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	5.48OE+02	0.000E-01	6.14E-05	5.53E-09
MVCD149C	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.83OE+02	0.000E-01	9.66E-06	9.44E-11
MVCDO91C	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.83OE+02	0.000E-01	9.66E-06	9.44E-11
MVCDO22C	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.83OE+02	0.000E-01	9.66E-06	9.44E-11
CVCD183C	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CSTFAIL	CST	DOES NOT SUPPLY WATE	8.48OE-10	5.10OE-17	ZPSS	1.83OE+02	0.000E-01	1.55E-07	1.71E-12
ESWAU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BUS131ZD	BUS	NO POWER-4 HR DETECT	7.64OE-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
BUS132ZD	BUS	NO POWER-4 HR DETECT	7.64OE-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
PAFO1PAM	MDP	MAINTENANCE FREQUENC	1.87OE-04	0.000E-01	ZPSS	1.90OE+01	0.000E-01	3.55E-03	0.00E-01
PAFO1PBM	DDP	MAINTENANCE FREQUENC	1.26OE-04	0.000E-01	AF1	1.90OE+01	0.000E-01	2.39E-03	0.00E-01
CCFAIL	CC	COMMON CAUSE FAILURE	1.93OE-04	0.000E-01	AF2	0.000E-01	0.000E-01	1.93E-04	0.00E-01
CVAFOO1AO	CV	FAIL TO SEAT/EXCESS	8.38OE-07	7.29OE-13	ZPSS	5.00OE+00	0.000E-01	4.19E-06	1.82E-11

TABLE 3.5-2 (Continued)

AUX FEED COMPONENT FAILURES-PS. 1, 3 DAY

CVAF001BO	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	5.000E+00	0.000E-01	4.19E-06	1.82E-11

TABLE 3.5-3

3 DAY LCO DATA INPUT FOR AUXILIARY FEEDWATER

FT IDENTIFIER	1	2	3	4	5	6
ESWAU	0	1	0	0	0	1
JBS141D	0	0	1	0	1	1
JBS142D	0	0	0	1	1	1

TABLE 3.5-4

AUX FEED COMPONENT FAILURES - PS. 1, 7 DAY

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
AFO1PBFS	DDP	FAIL TO START	2.330E-02	0.000E-01	TP	0.000E-01	0.000E-01	2.33E-02	0.00E-01
AFO1PFS	MDP	FAIL TO START	5.020E-03	9.260E-06	ZPSS	0.000E-01	0.000E-01	5.02E-03	9.26E-06
AFO1PBFR	DDP	FAIL DURING OPERATIO	1.090E-03	0.000E-01	TP	5.000E+00	0.000E-01	5.45E-03	0.00E-01
AFO1PFR	MDP	FAIL DURING OPERATIO	9.870E-05	1.980E-08	ZPSS	5.000E+00	0.000E-01	4.93E-04	4.95E-07
SVSX101AD	SV	FAIL TO OPERATE	2.000E-06	6.100E-12	NREP	0.000E-01	0.000E-01	2.00E-06	6.10E-12
AOVSX173D	AOV	FAIL TO OPERATE	1.440E-03	7.930E-07	ZPSS	0.000E-01	0.000E-01	1.44E-03	7.93E-07
AOVSX178D	AOV	FAIL TO OPERATE	1.440E-03	7.930E-07	ZPSS	0.000E-01	0.000E-01	1.44E-03	7.93E-07
MOVAFO17AD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MOVAFO17BD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MOVAFO06AD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MOVAFO06BD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MOVAFO13AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MOVAFO13BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MOVAFO13CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MOVAFO13DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MOVAFO13EC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
MOVAFO13FC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
MOVAFO13GC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
MOVAFO13HC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10

TABLE 3.5-4 (Continued)

AUX FEED COMPONENT FAILURES - PS. 1, 7 DAY

AOVAF005AC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.83OE+02	0.000E-01	2.05E-05	6.16E-10
AOVAF005BC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.83OE+02	0.000E-01	2.05E-05	6.16E-10
AOVAF005CC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.83OE+02	0.000E-01	2.05E-05	6.16E-10
AOVAF005DC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.83OE+02	0.000E-01	2.05E-05	6.16E-10
AOVAF005EC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	5.48OE+02	0.000E-01	6.14E-05	5.53E-09
AOVAF005FC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	5.48OE+02	0.000E-01	6.14E-05	5.53E-09
AOVAF005GC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	5.48OE+02	0.000E-01	6.14E-05	5.53E-09
AOVAF005HC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	5.48OE+02	0.000E-01	6.14E-05	5.53E-09
CVAFO14AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14CC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14DC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14EC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14FC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14GC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO14HC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO29AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO29BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO03AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO03BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO01AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVAFO01BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09

TABLE 3.5-4 (Continued)

AUX FEED COMPONENT FAILURES - PS. 1, 7 DAY

CVSX174C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSX175C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
MVSX176C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
MVSX177C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
MVAF002AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MVAF002BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	5.480E+02	0.000E-01	2.89E-05	8.47E-10
AOVAF004AC	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	1.830E+02	0.000E-01	2.05E-05	6.16E-10
AOVAF004BC	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	5.480E+02	0.000E-01	6.14E-05	5.53E-09
MVCD149C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MVCD091C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
MVCD022C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.830E+02	0.000E-01	9.66E-06	9.44E-11
CVCD183C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CSTFAIL	CST	DOES NOT SUPPLY WATE	8.480E-10	5.100E-17	ZPSS	1.830E+02	0.000E-01	1.55E-07	1.71E-12
ESWAU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BUS131ZD	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
BUS132ZD	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
PAFO1PAM	MDP	MAINTENANCE FREQUENC	1.870E-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	6.36E-03	0.00E-01
PAFO1PBM	DDP	MAINTENANCE FREQUENC	1.260E-04	0.000E-01	AF1	3.400E+01	0.000E-01	4.28E-03	0.00E-01
CCFAIL	CC	COMMON CAUSE FAILURE	1.930E-04	0.000E-01	AF2	0.000E-01	0.000E-01	1.93E-04	0.00E-01
CVAF001AO	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	5.000E+00	0.000E-01	4.19E-06	1.82E-11

TABLE 3.5-4 (Continued)

AUX FEED COMPONENT FAILURES - PS. 1, 7 DAY.

CVAF001BO	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	5.000E+00	0.000E-01	4.19E-06	1.82E-11

TABLE 3.5-5

7 DAY LCO DATA INPUT FOR AUXILIARY FEEDWATER

FT IDENTIFIER	1	2	3	4	5	6
ESWAU	0	1	0	0	0	1
JBS141D	0	0	1	0	1	1
JBS142D	0	0	0	1	1	1

TABLE 3.5-6

3 DAY LCO DATA INPUT FOR AUXILIARY FEEDWATER

TOP LOGIC FAULT TREE STRUCTURE

Identifier	Power State 1	2	3	4	5	6
CC FAIL	1.93×10^{-4}	1.93×10^{-4}	1.93×10^{-4}	1.93×10^{-4}	1.93×10^{-4}	1.93×10^{-4}
AAAA	3.06×10^{-4}	3.42×10^{-2}	3.41×10^{-2}	3.07×10^{-4}	3.42×10^{-2}	3.42×10^{-2}
BBBB	3.06×10^{-4}	3.42×10^{-2}	3.41×10^{-2}	3.07×10^{-4}	3.42×10^{-2}	3.42×10^{-2}
CCCC	3.06×10^{-4}	3.42×10^{-2}	3.41×10^{-2}	3.07×10^{-4}	3.42×10^{-2}	3.42×10^{-2}
DDDD	3.06×10^{-4}	3.42×10^{-2}	3.41×10^{-2}	3.07×10^{-4}	3.42×10^{-2}	3.42×10^{-2}

TABLE 3.5-7

7 DAY LCO DATA INPUT FOR AUXILIARY FEEDWATER
TOP LOGIC FAULT TREE STRUCTURE

Identifier	Power State 1	2	3	4	5	6
CC FAIL	1.93×10^{-4}	1.93×10^{-4}	1.93×10^{-4}	1.93×10^{-4}	1.93×10^{-4}	1.93×10^{-4}
AAAA	4.05×10^{-4}	3.60×10^{-2}	3.59×10^{-2}	4.06×10^{-4}	3.60×10^{-2}	3.60×10^{-2}
BBBB	4.05×10^{-4}	3.60×10^{-2}	3.59×10^{-2}	4.06×10^{-4}	3.60×10^{-2}	3.60×10^{-2}
CCCC	4.05×10^{-4}	3.60×10^{-2}	3.59×10^{-2}	4.06×10^{-4}	3.60×10^{-2}	3.60×10^{-2}
DDDD	4.05×10^{-4}	3.60×10^{-2}	3.59×10^{-2}	4.06×10^{-4}	3.60×10^{-2}	3.60×10^{-2}

TABLE 3.5-8

AUXILIARY FEEDWATER UNAVAILABILITY

Power State	3d LCO		7d LCO	
	L-1	L-2	L-1	L-2
1	5.0×10^{-4}	5.1×10^{-4}	6.0×10^{-4}	6.1×10^{-4}
2	3.4×10^{-2}	3.5×10^{-2}	3.6×10^{-2}	3.7×10^{-2}
3	3.4×10^{-2}	3.5×10^{-2}	3.6×10^{-2}	3.7×10^{-2}
4	5.0×10^{-4}	5.1×10^{-4}	6.0×10^{-4}	6.1×10^{-4}
5	3.4×10^{-2}	3.5×10^{-2}	3.6×10^{-2}	3.7×10^{-2}
6	3.4×10^{-2}	3.5×10^{-2}	3.6×10^{-2}	3.7×10^{-2}

TABLE 3.5-9

DOMINANT CUTSETS FOR AUXILIARY FEEDWATER (L-1) MODEL

Cutset Description	Percent of Unavailability 3 day LCO	7 day LCO
Common cause failure of pumps	39	32
Both pumps fail to start	23	20
Diesel-driven pump fails to start and the motor-driven pump is in maintenance	17	25
Diesel-driven pump fails to run and motor-driven pump fails to start	5	5
Diesel-driven pump fails to run and motor-driven pump is in maintenance	4	6
Motor-driven pump fails to start and AOV SX173 or SX178 transfers closed to block diesel cooling	3	2
Motor-driven pump fails to start and diesel pump is in maintenance	2	4
Diesel pump fails to start and motor-driven pump fails to run	2	2

TABLE 3.5-10

DOMINANT CUTSETS FOR AUXILIARY FEEDWATER (L-2) MODEL

Cutset Description	Percent of Unavailability 3 day LCO	7 day LCO
Common cause failure of pumps	38	32
Both pumps fail to start	23	19
Diesel-driven pump fails to start and the motor-driven pump is in maintenance	16	24
Diesel-driven pump fails to run and motor-driven pump fails to start	5	4
Diesel-driven pump fails to run and motor-driven pump is in maintenance	4	6
Motor-driven pump fails to start and AOV SX173 or SX178 transfers closed to block diesel cooling	3	2
Motor-driven pump fails to start and diesel pump is in maintenance	2	4
Diesel pump fails to start and motor-driven pump fails to run	2	2

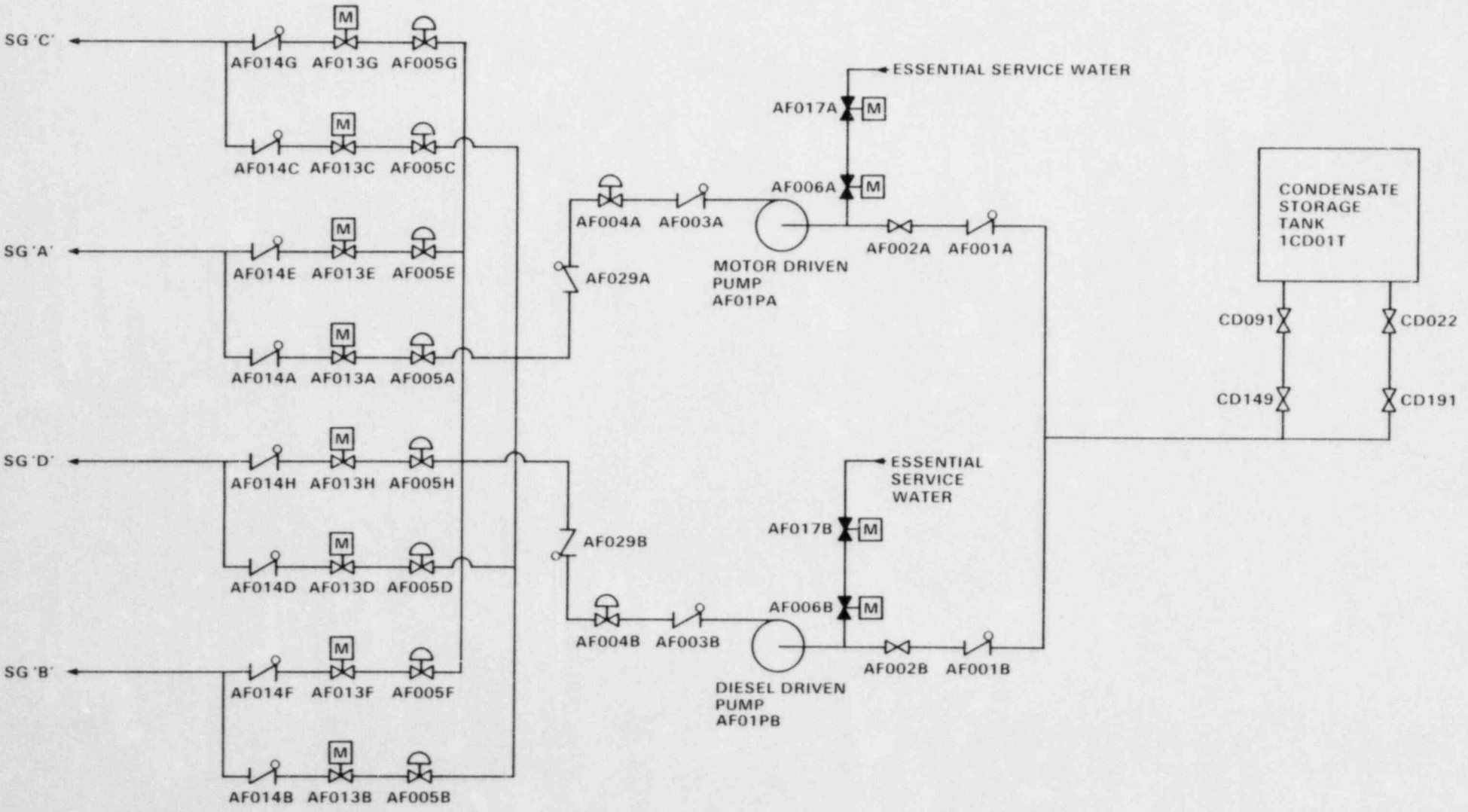


Figure 3.5-1 Auxiliary Feedwater System Simplified Flow Diagram

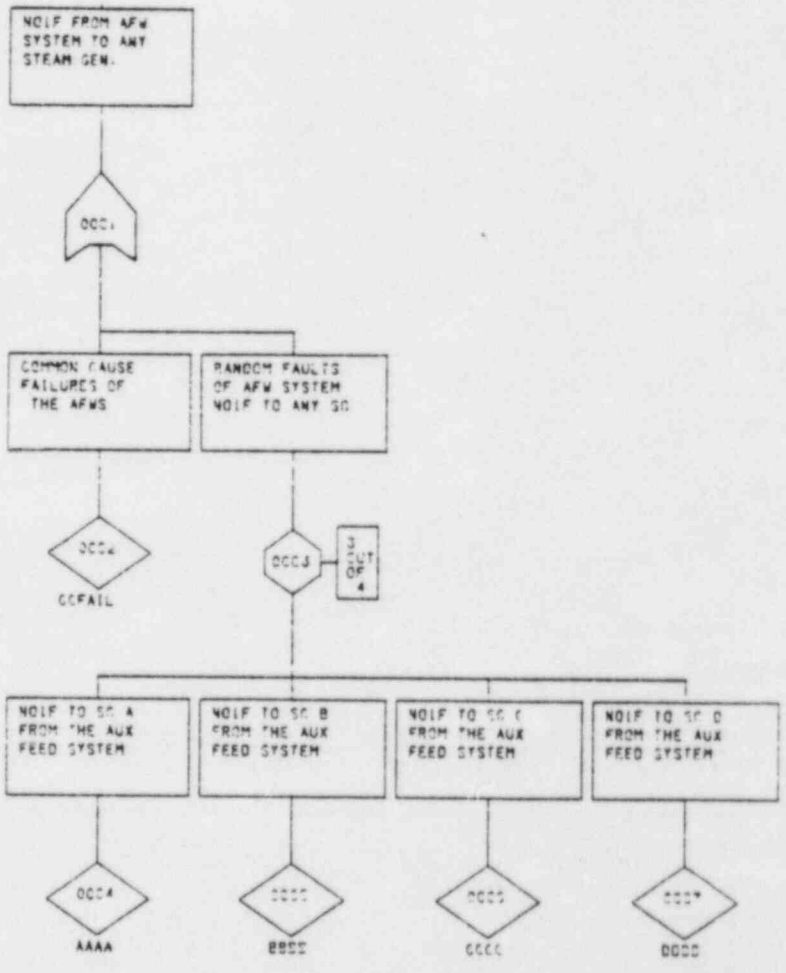


Figure 3.5-2 Auxiliary Feedwater System Top Logic

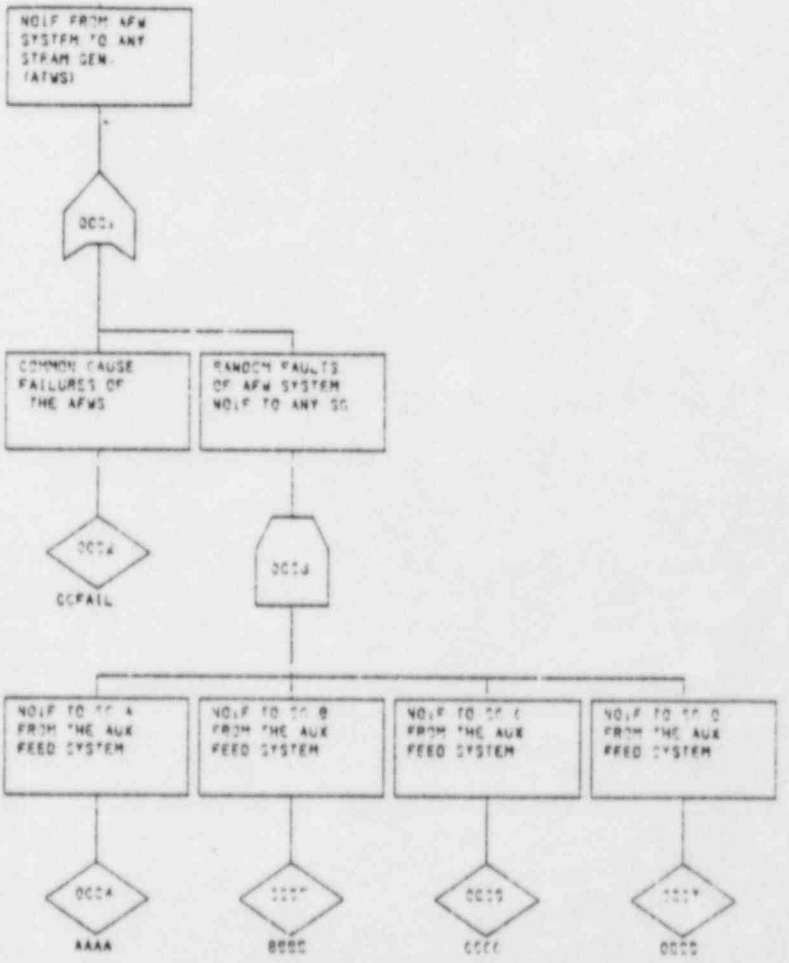


Figure 3.5-3 Auxiliary Feedwater System - ATWS Mitigation - Top Logic

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3.6 ACCUMULATORS AND LOW PRESSURE INJECTION SYSTEM

3.6.1 ACCUMULATOR INJECTION SYSTEM

3.6.1.1 SYSTEM DESCRIPTION

When a medium or large break occurs in the reactor coolant system, the accumulator tanks discharge to provide enough water to cover the reactor core in the interval of time prior to low pressure injection from the Residual Heat Removal System. The accumulator tanks are passive, and injection occurs when the reactor coolant system pressure drops below the nitrogen gas pressure in the tanks. One tank is provided for each reactor coolant cold leg pipe, and all the tanks are identical.

A minimum borated water volume of over 900 cu. ft. is maintained in the tanks at all times. Two level sensors provide control room readouts of the level in each accumulator. An alarm occurs if the level falls or rises by more than a set amount from the nominal level. Nitrogen gas is maintained in the tank at 625 psig and is monitored by two pressure sensors that provide a control room display of the pressure. An alarm occurs if the pressure falls or rises by more than a set amount from the nominal pressure.

Please refer to Figure 3.6.1-1 for a simplified P&ID for the accumulator injection system. An itemized list of components is presented in Table 3.6.1-1.

3.6.1.2 FAULT TREE MODEL

3.6.1.2.1 SUCCESS CRITERIA

Delivery of accumulator flow into the ruptured loop must be assumed to be ineffective given that a medium or large LOCA has occurred. Therefore, success is defined as the injection of flow from the accumulators on the remaining three intact loops.

3.6.1.2.2 DEPENDENCE ON SUPPORT STATES

The availability of the accumulator injection system is not dependent on Essential Service Water or electrical power, therefore there is no dependence on support states.

3.6.1.2.3 RANDOM FAILURE MODEL

Figure 3.6.1-2 depicts the fault tree model for the accumulator injection system. Note that the failure of the motor-operated valve or either check valve in any particular accumulator injection line will prevent the delivery of accumulator flow to the associated cold leg. The failure of any accumulator to deliver flow to the RCS will violate the system success criteria. Accumulator water level and pressure out of range faults are included in the fault tree even though they represent a very insignificant contribution to system unavailability.

3.6.1.2.4 COMMON CAUSE MODEL

There are no components which need to be activated to ensure accumulator flow, therefore common cause faults do not affect the availability of the accumulator injection system.

3.6.1.2.5 TEST OR MAINTENANCE

Motor operated valves SI8808 A,B,C,D are stroke tested quarterly, however, the contribution of MOV stroke testing to system unavailability is negligible and is not included in the fault tree. Since there is no contribution due to component maintenance, there is no dependence on maintenance outage time.

Table 3.6.1-1 lists all of the components in the fault tree model and indicates if they are tested or maintained.

3.6.1.2.6 HUMAN ERROR

There are no operator actions required to initiate accumulator flow, therefore human error does not affect the availability of the accumulators.

3.6.1.2.7 INPUT DATA

Table 3.6.1-2 lists all event identifiers, brief descriptions of the failure modes they represent, and the number used as input to the fault tree quantification. All numbers in this table are drawn from the data bank in Appendix 3D.

3.6.1.3 FAULT TREE QUANTIFICATION

3.6.1.3.1 SYSTEM UNAVAILABILITY CALCULATIONS

The fault tree was analyzed using the WAMBAM computer code. Figure 3.6.1-2 shows the accumulator injection system fault tree with the unavailability values included. These unavailabilities are not dependent on maintenance outage time or support state. The resultant accumulator injection system unavailability, applicable to all support states and 3 and 7 day LCO, is 4.3(-4).

Note that these unavailiabilities do not directly correspond to a single node used in the event trees. Accumulator injection is merely part of the low pressure injection node which includes both the accumulator injection system and the low pressure injection system (RHR). Please also refer to section 3.6.2.3.1 where they are combined.

3.6.1.3.2 DOMINANT CUTSETS

The WAMCUT computer code was used to obtain cutsets for the accumulator injection system model. The dominant cutsets are listed in Table 3.6.1-3 along with their respective contributions to system unavailability.

TABLE 3.6.1-1

COMPONENT LIST FOR THE ACCUMULATOR INJECTION SYSTEM

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error
CV SI8948A						
CV SI8948B						
CV SI8948C						
CV SI8948D						
CV SI8956A						
CV SI8956B						
CV SI8956C						
CV SI8956D						
MOV SI8808A				Quarterly		None (1)
MOV SI8808B				Quarterly		None (1)
MOV SI8808C				Quarterly		None (1)
MOV SI8808D				Quarterly		None (1)

NOTES:

1) Restoration failures are not plausible because of the surveillance requirements of Specification 4.5.2 of the Byron Tech Specs.

TABLE 3.6.1-2

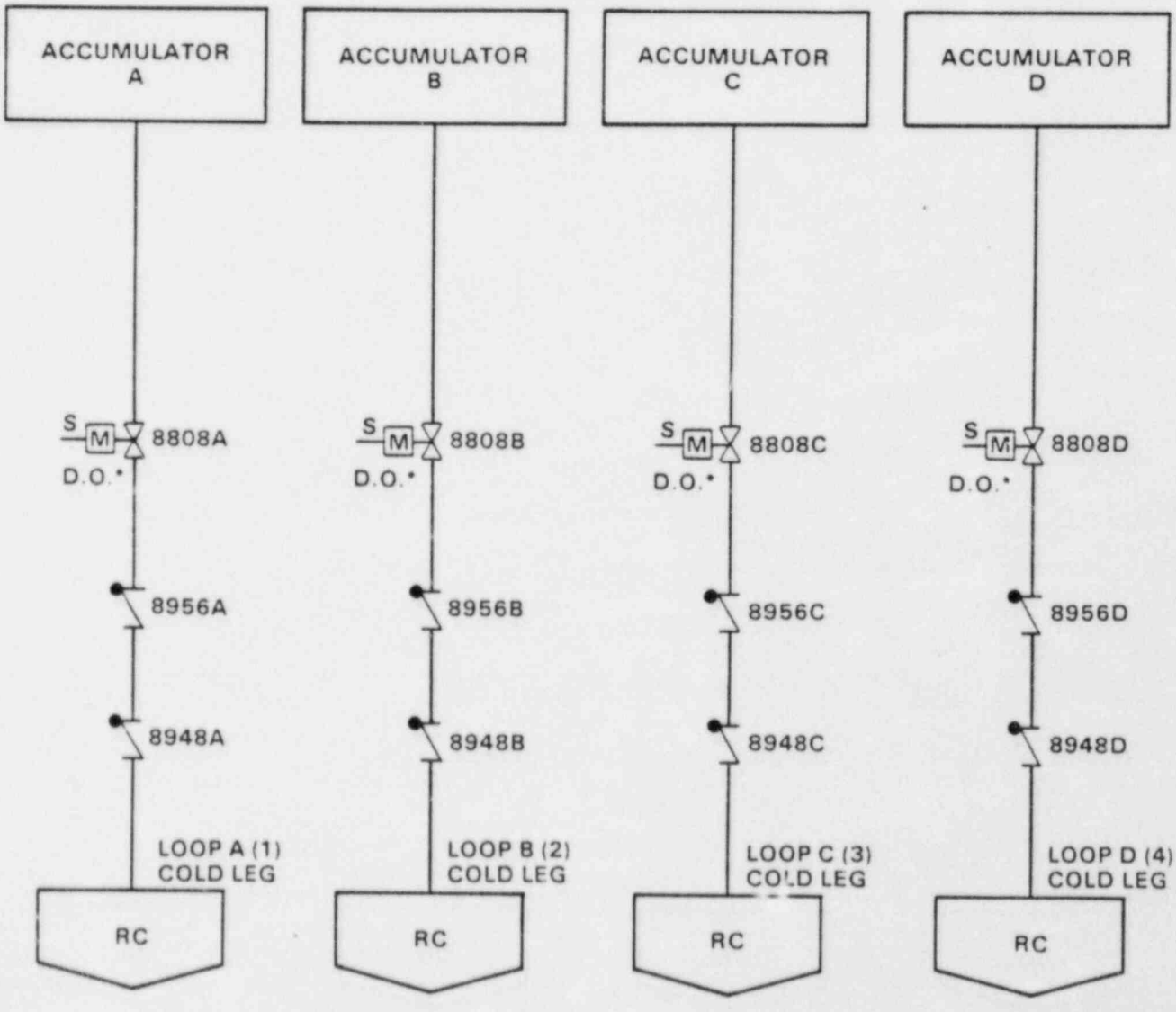
ACCUMULATOR INJECTION SYSTEM FAULT TREE INPUT

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
CVSI8948AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8956AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8956BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8956CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8808AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8808BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8808CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
ACCUMLVL	ACCU	ACCUM LEVEL OUT OF R	1.000E-06	0.000E-01	ZPSS	0.000E-01	0.000E-01	1.00E-06	0.00E-01
N2PRESSURE	ACCU	ACCUM N2 PR.OUT OF R	1.000E-06	0.000E-01	ZPSS	0.000E-01	0.000E-01	1.00E-06	0.00E-01

TABLE 3.6.1-3

DOMINANT CUTSETS FOR THE ACCUMULATOR INJECTION SYSTEM

Cutset Description	Percent Unavailability
Any Accumulator Isolation Valve Transfers Closed (SI8808 A,B,C)	40
Any Check Valve (SI8948 A,B,C) Fails to Open	60

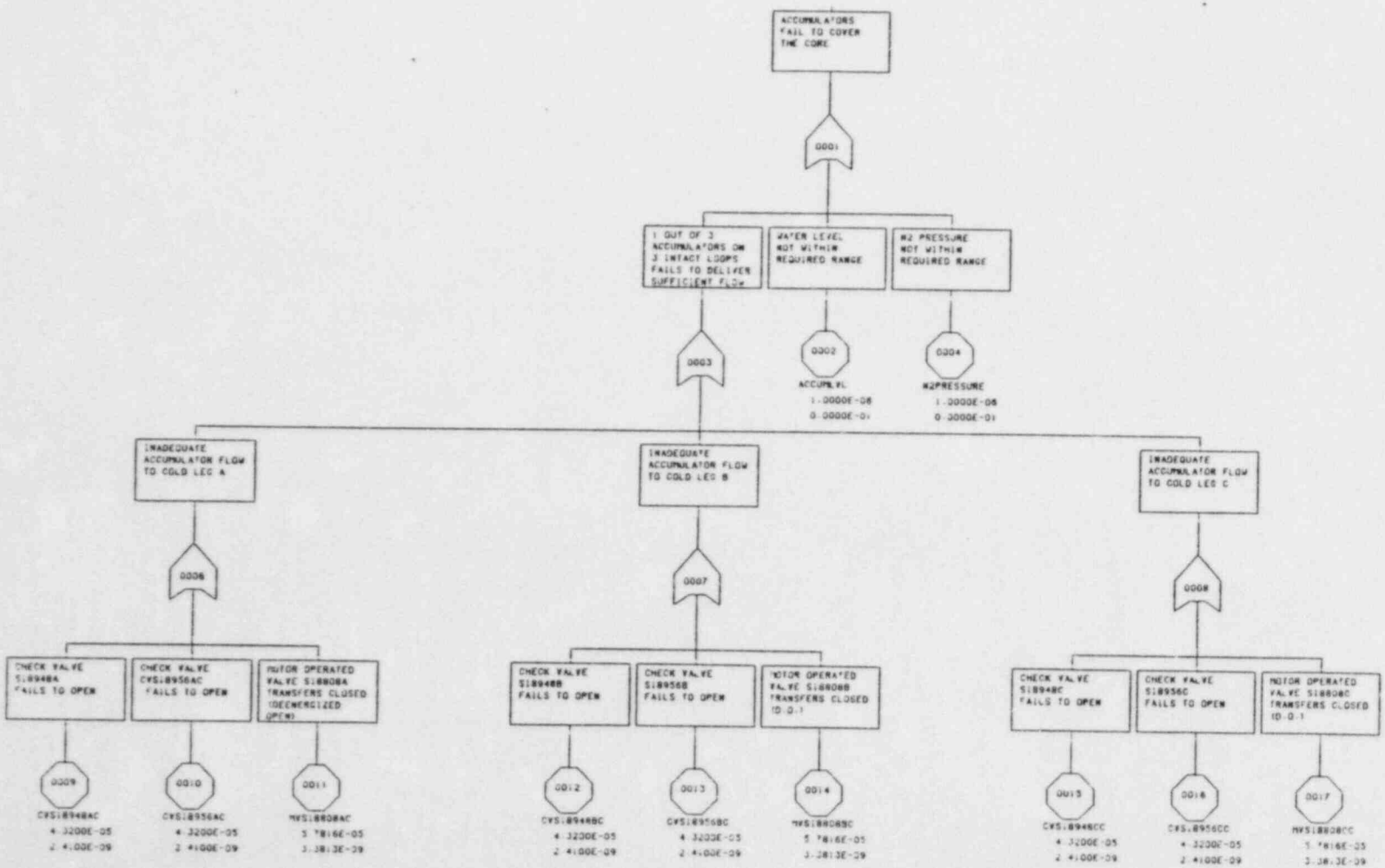


*D.O. = DEENERGIZED OPEN

Figure 3.6.1-1. Accumulator Simplified P&ID

Figure 3.6.1-2

Fault Tree Model for the Accumulator Injection System



3.6.2 LOW PRESSURE INJECTION AND RECIRCULATION

3.6.2.1 SYSTEM DESCRIPTION

The low pressure injection and recirculation system is primarily composed of the Residual Heat Removal (RHR) System and is a subsystem of the Emergency Core Cooling System. The intended function of this system in the injection mode is to supply water to the reactor pressure vessel in the early period (approximately 1 hour) following a large or medium LOCA. This system, in the recirculation mode, provides long term core cooling following a large or medium LOCA. The recirculation system is also required during normal plant cooldown operations to take the plant from hot shutdown to cold shutdown or refueling and is used at least once per refueling. In the recirculation mode, sump water is recirculated back into the core after being cooled in the residual heat removal heat exchangers.

Water is pumped from the water source through each of two redundant RHR trains. Each train consists of an RHR pump, check valve, manually-operated pump flow isolation valve, heat exchanger, and air-operated throttling valve. The two RHR trains are connected by a crosstie. The flow from each train passes through a motor-operated isolation valve before splitting into two lines directed to two cold legs. Flow from RHR train A is directed to the cold legs of loops A and D. Flow from RHR train B is directed to the cold legs of loops B and C. If the reactor coolant system pressure is greater than the pump shutoff head, the water is recirculated through the pump mini-flow lines. These lines are used to ensure that the minimum flow requirements are met to prevent the pumps from overheating or vibrating. Relief valves on each of the RHR cold leg discharge lines protect against overpressurization.

In the injection mode, the water source is the Refueling Water Storage Tank (RWST). Fluid is supplied to the RHR pumps through normally open motor-operated isolation valves. In the recirculation mode, the water source is the recirculation sump associated with the given train and water is supplied to the RHR pumps through normally closed motor-operated isolation valves. The switchover from the injection mode to the recirculation mode is initiated automatically and completed manually by operator action from the main control room. Protection logic is provided to automatically open the two

sump isolation valves when two of four RWST level channels indicate an RWST level less than the low-low level setpoint in conjunction with the presence of the engineered safeguards actuation signal ("S" signal). This automatic action aligns the two residual heat removal pumps to take suction from the containment sump and deliver water directly to the RCS. The residual heat removal pumps continue to operate during this switchover from injection to recirculation.

The simplified P and ID is shown in Figure 3.6.2-1. An itemized list of components is presented in Table 3.6.2-1.

3.6.2.2 FAULT TREE MODEL

3.6.2.2.1 SUCCESS CRITERIA

Success is defined as the injection of water from at least one RHR pump into at least one cold leg for one hour in the injection mode and 23 hours in the recirculation mode.

3.6.2.2.2 DEPENDENCE ON SUPPORT STATES

One train of RHR is dependent on ESF bus 141, the other on bus 142. The RHR pump of each train is dependent on electric power. In addition, during recirculation each train has three motor-operated valves which are dependent on electric power: one sump isolation valve, one RWST isolation valve, and a valve in the component cooling water path through the RHR heat exchangers.

In the injection mode, the RHR pumps are cooled implicitly by the fluid from the RWST. During recirculation, the RHR pumps require component cooling water (CCW) for pump cooling and heat exchanger cooling. Since essential service water (ESW) is required for CCW, these components are dependent on ESW in the recirculation mode.

3.6.2.2.3 RANDOM FAILURE MODEL

Unavailiabilities for both low pressure injection and low pressure recirculation are required for the LCORP event trees. Since the recirculation mode follows the injection mode, the availability of many components during recirculation are predicated on their availability during injection. Therefore, the most correct method for calculating unavailabilities for the two modes are to create a fault tree representing the success of both injection and recirculation and a fault tree representing the success of just injection. The unavailability during recirculation is then calculated using the following relation:

$$q(I+R) = q(I) + [1-q(I)]q(R)$$

or

$$q(R) \cong q(I+R)-q(I) \quad [\text{Since } 1-q(I) \sim 1]$$

The top structure is common to both trees and is depicted in Figure 3.6.2-2. The injection fault tree is enclosed as Figure 3.6.2-3 and the fault tree representing the total mission time for both the injection and recirculation modes is enclosed as Figure 3.6.2-4.

3.6.2.2.3.a ASSUMPTIONS COMMON TO BOTH THE RECIRCULATION AND INJECTION MODE

Fault Tree Structure

The random failure fault tree model was developed according to the LCORP Guide to Fault Tree Development in Appendix 3A.

The lo. pressure injection and recirculation system is required for large and medium LOCA events, therefore it must be assumed that flow into the cold leg of the faulted loop does not assist in mitigating the transient. The fault tree top structure, shown in Figure 3.6.2-2, for this system is developed with respect to system unavailability which constitutes insufficient flow from all three remaining cold leg injection lines. Loop D is assumed to be the faulted loop and flow from only loops A, B, and C help to mitigate the transient.

Insufficient flow to any particular cold leg might occur for any of the following reasons:

- Closure of either of the two check valves in the associated cold leg injection line.

- Closure of the motor-operated isolation valve associated with that cold leg injection line.

- Inadequate flow from the RHR train aligned to that injection line together with inadequate flow from the crosstie. Note that inadequate flow from the crosstie may be caused by a failure of the crosstie itself or of the other RHR train.

General Assumptions

- Relief valves SI8856 A,B and manual valves RH8734 A,B have a flow path area 6.7 percent of that of the main flow line. These valves are not assumed to be contributors and are not included in the fault tree due to their small size. Additionally, flow through the RH8734 valves would be blocked by a normally closed manual valve (CVHCV128) to the letdown heat exchangers.

- The following valves are alarmed, so the potential for their having been left failed open, and their contribution to system unavailability is negligible:

  SI8840 Hot Leg Recirculation
  CS009 A,B Containment Spray Valves
  SI8811 A,B Sump Isolation Valves (Failing open only a problem in the injection mode)

3.6.2.2.3.b RANDOM FAILURE MODEL FOR THE INJECTION MODE

During injection the RWST water source is required. A failure of either the check valve (SI8958) or the motor-operated valve (SI8812) causes the unavailability of the associated RHR train.

RHR pump seal cooling is only required when the suction temperature is greater than 300°F. Therefore, RHR pump cooling is not required during the injection phase. Additionally, the RHR heat exchanger is not required to cool the fluid entering the RCS during the injection phase.

3.6.2.2.3.c RANDOM FAILURE MODEL FOR THE RECIRCULATION MODE

For recirculation, the sump water source, RHR pump cooling, and heat removal through the RHR heat exchanger are required. Reverse flow into the RWST is unacceptable for this mode of operation for two reasons: 1) reverse flow would increase the potential for a reduction of the amount of fluid available to the RHR pump inlet, and 2) reverse flow would increase the potential for a radiological release to the environment. Therefore, check valve (SI8958) leakage coincident with the RWST isolation valve open during recirculation constitutes failure.

3.6.2.2.4 COMMON CAUSE MODEL

The common cause modeling is done in accordance with the common cause guidelines in Appendix 3B. All common cause calculations are the product of a β and a random failure probability. Table 3.6.2-2 lists the failure probabilities and β's used in the calculation of common cause failures in the low pressure injection and recirculation system fault trees.

Common cause failure of various motor-operated valves which require position changes is modeled in the fault trees. These include common cause failure of valves: SI8811A and B, SI8812A and B, and CC9412A and B. Also modeled is the common cause failure of the RHR pumps to start and run.

3.6.2.2.5 TEST AND MAINTENANCE MODEL

The following test and maintenance assumptions were used for the low pressure injection and recirculation system:

- Train maintenance is accomplished by closing:

  Train A: MOV SI8812A, RH8716A, and SI8809A
  Train B: MOV SI8812B, RH8716B, and SI8809B

- RHR pump testing is accomplishing by closing:

  Train A: MOV RH8716A and SI8809A
  Train B: MOV RH8716B and SI8809B

  Note that SI8809A and SI8809B could be left open during pump testing at a high RCS pressure, however this mode of testing would not be expected.

Test and maintenance of the RHR train is modeled so that when one train is in test or maintenance, the other is not. Therefore, one train of RHR will be available while the other is beiny tested or maintained.

Failure to restore a valve following test or maintenance is considered where applicable according to the guidelines in Appendix 3A.

Table 3.6.2-1 lists all of the components in the fault tree model, indicates if they are tested or maintained and whether a failure to restore is considered.

3.6.2.2.6 HUMAN ERROR MODEL

Following the initiation of low pressure injection, the RWST will drain down. Once the low-2 RWST level signal is generated in coincidence with a safety injection ("S") signal, the sump isolation valves (SI8811A,B) are automatically opened to initiate the recirculation phase. At this point the operator is instructed to leave the RHR pumps running, open MOVs CC9412A,B to

allow RHR heat exchanger cooling, and close the RWST isolation valves (SI8812A,B) to prevent backflow. Therefore the following human errors are modeled:

- Operator fails to open both CC9412 A and B.
- Operator fails to close both SI8812 A and B.

Also modeled are failures to restore valves to their proper position following test or maintenance.

Please see Appendix 3C for details regarding the calculation of these human error unavailabilities.

3.6.2.2.7 INPUT DATA

Tables 3.6.2-3 through 3.6.2-6 list all event identifiers, brief descriptions of the failure mode they represent, and the number used as input to the fault tree quantification. The first Table (3.6.2-3,5) presents all components and data used to quantify the fault tree. The second (3.6.2-4,6) presents only those components whose values have changed for quantification of system unavailability in the six support states. The first two tables are for the fault tree representing the success of both injection and recirculation, the last two for the fault tree representing the success of injection only. All numbers in these tables are drawn from the data bank in Appendix 3D.

3.6.2.3 FAULT TREE QUANTIFICATION

3.6.2.3.1 SYSTEM UNAVAILABILITY CALCULATIONS

The fault tree was analyzed using the WAMBAM computer code. For support states 5 and 6, the unavailability is 1.0 because of dependency on Essential Service Water and electric power. Figure 3.6.2-2 shows the top logic of the low pressure injection and recirculation system fault tree with unavailability values given in Tables 3.6.2-7 and 3.6.2-8 for 3 and 7 day LCO, respectively. The fault tree was quantified for all support states and all of the results are listed in Table 3.6.2-9.

3.6.2.3.2 DOMINANT CUTSETS

The WAMCUT computer code was used to obtain cutsets for the low pressure system model with 3 day and 7 day LCO. The dominant cutsets and their approximate unavailability contributions for the fault tree representing the success of both injection and recirculation are listed in Table 3.6.2-10 and for the fault tree representing the success of injection only are listed in Table 3.6.2-11.

TABLE 3.6.2-1

COMPONENT LIST FOR THE LOW PRESSURE INJECTION AND RECIRCULATION SYSTEM

System Component(2)	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error(1)
MOV SI8809A				Quarterly		FR(T M)
MOV SI8809B				Quarterly		FR(T M)
MOV SI8716A				Quarterly	X(3)	FR(T M)
MOV SI8716B				Quarterly	X(3)	FR(T M)
MOV SI8812A	X			Quarterly		FR(T M), FC
MOV SI8812B		X		Quarterly		FR(T M), FC
CV SI8948A						
CV SI8948B						
CV SI8948C						
CV SI8948D						
CV SI8818A						
CV SI8818B						
CV SI8818C						
CV SI8818D						
CV SI8958A					X(3)	None (4)
CV SI8958B					X(3)	None (4)
AOV RH0606				Refueling (9)	X(3)	FR(M)
AOV RH0607				Refueling (9)	X(3)	FR(M)
CV RH8730A				Quarterly (7)	X(3)	None (4)
CV RH8730B				Quarterly (7)	X(3)	None (4)
XV RH8724A				Quarterly (7)	X(3)	None (4)
XV RH8724B				Quarterly (7)	X(3)	None (4)
RHR Pump A	X		X	Quarterly	X	None (4)
RHR Pump B		X	X	Quarterly	X	None (4)
Sump A Gratings (R)						
Sump B Gratings (R)						

TABLE 3.6.2-1 (Continued)

COMPONENT LIST FOR THE LOW PRESSURE INJECTION AND RECIRCULATION SYSTEM

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error
MOV SI8811A (R)	X			Quarterly		None (5)
MOV SI8811B (R)		X		Quarterly		None (5)
AOV RH0618 (R)				Refueling (9)	X(3)	FR(M)
AOV RH0619 (R)				Refueling (9)	X(3)	FR(M)
XV CC9506A (R)				Quarterly (7)	X(3)	None (4)
XV CC9506B (R)				Quarterly (7)	X(3)	None (4)
XV CC9474A (R)				Quarterly (7)	X(3)	None (4)
XV CC9474B (R)				Quarterly (7)	X(3)	None (4)
XV CC9504A (R)				Refueling (9)	X(3)	None (8)
XV CC9504B (R)				Refueling (9)	X(3)	None (8)
XV CC9507A (R)				Refueling (9)	X(3)	None (8)
XV CC9507B (R)				Refueling (9)	X(3)	None (8)
MOV CC9412A (R)	X			Quarterly	X(3)	FO (6)
MOV CC9412B (R)		X		Quarterly	X(3)	FO (6)
RHR Heat Exchanger A (R)			X			
RHR Heat Exchanger B (R)			X			

NOTES TO TABLE 3.6.2-1

1. Operator Error Symbols:

   FR = Fails to restore following (T or M)
   T = Test
   M = Maintenance
   FO = Fails to Open
   FC = Fails to Close

2. "R" indicates component modeled for recirculation only. All others required for both modes of operation.

3. Maintained when the RHR pump is taken down for maintenance.

4. Following maintenance tested by virtue of a pump flow test.

5. Failure to restore following test is not a problem. If the valve were left open, the RWST would drain into the sump under normal operation, and this would be detected.

6. Failure to restore following test is not a problem, since this failure would only allow CCW flow.

7. Implicitly tested during RHR pump testing.

8. Flow tested following maintenance.

9. Tested by virtue of RHR cooling during refueling.

TABLE 3.6.2-2

COMMON CAUSE CALCULATIONS FOR LOW PRESSURE INJECTION AND RECIRCULATION

Failure Mode	Data Bank Source ID	β	Random Failure Mode	Random Failure	Result
Failure of two RHR pumps to start	HP2	0.311	Fail to Start	7.21(-4)/d	2.24(-4)/d
Failure of two RHR pumps to run	HP3	0.141	Fail during Operation	2.53(-6)/hr	3.57(-7)/hr
Failure of two motor-operated valves to operate (Applies to SI8811A,B; SI8812A,B; and CC9412A,B)	C3	0.030	Fail to Operate	1.55(-3)/d	4.65(-5)/d

TABLE 3.6.2-3

LOW PRESSURE (RHR) INJECTION AND RECIRCULATION FAULT TREE INPUT

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
MVSI8809AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8809BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVS8809AHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8809BHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8809AHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8809BHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
CVSI8818AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8818BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8818CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVRH8716AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVRH8716BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVR8716AHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716BHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716AHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716BHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVSI8812AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8812BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVS8812AHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8812BHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01

TABLE 3.6.2-3 (Continued)

LOW PRESSURE (RHR) INJECTION AND RECIRCULATION FAULT TREE INPUT

XVCC9507BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MVCC9412AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVCC9412BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CCWAU	CCW	CCW TRAIN A,PS1,3D L	2.200E-06	0.000E-01	CCW	0.000E-01	0.000E-01	2.20E-06	0.00E-01
CCWBU	CCW	CCW TRAIN B,PS1,3D L	1.600E-08	0.000E-01	CCW	0.000E-01	0.000E-01	1.60E-08	0.00E-01
CCCCW	CCW	CCW SYSTEM PS1,3D LC	4.400E-09	0.000E-01	CCW	0.000E-01	0.000E-01	4.40E-09	0.00E-01
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
TRAINAM	MDP	MAINTENANCE FREQUENC	6.120E-05	2.870E-10	ZPSS	1.900E+01	0.000E-01	1.16E-03	1.04E-07
TRAINBM	MDP	MAINTENANCE FREQUENC	6.120E-05	2.870E-10	ZPSS	1.900E+01	0.000E-01	1.16E-03	1.04E-07
CCRHRPMPFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
CCRHRPMPFR	CC	COMMON CAUSE PUMP RU	3.570E-07	1.270E-13	HP3	2.400E+01	0.000E-01	8.57E-06	7.32E-11
MVCC9412OP	OPER	OP FAILS TO OPEN CC9	9.600E-05	0.000E-01	HE4	0.000E-01	0.000E-01	9.60E-05	0.00E-01
CCSI8811O	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8812OP	OPER	OP FAILS TO CLOSE SI	1.400E-04	0.000E-01	HE7	0.000E-01	0.000E-01	1.40E-04	0.00E-01
CCSI8812O	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
CCCC9412O	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01

TABLE 3.6.2-3 (Continued)

LOW PRESSURE (RHR) INJECTION AND RECIRCULATION FAULT TREE INPUT

MVSI8812AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8812BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVS8812AHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8812BHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
CVSI8958AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8958BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8958AO	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	2.300E+01	0.000E-01	1.93E-05	3.86E-10
CVSI8958BO	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	2.300E+01	0.000E-01	1.93E-05	3.86E-10
AVRH0606HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRH0607HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRH0606C	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	6.570E+03	0.000E-01	7.36E-04	7.94E-07
AVRH0607C	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	6.570E+03	0.000E-01	7.36E-04	7.94E-07
CVRH8730AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVRH8730BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVRH8724AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVRH8724BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PMPRHRAFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PMPRHRBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PMPRHRBFR	MDP	FAIL DURING OPERATIO	2.530E-06	3.390E-11	ZPSS	2.400E+01	0.000E-01	6.07E-05	1.95E-08
PMPRHRAFR	MDP	FAIL DURING OPERATIO	2.530E-06	3.390E-11	ZPSS	2.400E+01	0.000E-01	6.07E-05	1.95E-08
PMPRHRAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
PMPRHRBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.6.2-3 (Continued)

LOW PRESSURE (RHR) INJECTION AND RECIRCULATION FAULT TREE INPUT

BS141K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BS142K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
CVSI8948AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
BS131K	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
BS132K	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
SUMPAB	SUMP	SUMP GRATINGS BLOCKE	5.000E-05	6.400E-06	ZPSS	0.000E-01	0.000E-01	5.00E-05	6.40E-06
SUMPBB	SUMP	SUMP GRATINGS BLOCKE	5.000E-05	6.400E-06	ZPSS	0.000E-01	0.000E-01	5.00E-05	6.40E-06
AVRH06190	AOV	TRANSFER OPEN/LEAK	3.140E-08	1.560E-14	NOT6	6.570E+03	0.000E-01	2.06E-04	6.73E-07
AVRH06180	AOV	TRANSFER OPEN/LEAK	3.140E-08	1.560E-14	NOT6	6.570E+03	0.000E-01	2.06E-04	6.73E-07
AVRH0619HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRH0618HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVSI8811AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8811BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XVCC9506AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9506BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9474BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9474AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9504AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVCC9504BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVCC9507AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07

TABLE 3.6.2-4

SUPPORT STATE CHANGES TO INPUT LISTING IN TABLE 3.6.2-3

3 Day LCO Input for RHR Injection and Recirculation Tree

	Support State					
Identifier	1	2	3	4	5	6
BS141K	0.0	0.0	1.0	0.0	1.0	1.0
BS142K	0.0	0.0	0.0	1.0	1.0	1.0
CCWAU	2.2(-6)	2.2(-6)	1.8(-5)	1.3(-5)	2.6(-4)	2.6(-4)
CCWBU	1.6(-8)	1.6(-8)	1.2(-6)	7.3(-6)	1.3(-3)	1.3(-3)
CCCCW	4.4(-9)	4.4(-9)	1.1(-5)	5.9(-6)	4.8(-2)	4.8(-2)
ESWU	0.0	1.0	0.0	0.0	0.0	1.0
TRAINAM	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)
TRAINBM	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)

7 Day LCO Input for RHR Injection and Recirculation Tree

	Support State					
Identifier	1	2	3	4	5	6
BB141K	0.0	0.0	1.0	0.0	1.0	1.0
BB142K	0.0	0.0	0.0	1.0	1.0	1.0
CCWAU	2.9(-6)	2.9(-6)	1.9(-5)	1.4(-5)	2.7(-4)	2.7(-4)
CCWBU	1.8(-8)	1.8(-8)	1.2(-5)	7.7(-6)	1.3(-3)	1.3(-3)
CCCCW	6.1(-9)	6.1(-9)	1.1(-5)	6.3(-6)	4.1(-2)	4.1(-2)
ESWU	0.0	1.0	0.0	0.0	0.0	1.0
TRAINAM	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)
TRAINBM	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)

TABLE 3.6.2-5

LOW PRESSURE (RHR) INJECTION FAULT TREE INPUT

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
MVSI8809AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8809BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVS8809AHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8809BHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8809AHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8809BHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
CVSI8818AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8818BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8818CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVRH8716AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVRH8716BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVR8716AHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716BHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716AHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716BHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVSI8812AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8812BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVS8812AHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8812BHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01

TABLE 3.6.2-5 (Continued)

LOW PRESSURE (RHR) INJECTION FAULT TREE INPUT

MVS8812AHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVS8812BHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
CVSI8958AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8958BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
AVRH0606HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRH0607HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRH0606C	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	6.570E+03	0.000E-01	7.36E-04	7.94E-07
AVRH0607C	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	6.570E+03	0.000E-01	7.36E-04	7.94E-07
CVRH8730AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVRH8730BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVRH8724AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVRH8724BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PMPRHRAFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PMPRHRBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PMPRHRBFR	MDP	FAIL DURING OPERATIO	2.530E-06	3.390E-11	ZPSS	1.000E+00	0.000E-01	2.53E-06	3.39E-11
PMPRHRAFR	MDP	FAIL DURING OPERATIO	2.530E-06	3.390E-11	ZPSS	1.000E+00	0.000E-01	2.53E-06	3.39E-11
PMPRHRAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
PMPRHRBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
BS141K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BS142K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
CVSI8948AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09

TABLE 3.6.2-5 (Continued)

LOW PRESSURE (RHR) INJECTION FAULT TREE INPUT

CVSI8948CC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
TRAINAM	MDP	MAINTENANCE FREQUENC	6.12OE-05	2.87OE-10	ZPSS	1.900E+01	0.000E-01	1.16E-03	1.04E-07
TRAINBM	MDP	MAINTENANCE FREQUENC	6.12OE-05	2.87OE-10	ZPSS	1.900E+01	0.000E-01	1.16E-03	1.04E-07
CCRHRPMPFS	CC	COMMON CAUSE PUMP ST	2.24OE-04	5.02OE-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
CCRHRPMPFR	CC	COMMON CAUSE PUMP RU	3.57OE-07	1.27OE-13	HP3	1.000E+00	0.000E-01	3.57E-07	1.27E-13

TABLE 3.6.2-6

SUPPORT STATE CHANGES TO INPUT LISTING IN TABLE 3.6.2-5

3 Day LCO Input for RHR Injection Tree

	Support State					
Identifier	1	2	3	4	5	6
BS141K	0.0	0.0	1.0	0.0	1.0	1.0
BS142K	0.0	0.0	0.0	1.0	1.0	1.0
TRAINAM	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)
TRAINBM	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)	1.2(-3)

7 Day LCO Input for RHR Injection Tree

	Support State					
Identifier	1	2	3	4	5	6
BS141K	0.0	0.0	1.0	0.0	1.0	1.0
BS142K	0.0	0.0	0.0	1.0	1.0	1.0
TRAINAM	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)
TRAINBM	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)	2.1(-3)

TABLE 3.6.2-7

3 DAY LCO DATA INPUT FOR TOP LOGIC FAULT TREE STRUCTURE

Low Pressure Injection

Identifier	Support State 1	2	3	4	5	6
AAAA, DDDD, B1	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)
BBBB	4.4(-3)	4.4(-3)	4.4(-3)	1.0	1.0	1.0
CCCC	4.1(-3)	4.1(-3)	1.0	4.1(-3)	1.0	1.0
FFFF	4.4(-3)	4.4(-3)	1.0	4.4(-3)	1.0	1.0
GGGG	4.1(-3)	4.1(-3)	4.1(-3)	1.0	1.0	1.0
B2	2.4(-4)	2.4(-4)	4.1(-3)	4.4(-3)	1.0	1.0
CVSI8948A,B,C	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)
CVSI8818A,B,C	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)

Low Pressure Recirculation and Injection

Identifier	Support State 1	2	3	4	5	6
AAAA, DDDD, B1	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)
BBBB	8.8(-3)	1.0	8.8(-3)	1.0	1.0	1.0
CCCC	8.5(-3)	1.0	1.0	8.5(-3)	1.0	1.0
FFFF	8.8(-3)	1.0	1.0	8.8(-3)	1.0	1.0
GGGG	8.5(-3)	1.0	8.5(-3)	1.0	1.0	1.0
B2	4.9(-4)	1.0	8.5(-3)	8.8(-3)	1.0	1.0
CVSI8948A,B,C	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)
CVSI8818A,B,C	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)

TABLE 3.6.2-8

7 DAY LCO DATA INPUT FOR TOP LOGIC FAULT TREE STRUCTURE

Low Pressure Injection

Identifier	Support State 1	2	3	4	5	6
AAAA, DDDD, B1	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)
BBBB	5.3(-3)	5.3(-3)	5.3(-3)	1.0	1.0	1.0
CCCC	5.0(-3)	5.0(-3)	1.0	5.0(-3)	1.0	1.0
FFFF	5.3(-3)	5.3(-3)	1.0	5.3(-3)	1.0	1.0
GGGG	5.0(-3)	5.0(-3)	5.0(-3)	1.0	1.0	1.0
B2	2.4(-4)	2.4(-4)	5.0(-3)	5.3(-3)	1.0	1.0
CVSI8948A,B,C	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)
CVSI8818A,B,C	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)

Low Pressure Recirculation and Injection

Identifier	Support State 1	2	3	4	5	6
AAAA, DDDD, B1	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)	1.5(-4)
BBBB	9.7(-3)	1.0	9.7(-3)	1.0	1.0	1.0
CCCC	9.4(-3)	1.0	1.0	9.4(-3)	1.0	1.0
FFFF	9.7(-4)	1.0	1.0	9.7(-3)	1.0	1.0
GGGG	9.4(-3)	1.0	9.4(-3)	1.0	1.0	1.0
B2	5.0(-4)	1.0	9.4(-3)	9.7(-3)	1.0	1.0
CVSI8948A,B,C	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)
CVSI8818A,B,C	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)	4.3(-5)

TABLE 3.6.2-9

LOW PRESSURE SYSTEM UNAVAILABILITY

Support State	Accumulators (Section 3.6.1.3.1)	RHR Injection (3 day LCO)	LP* (3 day LCO)	RHR Injection (7 day LCO)	LP* (7 day LCO)
1	4.3(-4)	2.4(-4)	6.7(-4)	2.4(-4)	6.7(-4)
2	4.3(-4)	2.4(-4)	6.7(-4)	2.4(-4)	6.7(-4)
3	4.3(-4)	4.1(-3)	4.5(-3)	5.0(-3)	5.4(-3)
4	4.3(-4)	4.1(-3)	4.5(-3)	5.0(-3)	5.4(-3)
5	4.3(-4)	1.0	1.0	1.0	1.0
6	4.3(-4)	1.0	1.0	1.0	1.0

Support State	R-1 (3 day LCO)	R-1 (7 day LCO)
1	2.5(-4)	2.6(-4)
2	1.0	1.0
3	4.5(-3)	4.5(-3)
4	4.5(-3)	4.5(-3)
5	1.0	1.0
6	1.0	1.0

* Note that the node "LP" is the sum of the accumulator injection system unavailability from section 3.6.1.3.1 and RHR injection taken as follows: $q(A + RHR) = q(A) + [(1-q(A)]q(RHR)$.

TABLE 3.6.2-10

DOMINANT CUTSETS FOR THE LOW PRESSURE INJECTION AND RECIRCULATION SYSTEM (SUPPORT STATE 1)

Cutset Description	Approximate Unavailability Contribution (Percent) 3-Day LCO	7-Day LCO
Common Cause Hardware Failures - Both RHR pumps fail to start	46	45
Operator fails to open the Component Cooling Isolation Valves in both trains (CC9412A,B)	20	19
Common Cause Hardware Failures - the Component Cooling Isolation Valves in both trains (CC9412A,B) fail to operate	10	9
Common Cause Hardware Failures - the Sump Isolation Valves in both trains (SI8811A,B) fail to operate	10	9
One train is in test or maintenance and either the Sump Isolation Valve (SI8811A or B) or the Component Cooling Isolation Valve (CC9412A or B) in the opposite train fails to operate	3	4
Common Cause Hardware Failures - Both RHR pumps fail to run	2	2

TABLE 3.6.2-10 (Continued)

DOMINANT CUTSETS FOR THE LOW PRESSURE INJECTION AND RECIRCULATION SYSTEM (SUPPORT STATE 1)

Cutset Description	Approximate Unavailability Contribution (Percent) 3-Day LCO	7-Day LCO
The Component Cooling Isolation Valve (CC9412A,B) and the Sump Isolation Valve (SI8811A,B) of the opposite train fail to operate	1	1
The RHR pump of one train fails to start and either the Sump Isolation Valve (SI8811A or B) or the Component Cooling Isolation Valve (CC9412A or B) in the opposite train fails to operate	1	1
Both Sump Isolation Valves (SI8811A,B) or both Component Cooling Isolation Valves (CC9412A,B) fail to operate	1	1
The air-operated throttle valve (RH0606 or RH0607) fails and either the Component Cooling Isolation Valve (CC9412A or B) or the Sump Isolation Valve (SI8811A or B) in the opposite train fails to operate	1	1

TABLE 3.6.2-11

DOMINANT CUTSETS FOR THE LOW PRESSURE INJECTION SYSTEM (SUPPORT STATE 1)

Cutset Description	Approximate Unavailability Contribution (Percent) 3-Day LCO	7-Day LCO
Common Cause Hardware Failures - Both RHR pumps fail to start	95	94
The air-operated throttle valve (RH0606 or RH0607) fails while the opposite train is in test or maintenance	1	2
The RHR pump of one train fails to start while the opposite train is in test or maintenance	1	2
The air-operated throttle valve (RH0606 or RH0607) fails while the RHR pump in the opposite train fails to start	1	1

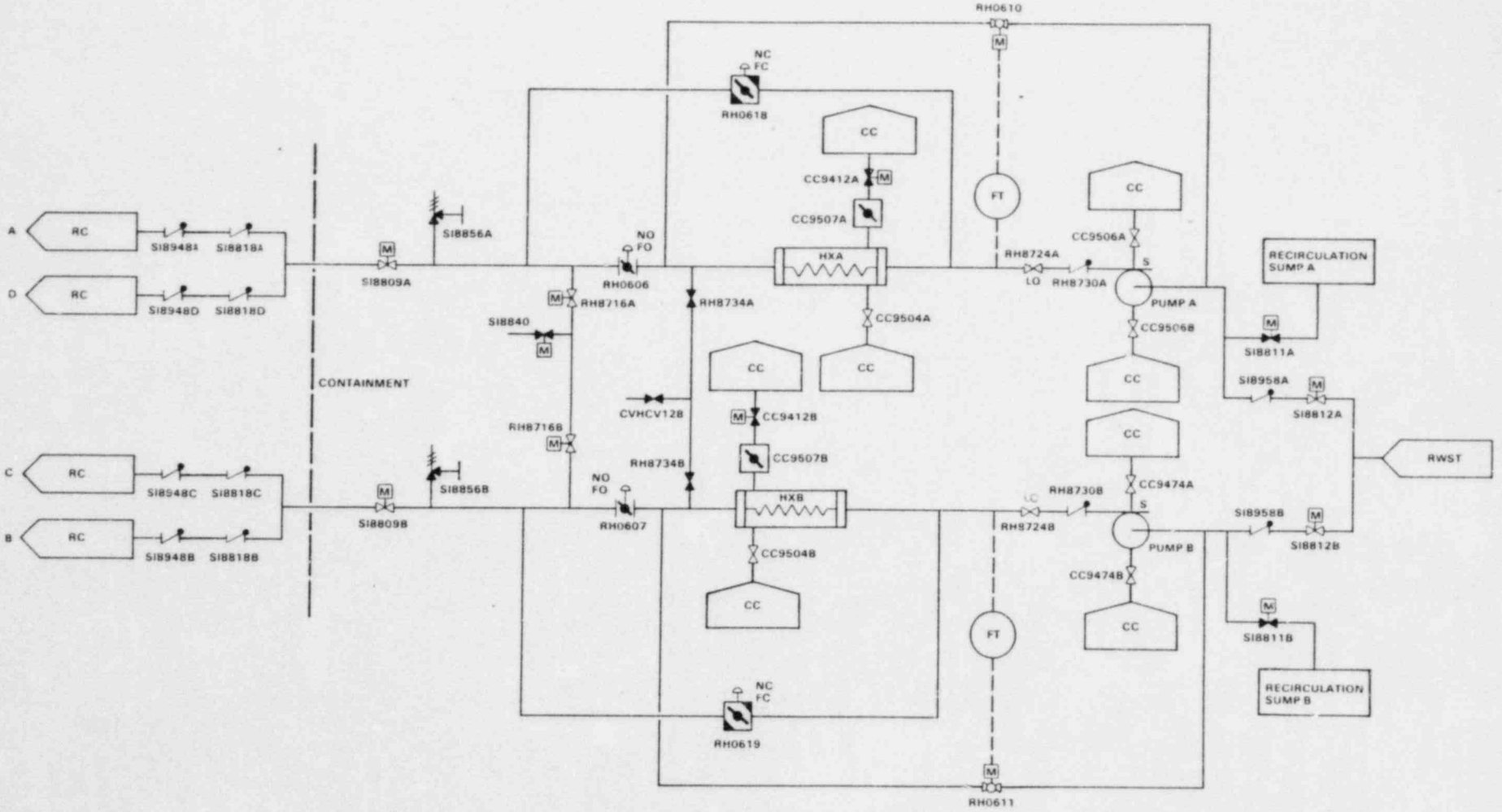
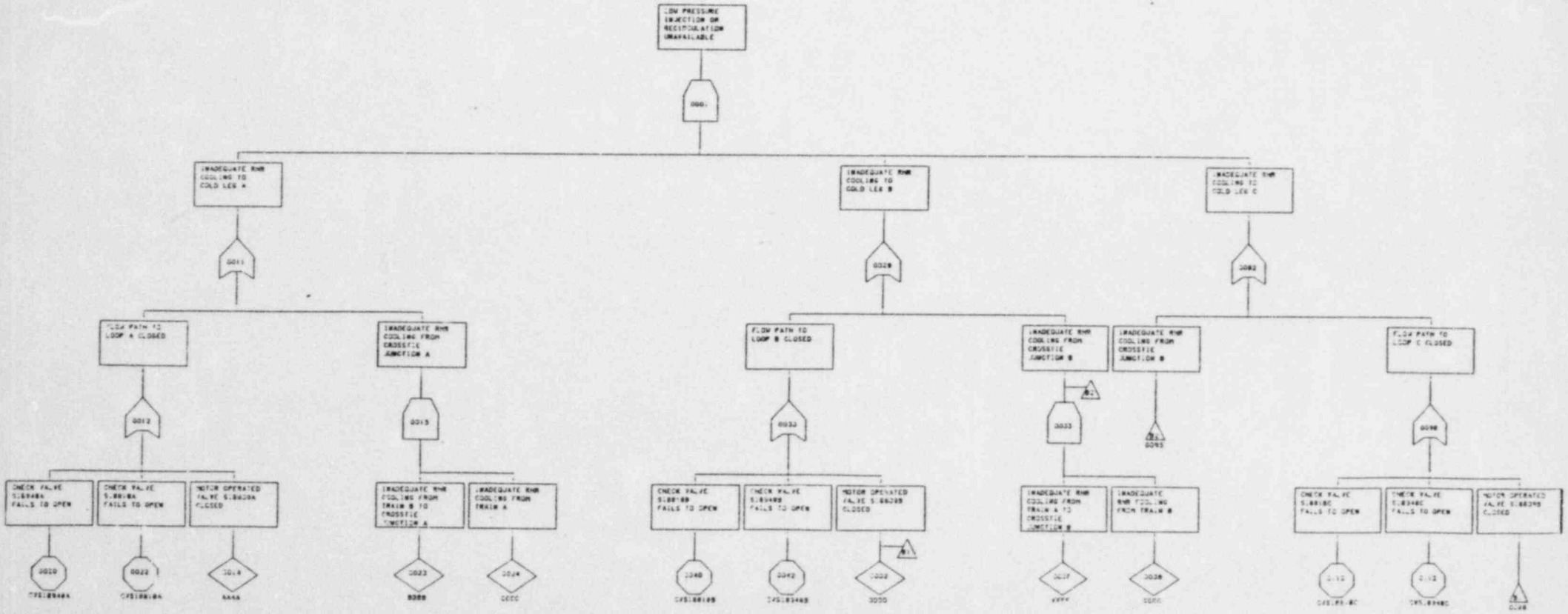


Figure 3.6.2-1 Low Pressure Injection and Recirculation System (RHR) Simplified P&ID

FIGURE 3.6.2-2

LOW PRESSURE (RHR) INJECTION AND RECIRCULATION FAULT TREE

TOP STRUCTURE


LOW PRESSURE INJECTION OR RECIRCULATION UNAVAILABLE
0001
INADEQUATE RHR COOLING TO COLD LEG A
INADEQUATE RHR COOLING TO COLD LEG B
INADEQUATE RHR COOLING TO COLD LEG C
0011
0329
0082
FLOW PATH TO LOOP A CLOSED
INADEQUATE RHR COOLING FROM CROSSTIE JUNCTION A
FLOW PATH TO LOOP B CLOSED
INADEQUATE RHR COOLING FROM CROSSTIE JUNCTION B
INADEQUATE RHR COOLING FROM CROSSTIE JUNCTION B
FLOW PATH TO LOOP C CLOSED
0012
0013
0033
0033
0098
CHECK VALVE S1E001A FAILS TO OPEN
CHECK VALVE S1E001B FAILS TO OPEN
MOTOR OPERATED VALVE S1E002A CLOSED
INADEQUATE RHR COOLING FROM TRAIN B TO CROSSTIE JUNCTION A
INADEQUATE RHR COOLING FROM TRAIN A
CHECK VALVE S1E001B FAILS TO OPEN
CHECK VALVE S1E001A FAILS TO OPEN
MOTOR OPERATED VALVE S1E002B CLOSED
INADEQUATE RHR COOLING FROM TRAIN A TO CROSSTIE JUNCTION B
INADEQUATE RHR COOLING FROM TRAIN B
CHECK VALVE S1E001C FAILS TO OPEN
CHECK VALVE S1E001C FAILS TO OPEN
MOTOR OPERATED VALVE S1E002C CLOSED
0020
0022
0023
0024
0040
0042
0037
0038
0000
0000
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3.7 HIGH PRESSURE SAFETY INJECTION AND RECIRCULATION SYSTEM

3.7.1 SYSTEM DESCRIPTION

The High Pressure Safety Injection System (HPIS) can supply cooling water to the core by using both the charging and safety injection systems to pump water from the refueling water storage tank through injection lines to the RCS cold legs. During normal plant operations, the centrifugal charging pumps use the coolant in the volume control tank to maintain the reactor coolant system pressure and boron concentration. When safety injection is required, the charging pumps are isolated from the volume control tank. When the safety injection signal occurs, two valves are automatically opened to provide 2,000 gpm of borated water from the refueling water storage tank to the centrifugal charging pumps through a check valve.

The two centrifugal charging pumps, A and B, are started automatically upon a safety injection signal. The flow rate during safety injection will depend upon the reactor coolant system pressure. The pumps have a shutoff head of 2,670 psig and, thus, are capable of injecting borated water into the reactor core up to the pressure set point of the primary safety valves. In addition to closing the valves from the volume control tank, the safety injection signal isolates other parts of the chemical and volume control system.

Unlike the centrifugal charging pumps, which are also used during normal operations, the safety injection pumps are used only for emergency core cooling. Following a safety injection signal, borated water flows from the RWST into two flowpaths, one to each pump. Isolation valves are provided on the line to each pump, which starts automatically on a safety injection signal.

The safety injection pump provides water to the reactor coolant system when the pressure is below the pump shutoff head. If the reactor coolant system is above this pressure, the water flows through a mini-flow line back to the refueling water storage tank. The mini-flow line has an orifice to limit the flow to an amount required to provide pump protection. A set of room operated isolation valves is provided for operator control of recirculation flow. The safety injection flow splits into four flowpaths that join the residual heat removal cold leg piping to the reactor coolant loops.

The high pressure recirculation system provides long term core cooling after a loss of coolant accident of any break size. It recirculates the sump water back into the core after cooling it in residual heat removal heat exchangers.

The changeover from the injection mode to recirculation mode is initiated automatically and completed manually by operator action from the main control room. Protection logic is provided to automatically open the two sump isolation valves when two of four refueling water storage tank level channels indicate a refueling water storage tank (RWST) level less than the low-low level setpoint in conjunction with the initiation of an engineered safeguards actuation signal ("S" signal). This automatic action would align the two residual heat removal pumps to take suction from the containment sump and to deliver directly to the RCS. The residual heat removal pumps would continue to operate during this changeover from injection mode to recirculation mode.

The two charging pumps and the two safety injection pumps would continue to take suction from the refueling water storage tank, following the above automatic action, until manual operator action is taken to align these pumps in series with the residual heat removal pumps. The simplified P and ID diagram is shown in Figure 3.7-7.

3.7.2 FAULT TREE MODEL

The fault tree analysis for the high pressure injection and recirculation functions is carried out as follows:

A. A high pressure injection fault tree is developed for the medium LOCA event tree. This fault tree is used to calculate the system unavailability P_{HH1} for the event tree node HH1.

B. A high pressure injection fault tree is developed for the small LOCA and other transient event trees. This fault tree is used to calculate the system unavailability P_{HH2} for the event tree node HH2.

C. A fault tree is developed for the total mission time of the injection and recirculation functions. This fault tree applies to small LOCA and other transient event trees. This fault tree is used to calculate the system unavailability (P_{HPT}) for the injection and recirculation phases.

The high pressure recirculation system unavailability (P_{R-2}) is calculated by subtracting the injection unavailability (P_{HH2}) from the system unavailability for total mission time (P_{HPT}). This accounts for the dependence of the recirculation on the success of the system components in the injection phase. The top logics for the high pressure tree and the safety injection fault trees for medium and small LOCA are shown in Figures 3.7-1, 3.7-2 and 3.7-3 respectively. Table 3.7-1 lists the components used in the fault trees. The total injection/recirculation tree is shown in Figure 3.7-4 and the high pressure safety injection trees for medium and small LOCA are illustrated in Figures 3.7-5 and 3.7-6 respectively.

3.7.2.1 SUCCESS CRITERIA FOR HIGH PRESSURE INJECTION AND RECIRCULATION

The success criteria for the high pressure injection and recirculation system fault trees is as follows:

A. Total high pressure tree - both injection and recirculation must be successful, as defined below.

B. High pressure recirculation - success requires one-out-of-two RHR pumps delivering flow to one-out-of-four trains of the injection system.

C. High pressure injection for small LOCA - success requires one-out-of-four high pressure pumps delivering flow to one-out-of-four cold legs of the reactor coolant system.

D. High pressure injection for medium LOCA - success requires two-out-of-four high pressure pumps delivering flow to two-out-of-three intact injection paths of the reactor coolant system.

The high pressure recirculation node in the event tree is labeled R-2. The high pressure injection node for a medium LOCA situation is labeled HH1 and the high pressure injection node for a small LOCA is labeled HH2 in the event trees.

3.7.2.2 DEPENDENCE OF HIGH PRESSURE SYSTEM IN SUPPORT STATES

Train A of the recirculation and injection systems depend on ESF bus 141 and Train B on ESF bus 142. Each train of the recirculation system contains a motor-driven RHR pump and two motor-operated valves which depend on electric power. The charging and safety injection trains of the high pressure system each has two motor-driven pumps and motor-operated valves which also depend on electric power. All recirculation trains depend on CCW (Component Cooling Water) cooling for the RHR pumps and RHR heat exchangers and the safety injection pumps and charging pumps depend on ESW (Essential Service Water) cooling. Since CCW is dependent on ESW, failure of the ESW system leads to failure of the recirculation system and the safety injection pumps in the high pressure injection system.

3.7.2.3 RANDOM FAILURE MODEL OF HIGH PRESSURE SYSTEM

The random failure fault tree models were developed according to the LCORP Guide to Fault Tree Development in Appendix 3A. The high pressure charging pumps are alternating pumps and the high pressure safety injection pumps are standby pumps and all are modeled for both failure to run and failure to start. Since one charging pump will be normally operating, it may be considered slightly conservative to include a failure to start mode for the centrifugal charging pumps. However, since there is also a positive displacement charging pump that may be normally operating, the failure to start mode must be considered for the centrifugal charging pumps in the safety injection system.

In the fault tree model for high pressure injection medium LOCA, the safety injection and charging systems both require two-out-of-three intact header paths available. This is slightly conservative because if one safety injection and one charging pump are working, only one path on each system is

required. This method avoids complicated modeling and causes a minimal increase in unavailibility. The random failure model for the RHR trains is consistent with what was previously described in Section 3.6.2.2.3.

3.7.2.4 COMMON CAUSE MODEL OF HIGH PRESSURE SYSTEM

The common cause modeling of the system is done in accordance with the common cause guidelines in Appendix 3B. All common cause calculations are the product of a β and a random failure probability. Table 3.7-2 lists the β's and failure probabilities used in the calculation of common cause failures in the high pressure injection fault trees. The β's and failure probabilities used in common cause calculation of the recirculation system in the total high pressure fault tree are also listed in Table 3.7-2.

Common cause failure of various motor-operated valves which require position changes is modeled in the fault trees. These include common cause failure of valves: SI8811A and B, SI8812A and B, LCV112D and E, SI8801A and B and CC9412A and B. Also modeled in the fault tree are common cause failure to start and common cause failure to run for all motor-driven pumps.

3.7.2.5 TEST AND MAINTENANCE MODEL OF HIGH PRESSURE SYSTEM

The high pressure system contains two high pressure charging pumps, two high pressure safety injection pumps and two low pressure RHR pumps. In the RHR trains, test and maintenance is accomplished as previously described in Section 3.6.2.2.5. The high pressure injection system contains a safety injection subsystem and a charging subsystem.

The safety injection subsystem of the high pressure system consists of two trains, each train having one high pressure safety injection pump which can be isolated for maintenance. The charging subsystem of the high pressure system also consists of two trains, each having a charging pump that can also be isolated for maintenance. The safety injection trains are maintained by closing valves MVSI8821A, MOVSI8923A, and MOVSI8814 for SI train A and MVSI8821B, MOVSI8923B and MOVSI8820 for SI train B. Test of the safety injection pumps is done quarterly by isolating the pumps using valve MVSI8821A for SI pump A and valve MVSI8821B for SI pump B. Flow is then pumped through a mini flow line back to RWST.

The charging subsystem like the safety injection subsystem consists of two high pressure safety injection pumps, one on each train. The maintenance of the charging trains is accomplished by closing valves MVSI8485A, MVSI8479A, and MVSI8471A for charging train A and MVSI8485B, MVSI8479B, and MVSI8471B for charging train B. Testing of the charging pumps is done by isolating the charging pumps by closing valve MVSI8485A to test pump A and MVSI8485B to test pump B and opening valves LCV112D and E to the RWST. Flow is then pumped through a mini flow line back to the RWST.

Train test and maintenance is modeled in the fault tree so that when one safety injection pump is in test or maintenance the other is not and likewise with the charging pumps. Therefore, one pump in each subsystem will be available while the other is being tested or maintained.

Failure to restore a valve following test or maintenance is considered where applicable according to Appendix 3A. Table 3.7-1 lists all of the components in the fault tree model, indicates if they tested or maintained and whether a failure to restore is considered.

3.7.2.6 HUMAN ERROR MODEL OF HIGH PRESSURE SYSTEM

The human errors considered in the fault trees are failure to restore valves following test or maintenance and failure to align valves to proper position. Appendix 3C, Human Error Modeling, explains the numbers used for the human error failure modes previously discussed. Motor-operated valves SI8812A and B and SI9412A and B do not receive an "S" signal; therefore, operator error to position these valves was modeled. The remaining operator errors are for manual valves that are used to isolate components for train test or maintenance.

Operator omission to align valves SI8804A and B, SI8807A and B, and LCV112D and E for switchover from the recirculation mode to the injection mode and SI8806 for switchover from the injection mode to the recirculation mode is also considered in the fault tree model. These valves are assumed to be aligned in the same sequence of procedures as valves SI8812A and B. The failure rate used as input to the fault trees for these valves is designated as HE7 in the Human Error Section, Appendix 3C, and is the same failure rate that is used for operator omission of valves SI8812A and B.

3.7.2.7 INPUT DATA FOR HIGH PRESSURE SYSTEM

Tables 3.7-3 through 3.7-14 lists all event identifiers, brief descriptions of the failure mode they represent, and the numbers used as input to the fault tree quantification. The first four tables contain input data for the total high pressure system fault tree for 3 day LCO, the next two for 7 day LCO. Tables 3.7-7 thru 3.7-10 are 3 day LCO and 7 day LCO values for the safety injection fault tree for a medium LOCA. The remaining four tables, Tables 3.7-11 thru 3.7-14, contain 3 day and 7 day LCO input data for the safety injection fault tree for a small LOCA. All numbers in these data tables are drawn from the data bank in Appendix 3D.

3.7.3 FAULT TREE QUANTIFICATION

3.7.3.1 SYSTEM UNAVAILABILITY CALCULATIONS FOR HIGH PRESSURE SYSTEM

The fault tree was analyzed using the WAMBAM computer code. For power states 2, 5 and 6 in all fault trees, the unavailability is 1.0 because of the dependencies of the systems on Essential Service Water and electrical power. Figure 3.7-1 shows the top logic for the total high pressure tree and Figures 3.7-2 and 3.7-3 show the top logic for the safety injection trees for a medium LOCA and small LOCA respectively. Unavailability values for 3 day and 7 day LCO for all top structures are listed in Tables 3.7-15 through 3.7-20. The calculated unavailability results that are used as input to the event tree nodes are listed in Tables 3.7-21 and 3.7-22.

3.7.3.2 DOMINANT CUTSETS FOR HIGH PRESSURE SYSTEM

The WAMCUT computer code was used to obtain cutsets for the high pressure system fault tree model, the safety injection fault tree model for medium LOCA and the safety injection fault tree model for small LOCA, all with 3 day and 7 day LCO. The dominant cutsets for all high pressure systems are listed in Table 3.7-23 through 3.7-25 along with the percent of the unavailability which they contribute.

TABLE 3.7-1

SYSTEM COMPONENT LIST FOR HIGH PRESSURE SYSTEM

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error [1]
MOV SI8811A	X			Quarterly		
MOV SI8811B		X		Quarterly		
CV SI8958A					X	
CV SI8958B					X	
MOV SI8812A	X			Quarterly		FC
MOV SI8812B		X		Quarterly		FC
MDP RHR Pump A	X		X	Quarterly	X	
MDP RHR Pump B		X	X	Quarterly	X	
CV RH8730A				Quarterly	X	
CV RH8730B				Quarterly	X	
MV RH8724A				Quarterly	X	
MV RH8724B				Quarterly	X	
HX RHRA			X			
HX RHRB			X			
AOV RH0618				Refueling	X	FR(M)
AOV RH0619				Refueling	X	FR(M)
MV CC9507A				Refueling	X	
MV CC9507B				Refueling	X	
MOV CC9412A	X			Quarterly	X	FO
MOV CC9412B		X		Quarterly	X	FO
MV CC9504A				Refueling	X	
MV CC9504B				Refueling	X	
AOV RH0606				Refueling	X	FR(M)

TABLE 3.7-1 (Continued)

SYSTEM COMPONENT LIST FOR HIGH PRESSURE SYSTEM

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error
AOV RH0607				Refueling	X	FR(M)
MOV RH8716A	X			Quarterly	X	FR(T M)
MOV RH8716B		X		Quarterly	X	FR(T M)
MOV SI8804A	X			Quarterly		FO
MOV SI8804B		X		Quarterly		FO
MOV SI8924		X		Quarterly		FR(T)
MOV SI8807A	X			Quarterly		FO
MOV SI8807B		X		Quarterly		FO
* MOV LCV112D		X		Quarterly		FC
* MOV LCV112E	X			Quarterly		FC
* CV SI8546				Quarterly		
* MOV SI8806	X			Quarterly		
* CV SI8926				Quarterly		
* MOV SI8923A	X			Quarterly		
* MOV SI8923B		X		Quarterly		
* MDP SI Pump A	X		X	Quarterly	X	
* MDP SI Pump B		X	X	Quarterly	X	
* MOV SI8802A	X			Quarterly		
* MOV SI8802B		X		Quarterly		
RHR Sump A						
RHR Sump B						
* CV SI8922A					X	
* CV SI8922B					X	
* MV SI8921A					X	FR(M)
* MV SI8921B					X	FR(M)
* MOV SI8821A	X			Quarterly		
* MOV SI8821B		X		Quarterly		

TABLE 3.7-1 (Continued)

SYSTEM COMPONENT LIST FOR HIGH PRESSURE SYSTEM

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error
* MOV SI8835	X			Quarterly		FR(T)
* MV SI8822A				Refueling		
* MV SI8822B				Refueling		
* MV SI8822C				Refueling		
* MV SI8822D				Refueling		
* CV SI8819A						
* CV SI8819B						
* CV SI8819C						
* CV SI8819D						
* CV SI8948A						
* CV SI8948B						
* CV SI8948C						
* CV SI8948D						
* MV SI8471A				Quarterly		
* MV SI8471B				Quarterly		
* MDP Charging Pump A	X		X	Quarterly	X	
* MDP Charging Pump B		X	X	Quarterly	X	
* MV SX0196A				Quarterly		
* MV SX0196B				Quarterly		
* MV SX0197A				Quarterly		
* MV SX0197B				Quarterly		
MV CC9506A				Quarterly	X	
MV CC9506B				Quarterly	X	
* CV SI8481A					X	
* CV SI8481B					X	
* MV SI8485A				Quarterly		FR(T M)

TABLE 3.7-1 (Continued)

SYSTEM COMPONENT LIST FOR HIGH PRESSURE SYSTEM

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error
* MV SI8485B				Quarterly		FR(T M)
* MOV SI8801A	X			Quarterly		
* MOV SI8801B		X		Quarterly		
* CV SI8815						
* MV SI8810A				Refueling		
* MV SI8810B				Refueling		
* MV SI8810C				Refueling		
* MV SI8810D				Refueling		
* CV SI8900A						
* CV SI8900B						
* CV SI8900C						
* CV SI8900D						
MV CC9474A				Quarterly		
MV CC9474B				Quarterly		

NOTES:

1 - Operator Error Symbols

FR = Fails to restore following (T, M or R)
T = Test
M = Maintenance
R = Refueling
FO = Fails to open
FC = Fails to close

2 - Negligible According to Generic Guidelines

3 - *Components in Safety Injection Tree

TABLE 3.7-2

COMMON CAUSE CALCULATIONS

Failure Mode	Data Bank Source ID	β	Random Failure Mode	Random Failure Probability	Result
Failure of two standby pumps to start	HP2	0.311	Fail to Start	7.21×10^{-4}	2.24×10^{-4}
Failure of two RHR pumps to run	HP3	0.141	Fail during Operation	2.53×10^{-6}	3.57×10^{-7}
Failure of two safety injection pumps to run	HP4	0.016	Fail during Operation	1.55×10^{-5}	2.48×10^{-7}
Failure of two centrifugal charging pumps to run	HP5	0.016	Fail during Operation	1.76×10^{-6}	2.82×10^{-8}
Failure of two alternating motor-driven pumps to start	C2	0.093	Fail to Start	7.21×10^{-4}	6.71×10^{-5}
Failure of two motor-operated valves to operate	C3	0.030	Fail to Operate	1.55×10^{-3}	4.65×10^{-5}

TABLE 3.7-3

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 3 DAY LCO SUPPORT STATE 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVSI8806C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8926C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8835C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8922AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8821AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
PSIO1PARFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	2.400E+01	0.000E-01	3.72E-04	1.70E-05
PSIO1PACFR	CC	COMMON CAUSE PUMP RU	2.480E-07	0.000E-01	HP4	2.400E+01	0.000E-01	5.95E-06	0.00E-01
XVSI8921AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
PSIO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XSI8921AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
PSIO1PAM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	1.900E+01	0.000E-01	7.68E-04	0.00E-01
PRHO1PACFR	CC	COMMON CAUSE PUMP RU	3.570E-07	1.270E-13	HP3	2.300E+01	0.000E-01	8.21E-06	6.72E-11
PRHO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PRHO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
CVSI8922BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8802A0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08

TABLE 3.7-3 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 3 DAY LCO SUPPORT STATE 1

MVSI8802BO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
PSIO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PBRFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	2.400E+01	0.000E-01	3.72E-04	1.70E-05
XVSI8921BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
PSIO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XSI8921BHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
PSIO1PBM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	1.900E+01	0.000E-01	7.68E-04	0.00E-01
PRHO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PACFS	CC	CC-ALT. PUMPS TO STA	6.710E-05	0.000E-01	C2	0.000E-01	0.000E-01	6.71E-05	0.00E-01
PCVO1PARFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
PCVO1PACFR	CC	COMMON CAUSE PUMP RU	2.820E-08	0.000E-01	HP5	2.400E+01	0.000E-01	6.77E-07	0.00E-01
XVSXO196AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8815C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8471AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8546C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVLCV112DD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVLCV112ED	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8801AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVSI8481AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.7-3 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 3 DAY LCO SUPPORT STATE 1

XVSI8485AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PAM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	2.76E-03	0.00E-01
CVSI8546O	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	1.095E+03	0.000E-01	9.18E-04	8.74E-07
MVSI8801BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XSI8485AHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XVSI8471BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PBRFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
XVSXO196BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8481BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
CVSI8926O	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	1.095E+03	0.000E-01	9.18E-04	8.74E-07
XVSI8485BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PBM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	2.76E-03	0.00E-01
MVSI8806Q	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XSI8485BHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485BHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
MVLCV112DQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVLCV112EQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVSI8948BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09

TABLE 3.7-3 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 3 DAY LCO SUPPORT STATE 1

CVSI8948CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8822BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
CVSI8900BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8810BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
CVRH8730AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
SUMPAB	SUMP	SUMP GRATINGS BLOCKE	5.000E-05	6.400E-06	ZPSS	0.000E-01	0.000E-01	5.00E-05	6.40E-06
MVSI8924C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVRH8724AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9507AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVCC9504AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
AVRH0619HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRH06190	AOV	TRANSFER OPEN/LEAK	3.140E-08	1.560E-14	NOT6	6.570E+03	0.000E-01	2.06E-04	6.73E-07

TABLE 3.7-3 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 3 DAY LCO SUPPORT STATE 1

PRHO1PARFR	MDP	FAIL DURING OPERATIO	2.530E-06	3.390E-11	ZPSS	2.300E+01	0.000E-01	5.82E-05	1.79E-08
CCWAU	CCW	CCW TRAIN A,PS1,3D L	2.200E-06	0.000E-01	CCW	0.000E-01	0.000E-01	2.20E-06	0.00E-01
XVCC9506BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9506AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVCC9412AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8812AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8811AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8804AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8807AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8807BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
PRHO1PAM	MDP	MAINTENANCE FREQUENC	6.120E-05	2.870E-10	ZPSS	1.900E+01	0.000E-01	1.16E-03	1.04E-07
CVRH8730BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVRH8724BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8811BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8812BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XVCC9507BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVCC9504BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
AVRHO618HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRHO6180	AOV	TRANSFER OPEN/LEAK	3.140E-08	1.560E-14	NOT6	6.570E+03	0.000E-01	2.06E-04	6.73E-07
MVS8812BOP	OPER	OP FAILS TO CLOSE SI	1.400E-04	0.000E-01	HE7	0.000E-01	0.000E-01	1.40E-04	0.00E-01
MVCC9412BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
SUMPBB	SUMP	SUMP GRATINGS BLOCKE	5.000E-05	6.400E-06	ZPSS	0.000E-01	0.000E-01	5.00E-05	6.40E-06

TABLE 3.7-3 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 3 DAY LCO SUPPORT STATE 1

PRHO1PBRFR	MDP	FAIL DURING OPERATIO	2.530E-06	3.390E-11	ZPSS	2.300E+01	0.000E-01	5.82E-05	1.79E-08
XVCC9474AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9474BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CCWBU	CCW	CCW TRAIN B,PS1,3D L	1.600E-08	0.000E-01	CCW	0.000E-01	0.000E-01	1.60E-08	0.00E-01
PRHO1PBM	MDP	MAINTENANCE FREQUENC	6.120E-05	2.870E-10	ZPSS	1.900E+01	0.000E-01	1.16E-03	1.04E-07
MVSI8923AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8923BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8804BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVRH8716AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
JBS131D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS141AD	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVR8716AHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716AHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVRH8716BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
JBS132D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS142AD	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVR8716BHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716BHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRH0606C	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	6.570E+03	0.000E-01	7.36E-04	7.94E-07
AVRH0606HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01

TABLE 3.7-3 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 3 DAY LCO SUPPORT STATE 1

AVRHO607C	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	6.570E+03	0.000E-01	7.36E-04	7.94E-07
AVRHO607HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
CCWCC	CCW	CCW SYSTEM PS1,3D LC	4.400E-09	0.000E-01	CCW	0.000E-01	0.000E-01	4.40E-09	0.00E-01
MVLCV112CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8812CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8811CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8801CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
CVSI8819AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVS.8900AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8810AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MV112DECC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
CVSI8958AO	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	2.300E+01	0.000E-01	1.93E-05	3.86E-10
CVSI8958BO	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	2.300E+01	0.000E-01	1.93E-05	3.86E-10
PRHO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
PRHO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
MVC9412BOP	OPER	OP FAILS TO OPEN CC9	9.600E-05	0.000E-01	HE4	0.000E-01	0.000E-01	9.60E-05	0.00E-01
MVCC9412CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8924HT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVSI8821BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVS8804AOP	OPER	OP FAILS TO CLOSE SI	1.400E-04	0.000E-01	HE7	0.000E-01	0.000E-01	1.40E-04	0.00E-01

TABLE 3.7-3 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 3 DAY LCO SUPPORT STATE 1

MVS8804BOP	OPER	OP FAILS TO CLOSE SI	1.40OE-04	O.OOOE-01	HE7	O.OOOE-01	O.OOOE-01	1.40E-04	O.OOE-01
MVSI8835HT	MV	FAIL TO RESTORE/INDI	4.40OE-05	O.OOOE-01	HE1	O.OOOE-01	O.OOOE-01	4.40E-05	O.OOE-01
MVLCV112OP	OPER	OP FAILS TO CLOSE SI	1.40OE-04	O.OOOE-01	HE7	O.OOOE-01	O.OOOE-01	1.40E-04	O.OOE-01
MVSI8807OP	OPER	OP FAILS TO CLOSE SI	1.40OE-04	O.OOOE-01	HE7	O.OOOE-01	O.OOOE-01	1.40E-04	O.OOE-01
MVSI8806OP	OPER	OP FAILS TO CLOSE SI	1.40OE-04	O.OOOE-01	HE7	O.OOOE-01	O.OOOE-01	1.40E-04	O.OOE-01

TABLE 3.7-4

3 DAY LCO DATA INPUT FOR TOTAL HIGH PRESSURE TREE

Probability

Support State

Identifier	1	2	3	4	5	6
ESWU	0.0	1.0	0.0	0.0	0.0	1.0
CCWAU	2.2(-06)	1.0	1.8(-05)	1.3(-05)	2.6(-04)	1.0
CCWBU	1.6(-08)	1.0	1.2(-05)	7.3(-06)	1.3(-03)	1.0
CCWCC	4.4(-09)	1.0	1.1(-05)	5.9(-06)	4.8(-02)	1.0
JBS141D	0.0	0.0	1.0	0.0	1.0	1.0
JBS141AD	0.0	0.0	1.0	0.0	1.0	1.0
JBS142D	0.0	0.0	0.0	1.0	1.0	1.0
JBS142AD	0.0	0.0	0.0	1.0	1.0	1.0

NOTES:

ESWU - Essential Service Water
CCWAU - Component Cooling Train A
CCWBU - Component Cooling Train B
CCWCC - Component Cooling Common
JBS141D - Bus 141
JBS141AD - Bus 141
JBS142D - Bus 142
JBS142AD - Bus 142

TABLE 3.7-5

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 7 DAY LCO SUPPORT STATE 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVSI8806C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8926C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8835C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8922AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8821AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
PSIO1PARFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	2.400E+01	0.000E-01	3.72E-04	1.70E-05
PSIO1PACFR	CC	COMMON CAUSE PUMP RU	2.480E-07	0.000E-01	HP4	2.400E+01	0.000E-01	5.95E-06	0.00E-01
XVSI8921AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
PSIO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XSI8921AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
PSIO1PAM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	3.400E+01	0.000E-01	1.37E-03	0.00E-01
PRHO1PACFR	CC	COMMON CAUSE PUMP RU	3.570E-07	1.270E-13	HP3	2.300E+01	0.000E-01	8.21E-06	6.72E-11
PRHO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PRHO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
CVSI8922BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8802A0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08

TABLE 3.7-5 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 7 DAY LCO SUPPORT STATE 1

MVSI8802BO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.97E-08
PSIO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PBRFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	2.400E+01	0.000E-01	3.72E-04	1.70E-05
XVSI8921BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
PSIO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XSI8921BHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
PSIO1PBM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	3.400E+01	0.000E-01	1.37E-03	0.00E-01
PRHO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PACFS	CC	CC-ALT. PUMPS TO STA	6.710E-05	0.000E-01	C2	0.000E-01	0.000E-01	6.71E-05	0.00E-01
PCVO1PARFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
PCVO1PACFR	CC	COMMON CAUSE PUMP RU	2.820E-08	0.000E-01	HP5	2.400E+01	0.000E-01	6.77E-07	0.00E-01
XVSXO196AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8815C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8471AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8546C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVLCV112DD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVLCV112ED	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8801AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVSI8481AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.7-5 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 7 DAY LCO SUPPORT STATE 1

XVSI8485AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PAM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	4.93E-03	0.00E-01
CVSI8546O	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	1.095E+03	0.000E-01	9.18E-04	8.74E-07
MVSI8801BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XSI8485AHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XVSI8471BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PB&FS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PBRFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
XVSXO196BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8481BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
CVSI8926O	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	1.095E+03	0.000E-01	9.18E-04	8.74E-07
XVSI8485BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PBM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	4.93E-03	0.00E-01
MVSI8806Q	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XSI8485BHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485BHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
MVLCV112DQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVLCV112EQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVSI8948BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09

TABLE 3.7-5 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 7 DAY LCO SUPPORT STATE 1

CVSI8948CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8822BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
CVSI8900BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8810BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
CVRH8730AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
SUMPAB	SUMP	SUMP GRATINGS BLOCKE	5.000E-05	6.400E-06	ZPSS	0.000E-01	0.000E-01	5.00E-05	6.40E-06
MVSI8924C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVRH8724AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9507AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVCC9504AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
AVRH0619HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRH06190	AOV	TRANSFER OPEN/LEAK	3.140E-08	1.560E-14	NOT6	6.570E+03	0.000E-01	2.06E-04	6.73E-07

TABLE 3.7-5 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 7 DAY LCO SUPPORT STATE 1

PRHO1PARFR	MDP	FAIL DURING OPERATIO	2.530E-06	3.390E-11	ZPSS	2.300E+01	0.000E-01	5.82E-05	1.79E-08
CCWAU	CCW	NOIF CCW TR A P.S.1.	2.900E-06	0.000E-01	CCW	0.000E-01	0.000E-01	2.90E-06	0.00E-01
XVCC9506BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9506AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVCC9412AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8812AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8811AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8804AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8807AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8807BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
PRHO1PAM	MDP	MAINTENANCE FREQUENC	6.120E-05	2.870E-10	ZPSS	3.400E+01	0.000E-01	2.08E-03	3.32E-07
CVRH8730BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVRH8724BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8811BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8812BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XVCC9507BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVCC9504BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
AVRHO618HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRHO618O	AOV	TRANSFER OPEN/LEAK	3.140E-08	1.560E-14	NOT6	6.570E+03	0.000E-01	2.06E-04	6.73E-07
MVS8812BOP	OPER	OP FAILS TO CLOSE SI	1.400E-04	0.000E-01	HE7	0.000E-01	0.000E-01	1.40E-04	0.00E-01
MVCC9412BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
SUMPBB	SUMP	SUMP GRATINGS BLOCKE	5.000E-05	6.400E-06	ZPSS	0.000E-01	0.000E-01	5.00E-05	6.40E-06

TABLE 3.7-5 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 7 DAY LCO SUPPORT STATE 1

PRHO1PBRFR	MDP	FAIL DURING OPERATIO	2.530E-06	3.390E-11	ZPSS	2.300E+01	0.000E-01	5.82E-05	1.79E-08
XVCC9474AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9474BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CCWBU	CCW	NOIF CCW TR B P.S.1,	1.800E-08	0.000E-01	CCW	0.000E-01	0.000E-01	1.80E-08	0.00E-01
PRHO1PBM	MDP	MAINTENANCE FREQUENC	6.120E-05	2.870E-10	ZPSS	3.400E+01	0.000E-01	2.08E-03	3.32E-07
MVSI8923AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8923BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8804BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVRH8716AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
JBS131D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS141AD	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVR8716AHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716AHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVRH8716BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
JBS132D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS142AD	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVR8716BHM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVR8716BHT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
AVRH0606C	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	6.570E+03	0.000E-01	7.36E-04	7.94E-07
AVRH0606HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01

TABLE 3.7-5 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 7 DAY LCO SUPPORT STATE 1

AVRH0607C	AOV	TRANSFER CLOSED/PLUG	1.120E-07	1.840E-14	ZPSS	6.570E+03	0.000E-01	7.36E-04	7.94E-07
AVRH0607HM	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
CCWCC	CCW	NOIF COMMON P.S.1.	6.100E-09	0.000E-01	CCW	0.000E-01	0.000E-01	6.10E-09	0.00E-01
MVLCV112CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8812CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8811CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8801CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
CVSI8819AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8810AC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822AC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MV112DECC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
CVSI8958AO	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	2.300E+01	0.000E-01	1.93E-05	3.86E-10
CVSI8958BO	CV	FAIL TO SEAT/EXCESS	8.380E-07	7.290E-13	ZPSS	2.300E+01	0.000E-01	1.93E-05	3.86E-10
PRHO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
PRHO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
MVC9412BOP	OPER	OP FAILS TO OPEN CC9	9.600E-05	0.000E-01	HE4	0.000E-01	0.000E-01	9.60E-05	0.00E-01
MVCC9412CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8924HT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVSI8821BC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVS8804AOP	OPER	OP FAILS TO CLOSE SI	1.400E-04	0.000E-01	HE7	0.000E-01	0.000E-01	1.40E-04	0.00E-01

TABLE 3.7-5 (Continued)

INPUT DATA FOR TOTAL HIGH PRESSURE TREE 7 DAY LCO SUPPORT STATE 1

MVS8804BOP	OPER	OP FAILS TO CLOSE SI	1.400E-04	0.000E-01	HE7	0.000E-01	0.000E-01	1.40E-04	0.00E-01
MVSI8835HT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVLCV112OP	OPER	OP FAILS TO CLOSE SI	1.400E-04	0.000E-01	HE7	0.000E-01	0.000E-01	1.40E-04	0.00E-01
MVSI8807OP	OPER	OP FAILS TO CLOSE SI	1.400E-04	0.000E-01	HE7	0.000E-01	0.000E-01	1.40E-04	0.00E-01

TABLE 3.7-6

7 DAY LCO DATA INPUT FOR TOTAL HIGH PRESSURE TREE

Probability

Support State

Identifier	1	2	3	4	5	6
ESWU	0.0	1.0	0.0	0.0	0.0	1.0
CCWAU	2.9(-06)	1.0	1.9(-05)	1.4(-05)	2.7(-04)	1.0
CCWBU	1.8(-08)	1.0	1.2(-05)	7.7(-06)	1.3(-03)	1.0
CCWCC	6.1(-09)	1.0	1.1(-05)	6.3(-06)	4.1(-02)	1.0
JBS141D	0.0	0.0	1.0	0.0	1.0	1.0
JBS141AD	0.0	0.0	1.0	0.0	1.0	1.0
JBS142D	0.0	0.0	0.0	1.0	1.0	1.0
JBS142AD	0.0	0.0	0.0	1.0	1.0	1.0

NOTES:

ESWU - Essential Service Water
CCWAU - Component Cooling Train A
CCWBU - Component Cooling Train B
CCWCC - Component Cooling Common
JBS141D - Bus 141
JBS141AD - Bus 141
JBS142D - Bus 142
JBS142AD - Bus 142

TABLE 3.7-7

INPUT DATA FOR HIGH PRESSURE SI TREE MEDIUM LOCA 3 DAY LCO SUPPORT STATE 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVSI8806C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8926C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8835C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8922AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8821AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
PSIO1PARFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
PSIO1PACFR	CC	COMMON CAUSE PUMP RU	2.480E-07	0.000E-01	HP4	1.000E+00	0.000E-01	2.48E-07	0.00E-01
XVSI8921AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XSI8921AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8922BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8802AO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
MVSI8807BO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
PSIO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PBRFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
XVSI8921BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.7-7 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE MEDIUM LOCA 3 DAY LCO SUPPORT STATE 1

XSI8921BHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
PSIO1PBM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	1.900E+01	0.000E-01	7.68E-04	0.00E-01
PCVO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PACFS	CC	CC-ALT PUMPS TO STA	6.710E-05	0.000E-01	C2	0.000E-01	0.000E-01	6.71E-05	0.00E-01
PCVO1PARFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	1.000E+00	0.000E-01	1.76E-06	9.62E-12
PCVO1PACFR	CC	COMMON CAUSE PUMP RU	2.820E-08	0.000E-01	HP5	1.000E+00	0.000E-01	2.82E-08	0.00E-01
XVSXO196AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8815C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8471AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8546C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVLCV112DD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVLCV112ED	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8801AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVSI8481AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSI8485AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PAM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	2.76E-03	0.00E-01
MVSI8801BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XSI8485AHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XVSI8471BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.7-7 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE MEDIUM LOCA 3 DAY LCO SUPPORT STATE 1

PCVO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PBRFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	1.000E+00	0.000E-01	1.76E-06	9.62E-12
XVSXO196BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8481BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSI8485BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PBM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	2.76E-03	0.00E-01
XSI8485BHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485BHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8948BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8822BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
CVSI8900BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09

TABLE 3.7-7 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE MEDIUM LOCA 3 DAY LCO SUPPORT STATE 1

XVSI8810BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MVSI8923AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
JBS131D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS132D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVLCV112CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8801CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
PSIO1PAM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	1.900E+01	0.000E-01	7.68E-04	0.00E-01
PSIO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
MVSI8923BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8835HT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVSI8821BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.7-8

3 DAY LCO DATA INPUT FOR SAFETY INJECTION (MEDIUM LOCA)

Probability

Support State

Identifier	1	2	3	4	5	6
ESWU	0.0	1.0	0.0	0.0	0.0	1.0
JBS141D	0.0	0.0	1.0	0.0	1.0	1.0
JBS142D	0.0	0.0	0.0	1.0	1.0	1.0

NOTES:

ESWU - Essential Service Water
JBS141D - Bus 141
JBS142D - Bus 142

TABLE 3.7-9

INPUT DATA FOR HIGH PRESSURE SI TREE MEDIUM LOCA 7 DAY LCO SUPPORT STATE 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVSI8806C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8926C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8835C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8922AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8821AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
PSIO1PARFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
PSIO1PACFR	CC	COMMON CAUSE PUMP RU	2.480E-07	0.000E-01	HP4	1.000E+00	0.000E-01	2.48E-07	0.00E-01
XVSI8921AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XSI8921AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8922BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8802A0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
MVSI8802B0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
PSIO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PBRFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
XVSI8921BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.7-9 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE MEDIUM LOCA 7 DAY LCO SUPPORT STATE 1

XSI8921BHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
PSIO1PBM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	3.400E+01	0.000E-01	1.37E-03	0.00E-01
PCVO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PACFS	CC	CC-ALT. PUMPS TO STA	6.710E-05	0.000E-01	C2	0.000E-01	0.000E-01	6.71E-05	0.00E-01
PCVO1PARFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	1.000E+00	0.000E-01	1.76E-06	9.62E-12
PCVO1PACFR	CC	COMMON CAUSE PUMP RU	2.820E-08	0.000E-01	HP5	1.000E+00	0.000E-01	2.82E-08	0.00E-01
XVSXO196AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8815C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8471AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8546C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVLCV112DD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVLCV112ED	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8801AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVSI8481AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSI8485AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PAM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	4.93E-03	0.00E-01
MVSI8801BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XSI8485AHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XVSI8471BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.7-9 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE MEDIUM LOCA 7 DAY LCO SUPPORT STATE 1

PCVO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PBATR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	1.000E+00	0.000E-01	1.76E-06	9.62E-12
XVSXO196PC	X,MV	TRANSFER CLOSED	5.280E-08	2.870E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8481BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSI8485BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PBM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	4.93E-03	0.00E-01
XSI8485BHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485BHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8948BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8822BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
CVSI8900BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09

TABLE 3.7-9 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE MEDIUM LOCA 7 DAY LCO SUPPORT STATE 1

XVSI8810BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MVSI8923AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
JBS131D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS132D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVLCV112CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8801CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
PSIO1PAM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	3.400E+01	0.000E-01	1.37E-03	0.00E-01
PSIO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
MVSI8923BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8835HT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVSI8821BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.7-10

7 DAY LCO DATA INPUT FOR SAFETY INJECTION (MEDIUM LOCA)

Probability

Support State

Identifier	1	2	3	4	5	6
ESWU	0.0	1.0	0.0	0.0	0.0	1.0
JBS141D	0.0	0.0	1.0	0.0	1.0	1.0
JBS142D	0.0	0.0	0.0	1.0	1.0	1.0

NOTES:

ESWU - Essential Service Water
JBS141D - Bus 141
JBS142D - Bus 142

TABLE 3.7-11

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 3 DAY LCO SS 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVSI8806C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8926C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8835C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8922AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8821AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
PSIO1PARFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
PSIO1PACFR	CC	COMMON CAUSE PUMP RU	2.480E-07	0.000E-01	HP4	1.000E+00	0.000E-01	2.48E-07	0.00E-01
XVSI8921AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XSI8921AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8922BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8802AO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
MVSI8802BO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
PSIO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PBRFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
XVSI8921BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
PSIO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.7-11 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 3 DAY LCO SS 1

XSI8921BHM	XV	FAIL TO RESTORE	2.10OE-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
PSIO1PBM	MDP	MAINTENANCE FREQUENC	4.04OE-05	0.000E-01	ZPSS	1.900E-01	0.000E-01	7.68E-04	0.00E-01
PCVO1PARFS	MDP	FAIL TO START	7.21OE-04	1.91OE-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PACFS	CC	CC-ALT. PUMPS TO STA	6.71OE-05	0.000E-01	C2	0.000E-01	0.000E-01	6.71E-05	0.00E-01
PCVO1PARFR	MDP	FAIL DURING OPERATIO	1.76OE-06	9.62OE-12	ZPSS	1.000E+00	0.000E-01	1.76E-06	9.62E-12
PCVO1PACFR	CC	COMMON CAUSE PUMP RU	2.82OE-08	0.000E-01	HP5	1.000E+00	0.000E-01	2.82E-08	0.00E-01
XVSXO196AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8815C	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8471AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8546C	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVLCV112DD	MOV	FAIL TO OPERATE	1.55OE-03	6.30OE-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVLCV112ED	MOV	FAIL TO OPERATE	1.55OE-03	6.30OE-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI8801AQ	MOV	FAIL TO OPERATE	1.55OE-03	6.30OE-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVSI8481AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PAT	MDP	PUMP TEST	9.13OE-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSI8485AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PAM	MDP	MAINTENANCE FREQUENC	1.45OE-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	2.76E-03	0.00E-01
MVSI8801BQ	MOV	FAIL TO OPERATE	1.55OE-03	6.30OE-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XSI8485AHT	XV	FAIL TO RESTORE	2.10OE-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485AHM	XV	FAIL TO RESTORE	2.10OE-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XVSI8471BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.7-11 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 3 DAY LCO SS 1

PCVO1PBRFS	MDP	FAIL TO START	7.21OE-04	1.91OE-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PBRFR	MDP	FAIL DURING OPERATIO	1.76OE-06	9.62OE-12	ZPSS	1.000E+00	0.000E-01	1.76E-06	9.62E-12
XVSXO196BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8481BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PBT	MDP	PUMP TEST	9.13OE-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSI8485BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PBM	MDP	MAINTENANCE FREQUENC	1.45OE-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	2.76E-03	0.00E-01
XSI8485BHT	XV	FAIL TO RESTORE	2.10OE-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485BHM	XV	FAIL TO RESTORE	2.10OE-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8948BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948CC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948DC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819CC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819DC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8822BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	6.57OE+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822CC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	6.57OE+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822DC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	6.57OE+03	0.000E-01	3.47E-04	1.22E-07
CVSI8900BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900CC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900DC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09

TABLE 3.7-11 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 3 DAY LCO SS 1

XVSI8810BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MVSI8923AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
JBS131D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS132D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVLCV112CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8801CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
PSIO1PAM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	1.900E+01	0.000E-01	7.68E-04	0.00E-01
PSIO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
CVSI8819AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8810AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MVSI8923BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8835HT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVSI8821BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.7-12

7 DAY LCO DATA INPUT FOR SAFETY INJECTION (SMALL LOCA)

Probability

Support State

Identifier	1	2	3	4	5	6
ESWU	0.0	1.0	0.0	0.0	0.0	1.0
JBS141D	0.0	0.0	1.0	0.0	1.0	1.0
JBS142D	0.0	0.0	0.0	1.0	1.0	1.0

NOTES:

ESWU - Essential Service Water
JBS141D - Bus 141
JBS142D - Bus 142

TABLE 3.7-13

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 7 DAY LCO SS 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVSI8806C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8926C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8835C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8922AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8821AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
PSIO1PARFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
PSIO1PACFR	CC	COMMON CAUSE PUMP RU	2.480E-07	0.000E-01	HP4	1.000E+00	0.000E-01	2.48E-07	0.00E-01
XVSI8921AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XSI8921AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8922BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8802A0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
MVSI8802B0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
PSIO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PBRFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
XVSI8921BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.7-13 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 7 DAY LCO SS 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVSI8806C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8926C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8835C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8922AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8821AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
PSIO1PARFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
PSIO1PACFR	CC	COMMON CAUSE PUMP RU	2.480E-07	0.000E-01	HP4	1.000E+00	0.000E-01	2.48E-07	0.00E-01
XVSI8921AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XSI8921AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8922BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8802A0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
MVSI8802B0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
PSIO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PBRFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
XVSI8921BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.7-13 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 7 DAY LCO SS 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVSI8806C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8926C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8835C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8922AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8821AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
PSIO1PARFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
PSIO1PACFR	CC	COMMON CAUSE PUMP RU	2.480E-07	0.000E-01	HP4	1.000E+00	0.000E-01	2.48E-07	0.00E-01
XVSI8921AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XSI8921AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8922BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8802AO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
MVSI8802BO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
PSIO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PBRFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
XVSI8921BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.7-13 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 7 DAY LCO SS 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
ESWU	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVSI8806C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8926C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8835C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8922AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8821AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PACFS	CC	COMMON CAUSE PUMP ST	2.240E-04	5.020E-08	HP2	0.000E-01	0.000E-01	2.24E-04	5.02E-08
PSIO1PARFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
PSIO1PACFR	CC	COMMON CAUSE PUMP RU	2.480E-07	0.000E-01	HP4	1.000E+00	0.000E-01	2.48E-07	0.00E-01
XVSI8921AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XSI8921AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8922BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVSI8802A0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
MVSI8802B0	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	1.095E+03	0.000E-01	3.44E-05	1.87E-08
PSIO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PSIO1PBRFR	MDP	FAIL DURING OPERATIO	1.550E-05	2.960E-08	ZPSS	1.000E+00	0.000E-01	1.55E-05	2.96E-08
XVSI8921BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PSIO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01

TABLE 3.7-13 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 7 DAY LCO SS 1

XSI8921BHM	XV	FAIL TO RESTORE	2.10OE-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
PSIO1PBM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	3.400E+01	0.000E-01	1.37E-03	0.00E-01
PCVO1PARFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PACFS	CC	CC-ALT. PUMPS TO STA	6.710E-05	0.000E-01	C2	0.000E-01	0.000E-01	6.71E-05	0.00E-01
PCVO1PARFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	1.000E+00	0.000E-01	1.76E-06	9.62E-12
PCVO1PACFR	CC	COMMON CAUSE PUMP RU	2.820E-08	0.000E-01	HP5	1.000E+00	0.000E-01	2.82E-08	0.00E-01
XVSXO196AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8815C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8471AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8546C	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
MVLCV112DD	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVLCV112ED	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
MVSI88O1AQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVSI8481AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSI8485AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PAM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	4.93E-03	0.00E-01
MVSI88O1BQ	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
XSI8485AHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485AHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XVSI8471BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.7-13 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 7 DAY LCO SS 1

PCVO1PBRFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCVO1PBRFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	1.000E+00	0.000E-01	1.76E-06	9.62E-12
XVSXO196BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO197BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVSI8481BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
PCVO1PBT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSI8485BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCVO1PBM	MDP	MAINTENANCE FREQUENC	1.450E-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	4.93E-03	0.00E-01
XSI8485BHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XSI8485BHM	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
CVSI8948BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8819DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8822BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8822DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
CVSI8900BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900CC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900DC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09

TABLE 3.7-13 (Continued)

INPUT DATA FOR HIGH PRESSURE SI TREE SMALL LOCA 7 DAY LCO SS 1

XVSI8810BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVSI8810DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MVSI8923AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
JBS131D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS132D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
MVLCV112CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
MVSI8801CC	CC	COMMON CAUSE MOV	4.650E-05	0.000E-01	C3	0.000E-01	0.000E-01	4.65E-05	0.00E-01
PSIC1PAM	MDP	MAINTENANCE FREQUENC	4.040E-05	0.000E-01	ZPSS	3.400E+01	0.000E-01	1.37E-03	0.00E-01
PSIO1PAT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
CVSI8819AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8900AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVSI8948AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVSI8810AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.750E+03	0.000E-01	3.56E-04	1.28E-07
XVSI8822AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.750E+03	0.000E-01	3.56E-04	1.28E-07
MVSI8923BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSI8835HT	MV	FAIL TO RESTORE/INDI	4.400E-05	0.000E-01	HE1	0.000E-01	0.000E-01	4.40E-05	0.00E-01
MVSI8821BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.7-14

7 DAY LCO DATA INPUT FOR SAFETY INJECTION (SMALL LOCA)

Probability

Support State

Identifier	1	2	3	4	5	6
ESWU	0.0	1.0	0.0	0.0	0.0	1.0
JBS141D	0.0	0.0	1.0	0.0	1.0	1.0
JBS142D	0.0	0.0	0.0	1.0	1.0	1.0

NOTES:

ESWU - Essential Service Water
JBS141D - Bus 141
JBS142D - Bus 142

TABLE 3.7-15

3 DAY LCO DATA INPUT FOR TOTAL HIGH PRESSURE TREE
FOR TOP LOGIC FAULT TREE STRUCTURE

Identifier	Support State 1	2	3	4	5	6
AAAA	4.8(-04)	1.0	1.0(-02)	8.4(-03)	1.0	1.0
BBBB	3.9(-03)	1.0	1.0	3.9(-03)	1.0	1.0
CCCC	4.8(-04)	1.0	9.9(-03)	1.2(-02)	1.0	1.0
DDDD	3.9(-03)	1.0	3.9(-03)	1.0	1.0	1.0
FFFF	4.8(-04)	1.0	1.2(-02)	9.9(-03)	1.0	1.0
GGGG	1.6(-06)	1.0	9.2(-04)	3.0(-06)	1.0	1.0
HHHH	5.4(-03)	1.0	1.0	8.4(-03)	1.0	1.0
IIII	5.4(-03)	1.0	8.4(-03)	1.0	1.0	1.0

TABLE 3.7-16

7 DAY LCO DATA INPUT FOR TOTAL HIGH PRESSURE TREE
TOP LOGIC FAULT TREE STRUCTURE

Identifier	Support State 1	2	3	4	5	6
AAAA	4.9(-04)	1.0	1.1(-02)	9.3(-03)	1.0	1.0
BBBB	4.5(-03)	1.0	1.0	4.5(-03)	1.0	1.0
CCCC	4.9(-04)	1.0	1.1(-02)	1.3(-02)	1.0	1.0
DDDD	4.9(-03)	1.0	4.5(-03)	1.0	1.0	1.0
FFFF	4.9(-04)	1.0	1.3(-02)	1.1(-02)	1.0	1.0
GGGG	1.6(-06)	1.0	9.2(-04)	3.0(-06)	1.0	1.0
HHHH	7.5(-03)	1.0	1.0	1.1(-02)	1.0	1.0
IIII	7.5(-03)	1.0	1.1(-02)	1.0	1.0	1.0

TABLE 3.7-17

3 DAY LCO DATA INPUT FOR SAFETY INJECTION (SMALL LOCA)
TOP LOGIC FAULT TREE STRUCTURE

	Support State					
Identifier	1	2	3	4	5	6
AAAA	3.3(-03)	1.0	1.0	3.3(-03)	1.0	1.0
BBBB	3.3(-03)	1.0	3.3(-03)	1.0	1.0	1.0
CCCC	5.3(-03)	1.0	1.0	8.4(-03)	1.0	1.0
DDDD	5 3(-03)	1.0	8.4(-03)	1.0	1.0	1.0

TABLE 3.7-18

7 DAY LCO DATA INPUT SAFETY INJECTION (SMALL LOCA)
FOR TOP LOGIC FAULT TREE STRUCTURE

Identifier	Support State 1	2	3	4	5	6
AAAA	3.9(-03)	1.0	1.0	3.9(-03)	1.0	1.0
BBBB	3.9(-03)	1.0	3.9(-03)	1.0	1.0	1.0
CCCC	7.5(-03)	1.0	1.0	1.1(-02)	1.0	1.0
DDDD	7.5(-03)	1.0	1.1(-02)	1.0	1.0	1.0

TABLE 3.7-19

3 DAY LCO DATA INPUT FOR SAFETY INJECTION (MEDIUM LOCA)
TOP LOGIC FAULT TREE STRUCTURE

Identifier	Support State 1	2	3	4	5	6
AAAA	3.3(-03)	1.0	1.0	3.3(-03)	1.0	1.0
BBBB	3.3(-03)	1.0	3.3(-03)	1.0	1.0	1.0
CCCC	5.3(-03)	1.0	1.0	8.4(-03)	1.0	1.0
DDDD	5.3(-03)	1.0	8.4(-03)	1.0	1.0	1.0

TABLE 3.7-20

7 DAY LCO DATA INPUT FOR SAFETY INJECTION (MEDIUM LOCA)

TOP LOGIC FAULT TREE STRUCTURE

	Support State					
Identifier	1	2	3	4	5	6
AAAA	3.9(-03)	1.0	1.0	3.9(-03)	1.0	1.0
BBBB	3.9(-03)	1.0	3.9(-03)	1.0	1.0	1.0
CCCC	7.5(-03)	1.0	1.0	1.1(-02)	1.0	1.0
DDDD	7.5(-03)	1.0	1.1(-02)	1.0	1.0	1.0

TABLE 3.7-21

EVENT TREE NODE DATA FROM FAULT TREE QUANTIFICATION
FOR HIGH PRESSURE SAFETY INJECTION

	3 day LCO		7 day LCO	
Support State	HH1	HH2	HH1	HH2
1	6.0 (-06)	1.1 (-07)	8.2 (-06)	1.2 (-07)
2	1.0	1.0	1.0	1.0
3	1.2 (-02)	2.8 (-05)	1.4 (-02)	4.1 (-05)
4	1.2 (-02)	2.8 (-05)	1.4 (-02)	4.1 (-05)
5	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0

Note:

HH1 - Medium LOCA
HH2 - Small LOCA

TABLE 3.7-22

NODE DATA FROM FAULT TREE QUANTIFICATION
FOR HIGH PRESSURE RECIRCULATION (R-2)

Support State	3 day LCO R-2	7 day LCO R-2
1	4.8 (-04)	4.9 (-04)
2	1.0	1.0
3	1.1 (-02)	1.2 (-02)
4	8.4 (-03)	9.3 (-03)
5	1.0	1.0
6	1.0	1.0

TABLE 3.7-23

CUTSETS FOR TOTAL HIGH PRESSURE TREE

Cutset Description	Percent of Unavailability for Support State 1 3 day	7 day
Two RHR pumps fail to start due to common cause	47	46
Operator error - failure to open motor-operated valve to RHR heat exchanger cooling	20	20
Motor-operated valves to recirculation sumps or two motor-operated valves to RHR heat exchanger cooling on both trains fail to open due to common cause	19	19
Failure to open of two motor-operated valves to heat exchanger cooling on both trains or two sump valves on both trains or a sump valve on one train and a heat exchanger cooling valve on the other	2	2
Two RHR pumps fail to run due to common cause	2	2
One RHR pump out for maintenance and a motor-operated heat exchanger cooling valve or a motor-operated sump valve on the other train fails to open	2	3
One RHR pump out for test and a motor-operated heat exchanger cooling valve or a motor-operated sump valve on the other train fails to open	1	1
Air-operated valve RH0607 or RH0606 transfers closed on one RHR train and a motor-operated heat exchanger cooling valve or a motor-operated sump valve on the other train fails to open	1	1

TABLE 3.7-23 (continued)

CUTSETS FOR TOTAL HIGH PRESSURE TREE

Cutset Description	Percent of Unavailability for Support State 1 3 day	7 day
One RHR pump fails to start and a motor-operated heat exchanger cooling valve or a motor-operated sump valve on the other train fails to open	1	1

TABLE 3.7-24

CUTSETS FOR HIGH PRESSURE SAFETY INJECTION (MEDIUM LOCA)

Cutset Description	Percent of Unavailability for Support State 1	
	3 day	7 day
Two SI pumps fail to start due to common cause and a charging pump is out for maintenance	21	27
A motor operated valve on a common header path of SI transfers closed and a charging pump is out for maintenance	11	14
Two SI pumps fail to start due to common cause and a charging pump is out for test	7	5
Two SI pumps fail to start due to common cause and a charging pump fails to start due to random failures	5	4
Check valve on a common header path of the SI fails to open and a charging pump out for maintenance	4	5
A motor operated valve on a common header path of SI transfers closed and a charging pump is out for test	4	3
Two SI pumps fail to start due to common cause and failure to restore a manual valve on a charging train following test or maintenance	4	2
A charging pump fails to start and a motor operated valve on a common header path of SI transfers closed	3	2

TABLE 3.7-24 (Continued)

CUTSETS FOR HIGH PRESSURE SAFETY INJECTION (MEDIUM LOCA)

Cutset Description	Percent of Unavailability for Support State 1	
	3 day	7 day
A charging pump or an SI pump fails to start and a check valve on a common header path on the opposite train fails to open	3	3
One SI pump in test and a check valve on the charging train fails to open	3	2

TABLE 3.7-25

CUTSETS FOR HIGH PRESSURE SAFETY INJECTION (SMALL LOCA)

Cutset Description	Percent of Unavailability for Support State 1 3 day	7 day
Two motor operated valves on the charging train fail to open due to common cause and two SI pumps fail to start due to common cause	18	18
A check valve on common path of the charging train fails to open and two SI pumps fail to start due to common cause	17	17
Two SI pumps and two charging pumps fail to start due to common cause	13	13
A check valve on the charging train fails to open and a motor operated valve on a common path of SI train transfers closed	9	9
Two motor operated valves on the charging train fail due to common cause and a motor operated valve on a common SI path transfers closed	10	9
Two charging pumps fail to start due to common cause and a motor operated valve on a common SI path transfers closed	7	7

TABLE 3.7-25 (Continued)

CUTSETS FOR HIGH PRESSURE SAFETY INJECTION (SMALL LOCA)

Cutset Description	Percent of Unavailability for Support State 1	
	3 day	7 day
Two motor operated valves on a common path of the charging train transfers closed and failure to restore a motor operated valve on a common path of the charging train following maintenance	4	4
A check valve on a common path of SI and a check valve on a common path of the charging train transfers closed	3	3
A check valve on a common path of the SI train transfers closed and two charging pumps fail to start due to common cause	3	3

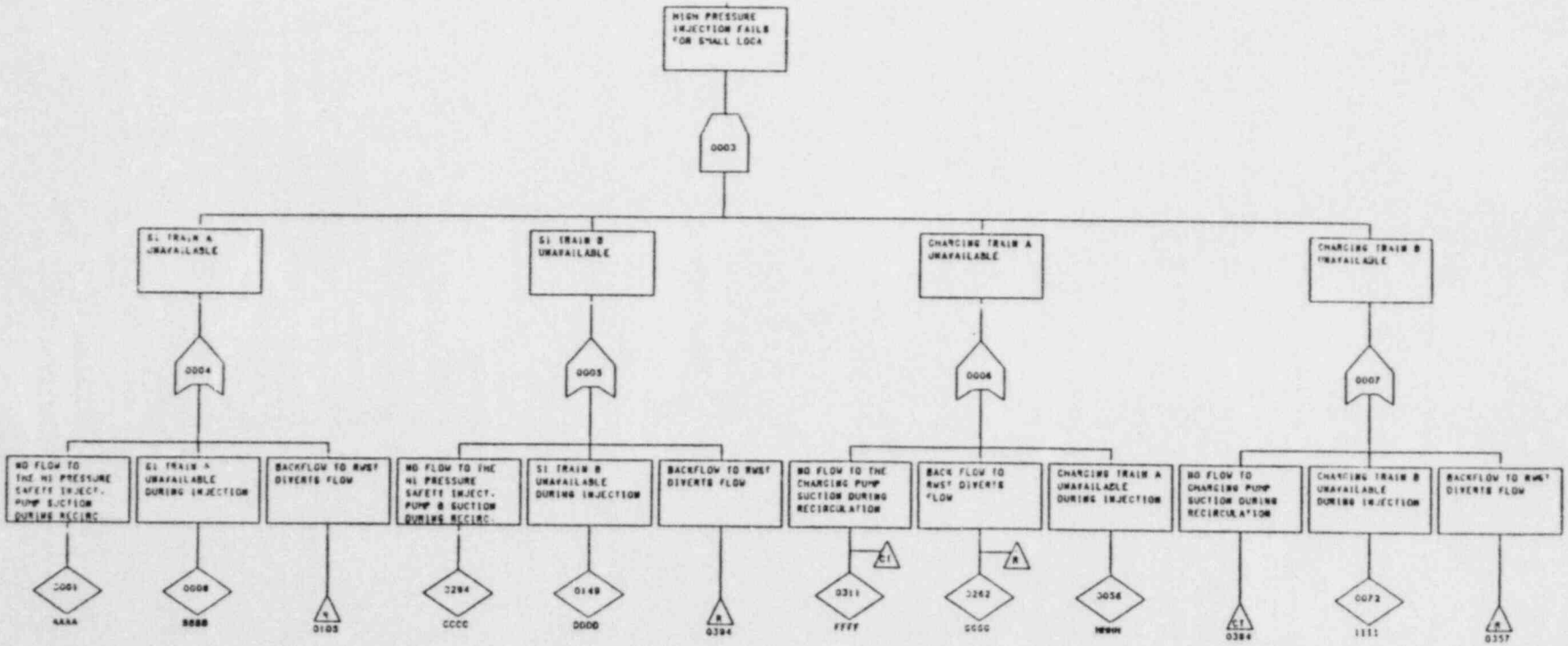

Figure 3.7-1

Top Logic For Total High Pressure System Fault Tree

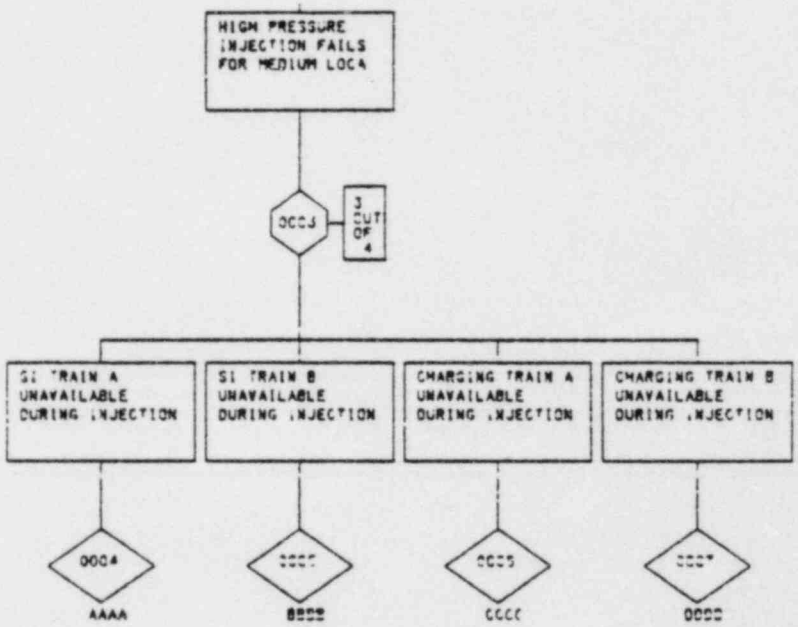

Figure 3.7-2

Top Logi: For High Pressure Safety
Injection Fault Tree For Medium LOCA

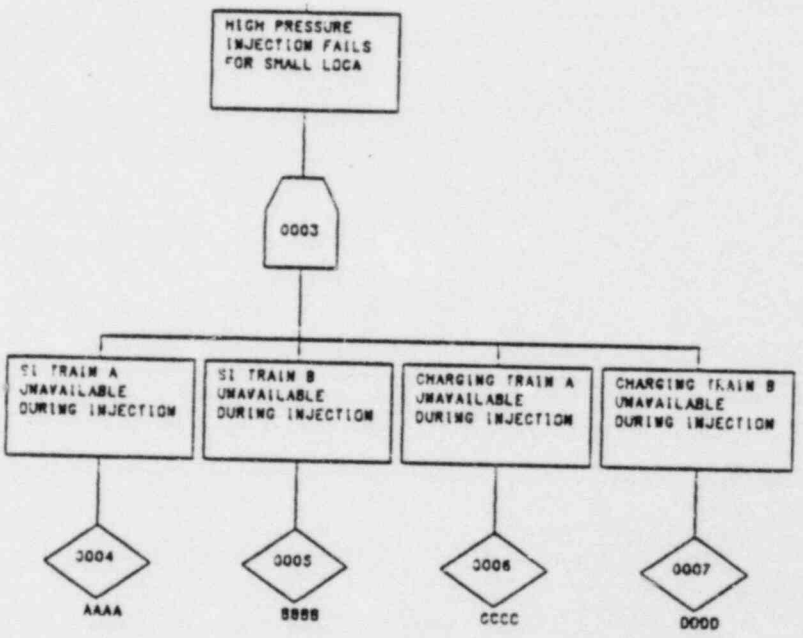

Figure 3.7-3

Top Logic For High Pressure Safety

Injection Fault Tree For Small LOCA

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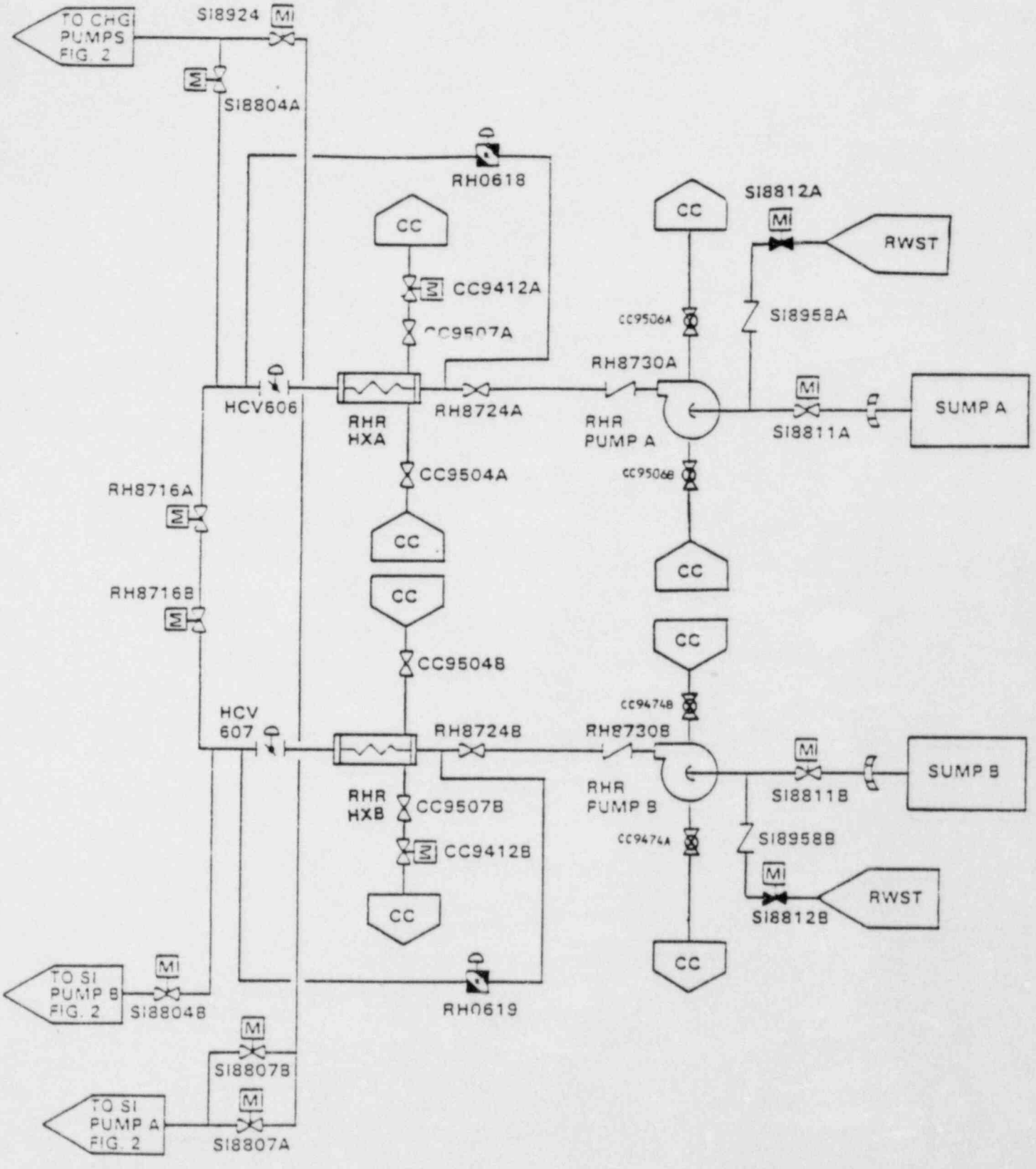

High Pressure Recirculation — Simplified P&ID

Figure 3.7-7

★ Valve Positions are shown in the Recirculation Mode

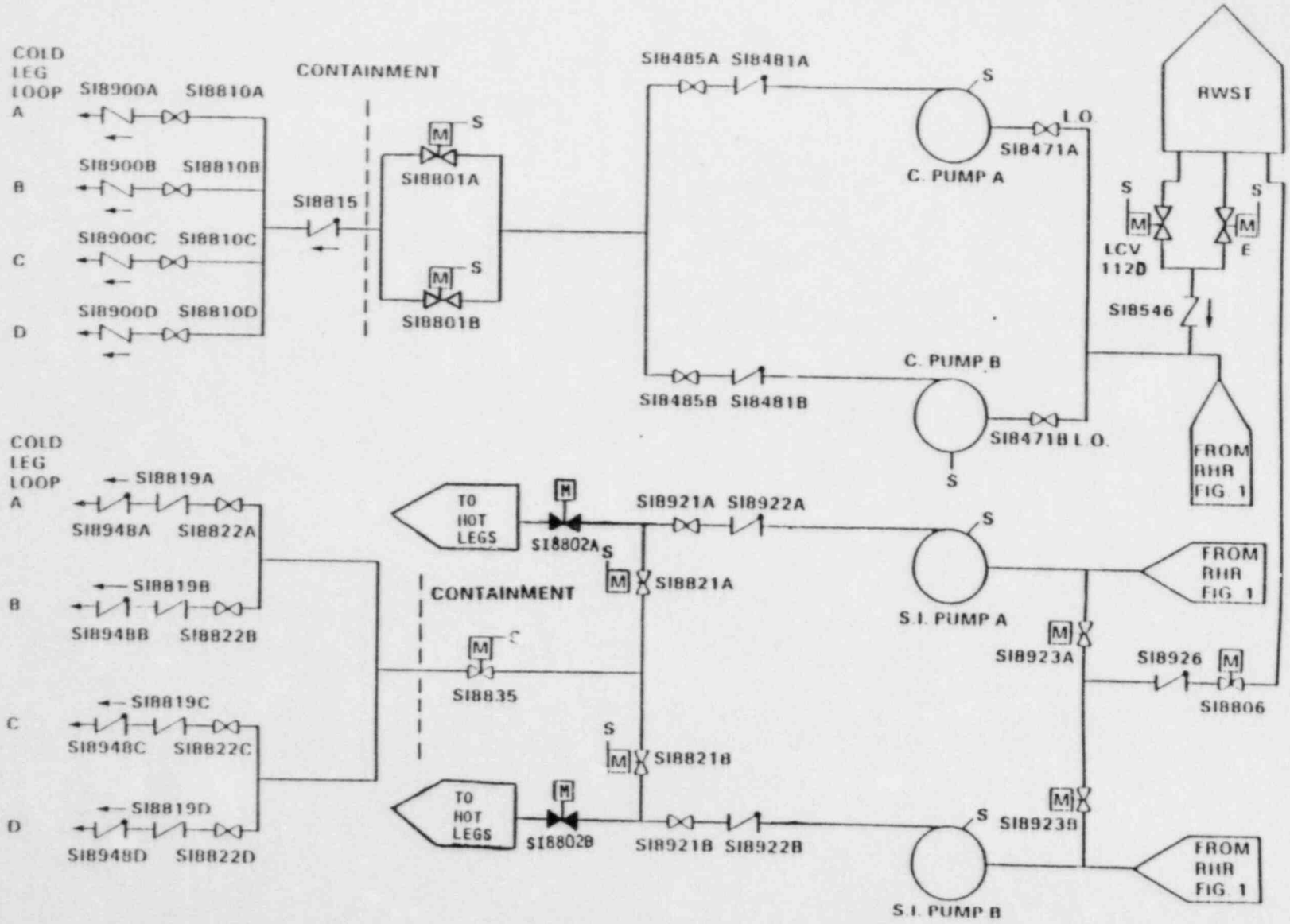

Figure 3.7-7 (Continued)

High Pressure Injection — Simplified P&ID

* Valve Positions are shown in Injection Mode

3.8 CONTAINMENT HEAT REMOVAL AND SODIUM HYDROXIDE ADDITION SYSTEMS

The Containment Heat Removal System includes the containment fan cooler and containment spray systems, since both these systems must fail for failure of heat removal to occur. The top logic of the fault tree model for this system is shown in Figure 3.8-1, followed by the entire fault tree model in Figure 3.8-2. The sodium hydroxide addition system is analyzed in a separate fault tree. The top logic and the tree itself are found in Figures 3.8-3 and 3.8-4, respectively.

3.8.1 CONTAINMENT FAN COOLER SYSTEM

3.8.1.1 SYSTEM DESCRIPTION

The Reactor Containment Fan Cooler System (RCFC) is designed to meet the following requirements:

A. During normal conditions, the system cools and dehumidifies the containment.

B. The reactor containment fan coolers provide the design heat-removal capacity for the containment following a loss-of-coolant accident, assuming that the core residual heat is released to the containment as steam. The system will accomplish this by continuously recirculating the air-steam mixture through cooling coils to transfer heat from containment to essential service water.

C. The reactor containment fan cooler system, the emergency core cooling system, and the containment spray system share in removing energy released following a postulated loss-of-coolant accident.

D. During a post-loss-of-coolant accident phase, the fan coolers shift to low speed to obtain a lower than normal airflow.

The system contains two trains, each powered from a separate redundant essential bus. Each train consists of two 50 percent-capacity RCFC units. Any two of the four RCFC units will provide sufficient heat-removal

capability to maintain the containment pressure below the design value following a loss-of-coolant accident. During normal operating conditions, the RCFC fan motor operates in the high-speed mode. On initiation of post-LOCA mode of operation, the motor will shift to low speed, resulting in lower air flow. The lower air flow compensates for the increase in containment air density resulting from the high pressure following a loss-of-coolant accident.

Each RCFC Unit consists of fan/motor assembly, essential service water (ESW) cooling coil assembly, chilled water cooling assembly, backdraft damper, housing and ductwork. The chilled water coil assembly is used only for normal operation.

The simplified P and ID is shown in Figure 3.8-5.

3.8.1.2 FAULT TREE MODEL OF CONTAINMENT FAN COOLER SYSTEM

The Containment Fan Cooler fault tree analysis is contained in the containment heat removal fault tree in Figure 3.8-2. The top logic of this tree is shown in Figure 3.8-1. Table 3.8-1 lists all the components used in the fault tree.

3.8.1.2.1 SUCCESS CRITERIA FOR FAN COOLER SYSTEM

System success requires two-out-of-four fan cooler units to be available for containment cooling. The fan cooler node in the event tree is labeled CF.

3.8.1.2.2 DEPENDENCE OF FAN COOLER SYSTEM ON SUPPORT STATES

One train of the system depends on ESF bus 141, the other on 142. Each train has two motor-driven fan cooler units and two motor-operated block valves which depend on electric power. All of the fan cooler units depend on essential service water for cooling; therefore, failure of the ESW system leads to failure of the fan cooler system.

3.8.1.2.3 RANDOM FAILURE MODEL OF CONTAINMENT FAN COOLER SYSTEM

The random failure fault tree model was developed according to the LCORP Guide to Fault Tree Development in Appendix 3A. The failures of the normally running fan coolers to switch to low speed and of the standby coolers to start are both included in one data value, so that it is not necessary, in the random model, to treat two fan coolers as standby and two as running. However, the common cause model requires some distinction between running and standby fan coolers as is explained in Section 3.8.1.2.4.

3.8.1.2.4 COMMON CAUSE MODEL OF CONTAINMENT FAN COOLER SYSTEM

The common cause modeling of the system is done in accordance with the common cause guidelines in Appendix 3B. All common cause calculations are the product of a β and a random failure probability. Table 3.8-2 lists the β's and failure probabilities used in the calculation of all common cause failures considered in the fan cooler system fault tree. The β used for the common cause failures of fan coolers were those available for motor-driven pumps, since the coolers are motor-driven and no fan cooler data is available.

Failure of standby fan cooler units and running units are treated as separate common cause failures. One common cause failure causes two coolers in the same operating mode to fail. Since the two coolers on a single train operate in the same mode, these two are linked by using transfers in the fault tree.

The random failure modes and β's used apply to alternating pumps, with no distinction between running and standby at the time of the LOCA. Therefore, the common cause probabilities are equal for both sets of fan cooler units.

3.8.1.2.5 TEST AND MAINTENANCE MODEL OF CONTAINMENT FAN COOLER SYSTEM

Each train of the fan cooler system includes two fan coolers. Fan coolers A and C are on one train; B and D are on the other. Each cooler can be isolated for maintenance. Two coolers can be maintained at the same time only if they are on the same train. Therefore, when maintenance of one cooler is considered, maintenance of the two coolers on the other train is not

considered. Testing of fan coolers does not affect their availability, since they are not isolated for test. Stroke testing of the service water valves (ISX016, ISX027) does not render them unavailable, since they receive an 'S' signal.

Failure to restore a valve following maintenance is considered for the cooling coil block valves (ISX018, ISX021, ISX022, ISX025). In the model, failure to restore any of these values is treated as one failure mode.

Table 3.8-1 lists all of the components in the fault tree model and indicates if they are tested or maintained.

3.8.1.2.6 HUMAN ERROR MODEL OF CONTAINMENT FAN COOLER SYSTEM

The only human errors considered in the model are failures to restore cooling coil block valves. Appendix 3C, Human Error Modeling, explains the number used for failure to restore manual valves. Since one failure mode represents failure to restore any of four valves, the number used for this mode is four times the number shown in Appendix 3C for failure to restore a manual valve. The source in the Data Bank (Appendix 3D) for this value is FC3 where:

$$FC3 = 4 \times (2.1 \times 10^{-4}) = 8.4 \times 10^{-4}$$

3.8.1.2.7 INPUT DATA FOR CONTAINMENT FAN COOLER SYSTEM

Tables 3.8-3 through 3.8-6 list all event identifiers, brief descriptions of the failure mode they represent, and the number used as input to the fault tree quantification. The first two tables are for 3 day LCO, the last two for 7 day LCO. All numbers in these table are drawn from the data bank in Appendix 3D.

3.8.1.3 FAULT TREE QUANTIFICATION FOR CONTAINMENT FAN COOLER SYSTEM

3.8.1.3.1 SYSTEM UNAVAILABILITY CALCULATIONS FOR CONTAINMENT FAN COOLER SYSTEM

The fault tree was analyzed using the WAMBAM computer code. For power states 2, 5, and 6, the unavailability is 1.0 because of dependency on Essential Service Water and electric power. Figure 3.8-1 shows the top logic of the Containment Heat Removal fault tree with unavailability values given in Table 3.8-7 and -8 for 3 and 7 day LCO, respectively. The fault tree was quantified for all support states and all of the results are listed in Table 3.8-9.

3.8.1.3.2 DOMINANT CUTSETS FOR CONTAINMENT FAN COOLER SYSTEM

3.8.1.3.2 DOMINANT CUTSETS

The WAMCUT computer code was used to obtain cutsets for the containment fan cooler model with 3 day and 7 day LCO. The dominant cutsets are listed in Table 3.8-10 along with the percent of the unavailability which they contribute.

3.8.2 CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

3.8.2.1 SYSTEM DESCRIPTION

The Containment Spray System and Sodium Hydroxide Addition System are designed to remove fission products, primarily elemental iodine, from the containment atmosphere for the purpose of minimizing the offsite radiological consequences following the design-basis loss-of-coolant accident. At the same time, the spray water serves to nominally reduce containment temperature and pressure during the injection phase.

The Containment Spray System consists of two, independent, 100 percent capacity pumping systems with no common headers or essential buses. Each pumping system takes water from the refueling water storage tank using a motor-driven pump and supplies three spray headers equipped with spray

nozzles. Pump A supplies 219 nozzles and pump B supplies 253 nozzles. Each pump also supplies motive fluid to an eductor when operating in the injection and caustic eduction phase.

In the event of a high-high-high (Hi-3) containment pressure signal (corresponding to approximately 23 psig), the containment spray pumps will start after 25 seconds and valves will open immediately.

The refueling water storage tank (RWST) (containing 2000 ppm of boric acid as boron) for each unit has a capacity of 450,000 gallons. Level switches are provided to automatically open the containment sump isolation valves when two-out-of-four RWST level channels indicate RWST level less than a low-low-level setpoint, in conjunction with an engineered safeguards activation signal ("S" signal). It should be noted that manual reset of safety injection does not defeat the automatic opening of the valves. Containment spray injection and caustic eduction at the rate of 55 gpm per eductor of the 30 percent NaOH solution will continue until 410,000 gallons have been pumped into the containment and the low-low level alarm of the RWST is annunciated. Containment spray injection and caustic addition may then be terminated, and the operating personnel may transfer the containment spray pumps from the injection to the recirculation mode by first closing the motor-operated valves in the section line from the RWST, the water and caustic lines to the eductor, and then opening the motor-operated valves in the section lines from the containment sumps.

Figure 3.8.2.1-1 is a simplified P and ID which includes both Containment Spray and Sodium Hydroxide Addition.

3.8.2.2 FAULT TREE MODEL OF CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

The Containment Spray model is contained within the Containment Heat Removal (CHR) fault tree in Figure 3.8-2. The Sodium Hydroxide Addition System fault tree is shown in Figure 3.8-4. Figures 3.8-1 and 3.8-3 show the top logic of these trees. Tables 3.8-11 and 3.8-12 list the components used in the containment spray and sodium hydroxide addition system models, respectively.

3.8.2.2.1 SUCCESS CRITERIA FOR CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

Containment spray system success requires that at least one containment spray pump deliver flow to one spray header. The event tree node for containment spray is labeled CS.

Sodium hydroxide addition system success requires that sodium hydroxide solution be added to at least one operating train of the containment spray system. The event tree node for this system is labeled NA.

3.8.2.2.2 DEPENDENCE OF CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS ON SUPPORT STATES

Train A and B of both containment spray and sodium hydroxide addition depend on buses 141 and 142, repsectively, for electric power. Neither system depends of essential service water for success.

3.8.2.2.3 RANDOM FAILURE MODEL OF CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

The random failure fault tree models were developed according to the LCORP Guide to Fault Tree Development in Appendix 3A.

3.8.2.2.4 COMMON CAUSE MODEL OF CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

The common cause modeling of these systems was done in accordance with the common cause guidelines in Appendix 3B. All common cause calculations are the product of a β and a random failure probability. Table 3.8-13 lists the β's and failure probabilities used in the calculation of all common cause failures models in the containment spray and sodium hydroxide addition systems. Three common cause failure modes are modeled in the containment spray fault tree: failure of pumps to start, failure of pumps to run, and failure of MOV's to operate.

3.8.2.2.5 TEST AND MAINTENANCE MODEL OF CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

The test and maintenance of the containment spray is modeled as that of trains, not individual components, as explained in Appendix 3A. No test or maintenance is modeled in the Sodium Hydroxide Addition System because none is appropriate according to the guidelines in Appendix 3A. Tables 3.8-11 and 3.8-12 list all the components considered in both systems and if they are tested or maintained. Failure to restore following test or maintenance is also addressed in this table.

3.8.2.2.6 HUMAN ERROR MODEL OF CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

The only human error considered in these systems is failure to restore flanges OCS001 or OCS002 to the proper position following refueling. One of these flanges is used to divert flow during refueling and must be restored as part of the procedure to return to normal operating condition. The probability of this error is presented in Appendix 3C as calculation HE6. No human error is modeled in the sodium hydroxide addition system.

3.8.2.2.7 INPUT DATA FOR CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

Tables 3.8-3 and 3.8-4 list input data for containment heat removal for 3 day LCO. Tables 3.8-5 and 3.8-6 show 7 day LCO data for the same tree. Tables 3.8-14 and 3.8-15 show the input data for sodium hydroxide fault tree for 3 day and 7 day LCO. Although no maintenance is considered in this fault tree, it is dependent on containment spray availability, which is affected by maintenance.

3.8.2.3 FAULT TREE QUANTIFICATION FOR CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

3.8.2.3.1 SYSTEM UNAVAILABILITY CALCULATIONS FOR CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

The fault trees were quantified for 3 day and 7 day LCO using the WAMBAM computer code. For power states 5 and 6, the unavailability of both systems is 1.0 because they depend on electric power. The unavailability values for the lower nodes of the CHR top logic tree in Figure 3.8-1 are given in Table 3.8-7 for 3 day LCO and in Table 3.8-8 for 7 day. The values for the sodium hydroxide top logic tree in Figure 3.8-3 are given in Tables 3.8-16 and 3.8-17 for 3 day and 7 day LCO, respectively. The final system unavailability values are given in Table 3.8-18 for both systems.

3.8.2.3.2 DOMINANT CUTSETS FOR CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SYSTEMS

The WAMCUT computer code was run to obtain cutsets for the fault trees. Table 3.8-19 lists the dominant cutsets for containment spray and the approximate percent of the unavailability which they represent. Table 3.8-20 is a similar list for the sodium hydroxide addition system.

TABLE 3.8-1

COMPONENTS IN CONTAINMENT FAN COOLER SYSTEM MODEL

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error [1]
fan cooler A	X		X		X	
fan cooler B		X	X		X	
fan cooler C	X		X		X	
fan cooler D		X	X		X	
MOV SX016A	X			Quarterly		
MOV SX016B		X		Quarterly		
MOV SX027A	X			Quarterly		
MOV SX027B		X		Quarterly		
XV SX018A						FR (M)
XV SX018B						FR (M)
XV SX018C						FR (M)
XV SX018D						FR (M)
XV SX021A						FR (M)
XV SX021B						FR (M)
XV SX021C						FR (M)
XV SX021D						FR (M)
XV SX022A						FR (M)
XV SX022B						FR (M)
XV SX022C						FR (M)
XV SX022D						FR (M)
XV SX025A						FR (M)
XV SX025B						FR (M)
XV SX025C						FR (M)
XV SX025D						FR (M)

TABLE 3.8-1 (Continued)

COMPONENTS IN CONTAINMENT FAN COOLER SYSTEM MODEL

Notes:

1 - Operator Error Symbols

FR = Fails to restore following (T, M or R)
T = Test
M = Maintenance
R = Refueling
FO = Fails to open
FC = Fails to close

TABLE 3.8-2

FAN COOLER COMMON CAUSE CALCULATIONS

Failure mode	Data Bank Source ID	β	Random Failure Mode	Random Failure Probability	Result
Failure of two fan coolers to run	FC1	.041	Fails to operate	3.53×10^{-6}	1.45×10^{-7}
Failure of two fan coolers to start or switch to low speed	FC2	.093	Fails to start	1.17×10^{-3}	1.09×10^{-4}

TABLE 3.8-3

INPUT DATA FOR CONTAINMENT HEAT REMOVAL FAULT TREE-3 DAY LCO

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
XVCS002AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCS002BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCS01PAFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCS01PBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCS01PAFR	MDI	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.000E+00	0.000E-01	2.64E-06	1.50E-11
PCS01PBFR	MDP	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.000E+00	0.000E-01	2.64E-06	1.50E-11
BS131XK	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
BS132XK	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
MVCS001AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVCS001BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVCS008AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVCS008BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVCS003AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVCS003BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVCS004AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCS004BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVCS007AQ	MOV	FAIL TO OPERATE	5.730E-03	1.840E-06	ZPSS	0.000E-01	0.000E-01	5.73E-03	1.84E-06
MVCS007BQ	MOV	FAIL TO OPERATE	5.730E-03	1.840E-06	ZPSS	0.000E-01	0.000E-01	5.73E-03	1.84E-06
XVSI001AHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01

TABLE 3.8-3 (Cont.)

INPUT DATA FOR CONTAINMENT HEAT REMOVAL FAULT TREE-3 DAY LCO

XVSIOO1BHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XVSIOO1AT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSIOO1BT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
PCSO1PAM	MDP	MAINTENANCE FREQUENC	6.540E-05	0.000E-01	ZPSS	1.900E+01	0.000E-01	1.24E-03	0.00E-01
PCSO1PBM	MDP	MAINTENANCE FREQUENC	6.540E-05	0.000E-01	ZPSS	1.900E+01	0.000E-01	1.24E-03	0.00E-01
FCVPO1CCFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FCVPO1CDFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FCVPO1CAFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FCVPO1CBFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FCVPO1CCFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FCVPO1CDFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
XVSXO22AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO22BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO22CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO22DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO25AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO25BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO25CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO25DC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO18AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO18BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO18CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.8-3 (Cont.)

INPUT DATA FOR CONTAINMENT HEAT REMOVAL FAULT TREE-3 DAY LCO

XVSXO18DC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO21AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO21BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO21CC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO21DC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSXO16AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSXO16BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSXO27AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSXO27BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
FCVPO1CAM	CFC	MAINTENANCE FREQUENC	2.19OE-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	4.16E-03	0.00E-01
FCVPO1CBM	CFC	MAINTENANCE FREQUENC	2.19OE-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	4.16E-03	0.00E-01
FCVPO1CCM	CFC	MAINTENANCE FREQUENC	2.19OE-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	4.16E-03	0.00E-01
FCVPO1CDM	CFC	MAINTENANCE FREQUENC	2.19OE-04	0.000E-01	ZPSS	1.900E+01	0.000E-01	4.16E-03	0.00E-01
BS141K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BS142K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
PCSCCFR	CC	COMMON CAUSE PUMP RU	2.12OE-06	0.000E-01	CS2	2.400E+01	0.000E-01	5.09E-05	0.00E-01
PCSCCFS	CC	COMMON CAUSE PUMP ST	2.24OE-04	0.000E-01	CS1	0.000E-01	0.000E-01	2.24E-04	0.00E-01
MVCSCC	CC	COMMON CAUSE MOV	1.72OE-04	0.000E-01	CS3	0.000E-01	0.000E-01	1.72E-04	0.00E-01
FGCSO01F	FLNG	FAIL TO RESTORE FOL	1.80OE-03	0.000E-01	HE6	0.000E-01	0.000E-01	1.80E-03	0.00E-01
FGCSO02F	FLNG	FAIL TO RESTORE FOL	1.80OE-03	0.000E-01	HE6	0.000E-01	0.000E-01	1.80E-03	0.00E-01
ESW1F	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
FCACCCFR	CC	CC-ALT. COOLERS FAIL	1.45OE-07	0.000E-01	FC1	2.400E+01	0.000E-01	3.48E-06	0.00E-01

TABLE 3.8-3 (Cont.)

INPUT DATA FOR CONTAINMENT HEAT REMOVAL FAULT TREE-3 DAY LCO

FCBDCCFS	CC	CC-ALT. COOLERS TO S	1.090E-04	0.000E-01	FC2	0.000E-01	0.000E-01	1.09E-04	0.00E-01
FCBDCCFR	CC	CC-ALT. COOLERS FAIL	1.450E-07	0.000E-01	FC1	2.400E+01	0.000E-01	3.48E-06	0.00E-01
FCVPO1CAFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FCACCCFS	CC	CC-ALT. COOLERS TO S	1.090E-04	0.000E-01	FC2	0.000E-01	0.000E-01	1.09E-04	0.00E-01
FCVPO1CBFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
XVSXDHM	XV	FAIL TO RESTORE-COIL	8.400E-04	0.000E-01	FC3	0.000E-01	0.000E-01	8.40E-04	0.00E-01
XVSXBHM	XV	FAIL TO RESTORE-COIL	8.400E-04	0.000E-01	FC3	0.000E-01	0.000E-01	8.40E-04	0.00E-01

TABLE 3.8-4

3 DAY LCO DATA INPUT FOR CONTAINMENT HEAT REMOVAL

FT IDENTIFIER	PROBABILITY POWER STATE 1	2	3	4	5	6
BS141K	0	0	1	0	1	1
BS142K	0	0	0	1	1	1
EWS1F	0	1	0	0	0	1

TABLE 3.8-5

INPUT DATA FOR CONTAINMENT HEAT REMOVAL FAULT TREE-7 DAY LCO

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
XVCS002AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCS002BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
PCS01PAFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCS01PBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCS01PAFR	MDP	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.000E+00	0.000E-01	2.64E-06	1.50E-11
PCS01PBFR	MDP	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.000E+00	0.000E-01	2.64E-06	1.50E-11
BS131XK	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
BS132XK	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
MVCS001AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVCS001BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
CVCS008AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVCS008BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVCS003AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVCS003BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVCS004AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCS004BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVCS007AQ	MOV	FAIL TO OPERATE	5.730E-03	1.840E-06	ZPSS	0.000E-01	0.000E-01	5.73E-03	1.84E-06
MVCS007BQ	MOV	FAIL TO OPERATE	5.730E-03	1.840E-06	ZPSS	0.000E-01	0.000E-01	5.73E-03	1.84E-06
XVSI001AHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01

TABLE 3.8-5 (Cont.)

INPUT DATA FOR CONTAINMENT HEAT REMOVAL FAULT TREE-7 DAY LCO

XVSI001BHT	XV	FAIL TO RESTORE	2.100E-04	0.000E-01	HE2	0.000E-01	0.000E-01	2.10E-04	0.00E-01
XVSI001AT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
XVSI001BT	MDP	PUMP TEST	9.130E-04	0.000E-01	ZPSS	0.000E-01	0.000E-01	9.13E-04	0.00E-01
PCSO1PAM	MDP	MAINTENANCE FREQUENC	6.540E-05	0.000E-01	ZPSS	3.400E+01	0.000E-01	2.22E-03	0.00E-01
PCSO1PBM	MDP	MAINTENANCE FREQUENC	6.540E-05	0.000E-01	ZPSS	3.400E+01	0.000E-01	2.22E-03	0.00E-01
FCVPO1CCFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FCVPO1CDFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FCVPO1CAFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FCVPO1CBFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FCVPO1CCFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FCVPO1CDFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
XVSXO22AC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO22BC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO22CC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO22DC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO25AC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO25BC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO25CC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO25DC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO18AC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO18BC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO18CC	X.MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 3.8-5 (Cont.)

INPUT DATA FOR CONTAINMENT HEAT REMOVAL FAULT TREE-7 DAY LCO

XVSXO18DC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO21AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO21BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO21CC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVSXO21DC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSXO16AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSXO16BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSXO27AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
MVSXO27BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
FCVPO1CAM	CFC	MAINTENANCE FREQUENC	2.19OE-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	7.45E-03	0.00E-01
FCVPO1CBM	CFC	MAINTENANCE FREQUENC	2.19OE-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	7.45E-03	0.00E-01
FCVPO1CCM	CFC	MAINTENANCE FREQUENC	2.19OE-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	7.45E-03	0.00E-01
FCVPO1CDM	CFC	MAINTENANCE FREQUENC	2.19OE-04	0.000E-01	ZPSS	3.400E+01	0.000E-01	7.45E-03	0.00E-01
BS141K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BS142K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
PCSCCFR	CC	COMMON CAUSE PUMP RU	2.12OE-06	0.000E-01	CS2	2.400E+01	0.000E-01	5.09E-05	0.00E-01
PCSCCFS	CC	COMMON CAUSE PUMP ST	2.24OE-04	0.000E-01	CS1	0.000E-01	0.000E-01	2.24E-04	0.00E-01
MVCSCC	CC	COMMON CAUSE MOV	1.72OE-04	0.000E-01	CS3	0.000E-01	0.000E-01	1.72E-04	0.00E-01
FGCSOC1F	FLNG	FAIL TO RESTORE FOL	1.80OE-03	0.000E-01	HE6	0.000E-01	0.000E-01	1.80E-03	0.00E-01
FGCSOC2F	FLNG	FAIL TO RESTORE FOL	1.80OE-03	0.000E-01	HE6	0.000E-01	0.000E-01	1.80E-03	0.00E-01
ESW1F	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
FCACCFR	CC	CC-ALT. COOLERS FAIL	1.45OE-07	0.000E-01	FC1	2.400E+01	0.000E-01	3.48E-06	0.00E-01

TABLE 3.8-5 (Cont.)

INPUT DATA FOR CONTAINMENT HEAT REMOVAL FAULT TREE-7 DAY LCO

FCBDCCFS	CC	CC-ALT. COOLERS TO S	1.090E-04	0.000E-01	FC2	0.000E-01	0.000E-01	1.09E-04	0.00E-01
FCBDCCFR	CC	CC-ALT. COOLERS FAIL	1.450E-07	0.000E-01	FC1	2.400E+01	0.000E-01	3.48E-06	0.00E-01
FCACCCFS	CC	CC-ALT. COOLERS TO S	1.090E-04	0.000E-01	FC2	0.000E-01	0.000E-01	1.09E-04	0.00E-01
FCVP01CAFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FCVP01CBFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
XVSXBHM	XV	FAIL TO RESTORE-COIL	8.400E-04	0.000E-01	FC3	0.000E-01	0.000E-01	8.40E-04	0.00E-01
XVSXDHM	XV	FAIL TO RESTORE-COIL	8.400E-04	0.000E-01	FC3	0.000E-01	0.000E-01	8.40E-04	0.00E-01

TABLE 3.8-6

7 DAY LCO DATA INPUT FOR CONTAINMENT HEAT REMOVAL

FT IDENTIFIER	PROBABILITY POWER STATE 1	2	3	4	5	6
BS141K	0	0	1	0	1	1
BS142K	0	0	0	1	1	1
EWS1F	0	1	0	0	0	1

TABLE 3.8-7

3 DAY LCO DATA INPUT FOR CONTAINMENT HEAT REMOVAL
TOP LOGIC FAULT TREE STRUCTURE

Identifier	Power State 1	2	3	4	5	6
CC FAIL	4.47×10^{-4}	4.47×10^{-4}	4.47×10^{-4}	4.47×10^{-4}	4.47×10^{-4}	4.47×10^{-4}
AAAA	1.08×10^{-2}	1.08×10^{-2}	1.0	1.08×10^{-2}	1.0	1.0
BBBB	1.08×10^{-2}	1.08×10^{-2}	1.08×10^{-2}	1.0	1.0	1.0
CCCC	5.83×10^{-3}	1.0	1.0	6.67×10^{-3}	1.0	1.0
DDDD	6.67×10^{-3}	1.0	6.67×10^{-3}	1.0	1.0	1.0
EEEE	5.83×10^{-3}	1.0	1.0	6.67×10^{-3}	1.0	1.0
FFFF	6.67×10^{-3}	1.0	6.67×10^{-3}	1.0	1.0	1.0

Note: In power state 1, the unavailability of two fan coolers is less than that of the other two because failure to restore the block valves following maintenance is not a credible event for the running fan coolers. For power states 3 and 4, it is conservatively assumed that the two running coolers are on the train which loses electric power.

TABLE 3.8-8

7 DAY LCO DATA INPUT FOR CONTAINMENT HEAT REMOVAL
TOP LOGIC FAULT TREE STRUCTURE

Identifier	Power State 1	2	3	4	5	6
CC FAIL	4.47×10^{-4}	4.47×10^{-4}	4.47×10^{-4}	4.47×10^{-4}	4.47×10^{-4}	4.07×10^{-4}
AAAA	1.18×10^{-2}	1.18×10^{-2}	1.0	1.18×10^{-2}	1.0	1.0
BBBB	1.18×10^{-2}	1.18×10^{-2}	1.18×10^{-2}	1.0	1.0	1.0
CCCC	9.04×10^{-3}	1.0	1.0	9.87×10^{-3}	1.0	1.0
DDDD	9.87×10^{-3}	1.0	9.87×10^{-3}	1.0	1.0	1.0
EEEE	9.04×10^{-3}	1.0	1.0	9.87×10^{-3}	1.0	1.0
FFFF	9.87×10^{-3}	1.0	9.87×10^{-3}	1.0	1.0	1.0

NOTE: In power state 1, the unavailability of two fan coolers is less than that of the other two because failure to restore the block valves following maintenance is not a credible event for the running fan coolers. For power states 3 and 4, it is conservatively assumed that the two running coolers are on the train which loses electric power.

TABLE 3.8-9

CONTAINMENT FAN COOLER UNAVAILABILITY

Power State	CF (3 day LCO)	CF (7 day LCO)
1	5.9×10^{-6}	9.2×10^{-6}
2	1.0	1.0
3	1.3×10^{-2}	1.9×10^{-2}
4	1.3×10^{-2}	1.9×10^{-2}
5	1.0	1.0
6	1.0	1.0

TABLE 3.8-10

CUTSETS FOR CONTAINMENT FAN COOLER SYSTEM

Cutset Description	Percent of Unavailability 3 day	7 day
One fan cooler is in maintenance and a motor-operated service water valve on the other train transfers closed	32	37
Two running fan coolers fail to switch to low speed due to common cause and one other cooler is in maintenance	31	35
Two fan coolers fail to start or switch to low speed due to common cause and one other cooler fails to start or switch due to random failure	9	6
One fan cooler fails to start or switch due to random failure and one motor-operated service water valve on the other train transfers closed	9	6
Two running fan coolers fail to switch to low and block valves are not restored on the other train following maintenance	3	2
A motor-operated service water valve transfers closed and block valves on the other train are not restored following maintenance	3	2
Two fan coolers are in maintenance and one other cooler fails to switch to low	1	3

TABLE 3.8-11

COMPONENTS IN CONTAINMENT SPRAY MODEL

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error [1]
Pump CS01PA	X			Quarterly	X	
Pump CS01PB		X		Quarterly	X	
XV CS002A						
XV CS002B						
XV CS004A						
XV CS004B						
XV SI001A						FR (T)
XV SI001B						FR (T)
CV CS003A						
CV CS003B						
CV CS008A						
CV CS008B						
MOV CS001A	X			Quarterly		
MOV CS001B		X		Quarterly		
MOV CS007A	X			Quarterly		
MOV CS007B		X		Quarterly		
MOV CS009A	X			Quarterly	X	
MOV CS009B		X		Quarterly	X	
Flange CS001						FR (R)
Flange CS002						FR (R)

TABLE 3.8-11 (Continued)

COMPONENTS IN CONTAINMENT SPRAY MODEL

Notes:

1 - Operator Error Symbols

FR = Fails to restore following (T, M or R)
T = Test
M = Maintenance
R = Refueling
FO = Fails to open
FC = Fails to close

TABLE 3.8-12

COMPONENTS IN SODIUM HYDROXIDE ADDITION SYSTEM MODEL

System Component	Bus Dependent 141	Bus Dependent 142	ESW Dependent	Tested	Maintained	Operator Error [1]
Spray Additive Tank				5 years		
AOV CS010A				Quarterly	X	
AOV CS010B				Quarterly	X	
CV CS011A						
CV CS011B						
CV CS020A						
CV CS020B						
XV CS035A						
XV CS035B						
XV CS017A						
XV CS017B						
XV CS040A						
XV CS040B						
XV CS018A						
XV CS018B						
XV CS046A						
XV CS046B						
XV CS031A						
XV CS031B						
MOV CS019A	X			Quarterly	X	
MOV CS019B		X		Quarterly	X	
Eductor A						
Eductor B						

TABLE 3.8-12 (Continued)

COMPONENTS IN SODIUM HYDROXIDE ADDITION SYSTEM MODEL

Notes:

1 - Operator Error Symbols

FR = Fails to restore following (T, M or R)
T = Test
M = Maintenance
R = Refueling
FO = Fails to open
FC = Fails to close

TABLE 3.8-13

CONTAINMENT SPRAY COMMON CAUSE CALCULATIONS

Failure Mode	Data Bank Source ID	β	Random Failure mode	Random Failure Probability	Result
Failure of both pumps to start	CS1	.311	CS pump fails to start	7.21×10^{-4}	2.24×10^{-4}
Failure of both pumps to run	CS2	.141	CS pump fails to operate	1.50×10^{-5}	2.12×10^{-6}
Failure of two MOV's to open	CS3 and NA1	.030	MOV fails to operate	5.73×10^{-3}	1.72×10^{-4}

TABLE 3.8-14

INPUT DATA FOR SODIUM HYDROXIDE ADDITION FAULT TREE-3 DAY LCO

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
NAOHCC	CC	COMMON CAUSE FAILURE	1.72OE-04	0.000E-01	NA1	0.000E-01	0.000E-01	1.72E-04	0.00E-01
TKNAOHF	SAT	INSUFFICIENT NAOH SO	7.30OE-04	6.10OE-13	ZPSS	0.000E-01	0.000E-01	7.30E-04	6.10E-13
EDCSO15AP	XV	FAIL TO RESTORE-COIL	8.40OE-04	0.000E-01	FC3	0.000E-01	0.000E-01	8.40E-04	0.00E-01
EDCSO15BP	XV	FAIL TO RESTORE-COIL	8.40OE-04	0.000E-01	FC3	0.000E-01	0.000E-01	8.40E-04	0.00E-01
XVCSO35AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.19OE+04	0.000E-01	1.16E-03	1.35E-06
XVCSO35BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.19OE+04	0.000E-01	1.16E-03	1.35E-06
AVCSO1OAC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.095E+03	0.000E-01	1.23E-04	2.21E-08
AVCSO1OBC	AOV	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	ZPSS	1.095E+03	0.000E-01	1.23E-04	2.21E-08
CVCSO11AC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVCSO11BC	CV	FAILURE TO OPEN ON D	4.32OE-05	2.41OE-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CSTRNAF	CSIT	CS TRAIN FAILS-3DAY	1.10OE-02	0.000E-01	CS	0.000E-01	0.000E-01	1.10E-02	0.00E-01
CSTRNBF	CSIT	CS TRAIN FAILS-3DAY	1.10OE-02	0.000E-01	CS	0.000E-01	0.000E-01	1.10E-02	0.00E-01
XVCSO17AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.19OE+04	0.000E-01	1.16E-03	1.35E-06
XVCSO17BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.19OE+04	0.000E-01	1.16E-03	1.35E-06
XVCSO4OAC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.19OE+04	0.000E-01	1.16E-03	1.35E-06
XVCSO4OBC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.19OE+04	0.000E-01	1.16E-03	1.35E-06
XVCSO18AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.19OE+04	0.000E-01	1.16E-03	1.35E-06
XVCSO18BC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.19OE+04	0.000E-01	1.16E-03	1.35E-06
XVCSO46AC	X,MV	TRANSFER CLOSED	5.28OE-08	2.82OE-15	ZPSS	2.19OE+04	0.000E-01	1.16E-03	1.35E-06

TABLE 3.8-14 (Cont.)

INPUT DATA FOR SODIUM HYDROXIDE ADDITION FAULT TREE-3 DAY LCO

XVCSO46BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.190E+04	0.000E-01	1.16E-03	1.35E-06
CVCSO20AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVCSO20BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
XVCSO31AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.190E+04	0.000E-01	1.16E-03	1.35E-06
XVCSO31BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.190E+04	0.000E-01	1.16E-03	1.35E-06
MVCSO19AQ	MOV	FAIL TO OPERATE	3.720E-03	2.710E-06	ZPSS	0.000E-01	0.000E-01	3.72E-03	2.71E-06
MVCSO19BQ	MOV	FAIL TO OPERATE	3.720E-03	2.710E-06	ZPSS	0.000E-01	0.000E-01	3.72E-03	2.71E-06
BS141K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BS142K	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BS19131X1K	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
BS19132X1K	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01

TABLE 3.8-15

3 AND 7 DAY LCO DATA INPUT FOR SODIUM HYDROXIDE ADDITION

FT IDENTIFIER	Probability Power State 1	2	3	4	5	6
BS141K	0	0	1	0	1	1
BS142K	0	0	0	1	1	1

NOTE: The number for CSTRNAF and CSTRNBF will change to 1.4×10^{-2} for 7 day LCO.

TABLE 3.8-16

3 DAY LCO DATA INPUT FOR SODIUM HYDROXIDE ADDITION
TOP LOGIC FAULT TREE STRUCTURE

Identifier	Power State 1	2	3	4	5	6
NAOHCC	1.72×10^{-4}	1.72×10^{-4}	1.72×10^{-4}	1.72×10^{-4}	1.72×10^{-4}	1.72×10^{-4}
TKNAOHF	7.30×10^{-4}	7.30×10^{-4}	7.30×10^{-4}	7.30×10^{-4}	7.30×10^{-4}	7.30×10^{-4}
AAAA	2.25×10^{-2}	2.25×10^{-2}	1.0	2.25×10^{-2}	1.0	1.0
BBBB	2.25×10^{-2}	2.25×10^{-2}	2.25×10^{-2}	1.0	1.0	1.0

TABLE 3.8-17

7 DAY LCO DATA INPUT FOR SODIUM HYDROXIDE ADDITION
TOP LOGIC FAULT TREE STRUCTURE

Identifier	Power State 1	2	3	4	5	6
NAOHCC	1.72×10^{-4}	1.72×10^{-4}	1.72×10^{-4}	1.72×10^{-4}	1.72×10^{-4}	1.72×10^{-4}
TKNAOHF	7.30×10^{-4}	7.30×10^{-4}	7.30×10^{-4}	7.30×10^{-4}	7.30×10^{-4}	7.30×10^{-4}
AAAA	2.35×10^{-2}	2.35×10^{-2}	1.0	2.35×10^{-2}	1.0	1.0
BBBB	2.35×10^{-2}	2.35×10^{-2}	2.35×10^{-2}	1.0	1.0	1.0

TABLE 3.8-18

CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION UNAVAILABILITIES

Power State	3 Day LCO		7 Day LCO	
	CS	NA	CS	NA
1	5.6×10^{-4}	1.4×10^{-3}	5.8×10^{-4}	1.5×10^{-3}
2	5.6×10^{-4}	1.4×10^{-3}	5.8×10^{-4}	1.5×10^{-3}
3	1.1×10^{-2}	2.4×10^{-2}	1.2×10^{-2}	2.6×10^{-2}
4	1.1×10^{-2}	2.4×10^{-2}	1.2×10^{-2}	2.6×10^{-2}
5	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0

TABLE 3.8-19

CUTSETS FOR CONTAINMENT SPRAY SYSTEM

Cutset Description	Percent of Unavailability 3 day	7 day
Both pumps fail to start due to common cause	40	39
Two MOV's fail to operate due to common cause	31	30
Both pumps fail to run due to common cause	9	9
MOV CS007A and B fail to operate	6	6
One flange is left in wrong position following refueling and the CS007 valve on the other train fails to open	4	4
One train is in maintenance and one CS007 valve on the other train fails to open	3	4
One train is in test and the CS007 valve on the other train fails to open	2	2

TABLE 3.8-20

CUTSETS FOR SODIUM HYDROXIDE ADDITION SYSTEM

Cutset Description	Percent of Unavailability 3 day	7 day
Insufficient NaOH solution in spray additive tank	52	49
One train of containment spray is unavailable and one manual valve on the other train of sodium hydroxide system transfers closed	11	11
Both trains of containment spray are unavailable	9	10
Common cause failure of MOV CS019A and B to open	12	12
One MOV CS019 fails to open and the other containment spray train is unavailable	6	6
One MOV CS019 fails to open and one manual valve on the other train transfers closed	4	3

FIGURE 3.8-1

CHR FAULT TREE TOP LOGIC

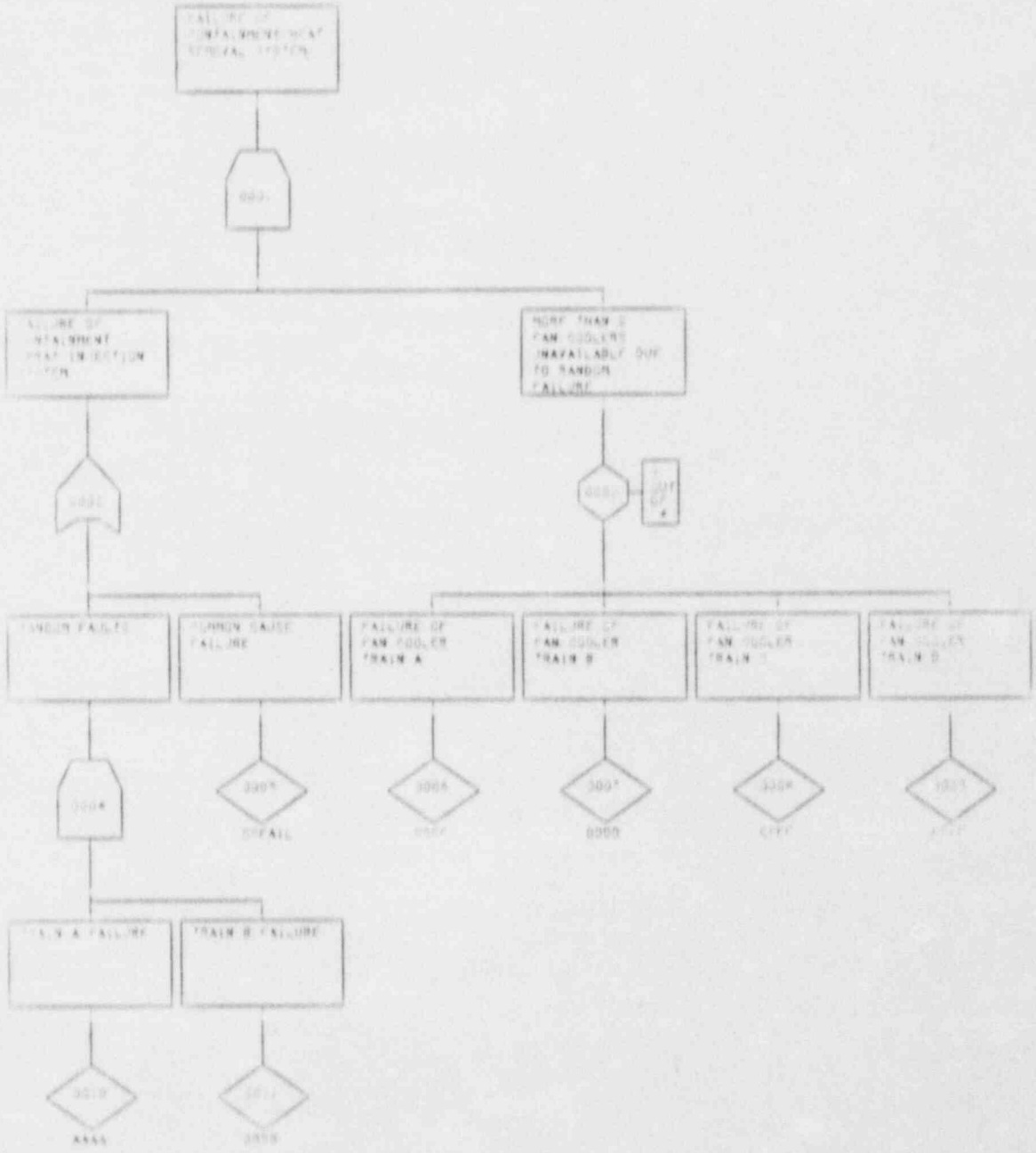

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FIGURE 3.8-3

SODIUM HYDROXIDE ADDITION SYSTEM TOP LOGIC

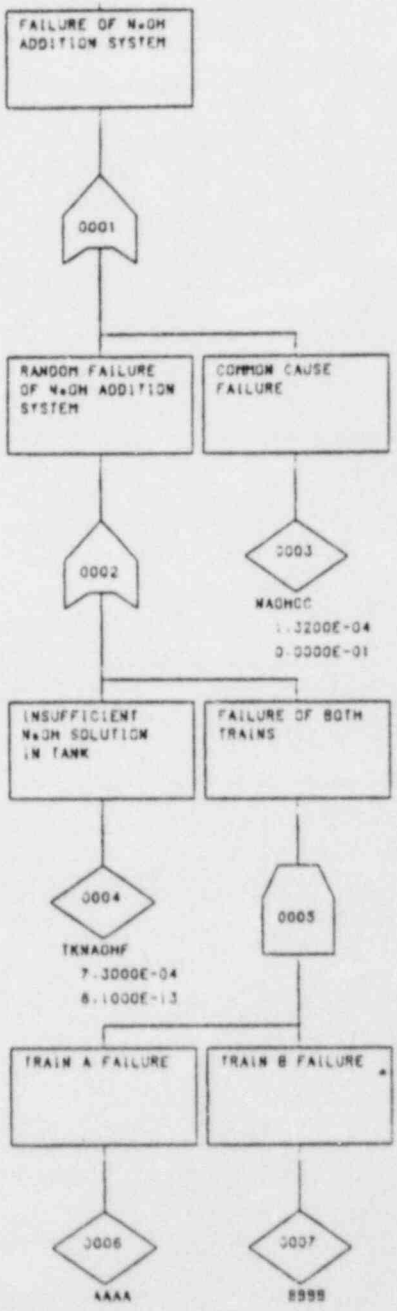

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FIGURE 3.8-5

FAN COOLER SYSTEM SIMPLIFIED P&ID

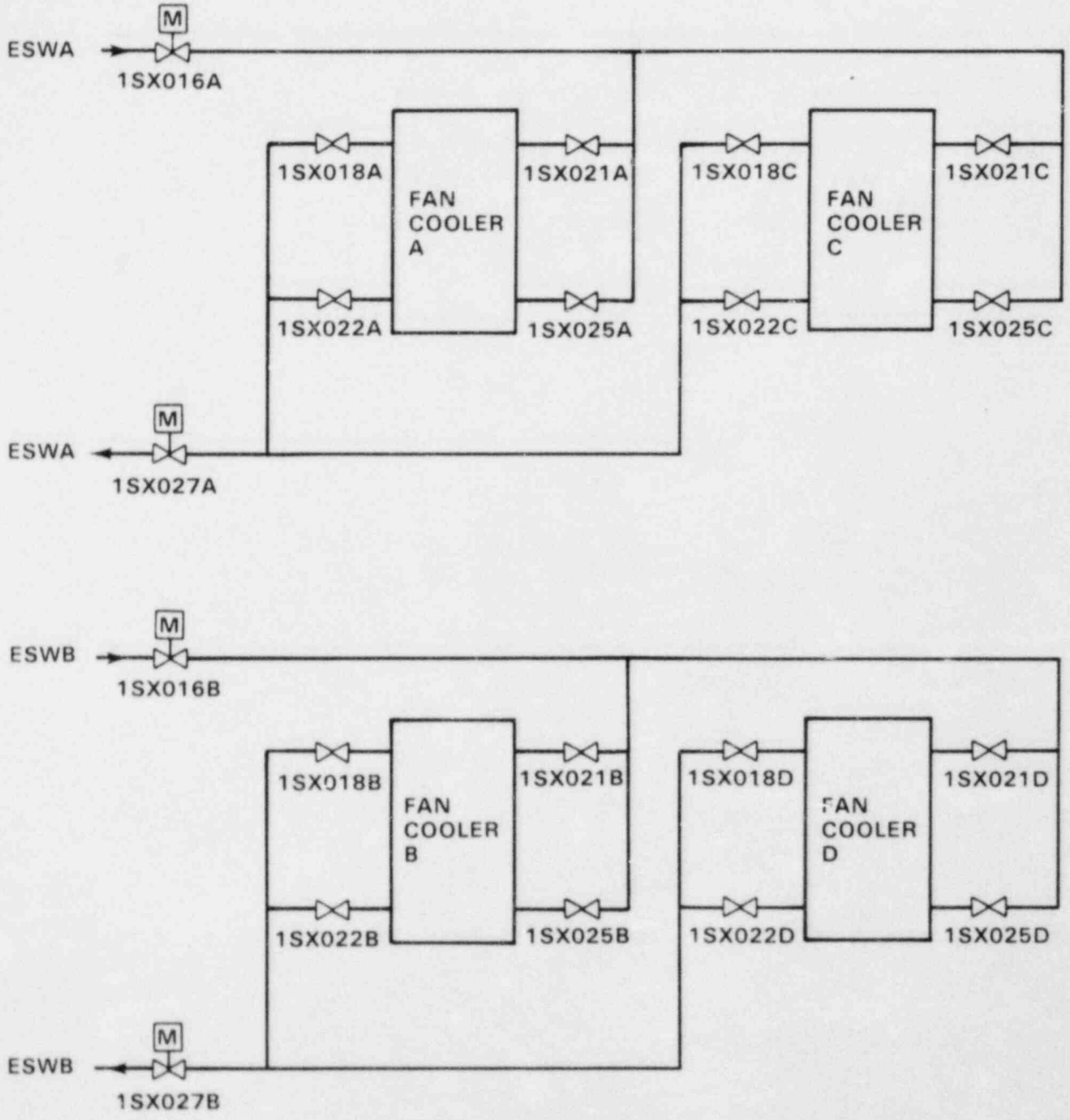
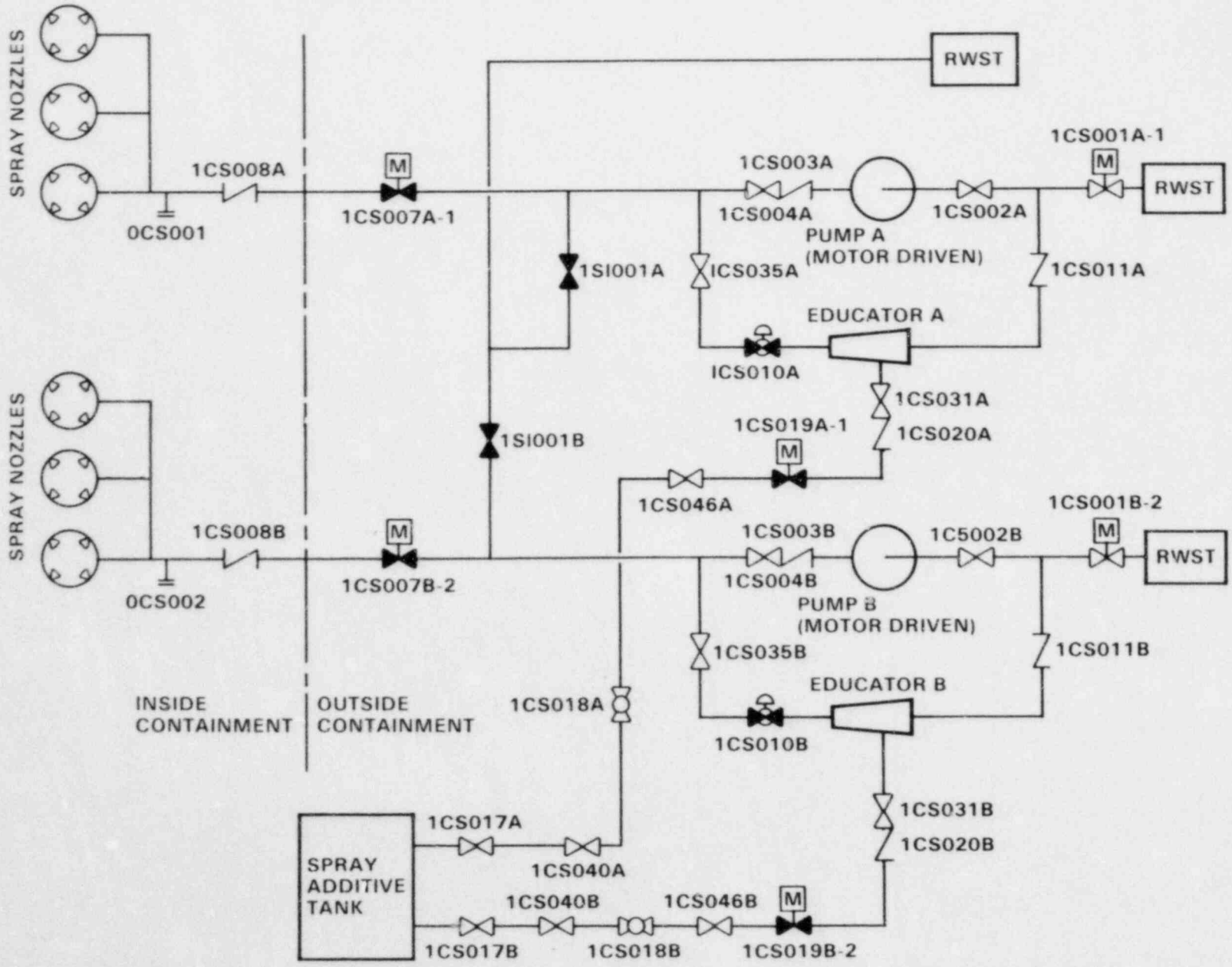


FIGURE 5.6-6

CONTAINMENT SPRAY AND SODIUM HYDROXIDE ADDITION SIMPLIFIED P&ID



APPENDIX 3A

BYRON LCORP GUIDE TO FAULT TREE DEVELOPMENT

3A.1 FLUID SYSTEM FAULT TREE GUIDELINES

3A.1.1 GENERAL

In order to assure consistency in the system fault trees for the Byron LCOR Program, Westinghouse will follow a set of basic guidelines for their systems analyses. The guidelines have been developed with the intent of following the principal methods now used in PRAs and as described in the "PRA Procedures Guide" (NUREG/CR-2300, Revision 1) and also outlined in "National Reliability Evaluation Program (NREP) Procedures Guide" (NUREG/CR-2815, 9/9/82). Engineering judgement will be the final arbiter in taking exception to these guidelines and should be noted by the analyst in his/her tree documentation.

3A.1.2 RANDOM FAULT POSTULATION AND CONSIDERATION

a) Pipe ruptures and orifice plugging are not considered as credible faults since their contribution to system fault, compared to that of other components, is insignificant.

   Although a system may be in standby for long periods of time prior to the accident, other system faults such as valves being mispositioned, valves not opening/closing on demand, or pumps not starting and running on demand will dominate.

b) Misposition of normally open manual, air, and motor-operated valves prior to the accident due to human error and/or spurious control signal will remain as a system fault, if credible (see test and maintenance Section 3A.1.3 below).

c) Misposition faults of valves prior to an accident will not be included in the fault trees if the valve receives an automatic signal to return

to its operable state under accident conditions. When opening time is critical for the accident condition, it should be evaluated on a case-by-case basis.

d) Potential flow diversion paths will be included as system faults if these paths contribute a flow diversion area that is greater than 5 percent of the desired flow path area. However, if the pressure differential between the desired path and the potential diversion path is extremely high, a flow area less than 5 percent in the diversion path may prove to be significant.

e) Potential flow diversion paths isolated from the main flow path by normally closed valves will be treated as faults of the system. Valve misposition prior to the accident due to human error and/or spurious control signal will be considered a system fault, if credible.

f) No credit is taken in the first cut of the fault trees for alternate sources of cooling water or electric power even in the cases where the source can be remotely lined up from the control room.

g) Control circuit faults of components after successful initial operation will be considered only in those cases where the component is expected to receive an additional signal during the course of the accident to readjust or change its operating state.

h) Tank failures are included in the fault trees, but failure of heat exchangers (coolers) to transfer heat due to plugging of the primary side and leakage (primary to secondary) are not.

i) Check valves failing closed to flow in the forward direction and failing open to flow in the reverse direction will be included as credible events.

3A.1.3 FAULTS DUE TO TEST AND MAINTENANCE

a) Unavailability of components due to test or maintenance and human errors associated with failing to restore components to their operable state, following test or maintenance, will be included along with random hardware faults. The maintenance unavailabilities will be treated at a train level; namely, a maintenance unavailability will be assigned to each maintainable train, not to individual components.

In order to avoid counting test or maintenance faults that are not allowed by tech specs, such as having two trains of a system simultaneously out for test or maintenance, "not" gates will be used where appropriate.

b) Only those components whose failure is detected by normal testing conducted during power operation of the plant will be considered maintainable. Additionally, if maintenance on any component causes the plant to operate at less than nominal power then that component will still be considered to be maintainable.

c) The test mode of a pump and its associated valves and other components that prevent a system from meeting its design safety function will be considered as a credible failure mode, unless automatically realigned within acceptable time limits.

d) The failure of test personnel to return valves or pump trains to their normal position after a test will be considered as a credible event if they 1) do not receive an "S" signal and 2) are not alarmed or annunciated at the control board. This event will be considered equivalent to a random failure and will be included in the fault tree as "failure to restore component XXX after test".

e) A component is considered maintainable if it can be flow isolated from the system by a manual valve or a power-operated valve (MOV or AOV) in series with the component. Check valves cannot be used to isolate a component for maintenance due to backflow leakage.

f) The failure of maintenance personnel to return valves or pump trains to their normal position after valve or pump maintenance will be considered as credible events if (1) proper positioning can not be detected using the required pump flow test, (2) valve misposition is not immediately detected at the control board by alarm or annunciation, or 3) the component does not receive an "S" signal. Credit is not taken for control indication. If credible, this event will be considered equivalent to a random failure and will be included in the fault tree as "failure to restore component XXX after maintenance".

g) Maintainable components will be separately addressed only if they cannot be considered in the maintenance of a train.

3A.1.4 INCLUSION OF OPERATION ACTION

Operator errors which fail to align valves or fail to operate other components in response to the accident will be included only for those components which are specifically identified in procedures as requiring operator manipulation.

3A.2 FAULT TREE CONSTRUCTION

3A.2.1 GENERAL

The fault tree construction shall be performed according to procedures suggested in SAND81-0062 "Fault Tree Analysis Procedures for the Interim Reliability Evaluation Program (IREP)" (December 1980).

Firstly, the fluid systems interfacing with the system of interest are to be determined from P and ID's.

The system piping drawings are to be simplified by canceling those pipe segments which either cannot affect system performance significantly, or contain normally closed manual valves which could only improve system performance if opened (i.e., some types of test and bypass lines).

On the basis of system failure criteria, a system TOP event is established and a failure logic for the discharge ends of the system is developed as input to the TOP event. The development of system fault trees is continued by working back through the system and considering, initially, only the faults at the segment level. Finally, the component fault logic is developed as shown in Section 3A.2.2.

3A.2.2 COMPONENT LOGIC MODULES

Modular logic models have been developed for the following components to assure consistency between fault trees.

- motor-driven pumps (Fig. 3A.2.2-1)
- motor-operated valves (Fig. 3A.2.2-3 and Fig. 3A.2.2-5)
- solenoid-operated valves (Fig. 3A.2.2-2)
- air-operated valves (Fig. 3A.2.2-12)
- heat exchangers (Fig. 3A.2.2-11)
- tanks (Fig. 3A.2.2-7)
- check valves (Fig. 3A.2.2-4 and Fig. 3A.2.2-10)
- test or maintenance (Fig. 3A.2.2-8)
- failure to restore following test or maintenance (Fig. 3A.2.2-9)

Each module should include the following types of events:

- local faults
- support system faults
- component unavailability due to test or maintenance.

A local fault is a basic event including a wide variety of causes resulting in the same failure mode. Component support systems could be electric power, control power, actuation, cooling water, control and other systems whose failure directly or indirectly affect correct component operation.

The ESF (6KV) electric power is considered to be a support system.

3A.2.3 FAULT EVENT IDENTIFICATION

The codes to be used for component failure identification will result in nine or ten characters. The format of component failures in system fault trees is XXWWYYYYZZ where:

- XX is the component identification code (see Table 3A.2.3-1)
- WW is the system identification code (see Table 3A.2.3-2)
- YYYY is the number individuating the single component in system P and I drawings
- ZZ is the specific component failure mode (see Table 3A.2.3-3).

TABLE 3A.2.3-1

COMPONENT IDENTIFICATION

XX	Component
MV	Valve, Motor-operated
XV	Valve, Manual
AV	Valve, Air-operated
SV	Valve, Solenoid-operated
CV	Valve, Check
P	Pump
HX	Heat Exchanger
TK	Tank

TABLE 3A.2.3-2

SYSTEM IDENTIFICATION

WW	System
SI	Safety Injection
RHR	Residual Heat Removal
CC	Component Cooling
SX	Essential Service Water, Fan Coolers
CS	Containment Spray, Sodium Hydroxide Addition, Auxiliary Feedwater

TABLE 3A.2.3-3

FAILURE MODES

ZZ	Failure Mode
C	Valve, Check, Fails to Open
	Valve, Manual, Transfers Closed
	Valve, Motor Operated, Transfers Closed
O	Valve, Manual, Transfers Open
	Valve, Motor-operated, Transfers Open
Q or D	Valve, Manual, Fails to Operate
	Valve, Air-operated, Fails to Operate
	Valve, Solenoid, Fails to Operate
HM	Valves, All, Failure to Restore Following Maintenance
HT	Valves, All, Failure to Restore Following Test
FS	Pump, Fails to Start
FR	Pump, Fails to Run
M	Component, Unavailable Due to Maintenance
T	Component, Unavailable Due to Test
F	Component, Miscellaneous Failure

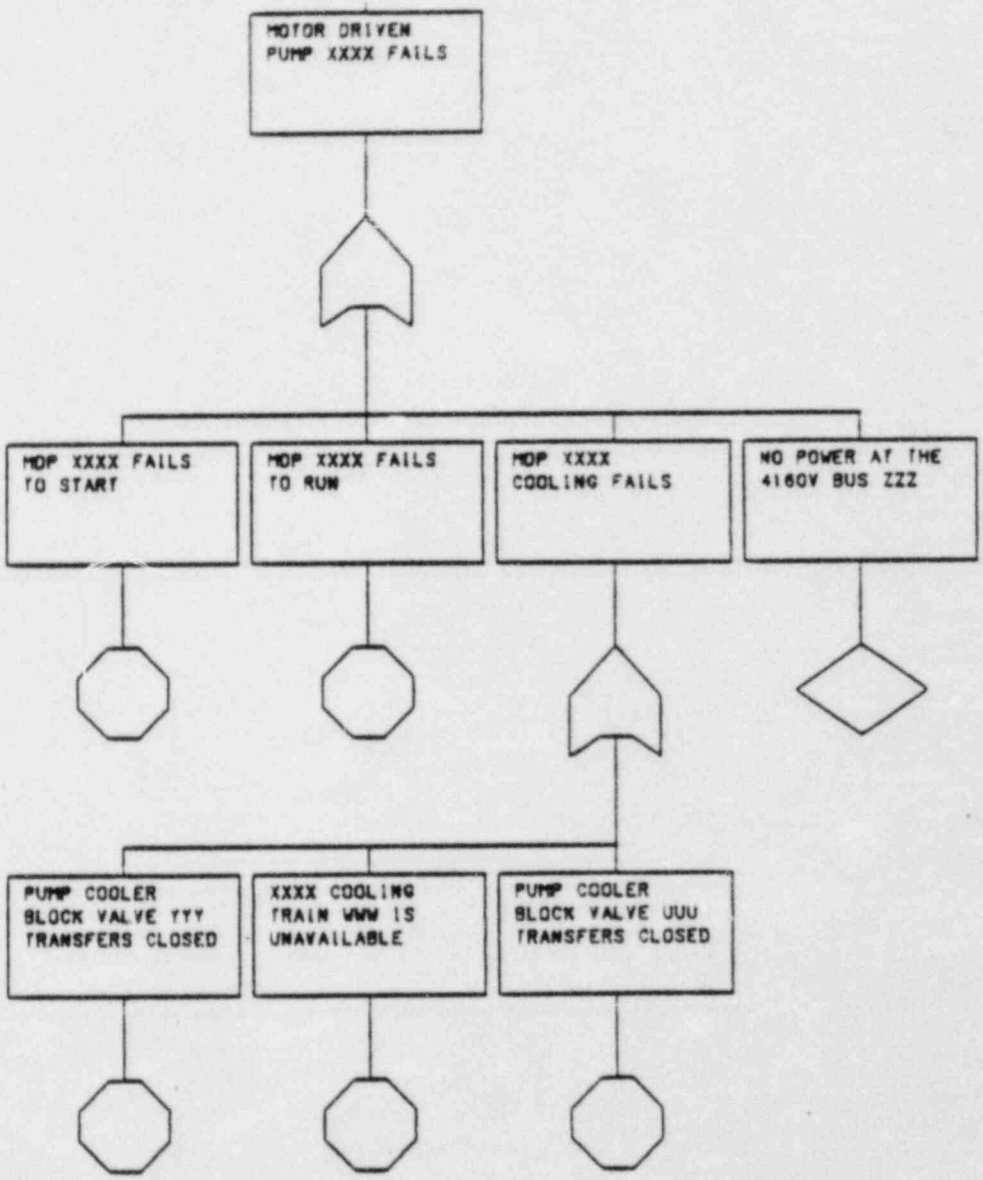


FIGURE 3A.2.3-1

LOGIC MODULE FOR MOTOR DRIVEN PUMP

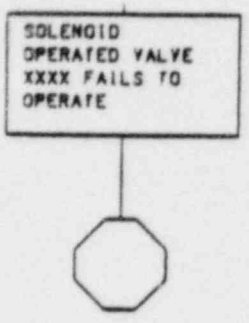


FIGURE 3A.2.3-2

LOGIC MODULE FOR SOLENOID OPERATED VALVE

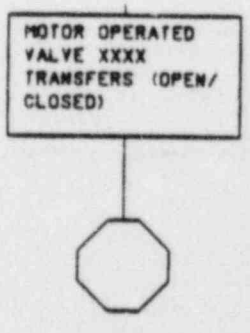


FIGURE 3A.2.3-3

LOGIC MODULE FOR MOTOR OPERATED VALVE - NOT REQUIRED TO MOVE

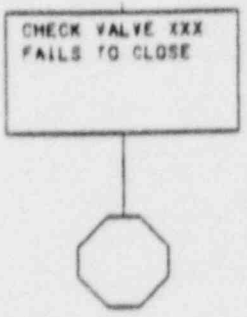


FIGURE 3A.2.3-4

LOGIC MODULE FOR CHECK VALVE - EXCESSIVE LEAKAGE

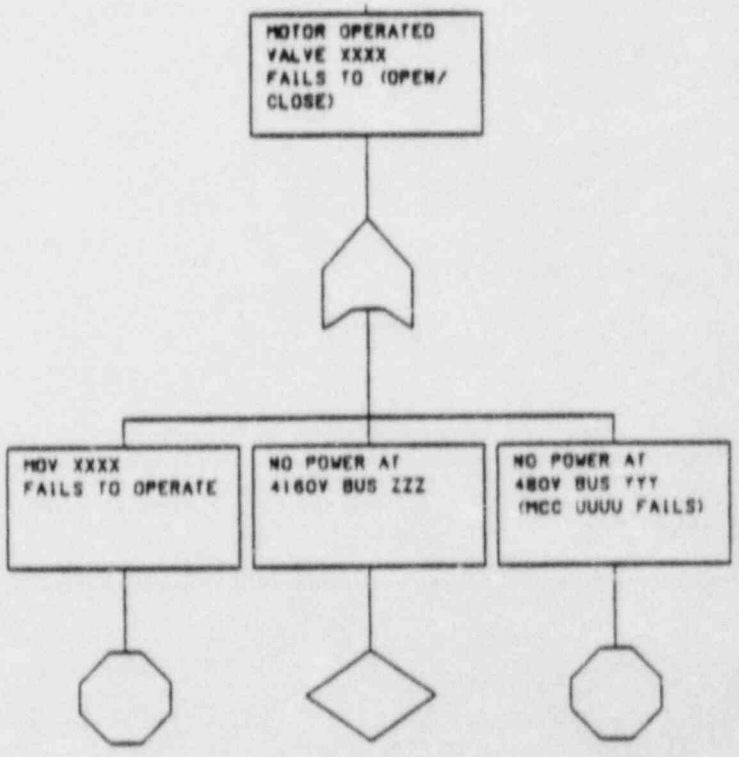


FIGURE 3A.2.3-5

LOGIC MODULE FOR MOTOR OPERATED VALVE - FAILS TO MOVE

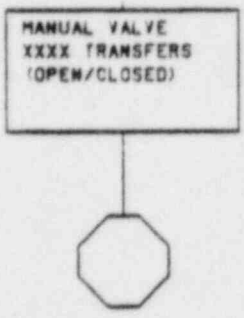


FIGURE 3A.2.3-6

LOGIC MODULE FOR MANUAL VALVE

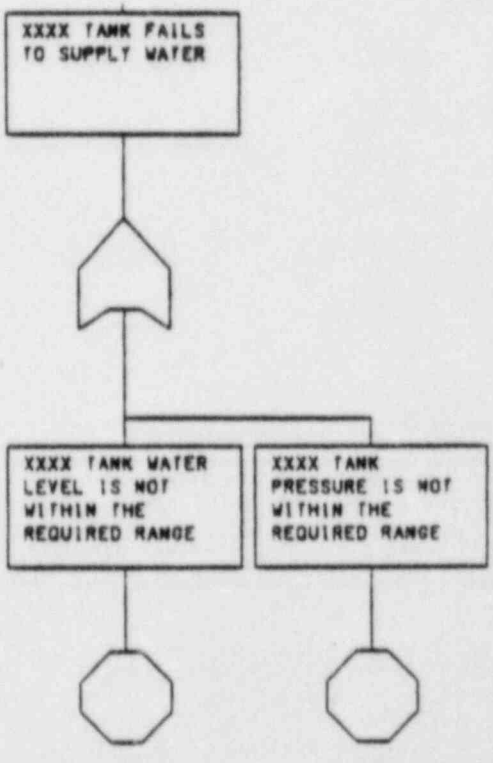


FIGURE 3A.2.3-7

LOGIC MODULE FOR TANK

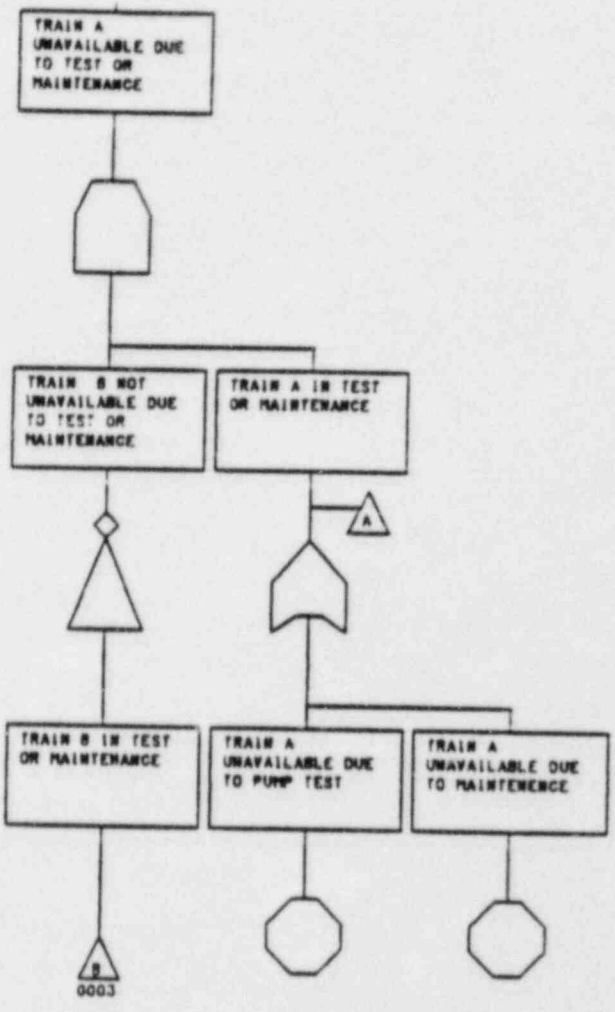


FIGURE 3A.2.3-8

LOGIC MODULE FOR TEST AND MAINTENANCE

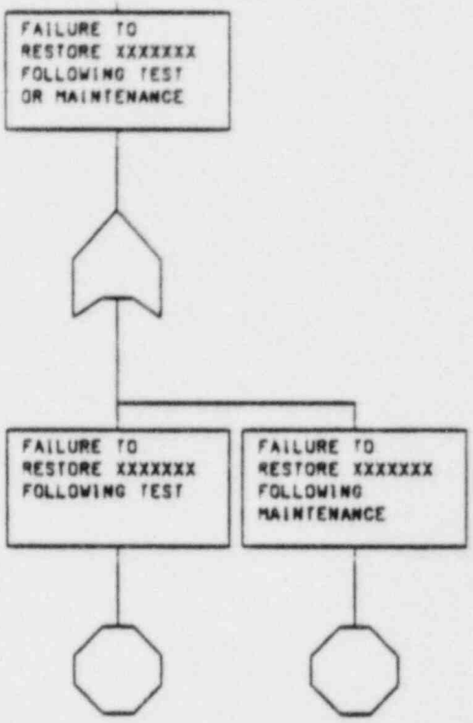


FIGURE 3A.2.3-9

LOGIC MODULE FOR FAILURE TO RESTORE FOLLOWING TEST OR MAINTENANCE

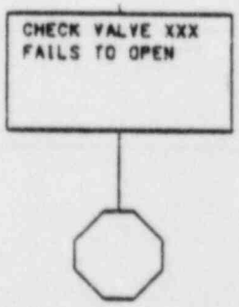


FIGURE 3A.2.3-10

LOGIC MODULE FOR CHECK VALVE - BLOCKED

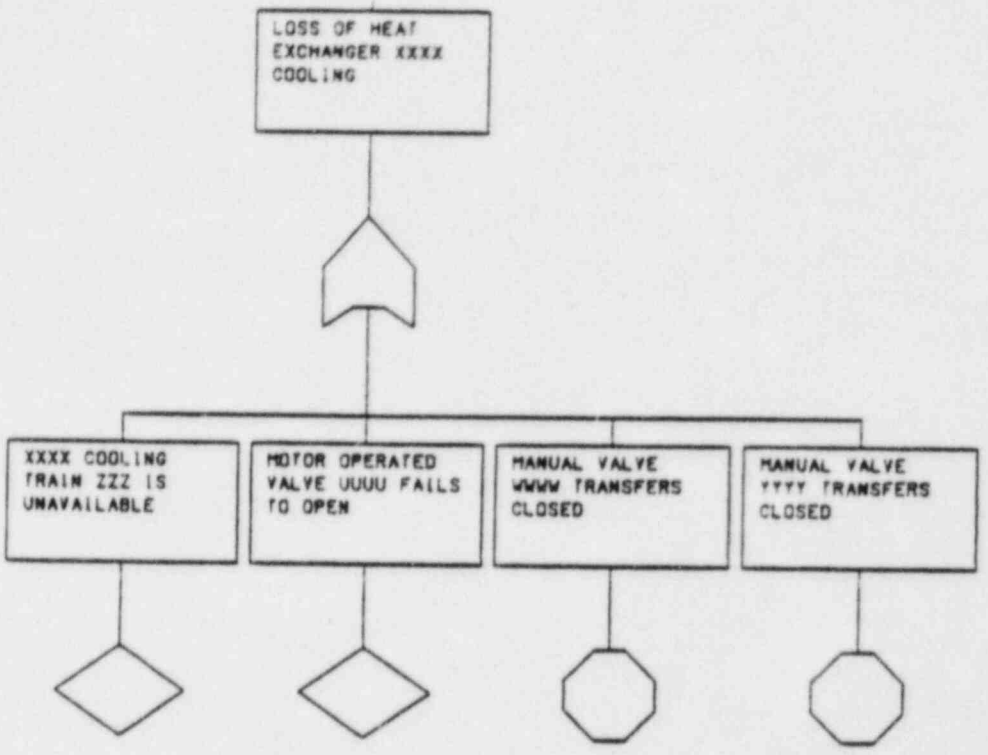


FIGURE 3A.2.3-11

LOGIC MODULE FOR HEAT EXCHANGER

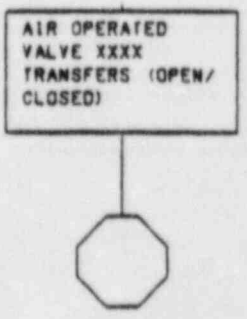


FIGURE 3A.2.3-12

LOGIC MODULE FOR AIR-OPERATED VALVE

APPENDIX 3B

COMMON CAUSE

3B.1 MODEL

The following guidelines are used for common cause modeling in fault trees:

A. Explicitly identifiable common cause sources, such as AC/DC power, service water, component cooling water, will be specifically modeled with transfers within the fault tree.

B. For common causes that are not explicitly addressed, the common cause contribution will be either placed near the top of the tree, as shown by Figure 3B.1-1 or at the component level as illustrated by Figure 3B.1-2.

C. Common cause will be addressed at least for active components in the system, e.g., pumps and valves that change position.

D. β factor approach will be used for cases involving 2 components/trains. The β factors to be used are given by Table 3B.1-1 for active components.

E. For other components, if the analyst determines that common cause potential exists and must be modeled, a β value in the range of 0.01-0.1 is suggested, unless specific data exists.

F. For modeling of highly redundant systems (3 or 4 components/train redundancy), the following extended β factor method will be used:

The β_2, β_3 and β_4 factors will be defined as follows:

β_i = fraction of random failures of a given train/component that will result in failure of another i-1 specific train(s)/component(s) with i = 2,3,4.

For a system involving an m/n (m-out-of-n trains or components) success criteria, the equations to calculate the common cause contribution to system failure are given by Table 38.1-2. The value of β_2 is estimated conservatively as:

$$\beta_2 = \beta$$

The other β factors are estimated as follows:

$$\beta_3 = \frac{1}{5}\,\beta_2$$

$$\beta_4 = \frac{1}{2}\,\beta_3 = \frac{1}{10}\,\beta_2$$

The physical implications of the above definitions are as follows:

Changing a one-out-of-two system to a one-out-of-three system will decrease the system unreliability approximately by a factor of 5; adding a fourth redundant train/component will decrease the system unreliability by another factor of 2. No credit will be taken for a fifth train/component. Thus, going from a 1/2 success criteria to a 1/4 success criteria will approximately improve system failure probability by an order of magnitude.

38.2 A CALCULATIONAL EXAMPLE

The following example is provided to illustrate the above model for a 1/n success criteria.

Given that

Q_T = 1 train unavailability = 1.0×10^{-2}

$\beta_2 = \beta = 5.0 \times 10^{-2}$,

The following system unavailabilities (Qs) are calculated using equations from Table 3B.1-2:

m/n	Q_s	System Unavailability Equation
1/1	1.0×10^{-2}	$Q_s = Q_T$
1/2	6.0×10^{-4}	$Q_s = Q_T^2 + \beta_2 Q_T$
1/3	1.2×10^{-4}	$Q_s = Q_T^3 + 3\beta_2 Q_T^2 + \beta_3 Q_T$
1/4	5.3×10^{-5}	$Q_s = Q_T^4 + 6\beta_2 Q_T^3 + 3\beta_3 Q_T^2 + \beta_4 Q_T$

The general equation for Q_s is:

$$Q_s = Q_R + Q_{CC}$$

where Q_R is the random failure probability and Q_{CC} is the common cause failure probability for a 1/n system, Q_R is given by:

$$Q_R = Q_T^n$$

TABLE 3B.1-1

β-FACTORS FOR ACTIVE COMPONENTS

Component/Failure Type	β	β Upper Bound
[1]Diesel Generators	0.026	0.176
[2]Pumps		
Running Pumps/fail to operate	0.016	0.755
Alternating Pumps/fail to start	0.093	0.476
/fail to operate	---	0.500
/fail to operate no command faults	0.041	0.629
Auxfeed Pumps/fail to start MDP	0.204	0.533
/fail to operate MDP	0.100	0.270
/fail to start TDP	0.113	0.546
/fail to operate TDP	0.063	0.485
/fail to start DDP	0.008	0.019
/fail to operate DDP	0.006	0.031
Standby Pumps/fail to start	0.311	0.600
/fail to operate	0.141	0.558
[3]Valves		
AOV/fail to open, close or operate	0.191	0.863
AOV/improper valve configuration	0.267	0.941
MOV/fail to open, close or operate	0.023	0.396
MOV/improper valve configuration	0.464	0.584

References

1 Nureg/CR-2099

2 Nureg/CR-2098

3 Nureg/CR-2770

TABLE 3B.1-2

EQUATIONS FOR COMMON CAUSE CALCULATIONS

Success Criteria	Equation for Q_{cc}
1/2	$\beta_2 Q_T$
1/3	$3\beta_2 Q_T^2 + \beta_3 Q_T$
2/3	$3\beta_2 Q_T + \beta_3 Q_T$
1/4	$6\beta_2 Q_T^3 + 3\beta_3 Q_T^2 + \beta_4 Q_T$
2/4	$6\beta_2 Q_T^2 + 3\beta_3 Q_T + \beta_4 Q_T$
3/4	$6\beta_2 Q_T + 3\beta_3 Q_T + \beta_4 Q_T$

where

Q_{cc} = Common cause contribution to total system failure probability

Q_T = Random one train/component failure probability

FIGURE 3B.1-1

COMMON CAUSE IN A FAULT TREE: 1/4 SYSTEM

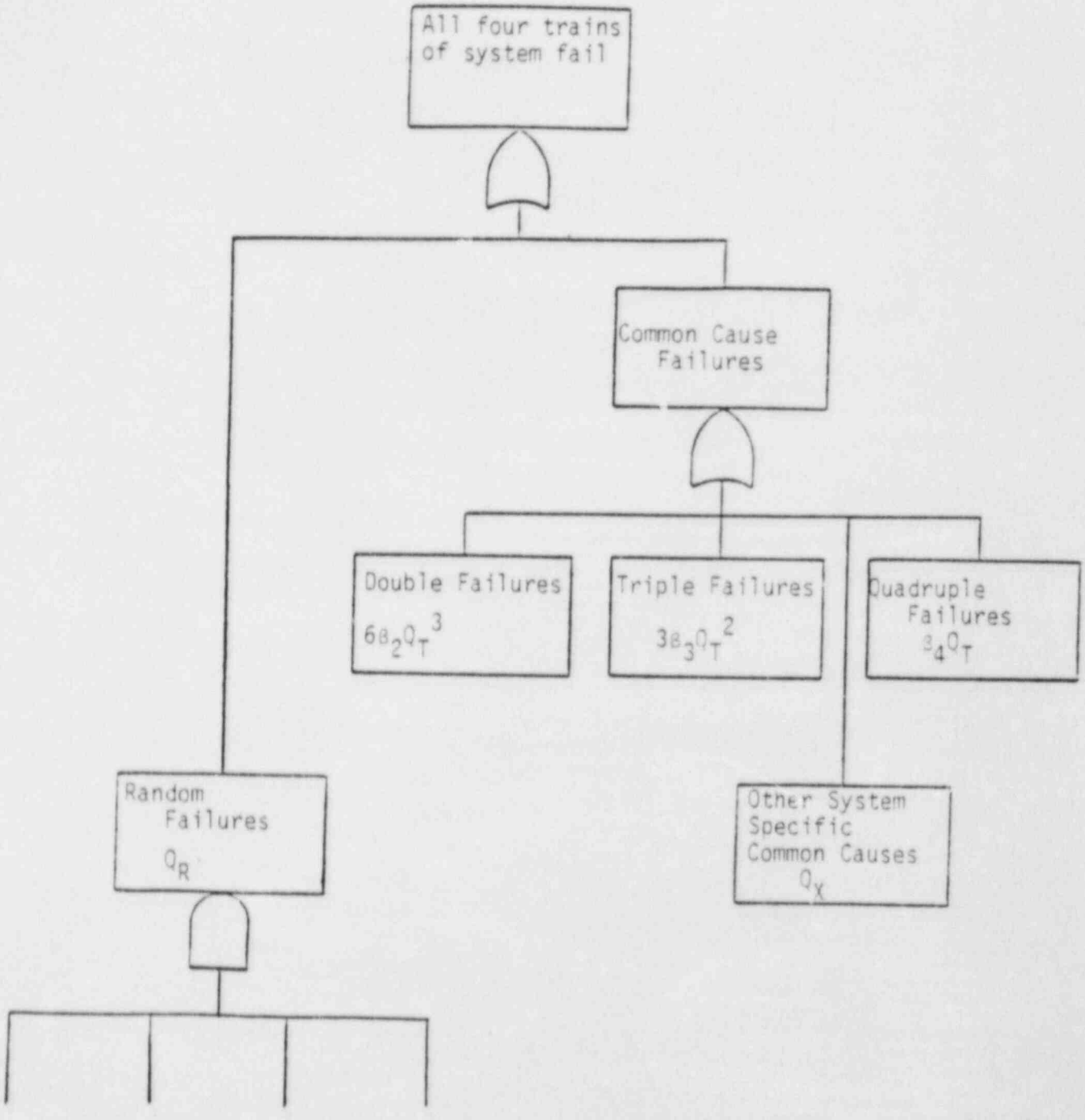
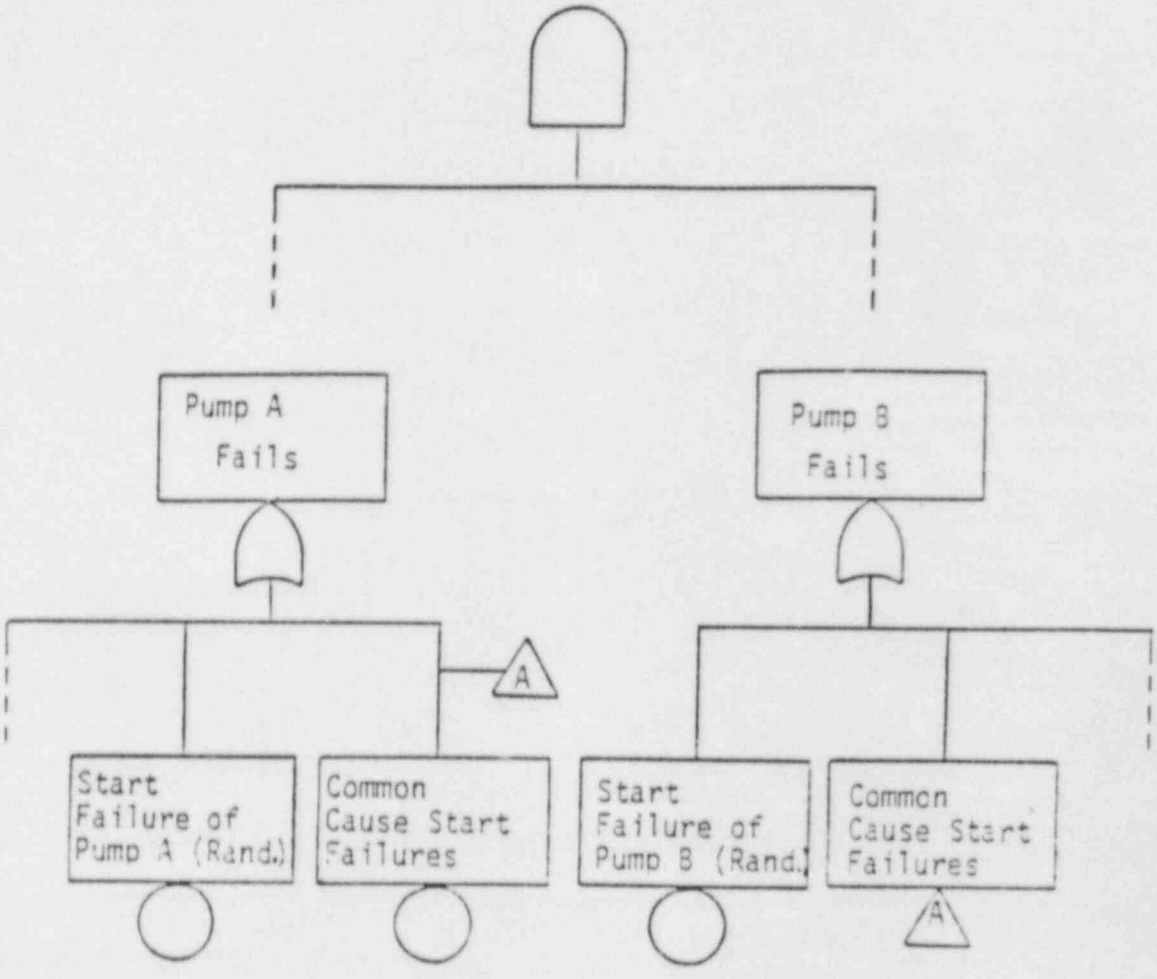


FIGURE 3B.1-2

PLACEMENT OF COMMON CAUSE AT COMPONENT LEVEL



APPENDIX 3C

HUMAN ERROR PROBABILITIES

3C.1 INTRODUCTION

Human errors are addressed in two areas in the study:

1. Operator actions modeled in event tree nodes.

2. Operator actions and test/maintenance-related human errors modeled in fault trees.

The operator actions modeled in event trees are related to events that take place after an accident sequence is initiated. For failure probabilities related to these actions, labeled by OP 1 through OP 9, calculations are made in Section 4.

For the human errors that are modeled in fault trees, probabilities (HEPS) are calculated using the data bank generated from NUREG-1278. The calculated probabilities are summarized in Table 3C.1-1. The calculations for these probabilities are provided below, labeled as HE1 through HE8.

Type of Error No.	Description
HE1	Failure to restore a motor-driven pump or an air or motor-operated valve after T and M

Assumptions:

- Level 1 tagging
- Valve position indicator on control panel

- o ESF panel is formally scanned at start of each shift (use of a checklist is required)

- o Similar to NUREG/CR-2254, Appendix A, Example 6, the median failure probability is calculated to be 1.0×10^{-5}.

The median value is converted to mean, using the conversion factor from Table 3C.4-2 with an error factor of 30. The resulting failure probability is:

$$Q = 4.4 \times 10^{-5}$$

*NUREG/CR-1278, Draft Report, October 1980.

Type of Error No.	Description
HE2	Failure to restore a manual valve after test and maintenance

Assumptions:

- o Level 1 tagging

- o Independent valve line-up performed after restoration

- o Checklist required ($\leq$ 10 items)

Type of Error No.	Description
HE4	Operator fails to open CC valves to RHR exchanger MOV CC9412A,B

Assumptions:

1. The operators will nave 20 minutes to identify the need to carry out the action.

2. A complete dependence between two valves is modeled.

3. A procedural step to check CCW flow exists and provides a recovery mechanism.

Calculation:

The quantification for action is done as:

$$q_A = q_3$$

$$q_A = 9.6 \times 10^{-3}$$

The recovery is modeled as:

$$q_R = (q_1 + q_4)$$
$$= 9.2 \times 10^{-3}$$

from Item 33 of Table 3C.4-1.

The resulting HEP is:

$$Q = q_A \, q_R$$

$$Q = 8.8 \times 10^{-5}$$

Type of Error No.	Description
HE5	Operator error of omission to open manual valve 9453A

Assumptions:

1. The procedures exist for this action.

Calculation:

Omission and recovery is modeled as:

$$Q = q_1 * q_5$$

$$Q = 1.1 \times 10^{-3}$$

Type of Error No.	Description
HE6	Failure to restore CSS flange following refueling

Assumptions:

1. The procedures for this action are a part of a long list of procedures with checkoff.

2. An omission error is modeled. No recovery is considered. This model is conservative.

3. This failure cannot be detected during normal train testing.

4. Stress level is taken as 1.

Calculation:

Omission and recovery is modeled as:

$$Q = q_7 * q_6$$
$$= 1.8 \times 10^{-3}$$

Type of Error No.	Description
HE7	Operator fails to close MOVs SI 8812 A and B.

Assumptions:

1. Procedures for this action exist. A low-low level alarm is present.

2. Operator makes an omission or a selection error.

3. The action of closing the record valve is modeled to be totally dependent on closure of the first valve.

Calculation:

The probability of failure is estimated as:

$$Q = (q_3 * q_5)\ 0.1$$

$$Q = 1.4 \times 10^{-4}$$

An additional order of magnitude credit is taken for the existence of an alarm and a second operator who is also well trained in this routinely simulated task.

Type of Error No.	Description
HE8	Operator error of omission to open MOV 9473 A or B or Manual Valves 9467A and 9459B

Assumptions:

1. Procedures for this action exist.

Calculation:

The failure probability is modeled as an omission or selection error and recovery is modeled as:

$$Q = q_3 * q_5$$

$$Q = 1.4 \times 10^{-3}$$

No other credits are taken since the action is not a routine one.

TABLE 3C.1-1

HUMAN ERRORS MODELED IN FAULT TREES
(FROM SIMON DATA BANK-SEE APPENDIX 3D)

No.	Comp.	System	Failure Mode	Failure Prob. per Demand	Source Calc No.
67	MV	ALL	Fail to restore/indicated	4.4×10^{-5}	HE1
68	XV	ALL	Fail to restore	2.1×10^{-4}	HE2
87	HE	ESW	Operator fails to align	2.0×10^{-3}	HE3
108	OPER	RHR	Operator error CC92 open	8.8×10^{-5}	HE4
110	OPER	CCW	Operator error manual VLV	1.1×10^{-3}	HE5
112	FLNG	CSS	Fail to restore following refueling	1.8×10^{-3}	HE6
119	OPER	RHR	Op error SI8812 closed	1.4×10^{-4}	HE7
111	OPER	CCW	Op error MOV	1.4×10^{-3}	HE8

TABLE 3C.1-2

HEPS USED IN CALCULATIONS HE3 THROUGH HE8

Symbol	Error Description	HEP*	Source**
q1	Omission	7.2×10^{-3}	15
q2	Selection	2.4×10^{-3}	21
q3	Omission + Selection	9.6×10^{-3}	$q_1 + q_2$
q4	Reading	3.0×10^{-3}	37
q5	Checking - safety involved	1.5×10^{-1}	33
q6	Checking routine	5.0×10^{-1}	36
q7	Omission - stress level 1	3.6×10^{-3}	15

Notes:

* All HEPs except q_6 and q_7 are with a stress factor of 2 already included.

** Source refers to item number in Table 3C.4-1.

3C.2 HUMAN ERROR DATA BANK FOR PRA APPLICATIONS

A human error data bank is created to be used with the WTHERP[1] code, which calculates operator action failure probabilities for fault tree and event tree analyses. The following considerations are considered in the generation of the data bank:

1. The data bank must be consistent with the other generic random failure and common cause data banks[2] used in Westinghouse studies. For this purpose a loguniform distribution is used on the data provided in NUREG-1278.[3]

2. The point estimate values must be mean values, variances must be available. For this purpose the median values and error factor in NUREG-1278 are converted to mean values and variances.

3C.3 GENERATION OF THE DATA BANK

The truncated loguniform distribution is characterized by the density function f(x):

$$f(x) = \frac{1}{x(m-l)}$$

where

$l = \ln(L)$
$m = \ln(M)$
L = minimum value (lower bound) of the distribution
M = maximum value (upper bound) of the distribution

The mean, median and variance of the distribution are given by

Mean: $$\mu = \frac{(M-L)}{(m-l)}$$

Median: $X_{50} = \exp[0.5(m+1)]$

Variance: $\sigma^2 = \frac{M^2 - L^2}{2(m-1)} - \frac{(M-L)^2}{(m-1)}$

To find the mean and the variance of the distribution, given the median (nominal value) and the error factor, (EF) the maximum value is calculated:

$$M = \begin{cases} (EF)\,(median) & \text{if the product is} \leq 1 \\ 1 & \text{if the product is} > 1 \end{cases}$$

If M is approximated by 1, the lower bound is also changed to keep the median the same. The lower bound is calculated as:

$$L = \begin{cases} (median) \,/\, (EF) & \text{if } M < 1 \\ (median) \,/\, [M/median] & \text{if } M = 1 \end{cases}$$

A code named LOGUNI is used to calculate the means and variances of the human error probabilities. The code listing is given on Table 3C.3-1. The conversions for all needed nominal human error probabilities into mean values is summarized in Table 3C.3-2, as calculated by the LOGUNI code.

The conversion given by Table 3C.3-2 is used to generate the data bank from nominal NUREG-1278 data.

3C.4 DATA BANK

The following tables of NUREG-1278 are found to be useful for operator actions during emergency operations:

Table	Description	No. of Items
20-3	Diagnosis by Control Room Personnel	6
20-6	Failure of Administrative Control	8
20-7	Errors of Omission	5
20-12	Errors of Commission	12
20-22	Detection of Errors	8
20-23	Response to Multiple Annunciators	14
20-24	Response to an Annunciator	4

The HEPs corresponding to the entries in the above tables are given in Table 3C.4-1.

3C.5 REFERENCES

1. WTHERP, W PRA Group, June 1983.

2. NS-PRA-83-066

3. NUREG-1278, 1983 revision

TABLE 3C.4-1

HEP DATA BANK

No.	HEP Description	HEP(Mean)	Variance
	DIAGNOSIS BY CONTROL ROOM PERSONNEL AN AN ABNORMAL EVENT		
1	Within 10 minutes of a compelling signal	2.1-01	6.2-02
2	Within 20 minutes of a compelling signal	2.1-02	6.2-04
3	Within 30 minutes of a compelling signal	2.1-03	6.2-06
4	Within 60 minutes of a compelling signal	4.4-04	4.7-07
5	Within 1500 minutes of a compelling signal	4.4-05	4.7-09
	FAILURE OF ADMINISTRATIVE CONTROL		
6	Carry out a plant policy or scheduled tasks such as periodic tests or maintenance performed weekly, monthly, or at long intervals	1.5-02	1.7-04
7	Initiate a scheduled shiftly checking or inspection function	1.2-03	5.5-07
	Use written operations procedures under:		
8	normal operating conditions	1.2-02	5.5-05
9	abnormal operating conditions	1.1-02	1.6-04
10	Use a valve change or restoration list	1.2-02	5.5-05
11	Use written test or calibration procedures	7.5-02	4.1-03
12	Use written maintenance procedures*	3.0-01	0.1
13	Uses a checklist properly*	5.0-01	0.3
	ERRORS OF OMISSION		
	When procedures with checkoff provisions are correctly used:		
14	Short List, < 10 items	1.2-03	5.5-07
15	Long List, > 10 items	3.6-03	4.9-06

TABLE 3C.4-1 (Continued)

HEP DATA BANK

No.	HEP Description	HEP(Mean)	Variance
	When procedures without checkoff provisions are used, or when checkoff provisions are incorrectly used		
16	Short list, < 10 items	3.6-03	4.9-06
17	Long list, > 10 items	1.2-02	5.5-05
18	When written procedures are available and should be used but are not used	7.5-02	4.1-03
19	Same as item 18, but is judged to be a "second nature"	1.5-02	1.7-04
ERRORS OF COMMISSION			
	Select wrong control from an array of similar-appearing controls:		
20	identified by labels only	3.6-03	4.9-06
21	from a functionally grouped set of controls	1.2-03	5.5-07
22	from a panel with clearly drawn mimic lines	1.1-03	1.6-06
	Turn control in wrong direction:		
23	when there is no violation of populational stereotypes	1.1-03	1.6-06
24	when design violates a strong populational stereotype and operating conditions are normal	7.5-02	4.2-03
25	when design violates a strong populational stereotype and operation is under high stress	5.9-01	4.5-0..
26	Turn a two-position switch in wrong direction: no violation of populational stereotypes	2.1-04	6.2-08
27	Set a multiposition selector switch to an incorrect setting (this error is a function of the clarity with which indicator position can be determined: designs of switch knobs and their position indications vary greatly)	2.1-03	6.2-06

TABLE 3C.4-1 (Continued)

HEP DATA BANK

No.	HEP Description	HEP(Mean)	Variance
28	Failure to complete change of state of a component if switch must be held until change is completed	3.6-03	4.9-06
29	Select wrong circuit breaker in a group of circuit breakers	6.1-03	1.9-05
30	Improperly mate a connector (this includes failures to seat connectors completely and failure to test locking features of connectors for engagement)	3.6-03	4.9-06
	CHECKER FAILS TO DETECT ERROR		
31	Checking routine tasks, checker using written materials (includes over-the-shoulder inspections, verifying position of locally operated valves, switches, circuit breakers, connectors, etc., and checking written lists, tags, or procedures for accuracy)	1.5-01	1.7-02
33	Special short-term, one-of-a-kind checking with alerting factors	7.5-02	4.1-03
34	Checking that involves active participation, such as special measurements	1.5-02	1.7-04
35	Given that the position of a locally operated* valve is checked (item 31 above), checking that it is completely opened or closed after being changed or restored	5.0-01	2.5-01
36	Checking by reader/checker of the task* performer in a two-man team, or checking by a second checker, routine task (no credit for more than 2 checkers)	5.0-01	2.5-01
37	Checking of status of equipment if that status affects one's safety when performing his tasks	1.5-03	1.7-06
38	An operator checks change or restoration tasks performed by a maintainer	7.5-04	8.5-07

TABLE 3C.4-1 (Continued)

HEP DATA BANK

NO.	HEP Description	HEP(Mean)	Variance
	FAIL TO RESPOND TO ONE OF MANY ANNUNCIATORS ALARMING CLOSELY IN TIME		
39	1 annunciator alarming	2.1-04	6.2-08
40	2 annunciators alarming	1.3-03	2.2-06
41	3 annunciators alarming	2.1-03	6.2-06
42	4 annunciators alarming	4.2-03	2.5-05
43	5 annunciators alarming	6.3-03	5.6-05
44	6 annunciators alarming	1.1-02	1.6-04
45	7-10 annunciators alarming	1.0-01	1.6-02
46	>10 annunciators alarming	3.4-01	6.5-02
	FAILURE TO RESPOND TO AN ANNUNCIATED LEGENL LIGHT		
47	Resume attention to a legend light within 1 minute after an interruption (sound and blinking cancelled before interruption)	1.2-03	5.5-07
48	Respond to a legend light if more than 1 minute elapses after an interruption (sound and blinking cancelled before interruption)	~1.0	
49	Respond to a steady-on legend light during initial audit	~1.0	
50	Respond to a steady-on legend light during other hourly scans	~1.0	

Notes

* Nominal HEPs are used, instead of means.

TABLE 3C.4-2

CONVERSION FROM MEDIAN TO MEAN

Median	EF	Mean	Variance
0.5	5	5.4-01	4.5-02
0.3	5	6.0-01	6.4-02
0.2	5	3.0-01	6.6-02
0.1	5	1.5-01	1.7-01
0.1	10	2.1-01	6.2-02
0.05	5	7.5-02	4.1-03
0.05			
0.01	3	1.2-02	5.5-05
0.01	5	1.5-02	1.7-04
0.01	10	2.1-02	6.2-04
0.005	3	6.1-03	1.4-05
0.005	10	1.1-02	1.6-04
0.003	3	3.6-03	4.9-06
0.003			
0.001	3	1.2-03	5.5-07
0.001	5	1.5-03	1.7-06
0.001	10	2.1-03	6.2-06
0.0005	10	1.1-03	1.6-06
0.0005			
0.0001	10	2.1-04	6.2-08
0.0001	30	4.4-04	4.7-07
0.0001			
0.00001	30	4.4-05	4.7-09
0.25	5	3.3-01	6.5-02

TABLE 3C.3-1

LOGUNI CODE LISTING

```
C     LOGUNI. A CODE TO CALCULATE MEAN AND VARIANCE FOR TRUNCATED LOGUNIFORM DISTRIBUTION.
C     SELIM SANCAKTAR, AUG 30,1983.
C
      CHARACTER*32 OUTPUT
      WRITE(6,100)
100   FORMAT(10X,'ENTER NAME OF OUTPUT FILE',//)
      READ(5,110) OUTPUT
110   FORMAT(A32)
      OPEN(20,FILE=OUTPUT, CARRIAGECONTROL='FORTRAN')
      OPEN(21,FILE='LOUT', CARRIAGECONTROL='FORTRAN')
      WRITE(20,120)
      WRITE(21,121)
120   FORMAT(///,11X,'I',6X,'L',14X,'MEDIAN',9X,'MEAN',11X,'M',14X,'VA
     'R',//)
121   FORMAT(///,16X,'MEDIAN',7X,'EF',6X,'MEAN',8X,'VARIANCE',4X,//)
      I=0
C
1     WRITE(6,2)
2     FORMAT(10X,'ENTER MEDIAN VALUE',//)
      READ (5,*) XMED
      IF(XMED.EQ.1.0) GOTO 999
      WRITE(6,4)
4     FORMAT(10X,'ENTER ERROR FACTOR VALUE',//)
      READ(5,*) EF
      XM=EF*XMED
      IF(XM.GT.1.00) GOTO 7
      XL=XMED/EF
      GOTO 8
7     EF=1.00/XMED
      XM=1.00
8     XL=XMED/EF
      CONTINUE
      I=I+1
      YM=ALOG(XM)
      YL=ALOG(XL)
      V=((XM)**2-(XL)**2)/(2.0*(YM-YL))-((XM-XL)/(YM-YL))**2
      XXX=(YM+YL)/2.0
      X50=EXP(XXX)
      XMEAN=(XM-XL)/(YM-YL)
      WRITE(6,11) X50,EF,XMEAN,V
      WRITE(20,10) I,XL,X50,XMEAN,XM,V
12    WRITE(21,12) X50,EF,XMEAN,V
10    FORMAT(11X,1P,E12.1,0P,F9.1,1P,2E12.1,//)
11    FORMAT(10X,I3,2X,1P,5(E10.1,5X),//)
999   FORMAT(10X,1P,4E10.2)
      GOTO 1
      END
```

TABLE 3C.3-2

CONVERSION FROM MEDIAN TO MEAN VALUES

MEDIAN	EF	MEAN	VARIANCE
5.0E-01	2.0	5.4E-01	4.5E-02
3.0E-01	3.3	3.8E-01	6.3E-02
2.5E-01	4.0	3.4E-01	6.5E-02
2.0E-01	5.0	3.0E-01	6.6E-02
1.0E-01	5.0	1.5E-01	1.7E-02
1.0E-01	10.0	2.1E-01	6.2E-02
5.0E-02	5.0	7.5E-02	4.1E-03
1.0E-02	3.0	1.2E-02	5.5E-05
1.0E-02	5.0	1.5E-02	1.7E-04
1.0E-02	10.0	2.1E-02	6.2E-04
5.0E-03	3.0	6.1E-03	1.4E-05
5.0E-03	10.0	1.1E-02	1.6E-04
3.0E-03	3.0	3.6E-03	4.9E-06
1.0E-03	3.0	1.2E-03	5.5E-07
1.0E-03	5.0	1.5E-03	1.7E-06
1.0E-03	10.0	2.1E-03	6.2E-06
5.0E-04	10.0	1.1E-03	1.6E-06
1.0E-04	10.0	2.1E-04	6.2E-08
1.0E-04	30.0	4.4E-04	4.7E-07

APPENDIX 3D

DATA BASE

3D.1 STORAGE OF DATA

In order to assure the use of proper data on all analyses, one data file is used for all quantifications. The numbers that were calculated or taken from previous reports are all rounded to three significant digits while those obtained from fault tree results are rounded to two significant digits. This file is updated each time a new value is calculated. This process eliminates use of obsolete or incomplete data. Table 3D.1-1 is a list of the data base as of November 4, 1983. The far right column gives the source of the data. The following is an explanation of these sources:

ZPSS - Zion Probabilistic Safety Study (Table 1.5.1-5, except maintenance frequencies which come from appropriate fault tree analysis write-up)

TP - Torrey Pines Auxiliary Feedwater Reliability Study, Report No. GA-C16444

BRS - Byron Risk Report (Page 4.6.5-2)

CS - Containment Spray fault tree

NREP - National Reliability Evaluation Program

ESW - Essential Service Water fault tree

CCW - Component Cooling Water fault tree

AF1-AF2 - Calculations found in Auxiliary Feedwater Write-Up (Section 3.5)

HE1-HE8 - Calculations explained in Section 3C.1

CC1-CC2 - Calculations found in Component Cooling Water Write-Up (Section 3.4)

ES1-ES5 - Calculations found in Essential Service Water Write-Up (Section 3.3)

NA1 - Calculations found in Containment Heat Removal Write-Up (Section 3.8)

AC1 - Calculations found in AC Power Write-Up (Section 3.2)

HP2-HP5 - Calculations found in High Pressure Injection Write-Up (Section 3.7)

CS1-CS3 - Calculations found in Containment Heat Removal Write-Up (Section 3.8)

FC1-FC2 - Calculations found in Containment Heat Removal Write-Up (Section 3.8)

C1-C3 - Calculations explained below

C1 = (4 hours) (hourly failure rate of bus)
= 4 (1.91×10^{-8})

C2 = Common cause β x failure probability of alt. pump
(.093) (7.21×10^{-4})

C3 = Common cause β x failure probability of MOV to operate
(.023) (1.55×10^{-3})

3D.2 SUPPORT STATES

Each system will require only one fault tree to analyze all power states. This is done by explicitly modeling failure of 4160V buses within the tree and switching these nodes "on" and "off." For example, for power state 1, both 141 and 142 buses are available. In this case the failure nodes for both 141 and 142 are "switched off" or set equal to zero. For power state 3, in which bus 141 fails, the node for failure of bus 141 is "switched on," or set equal to 1.0. The same method is used for ESW availability. Therefore, changing power states involves changing a few node values, not creating separate fault trees. Table 3D.2-1 lists the support states quantified.

TABLE 3D.2-1

SUPPORT STATES

Support State	ESW Available	ESF Buses Available
1	Yes	141, 142
2	No	141, 142
3	Yes	142
4	Yes	141
5	Yes	None
6	No	None

TABLE 3D-1 (Sheet 1 of 8)

MASTER DATA FILE FOR BYRON LCOR PROGRAM

#	COMP	SYSTEM	FAILURE MODE	FAIL RATE	VARIANCE	UNIT	SOURCE
1	X,MV	ALL	TRANSFER CLOSED	5.28OE-08	2.82OE-15	HR	ZPSS
2	XV	ALL	TRANSFER OPEN/EXCESS LEAKAGE	0.000E-01	0.000E-01	HR	ZPSS
3	CV	ALL	FAILURE TO OPEN ON DEMAND	4.32OE-05	2.41OE-09	D	ZPSS
4	CV	ALL	FAIL TO SEAT/EXCESS LEAKAGE	8.38OE-07	7.29OE-13	HR	ZPSS
5	RV	ALL	PREMATURE OPEN OR LEAK	1.63OE-06	1.81OE-12	HR	ZPSS
6	MOV	ALL/CS,CVC	FAIL TO OPERATE	1.55OE-03	6.30OE-08	D	ZPSS
7	MOV	CS	FAIL TO OPERATE	5.73OE-03	1.84OE-06	D	ZPSS
8	MOV	CVC	FAIL TO OPERATE	3.72OE-03	2.71OE-06	D	ZPSS
9	MOV	ALL	TRANSFER OPEN/EXCESS LEAK	3.14OE-08	1.56OE-14	HR	ZPSS
10	AOV	ALL	FAIL TO OPERATE	1.44OE-03	7.93OE-07	D	ZPSS
11	AOV	ALL	TRANSFER CLOSED/PLUG	1.12OE-07	1.84OE-14	HR	ZPSS
12	AOV	ALL	TRANSFER OPEN/LEAK	3.14OE-08	1.56OE-14	HR	NOT6
13	MDP	ALL/AFW	FAIL TO START	7.21OE-04	1.91OE-07	D	ZPSS
14	TDP	AFW	FAIL TO START	2.29OE-02	7.60OE-05	D	ZPSS
15	MDP	SIS	FAIL DURING OPERATION	1.55OE-05	2.96OE-08	HR	ZPSS
16	MDP	RHR	FAIL DURING OPERATION	2.53OE-06	3.39OE-11	HR	ZPSS
17	MDP	CCW	FAIL DURING OPERATION	1.76OE-06	9.62OE-12	HR	ZPSS
18	MDP	ESW	FAIL DURING OPERATION	1.32OE-06	3.74OE-12	HR	ZPSS

MASTER DATA FILE FOR BYRON LCOR PROGRAM

19	MDP	CSS	FAIL DURING OPERATION	1.500E-05	1.960E-08	HR	ZPSS
20	MDP	AFW	FAIL DURING OPERATION	9.870E-05	1.980E-08	HR	ZPSS
21	TDP	AFW	FAIL DURING OPERATION	7.630E-06	1.200E-09	HR	ZPSS
22	CFC	CFC	FAIL TO START	1.170E-03	7.600E-07	D	ZPSS
23	CFC	CFC	FAIL DURING OPERATION	3.530E-06	1.330E-11	HR	ZPSS
24	HX	ALL	LEAKAGE	7.130E-07	1.130E-12	HR	ZPSS
25	HX	ALL	TUBE SIDE PLUGGED	0.000E-01	0.000E-01	HR	ZPSS
26	HX	ALL	SHELL SIDE PLUGGED	0.000E-01	0.000E-01	HR	ZPSS
27	DG	DG	FAIL TO START	1.820E-02	1.260E-05	D	ZPSS
28	DG	DG	FAIL DURING OPERATION	5.970E-03	4.050E-06	HR	ZPSS
29	BKR	AC	FAIL TO CLOSE	1.260E-03	2.870E-07	D	ZPSS
30	BKR	AC	FAIL TO OPEN	5.310E-04	9.730E-08	D	ZPSS
31	BKR	AC	TRANSFER OPEN	2.320E-07	3.030E-13	HR	ZPSS
32	XFMR	AC	FAIL DURING OPERATION	1.730E-06	3.170E-12	HR	ZPSS
33	INV	AC	FAIL DURING OPERATION	1.090E-05	3.040E-12	HR	ZPSS
34	BAT	DC	FAIL DURING OPERATION	7.610E-08	4.270E-14	HR	ZPSS
35	BCHG	DC	FAIL DURING OPERATION	5.540E-07	6.940E-12	HR	ZPSS
36	MDP	AFW	FAIL TO START	5.020E-03	9.260E-06	D	ZPSS
37	DDP	AFW	MAINTENANCE FREQUENCY	1.260E-04	0.000E-01	HR	AF1
38	MDP	AFW	MAINTENANCE FREQUENCY	1.870E-04	0.000E-01	HR	ZPSS
39	DAMP	CFC	FAIL TO OPERATE	1.850E-03	1.390E-06	D	ZPSS
40	MDP	CVC	FAIL DURING OPERATION	1.760E-06	9.620E-12	HR	ZPSS

TABLE 3D-1 (Sheet 3 of 8)

MASTER DATA FILE FOR BYRON LCOR PROGRAM

41	BUS	EP	OPEN CIRCUIT	1.910E-08	2.220E-15	HR	ZPSS
42	SWTC	EP	TRANSFER OPEN	0.000E-01	0.000E-01	HR	ZPSS
43	CBL	RPS	LINE TO LINE SHORT	3.220E-06	8.960E-11	HR	ZPSS
44	CBL	RPS	LINE TO GROUND SHORT	7.520E-06	4.880E-10	HR	ZPSS
45	RLY	EP	FAIL TO OPEN	6.280E-06	2.490E-11	D	ZPSS
46	<3"	ALL	RUPTURES/PLUGS	8.600E-09	6.000E-15	HR	ZPSS
47	>3"	ALL	RUPTURES/PLUGS	8.600E-10	6.000E-17	HR	ZPSS
48	CST	AFW	DOES NOT SUPPLY WATER	8.480E-10	5.100E-17	HR	ZPSS
49	BKR	RPS	FAIL TO OPEN	9.790E-03	4.390E-05	D	ZPSS
50	FUSE	ESFAS	OPEN PREMATURELY	8.320E-07	1.080E-09	HR	ZPSS
51	LATC	ESFAS	FAIL TO ENERGIZE	1.150E-05	3.380E-09	D	ZPSS
52	RELA	ESFAS	CONTACTS OPEN	2.430E-07	3.260E-13	HR	ZPSS
53	BSTB	ESFAS	FAIL TO OPEN	3.880E-07	1.470E-13	D	ZPSS
54	XMTR	ESFAS	FAIL PROPER OUTPUT	1.660E-06	6.280E-12	HR	ZPSS
55	SWTC	ESFAS	SHORT ACROSS CONTACTS	4.280E-07	3.360E-10	HR	ZPSS
56	SV	ALL	FAIL TO OPERATE	2.000E-06	6.100E-12	D	NREP
57	DDP	AFW	FAIL TO START	2.330E-02	0.000E-01	D	TP
58	DDP	AFW	FAIL DURING OPERATION	1.090E-03	0.000E-01	HR	TP
59	CFC	CFC	MAINTENANCE FREQUENCY	2.190E-04	0.000E-01	HR	ZPSS
60	BUS	ALL	NO POWER-4 HR DETECTION TIME	7.640E-08	0.000E-01	D	C1
61	BAT	NA	INSUFFICIENT NAOH S	7.300E-04	00E-13	D	ZPSS
62	XV	CFC	FAIL TO RESTORE-COIL MAINT.	8.400E-04	0.000E-01	D	FC3

MASTER DATA FILE FOR BYRON LCOR PROGRAM

63	CSIT	NA	CS TRAIN FAILS-3DAY	1.100E-02	0.000E-01	D	CS
64	CSIT	NA	CS TRAIN FAILS-7DAY	1.200E-02	0.000E-01	D	CS
65	ESW	ALL	NOIF ESW LOCA PS 1,3D LCO	2.000E-05	0.000E-01	D	ESW
66	ESW	ALL	NOIF ESW LOCA PS 1,7D LCO	2.200E-05	0.000E-01	D	ESW
67	MV	ALL	FAIL TO RESTORE/INDICATED	4.400E-05	0.000E-01	D	HE1
68	XV	ALL	FAIL TO RESTORE	2.100E-04	0.000E-01	D	HE2
69	DG	AC	DIESEL MAINTENANCE FREQUENCY	8.090E-04	0.000E-01	HR	ZPSS
70	ACCU	ACCU	ACCUM LEVEL OUT OF RANGE	1.000E-06	0.000E-01	D	ZPSS
71	ACCU	ACCU	ACCUM N2 PR.OUT OF RANGE	1.000E-06	0.000E-01	D	ZPSS
72	SWT+	ALL	SWITCH ON	1.000E+00	0.000E-01	D	NONE
73	SWT-	ALL	SWITCH OFF	0.000E-01	0.000E-01	D	NONE
74	SUMP	LPR	SUMP GRATINGS BLOCKED	5.000E-05	6.400E-06	D	ZPSS
75	STR	ESW	STRAINER FAILURE	2.400E-04	1.400E-05	D	BRS
77	MDP	ES/CC	CCW PUMP MAINT. FREQUENCY	2.360E-04	0.000E-01	HR	CC1
78	STR	ESW	STRAINER MAINT. FREQUENCY	1.000E-05	0.000E-01	HR	ES1
79	MDP	RHR	MAINTENANCE FREQUENCY	6.120E-05	2.870E-10	HR	ZPSS
80	MDP	CSS	MAINTENANCE FREQUENCY	6.540E-05	0.000E-01	HR	ZPSS
81	MDP	CHG	MAINTENANCE FREQUENCY	1.450E-04	0.000E-01	HR	ZPSS
82	MDP	SIS	MAINTENANCE FREQUENCY	4.040E-05	0.000E-01	HR	ZPSS
83	MV	ALL	MAINTENANCE FREQUENCY	7.080E-07	0.000E-01	HR	ZPSS
84	CC	NAOH	COMMON CAUSE FAILURES	1.720E-04	0.000E-01	D	NA1
85	AOV	ALL	MAINTENANCE FREQUENCY	6.580E-07	0.000E-01	HR	ZPSS

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86	MDP	ALL	PUMP TEST	9.130E-04	0.000E-01	D	ZPSS
87	HE	ESW	OPERATOR FAILS TO ALIGN	2.000E-03	0.000E-01	D	HE3
88	CC	CCW	CC RUNNING CCW TRAINS	4.590E-06	0.000E-01	D	CCW
89	CC	AFW	COMMON CAUSE FAILURES	1.930E-04	0.000E-01	D	AF2
90	CC	AC	COMMON CAUSE FAILURES	6.300E-04	0.000E-01	D	AC1
92	CC	RH/SI	COMMON CAUSE PUMP START	2.240E-04	5.020E-08	D	HP2
93	CC	CSS	COMMON CAUSE PUMP START	2.240E-04	0.000E-01	D	CS1
94	CC	CSS	COMMON CAUSE PUMP RUN	2.120E-06	0.000E-01	HR	CS2
95	CC	RHR	COMMON CAUSE PUMP RUN	3.570E-07	1.270E-13	HR	HP3
96	CC	CSS	COMMON CAUSE MOV	1.720E-04	0.000E-01	D	CS3
97	CCW	ALL	CCW TRAIN A,SS1,3D LCO	2.200E-06	0.000E-01	D	CCW
98	CCW	ALL	CCW TRAIN B,SS1,3D LCO	1.600E-08	0.000E-01	D	CCW
99	ESWH	ESW	COMMON CAUSE HEAT EXCH	8.920E-05	0.000E-01	D	ES2
100	ESWP	ESW	CC RUNNING ESW TRAINS	1.130E-05	0.000E-01	D	ES3
101	ESWP	ESW	CC STANDBY ESW TRAINS	8.700E-05	0.000E-01	D	ES4
102	ESWU	ESW	CC ESW BETWEEN UNITS	1.200E-05	0.000E-01	D	ES5
103	FANS	ESW	UHS FAN MAINT. FREQ.	5.850E-05	0.000E-01	HR	ESW
108	OPER	RHR	OP FAILS TO OPEN CC9412A,B	9.600E-05	0.000E-01	D	HE4
109	CC	CCW	COMMON CAUSE STANDBY PUMPS	7.160E-05	0.000E-01	D	CC2
110	OPER	CCW	OPERATOR ERROR MANUAL VLV	1.100E-03	0.000E-01	D	HE5
111	[illegible]ER	CCW	OPERATOR ERROR MOTOR [illegible]/LV	1.400E-03	0.[illegible]E-01	D	[illegible]
112	FLNG	CSS	FAIL TO RESTORE FOL REFUEL	1.800E-03	0.000E-01	D	HE6

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113	CC	CFC	CC-ALT. COOLERS FAIL TO RUN	1.450E-07	0.000E-01	HR	FC1
114	CC	CFC	CC-ALT. COOLERS TO START	1.090E-04	0.000E-01	D	FC2
115	CC	ALL/AFW	CC-ALT. PUMPS TO START	6.710E-05	0.000E-01	D	C2
116	CC	SIS	COMMON CAUSE PUMP RUN	2.480E-07	0.000E-01	HR	HP4
117	CC	CVC	COMMON CAUSE PUMP RUN	2.820E-08	0.000E-01	HR	HP5
118	CC	ALL/CS,CVC	COMMON CAUSE MOV	4.650E-05	0.000E-01	D	C3
119	OPER	RHR	OP FAILS TO CLOSE SI8812A,B	1.400E-04	0.000E-01	D	HE7
127	CCW	ALL	CCW SYSTEM SS1,3D LCO	4.400E-09	0.000E-01	D	CCW
128	CCW	ALL	CCW TRAIN A SS2,3D LCO	1.800E-05	0.000E-01	D	CCW
129	CCW	ALL	CCW TRAIN B SS2,3D LCO	1.200E-05	0.000E-01	D	CCW
130	CCW	ALL	CCW SYSTEM SS2,3D LCO	1.100E-05	0.000E-01	D	CCW
131	CCW	ALL	CCW TRAIN A SS3,3D LCO	1.300E-05	0.000E-01	D	CCW
132	CCW	ALL	CCW TRAIN B SS3,3D LCO	7.300E-06	0.000E-01	D	CCW
133	CCW	ALL	CCW SYSTEM SS3,3D LCO	5.900E-06	0.000E-01	D	CCW
134	CCW	ALL	CCW TR A SS4,3D LCO	2.600E-04	0.000E-01	D	CCW
135	CCW	ALL	CCW TR B SS4,3D LCO	1.300E-03	0.000E-01	D	CCW
136	CCW	ALL	CCW COMMON,3D LCO	4.800E-02	0.000E-01	D	CCW
157	CCW	ALL	NOIF CCW TR A S.S.1,7D	2.900E-06	0.000E-01	D	CCW
158	CCW	ALL	NOIF CCW TR B S.S.1,7D	1.800E-08	0.000E-01	D	CCW
159	CCW	ALL	NOIF COMMON S.S.1,7D	6.100E-09	0.000E-01	D	CCW
160	CCW	ALL	NOIF CCW TR A S.S.2,7D	1.900E-05	0.000E-01	D	CCW
161	CCW	ALL	NOIF CCW TR B S.S.2,7D	1.200E-05	0.000E-01	D	CCW

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MASTER DATA FILE FOR BYRON LCOR PROGRAM

162	CCW	ALL	NOIF COMMON S.S.2,7D	1.100E-05	0.000E-01	D	CCW
163	CCW	ALL	NOIF CCW TR A S.S.3,7D	1.400E-05	0.000E-01	D	CCW
164	CCW	ALL	NOIF CCW TR B S.S.3,7D	7.700E-06	0.000E-01	D	CCW
165	CCW	ALL	NOIF COMMON S.S.3,7D	6.300E-06	0.000E-01	D	CCW
166	CCW	ALL	NOIF CCW TR A S.S.4,7D	2.700E-04	0.000E-01	D	CCW
167	CCW	ALL	NOIF CCW TR B S.S.4,7D	1.300E-03	0.000E-01	D	CCW
168	CCW	ALL	NOIF COMMON P.S.4,7D	4.100E-02	0.000E-01	D	CCW
169	N#7	ALL	S/U NOIF COMMON PS1,3D	8.600E-07	0.000E-01	D	CCW
170	CCW	ALL	S/U NOIF TRAINA PS1,3D	2.200E-06	0.000E-01	D	CCW
171	CCW	ALL	S/U NOIF TRAINB PS1,3D	9.300E-07	0.000E-01	D	CCW
172	CCW	ALL	S/U NOIF COMMON PS2,3D	1.000E-03	0.000E-01	D	CCW
173	CCW	ALL	S/U NOIF TRAINA PS2,3D	1.100E-03	0.000E-01	D	CCW
174	CCW	ALL	S/U NOIF TRAINB PS2,3D	1.000E-03	0.000E-01	D	CCW
175	CCW	ALL	S/U NOIF COMMON PS3,3D	8.400E-04	0.000E-01	D	CCW
176	CCW	ALL	S/U NOIF TRAINA PS3,3D	8.400E-04	0.000E-01	D	CCW
177	CCW	ALL	S/U NOIF TRAINB PS3,3D	2.600E-03	0.000E-01	D	CCW
178	CCW	ALL	S/U NOIF COMMON PS1,7D	9.400E-07	0.000E-01	D	CCW
179	CCW	ALL	S/U NOIF TRAINA PS1,7D	2.300E-06	0.000E-01	D	CCW
180	CCW	ALL	S/U NOIF TRAINB PS1,7D	1.000E-06	0.000E-01	D	CCW
181	CCW	ALL	S/U NOIF COMMON PS2,7D	1.100E-03	0.000E-01	D	CCW
182	CCW	ALL	S/U NOIF TRAINA PS2,7D	1.100E-03	0.000E-01	D	CCW
183	CCW	ALL	S/U NOIF TRAINB PS2,7D	1.100E-03	0.000E-01	D	CCW

MASTER DATA FILE FOR BYRON LCOR PROGRAM

184	CCW	ALL	S/U NOIF COMMON PS3,7D	8.800E-04	0.000E-01	D	CCW
185	CCW	ALL	S/U NOIF TRAINA PS3,7D	8.900E-04	0.000E-01	D	CCW
186	CCW	ALL	S/U NOIF TRAINB PS3,7D	2.700E-03	0.000E-01	D	CCW

NOTES: 1) ZION FAILURE DATA FOR FAULTS 1 THRU 55 TAKEN FROM ZPSS TABLE 1.5.1-5

2) BYRON RISK REPORT (BRS) SYSTEM FAILURE RATE FOR ESWS TAKEN FROM PG.4.6.5-2.

3) TORREY PINES AFW REPORT (TP) DATA TAKEN FROM TABLE A.I

4) MAINTENANCE FREQUENCIES FOR COMPONENTS TAKEN FROM ZPSS TABLE 1.5.1-29

5) HUMAN ERROR RATES TAKEN FROM NUREG/CR-1278

6) ASSUME SAME VALUE AS USED FOR MOV IN #9,ABOVE

7) S/U REFERS TO SINGLE UNIT OPERATION. ALSO, NOTE A DISTINCTION BETWEEN SUPPORT STATES AND POWER STATES, I.E. PS 1 EQUALS SS 1, PS 2 EQUALS SS3, AND PS 3 EQUAL

SECTION 4.0

PLANT RISK QUANTIFICATION

In this section, accident sequences modeled by event trees in Section 2.0 are quantified using system failure probabilities calculated in Section 3.0. The calculations are done in three phases for 3-day and 7-day plant LCO. These phases are:

A. Calculation of event tree nodal probabilities

B. Calculation of core melt frequency

C. Calculation of plant risk

Section 4.1 contains the 3-day LCO, and Section 4.2 contains the 7-day LCO calculations and results.

A summary of the nodes required for each event tree is tabulated in Table 4-1.

The containment response analysis is given by Appendix 4A. The results of the analysis are summarized in terms of the containment matrix, "C-matrix."

The consequence analysis is given by Appendix 4B. The results of the analysis are summarized in terms of five site matrices, S-matrices, one for each of the five consequence categories studied.

The risk assembly process is done in a matrix format as described by Appendix 4C.

TABLE 4-1

EVENT TREE SYNOPSIS

	TK	TR	SA	LP	CS	NA	CF	CC	R	HH	K	L	OP	MT	LK	S2	MS	TT
ET01 Large LOCA	X	1	1	X	X	X	X	X	1									
ET02 Medium LOCA	X	1	1	X	X	X	X	X	1	1								
ET03 Small LOCA	X		1		X	X	X	X	2	2	3	1	1					
ET04 SG Tube Rupture			2						2		3	1	5,8	X	X			
ET05 Secondary Break (inside containment)		3	2		X	X	X		2		3	1	3			X	1	
ET06 Secondary Break (outside containment)		3	2		X	X	X		2		3	1	3			X	1	
ET07 Loss of Feedwater		2			X	X	X		2		3	1	2			X	2	1
ET08 Single MSIV Closure		2			X	X	X		2		3	1	2,4			X	2	1
ET09 Low RCS Flow		2			X	X	X		2		3	1	2			X	2	1

TABLE 4-1 (Continued)

EVENT TREE SYNOPSIS

	TR	CS	NA	CF	R	K	L	OP	S2	MS	TT	E30	120	PL	PR	SO	V
ET10 Core Power Excursion	2	X	X	X	2	3,5	1	2,9	X								
ET11 Turbine Trip	2	X	X	X	2	3	1	2	X								
ET12 LOOP	2 (SS 1-4)	X	X	X	2	3	1	2	X			X (SS 5,6 only)	X				
ET13 Spurious SI	2	X	X	X	2	3	1	3	X	2	1						
ET14 Reactor Trip	2	X	X	X	2	2	1	2	X	2	1						
ET15 Interfacing Systems LOCA																	X
ET16 ATWS		X	X	X	2		1,2	2,6,7			2			X	1,2	X	

4.1 THREE DAY LCO PLANT RISK QUANTIFICATION

In this section plant risk is quantified by first calculating core melt frequency using event tree analysis for 3-day LCO. The above information is used to determine the radiological release and exposure to the public to yield total plant risk. In the following three subsections, the event tree nodal probabilities, the core melt frequency and plant risk are calculated.

4.1.1 CALCULATION OF EVENT TREE NODES FOR 3 DAY LCO

The unavailabilities used for each node are contained in the following tables:

Fluid System	-	Table 4.1.1.a
Plant Functions	-	Table 4.1.1.b
Operator Actions	-	Table 4.1.1.c
Consequential Failure Rates	-	Table 4.1.1.d

TABLE 4.1.1.a

FLUID SYSTEM MEAN UNAVAILABILITIES (3 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
CC	Note 4.1.1.a.1	0	0	0	0	0	0
CF	Note 4.1.1.a.2	5.9(-6)	1.0	1.3(-2)	1.3(-2)	1.0	1.0
CS	Note 4.1.1.a.2	5.6(-4)	5.6(-4)	1.1(-2)	1.1(-2)	1.0	1.0
HH1	Section 3.7	6.0(-6)	1.0	1.2(-2)	1.2(-2)	1.0	1.0
HH2	Section 3.7	1.1(-7)	1.0	2.8(-5)	2.8(-5)	1.0	1.0
L-1	Section 3.5	5.0(-4)	3.4(-2)	3.4(-2)	5.0(-4)	3.4(-2)	3.4(-2)
L-2	Section 3.5	5.1(-4)	3.5(-2)	3.5(-2)	5.1(-4)	3.5(-2)	3.5(-2)
LP	Note 4.1.1.a.3	6.7(-4)	6.7(-4)	4.5(-3)	4.5(-3)	1.0	1.0
NA	Note 4.1.1.a.2	1.4(-3)	1.4(-3)	2.3(-2)	2.3(-2)	1.0	1.0
R-1	Section 3.6.2	2.5(-4)	1.0	4.5(-3)	4.5(-3)	1.0	1.0
R-2	Note 4.1.1.a.4	4.8(-4)	1.0	1.1(-2)	8.4(-3)	1.0	1.0

Fluid System Mean Unavailability Notes
(Three Day LCO)

4.1.1.a.1 CC

The contribution of component cooling is considered within the fault tree. Therefore, the unavailability of node CC in the event tree is set equal to zero.

4.1.1.a.2 CF, CS, NA

The unavailability of each of the following systems is taken from the referenced section for all event trees except Loss of Offsite Power (LOOP). For the LOOP tree, an additional unavailability conditional on the recovery of AC power (node 120) is modeled for support state 5.

System	Section	Unavailability in Support State 5
Containment Fan Coolers	3.8	5.9 (-6)/demand
Containment Spray	3.9.1	5.6 (-4)/demand
Sodium Hydroxide Tanks	3.9.2	1.4 (-3)/demand

4.1.1.a.3 LP

The unavailability due to the low pressure safety injection and accumulator injection systems are taken from Section 3.6.2 of this report. Although accumulator injection is not required for a medium LOCA, no distinction was made between low pressure safety injection with or without accumulator injection. Low pressure SI with accumulator injection is dominant and is used for both.

4.1.1.a.4 R-2

The unavailability due to the high pressure recirculation system is taken from Section 3.7 of this report. R-2 recirculation applies to event trees where the initiating event leaves the reactor coolant system at a pressure high enough

to require high head recirculation cooling. Although one could develop separate nodes which would apply to non-LOCA transients where "feed and bleed" core cooling is used or to a steam generator tube rupture transient where only long term cooling is required, the unavailability of both of these states is bounded by the unavailability of R-2. Therefore, R-2 applies to small LOCA, steam generator tube rupture, and non-LOCA transients.

TABLE 4.1.1.b

PLANT FUNCTION MEAN UNAVAILABILITIES (3 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
K-2	(1) Tbl. 4.5-4	1.3(-6)	1.3(-6)	1.3(-6)	1.3(-6)	1.3(-6)	1.3(-6)
K-3	(1) Tbl. 4.5-4	1.8(-6)	1.8(-6)	1.8(-6)	1.8(-6)	1.8(-6)	1.8(-6)
K-5	(1) Tbl. 4.5-4	1.0(-3)	1.0(-3)	1.0(-3)	1.0(-3)	1.0(-3)	1.0(-3)
MS-1	(1) Tbl. 4.5-4	1.0(-4)	1.0(-4)	1.0(-4)	1.0(-4)	1.0(-4)	1.0(-4)
MS-2	(1) Tbl. 4.5-4	9.4(-2)	9.4(-2)	9.4(-2)	9.4(-2)	9.4(-2)	9.4(-2)
PL	(1) Tbl. 4.5-4	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)
PR1	(1) Tbl. 4.5-4	1.0(-6)	1.0(-6)	1.0(-6)	1.0(-6)	1.0(-6)	1.0(-6)
PR2	Note 4.1.1.b.1	1.2(-2)	1.2(-2)	1.2(-2)	1.2(-2)	1.0	1.0
SA1	(1) Tbl. 4.5-4	2.9(-7)	2.9(-7)	2.9(-7)	2.9(-7)	2.9(-7)	2.9(-7)

Reference 1 - Byron Risk Study, February 1983

TABLE 4.1.1.b (Continued)

PLANT FUNCTION MEAN UNAVAILABILITIES (3 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
SA2	Note 4.1.1.b.2	4.0(-7)	1.0	2.8(-5)	2.8(-5)	1.0	1.0
SO	(1) Tbl. 4.5-4	1.0(-2)	1.0(-2)	1.0(-2)	1.0(-2)	1.0(-2)	1.0(-2)
TK	(1) Tbl. 4.5-4	2.4(-8)	2.4(-8)	2.4(-8)	2.4(-8)	2.4(-8)	2.4(-8)
TT1	(1) Tbl. 4.5-4	2.8(-6)	2.8(-6)	2.8(-6)	2.8(-6)	2.8(-6)	2.8(-6)
TT2	(2) Pg. 2.2-51	1.4(-1)	1.4(-1)	1.4(-1)	1.4(-1)	1.4(-1)	1.4(-1)
E60	Note 4.1.1.b.3	N.A	N/A	N/A	N/A	1.0	1.0
120	Note 4.1.1.b.4	N/A	N/A	N/A	N/A	7.4(-1)	7.4(-1)
V	Note 4.1.1.b.5	1.0	1.0	1.0	1.0	1.0	1.0

Reference 1 - Byron Risk Study, February 1983

Reference 2 - Millstone Probabilistic Safety Study, August 1983

Plant Function Mean Unavailability Notes
(Three Day LCO)

4.1.1.b.1 PR2 PRIMARY SYSTEM PRESSURE RELIEF VALVE CLOSURE

Failure of this function is dominated by failure of the operator to close the PORVs (or block valves). The failure of the safety valves to reclose is a secondary failure mechanism for this node.

The failure is modeled as a diagnostic failure by operators within a 20 minute period with a stress level of 3. Two experienced operators with a medium dependence between them are modeled. The equation used to calculate the failure probability is:

$$q_{PR2} = 3q_1 \left(\frac{1+6\ (3\ q_1)}{7}\right)$$

The failure probability q_1 for one operator is taken from Appendix 3C, Table 3C.4-1, item 2 as:

$$q_1 = 2.1 \times 10^{-2}$$

Then the probability q_{PR2} is calculated as:

$$q_{PR2} = 1.2 \times 10^{-2}$$

The nodal probabilities for support states are given below:

Support State No.	Probability of Failure of PR2
1	1.2×10^{-2}
2	1.2×10^{-2}
3	1.2×10^{-2}
4	1.2×10^{-2}
5	1.0
6	1.0

4.1.1.b.2 SA2 SI SIGNAL AND HIGH HEAD PUMPS

Node SA2 signifies the presence of an SI signal and the operation of the high head SI pumps.

$$q(SA2) = q(SA1) + q(HH2) * [1 - q(SA1)] \sim q(SA1) + q(HH2)$$

Support State	q(SA1)	q(HH2)	q(SA2)
1	2.9(-7)	1.1(-7)	4.0(-7)
2	2.9(-7)	1.0	1.0
3	2.9(-7)	2.8(-5)	2.8(-5)
4	2.9(-7)	2.8(-5)	2.8(-5)
5	2.9(-7)	1.0	1.0
6	2.9(-7)	1.0	1.0

4.1.1.b.3 E60 AC POWER RECOVERY WITHIN 60 MINUTES

The modeling of E60 is implicit in the support states. If electric power is recovered support states 5 and 6 for event tree 12 do not apply. If electric power is not recovered, E60 unavailability must be equal to 1.0.

4.1.1.b.4 120V AC POWER RECOVERY BETWEEN 60-120 MINUTES

This node is quantified, taking credit only for the offsite power recovery. From EPRI NP-2301 Page 3-6, the conditional probability of power recovery within 60-120 minute period is calculated as:

$$P_{120} = \frac{10}{39} = 0.26$$

Thus the failure to recover in the applicable time period (i.e., 60-120 minutes) is:

$$q_{120} = 0.74$$

4.1.1.b.5 V INTERFACING SYSTEM LOCA

The node V is used in the Interfacing Systems LOCA event tree and has the value of 1.0 so that the fault initiating frequency becomes the core melt frequency.

TABLE 4.1.1.c

OPERATOR ACTION MEAN UNAVAILABILITIES (3 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
OP1	Note 4.1.1.c.1	1.5(-4)	1.5(-4)	1.5(-3)	1.5(-3)	1.0	1.0
OP2	Note 4.1.1.c.2	2.1(-4)	1.0	1.6(-3)	1.6(-3)	1.0	1.0
OP3	Note 4.1.1.c.3	4.5(-4)	1.0	4.5(-4)	4.5(-4)	1.0	1.0
OP4	Note 4.1.1.c.4	1.0(-5)	1.0(-5)	1.0	1.0	1.0	1.0
OP5 (SA2 and MT success)	Note 4.1.1.c.5	7.8(-4)	7.8(-4)	7.8(-4)	7.8(-4)	1.0	1.0
OP5 (SA2 Fails)	Note 4.1.1.c.5	1.0	1.0	1.0	1.0	1.0	1.0
OP5 (MT Fails)	Note 4.1.1.c.5	7.8(-3)	7.8(-3)	7.8(-3)	7.8(-3)	1.0	1.0
OP6	Note 4.1.1.c.6	2.2(-1)	2.2(-1)	2.2(-1)	2.2(-1)	2.2(-1)	2.2(-1)
OP7	Note 4.1.1.c.7	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)

TABLE 4.1.1.c (con't)

OPERATOR ACTION MEAN UNAVAILABILITIES (3 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
OP8 (OP5, SA2, and MT Success)	Note 4.1.1.c.8	4.5(-4)	1.0	4.5(-4)	4.5(-4)	1.0	1.0
OP8 (OP5 Fails)	Note 4.1.1.c.8	1.3(-2)	1.0	1.3(-2)	1.3(-2)	1.0	1.0
OP8 (SA2 Fails)	Note 4.1.1.c.3	1.0	1.0	1.0	1.0	1.0	1.0
OP8 (MT Fails)	Note 4.1.1.c.8	1.0(-1)	1.0	1.0(-1)	1.0(-1)	1.0	1.0
OP9	Note 4.1.1.c.9	3.4(-3)	3.4(-3)	3.4(-3)	3.4(-3)	3.4(-3)	3.4(-3)

Operator Action Mean Unavailability Notes
(3 Day LCO)

4.1.1.c.1 OP1 PRIMARY BLEED

The failure probability of this operator action node is calculated by using the following model:

A. Diagnosis Phase:

The operators must diagnose the need for primary bleed action within 60 minutes. Two experienced operators with a medium dependence between them are available. The stress factor is taken as 2. The failure probability q_D of the diagnosis phase is calculated as:

$$q_D = 2q_1 \left(\frac{1+6(2q1)}{7}\right)$$

q_1 is taken from Appendix 3C, Table 3C.4-1, item 4 as 4.4×10^{-4}, failure to diagnose within 60 minutes. Thus, q_D is calculated to be 1.3×10^{-4}.

B. Action Phase

Opening of 1 PORV is sufficient for success. No PORV block valve opening is necessary. This action is well stressed in training and procedures exist. Recovery in case of omission and selection errors is very likely. In this case, only the hardware failures will dominate.

1. For support states 1,2 both PORV's are available. A β factor of 0.01 is modeled by using engineering judgement for the common cause failure of both PORV's. The failure probability of a PORV is taken from ZPSS (page 1.3-39) as $q_2 = 1.44 \times 10^{-3}$. Then the failure of both PORV's to open is calculated as:

$$q_A = q_2^2 + \beta q_2$$

$$q_A = 1.6 \times 10^{-5}$$

2. For support states 3,4, only one PORV is available and

$$q_A = q_2$$
$$q_A = 1.4 \times 10^{-3}$$

3. For support states 5 and 6, no PORV is available and

$$q_A = 1.0$$

C. Quantification of Nodal Probability

The nodal probability for OP1 is calculated by using the equation:

$$q_{OP1} \tilde{=} q_D + q_A$$

The results for each support state are provided in Table 4.1.1.c.

4.1.1.c.2 OP2 FEED AND BLEED

This operator action is similar to OP1 except that it includes an additional step of starting a charging or a safety injection pump and establishing valve lineup, if needed. This action is modeled and quantified in three phases.

A. Diagnosis Phase

It is implicit in this model that 60 minutes are available for diagnosis. A stress factor of 2 is assigned. The equation to calculate failure probability q_D of diagnosis is:

$$q_D = (2q_1)\left(\frac{1+6(2q_1)}{7}\right)$$

Where q_1 is taken from Appendix 3C, Table 3C.4-1, item 4 as 4.4(-4). The result is calculated to be:

$$q_D = 1.3 \times 10^{-4}$$

B. Action Phase

The action phase will be modeled as a selection or omission error associated with each of the main phases of feed and bleed procedures. The omission error from Table 3C.4-1 item 15 is:

$$q_3 = 3.6 \times 10^{-3}$$

The selection error from the same table, item 21 is:

$$q_4 = 1.2 \times 10^{-3}$$

The total human error q_A with a stress factor of 2 is calculated as:

$$q_A = (2q_3) + (2q_4) + (2q_3) + (2q_4)$$
$$= 1.9 \times 10^{-2}$$

Note that this value includes both action for feed and action for bleed.

C. Recovery Phase

If the action phase fails, operators have recovery mechanisms in the form of:

1. observation of increasing plant parameters, such as temperature and pressure;

2. flow indicators;

3. procedural steps for verification.

The recovery is modeled as failure of checking involving an individual's safety (Table 3C.4-1 item 37).

$$q_5 = 1.5 \times 10^{-3}$$

With a stress factor of 2, the recovery probability q_R is calculated as:

$$q_R = 3.0 \times 10^{-3}$$

D. Quantification of Nodal Probability

The nodal failure probablity is calculated as:

$$q_{OP2} = q_D + q_A\, q_R + q_{HH2} + q_{PORV}$$

where q_{HH2} is the hardware failure probability of injection as calculated by fault tree analysis, and labeled as node HH2, and q_{PORV} is calculated in OP1 for one and two PORVs.

The results of the calculation for each support state is given below.

Support State	$q_{HH2} + q_{PORV}$	$q_D + q_A\, q_R$	q_{OP2}
1	1.6×10^{-5}	1.9×10^{-4}	2.1×10^{-4}
2	1.0	1.9×10^{-4}	1.0
3	1.4×10^{-3}	1.9×10^{-4}	1.6×10^{-3}
4	1.4×10^{-3}	1.9×10^{-4}	1.6×10^{-3}
5	1.0	-	1.0
6	1.0	-	1.0

4.1.1.c.3 OP3 OPERATOR CONTROLS FEED AND BLEED

This action is defined as the cycling of PORV's and starting and stopping of safety injection or charging pumps to keep primary system parameters in prescribed ranges. The failure of this action is conservatively modeled as follows:

A. Operators will have 24 hours in this mode of operation and will be challenged to respond to plant parameter changes once an hour (with a total of 24 opportunities for error).

B. Operators will have 30 minutes to diagnose the need for action and 30 minutes to recover if action is not carried out.

C. The failures will be dominated by diagnosis phase rather than action phase.

D. The contribution of hardware failures is negligible.

E. Stress level is 2. The stress level probability will be calculated as:

$$q = 24 * q_D * q_R$$

where:

q_D = probability of failure in diagnosis phase

q_R = probability of failure in recovery phase

Calculation of q_D:

$$q_D = 2q_1 \left(\frac{1 + 6(2q_1)}{7}\right.$$

q_1 is taken from Appendix 3C, Table 3C.4-1, item 3 as 2.1 (-3) failure to diagnose within 30 minutes. Thus, q_D is calculated to be 6.2 (-4).

Calculation of q_R:

Recovery will be modeled as item 34 from Table 3C.4-1 of Appendix 3C.

q_5 = 1.5 (-2) checking involving active participation

with a stress factor of 2, the recovery probability q_R is calculated as:

$$q_R = 3.0(-2)$$

Then q will be calculated as:

$$q = 24 * q_D * q_R = 4.5\ (-4)$$

The results for each support state are provided in Table 4.1.1.c.

4.1.1.c.4 OP4 OPERATOR STABILIZES TRANSIENT

The action of the operator stabilizing the transient is included, for cases where it could be effective. In the case of Closure of One MSIV, it results in the plant operating in a three-loop mode until the plant is shutdown in a controlled manner per normal operating procedures. The situation is possible if the plant was at low power levels when the MSIV was closed. Since, if no reactor trip occurs, the plant should easily stabilize and in any case no core damage would ensure, OP4 is assigned a small unavailability of 1.0×10^{-5} for the closure of one MSIV. This only applies to electrical power support states 1 and 2, for the remaining states the reactor would be tripped and thus the unavailability of OP4 is 1.0.

The results for each support state are provided in Table 4.1.1.c.

4.1.1.c.5 OP5 OPERATOR INITIATED SHUTDOWN FOR SGTR

This action precedes OP8 in the SGTR event tree and is dominated by diagnosis error failures; it is well defined by procedures and is routinely emphasized in operator training. The modeling will be done, based on a 20-minute diagnosis period and two experienced operators with a minimum dependence between them with a stress level of 2. From Table 3.C.4-1, item 2:

A. Diagnosis Phase

$q_1 = 2.1(-2) * 2$

$$q_D = q_1 \left(\frac{1 + 6q_1}{7}\right)$$

q_D = 7.5 (-3) with a 20-minute diagnosis period (support states 1, 2, 3, 4)

= 1.0 (support states 5, 6)

q_D is decreased by one order of magnitude to q_D = 7.5(-4) for support states 1, 2, 3, 4 to account for heavy emphasis during training.

B. Action Phase

The action phase will be modeled as a selection or omission error associated with each of the main phases of feed and bleed procedures. The omission error from Table 3C.4-1 item 15 is:

$$q_3 = 3.6 \times 10^{-3}$$

The selection error from the same table, item 21 is:

$$q_4 = 1.2 \times 10^{-3}$$

The total human error q_A with a stress factor of 2 is calculated as:

$$q_A = (2q_3) + (2q_4)$$

$$= 9.6 \times 10^{-3}$$

Note that this value includes only action for bleed.

C. Recovery Phase

If the action phase fails, operators have recovery mechanisms in the form of:

1. observation of increasing plant parameters, such as temperature and pressure;

2. flow indicators;

3. procedural steps for verification.

The recovery is modeled as failure of checking involving an individual's safety (Table 3C.4-1 item 37).

$$q_5 = 1.5 \times 10^{-3}$$

With a stress factor of 2, the recovery probability q_R is calculated as:

$$q_R = 3.0 \times 10^{-3}$$

D. Quantification of Nodal Probability

The nodal failure probability is calculated as:

$$q_{OP5} = q_D + q_A \, q_R$$

q_{OP5} = 7.8(-4) (support states 1, 2, 3, 4)
= 1.0 (support states 5, 6)

2. If SA2 fails, OP5 is also modeled to fail since no bleed action is possible:

q = 1.0 for all support states

3. If multiple tube ruptures occur, OP5 failure probability will be estimated to be an order of magnitude higher than that of case 1, above, namely:

   q = 7.8 (- 3) for support states 1, 2, 3, 4

     = 1.0 for support states 5, 6

4.1.1.c.6 OP6 MANUAL REACTOR TRIP

The conditional probability of failure of the manual reactor trip, given the failure of the automatic reactor trip is modeled in detail in the Millstone Probabilisic Safety Study (MPSS). The same value will be used in the present study; namely:

$q = 2.2 \times 10^{-1}/D$ (page 2.2-48 of MPSS)

This value is based in a human error probability of $10^{-2}/D$ to carry out a manual reactor trip and a common cause failure probability due to two or more stuck rods. This probability is applicable to all support states.

4.1.1.c.7 OP7 DEENERGIZE MAGNETS FOR CONTROL ROD DROP

This action will follow the failure of the manual trip, if the operator realizes the need for reactor trip but is unable to carry it out manually. He is modeled to have 10 minutes to carry out this action. In the absence of data, a value of 0.5 is assigned for the failure probability of this action.

4.1.1.c.8 OP8 OPERATOR CONTROLS FEED AND BLEED FOR SGTR

This action will be quantified based on four prior conditions:

1. OP5 is successful.

2. OP5 fails.

3. SA2 fails.

4. MT occurs.

   1. If OP5 is successful, this action is similar to the model used for OP3; control feed and bleed and will be represented by that action:

      q = 4.5 (-4) for Support States 1,3,4
        = 1.0 for Support States 2,5,6

   2. If OP5 fails, the conditional probability of OP8 is greater than if OP5 is successful and is bounded by the total operator action failure probability along an accident sequence:

	Support States
q = 0.013	1,3,4
= 1.0	2,5,6

      This is based on the conservative modeling that:

      $$q(OP5) * q(OP8) \geq 1.0 \times 10^{-5},$$

      namely the total failure probability of operator actions along an accident sequence is bounded by 1×10^{-5}.

   3. If SA2 fails, OP8 will also fail since feed action is not possible.

      q = 1.0 for all support states

4. If multiple tube ruptures occur, OP8 failure is conservatively estimated to be:

$q = 0.1$ for support state 1, 3, 4

and

$q = 1.0$ for support state 2, 5, 6

4.1.1.c.9 OP9 OPERATOR INITIATED SHUTDOWN FOR CORE POWER EXCURSION

For the Core Power Excursion event tree, it is possible for the operator to take action by emergency boration, manually inserting control rods, or changing power level on the turbine-generator. Here, positive action ends the transient while failure simply calls upon the next level of protection. While the time to act can be fairly short before backup measures are encountered (less than 15 minutes), the stress is low because this is not an emergency situation at this point in time and the backup systems actuation serve to alert the operators. The modeling will be done, based on a 20-minute diagnosis period and two experienced operators with a medium dependence between them with a stress level of 1. From Appendix 3C, Table 3.c.4-1, Item 2:

$q_1 = 2.1\ (-2)$ for diagnosis within 20 minutes,

$$q = q_1 \frac{(1 + 6q_1)}{7}$$

$$= 3.4\ (-3)$$

This value is used for all support states.

TABLE 4.4.1.d

CONSEQUENTIAL MEAN VALUE FAILURE RATES (3 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
LK (OP5 Success)	(1) Tbl 4.5-6	4.5 (-3)	4.5 (-3)	4.5 (-3)	4.5 (-3)	1.2 (-1)	1.2 (-1)
LK (OP5 Fails)	Note 4.1.1.d.1	1.0	1.0	1.0	1.0	1.0	1.0
MT	(1) Tbl 4.5-6	1.0 (-1)	1.0 (-1)	1.0 (-1)	1.0 (-1)	1.0 (-1)	1.0 (-1)
S2	Note 4.1.1.d.2	1.0 (-4)	5.0 (-1)	1.0 (-3)	1.0 (-3)	1.0 (-3)	5.0 (-1)
TR1	Note 4.1.1.d.3	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)
TR2	Note 4.1.1.d.4	1.0 (-4)	1.0 (-4)	1.0 (-4)	1.0 (-4)	1.0 (-4)	1.0 (-4)
TR3	Note 4.1.1.d.5	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)

Reference 1 - Byron Risk Study, February 1983.

Consequential Mean Value Failure Rate Notes
(Three Day LCO)

4.1.1.d.1 LK

If operator action (OP5) fails, primary pressure is not controlled and a continual steam release to the environment through the faulted steam generator is expected. Therefore, the conditional probability of a leak is conservatively taken to be 1.0 for all support states.

4.1.1.d.2 S2

S2 corresponds to a small primary system break which considers the possibility of a stuck open PORV and block valve or a small LOCA due to an RCP seal failure. Since all of the above initiators produce a small LOCA, the same node is used regardless of whether the LOCA was caused by a valve or seal failure. Data for support states which include ESW availability was taken from Table 4.5-6 of the Byron Risk Study. Supports states for which ESW is unavailable will assume a probability of 0.5 for a small LOCA due to RCP seal failure.

4.1.1.d.3 TR1

TR1 is a multiple or single tube rupture probability for LOCA events. This probability is bounded by the probability of three or more tube ruptures during a secondary line break event (TR3) and is conservatively taken to be 1.0(-5) for all support states.

4.1.1.d.4 TR2

TR2 is concerned with non-LOCA transients which involve a larger than normal primary to secondary pressure differential and may result in a single tube rupture. The unavailability of TR2 is taken to be the initiating frequency of a tube rupture event scaled down to a frequency per diem (3.7(-2)/reactor year x 1 day/365 days/year) = 1.0(-4).

4.1.1.d.5 TR3

TR3 is a rupture of three or more steam generator tubes during secondary line breaks. The probability of this occurrence is dominated by the probability of three or more tube ruptures. This probability of 1.0 (-5) is taken from the table in Section 4.6.2.2 of the Byron Risk Study.

4.1.2 CALCULATION OF SUPPORT STATE SPLIT FRACTIONS FOR 3 DAY LCO

4.1.2.1 DESCRIPTION

The performance of the event tree analysis for this study required the establishment of electric power and service water split fractions for these types of events: LOCA, LOOP, and transients. The support states are identified as follows:

1. Both 4160 V AC busses and service water at the unit 1 header available;

2. Both busses available and no service water at the unit 1 header;

3. Bus 142 and service water available;

4. Bus 141 and service water available;

5. Neither bus available but service water (from unit 2) available;

6. Neither bus nor service water available.

4.1.2.2 ASSUMPTIONS

The basic assumptions for the establishment of these support states are as follows:

1. The loss of power to any one bus follows loss of offsite AC and the failure of the onsite diesel generator associated with that bus; (this is the result of the minimal probability that a bus will deenergize following a transient or LOCA compared to a loss of the grid to the whole station).

2. Service water from unit 2 is only available for transient and LOOP events where the operators have sufficient time to align the SX005 crosstie valves. This is considered proper due to the need for

service water flow (to the High Pressure Safety Injection and charging pumps following an SI signal) within several minutes of pump start to prevent damage to the pumps.

3. The loss of service water following a loss of offsite power will result in diesel generator failure, the split fraction for this support state includes these secondary events due to the grouping of support states as shown in Figure 4.1.2-1.

4.1.2.3 CALCULATIONS

The calculation of support state split fractions for 3-day LCO are carried out on Figures 4.1.2-2 through 4.1.2-4, with the summary of results presented in Table 4.1.2-1.

TABLE 4.1.2-1

3 DAY LCO - RESULTS

Support State	LOCA	Transient	LOOP
1	.999	.999	.980
2	2.0(-5)	3.2(-6)	2.0(-6)
3	6.0(-6)	1.6(-6)	1.0(-2)
4	6.0(-6)	1.6(-6)	1.0(-2)
5	0.0	3.8(-8)	2.4(-4)
6	3.8(-7)	2.2(-8)	1.3(-4)

THREE DAY LCO SUPPORT STATE SPLIT FRACTIONS

Event Tree	LOCA	Transient	LOOP
1	X		
2	X		
3	X		
4	X		
5	X		
6	X		
7		X	
8		X	
9		X	
10		X	
11		X	
12			X
13		X	
14		X	
15	X		
16	X		

Figure 4.1.2-1

FIGURE 4.1.2-2

3-DAY LCO TRANSIENT

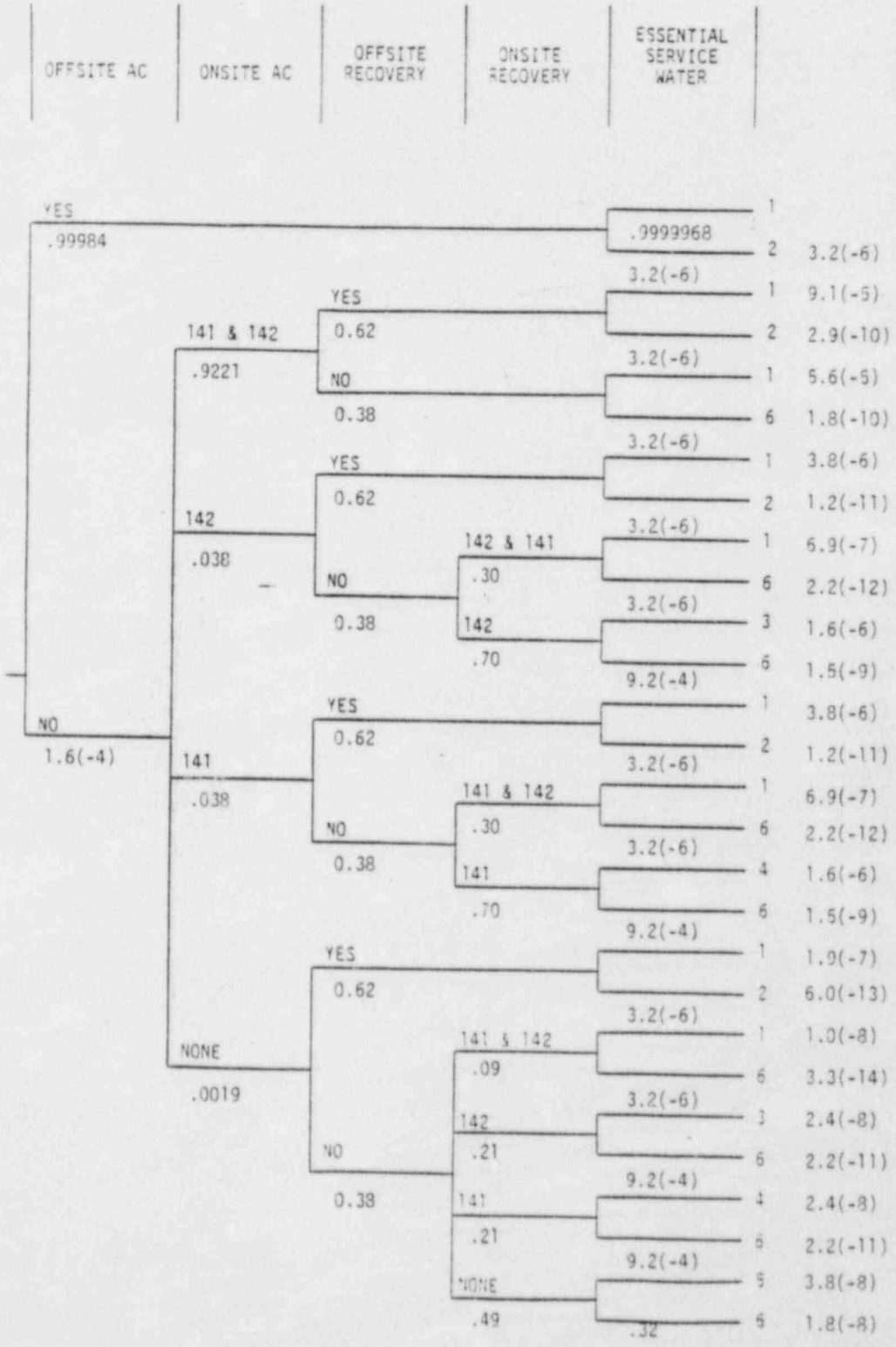


FIGURE 4.1.2-3

3-DAY LCO LOOP

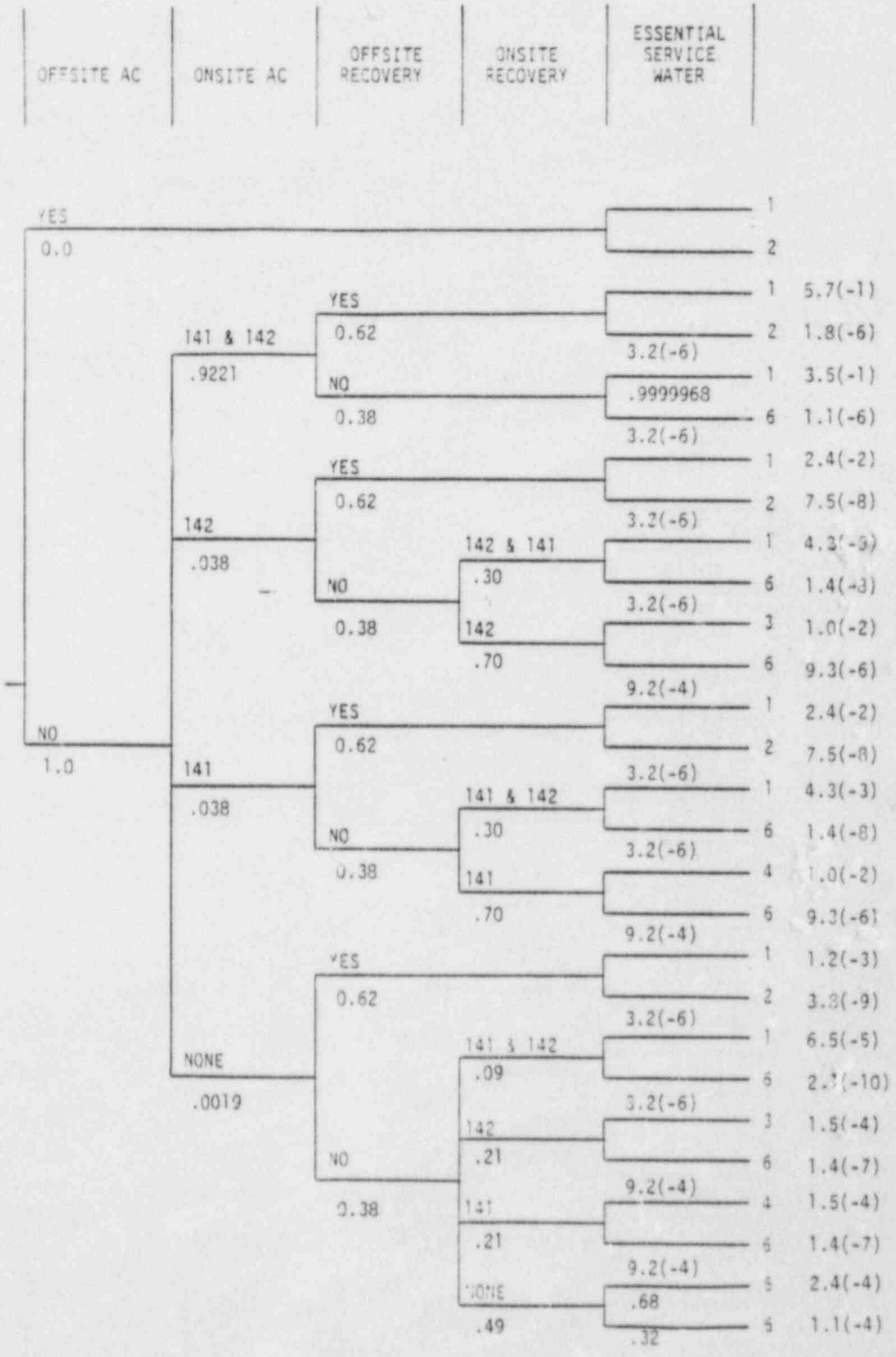
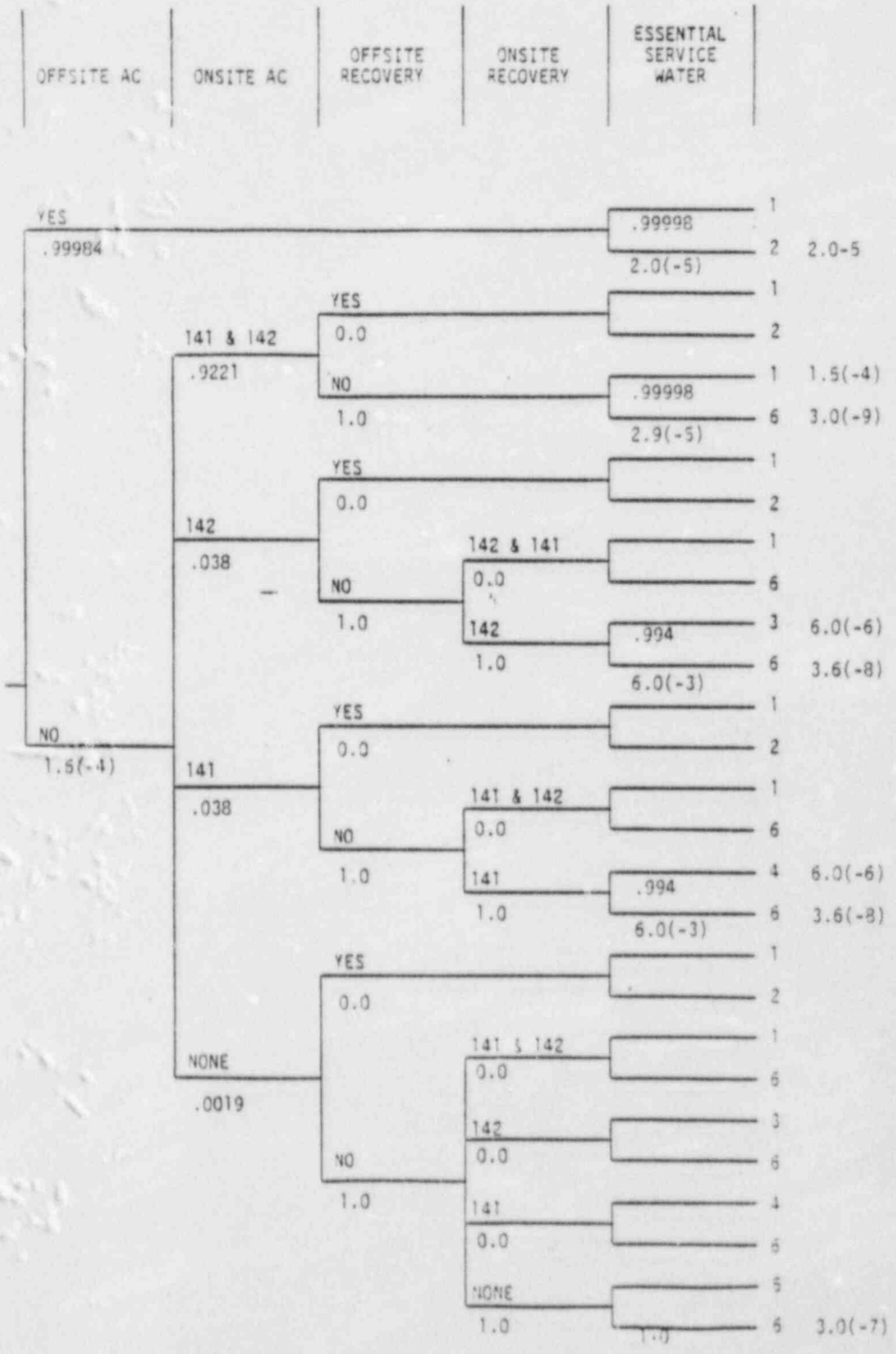


FIGURE 4.1.2-4

3-DAY LCO LOCA
(No Recovery)



4.1.3 CALCULATION OF CORE DAMAGE FOR 3 DAY LCO

In this section, the plant core melt frequency from the internal initiating events is calculated.

To calculate the plant matrix, M, and the plant core melt frequency, the event trees of section 2 are quantified for each of the six support states, using nodal probabilities calculated in Section 4.1.1. The plant matrix generated is given by Table 4.1.3-1.

The internal initiating event frequency vector (ϕ) is taken from the section 1 and is repeated as Table 4.1.3-2.

The product ϕM provides the frequencies of damage states given by Table 4.1.3-3.

The contribution of each initiating event category to the total internal core melt frequency is calculated and is displayed by Table 4.1.3-4. The contribution of each support state to the total core melt frequency is given by Table 4.1.3-5.

The ranking of initiating event-support state cases by their contribution to core melt is displayed on Table 4.1.3-6. Finally, Table 4.1.3-7 contains the percent contributions to each core melt state by initiating event-support state case.

TABLE 4.1.3-1

PLANT MATRIX (M MATRIX)

	AEFC SEC V2E	AEF SE V2L	AEC SLFC V	AE SLF	AIFC SLC	ALF SL	ALC TEFC	AL TEF	SEFC TEC	SEF TE
1	6.70E-04	4.00E-07	1.80E-08	3.80E-07	2.50E-04	1.40E-07	2.00E-05	1.12E-08	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	6.70E-09	9.99E-06	0.00E-01							
2	6.76E-04	4.05E-07	2.00E-05	3.91E-07	2.50E-04	1.40E-07	2.16E-09	8.47E-12	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	6.96E-09	9.99E-06	0.00E-01							
3	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.87E-07	2.42E-08
	2.03E-05	3.91E-07	4.80E-04	2.70E-07	4.33E-09	1.82E-11	4.44E-11	2.49E-14	4.69E-12	9.18E-14
	0.00E-01	0.00E-01	0.00E-01							
4	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	5.13E-16	2.94E-19
	4.72E-12	1.23E-13	8.25E-17	6.13E-20	1.93E-20	2.09E-22	1.79E-17	1.13E-20	4.69E-12	9.18E-14
	2.08E-05	8.25E-06	0.00E-01							
5	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.30E-09	3.15E-12
	9.99E-06	1.96E-07	5.54E-07	3.36E-10	3.47E-11	4.02E-13	2.70E-07	1.52E-10	3.41E-07	6.67E-09
	2.04E-10	1.00E-05	0.00E-01							
6	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.30E-09	3.15E-12
	9.99E-06	1.96E-07	5.54E-07	3.36E-10	3.47E-11	4.02E-13	2.70E-07	1.52E-10	3.41E-07	6.67E-09
	2.04E-10	1.00E-05	0.00E-01							
7	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.30E-09	3.14E-12
	1.60E-06	1.14E-08	2.89E-07	1.68E-10	9.86E-12	9.17E-14	1.05E-07	5.98E-11	5.44E-08	1.68E-09
	2.05E-10	8.24E-10	0.00E-01							
8	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.88E-11	2.42E-12
	1.60E-06	1.14E-08	2.88E-07	1.68E-10	9.86E-12	9.17E-14	1.05E-07	5.98E-11	5.44E-08	1.68E-09
	2.05E-10	8.24E-10	0.00E-01							
9	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.30E-09	3.14E-12
	1.60E-06	1.14E-08	2.89E-07	1.68E-10	9.86E-12	9.17E-14	1.05E-07	5.98E-11	5.44E-08	1.68E-09
	2.05E-10	8.24E-10	0.00E-01							
10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	4.42E-15	1.07E-17
	5.44E-12	3.89E-14	9.81E-13	5.72E-16	3.35E-17	3.12E-19	3.57E-13	2.03E-16	1.85E-13	5.71E-15
	6.97E-16	2.80E-15	0.00E-01							
11	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.30E-09	3.14E-12
	1.60E-06	1.14E-08	2.89E-07	1.68E-10	9.86E-12	9.17E-14	1.05E-07	5.98E-11	5.44E-08	1.68E-09
	2.05E-10	8.24E-10	0.00E-01							

TABLE 4.1.3-1 (Continued)

PLANT MATRIX (M MATRIX)

12	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	6.48E-08	5.61E-11
	1.79E-05	4.83E-05	4.15E-06	4.32E-08	5.10E-08	5.67E-10	2.76E-06	7.23E-09	6.15E-07	7.67E-06
	1.95E-10	1.65E-09	0.00E-01							
13	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.30E-09	3.14E-12
	1.60E-06	1.14E-08	5.04E-07	2.89E-10	1.54E-06	4.77E-08	2.25E-07	1.26E-10	5.44E-08	1.68E-09
	2.05E-10	8.24E-10	0.00E-01							
14	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	9.44E-10	2.94E-12
	1.60E-06	1.14E-08	2.89E-07	1.68E-10	9.86E-12	9.17E-14	1.05E-07	5.98E-11	5.44E-08	1.68E-09
	2.05E-10	8.24E-10	0.00E-01							
V	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	1.00E+00							

TABLE 4.1.3-2

INITIATING EVENT DEFINITIONS AND MEAN FREQUENCIES

EVENT SYMBOL	EVENT DESCRIPTION	FREQUENCY / REACTOR YEAR
1	LARGE LOCA	9.40E-04
2	MEDIUM LOCA	9.40E-04
3	SMALL LOCA	3.54E-02
4	STEAM GENERATOR TUBE RUPTURE	3.70E-02
5	STEAM BREAK INSIDE CONTAINMENT	9.40E-04
6	STEAM BREAK OUTSIDE CONTAINMENT	9.40E-04
7	LOSS OF MAIN FEEDWATER	3.00E+00
8	CLOSURE OF ONE MSIV	2.52E-01
9	LOSS OF RCS FLOW	3.58E-01
10	CORE POWER EXCURSION	2.28E-02
11	TURBINE TRIP	4.00E+00
12	LOSS OF OFFSITE POWER	5.76E-02
13	SPURIOUS SAFETY INJECTION	8.00E-02
14	REACTOR TRIP	3.00E+00
V	INTERFACING SYSTEMS LOCA	2.10E-07

TABLE 4.1.3-3

CORE MELT STATE DEFINITIONS AND CALCULATED MEAN FREQUENCIES

SYMBOL	DESCRIPTION	FREQUENCY / REACTOR YEAR	PERCENT CONTRIBUTION
AEFC	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.27E-06	2.65
AEF	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	7.57E-10	<0.1
AEC	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.88E-08	<0.1
AE	LARGE LOCA EARLY NO CONTAINMENT COOLING	7.25E-10	<0.1
ALFC	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	4.70E-07	.98
ALF	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.64E-10	<0.1
ALC	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	1.88E-08	<0.1
AL	LARGE LOCA LATE MELT NO CONTAINMENT COOLING	1.05E-11	<0.1
SEFC	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	2.29E-08	<0.1
SEF	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	8.91E-10	<0.1
SEC	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.89E-05	39.50
SE	SMALL LOCA EARLY MELT NO CONTAINMENT COOLING	2.92E-06	6.11
SLFC	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.03E-05	42.57
SLF	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	1.39E-08	<0.1
SLC	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	1.27E-07	.27
SL	SMALL LOCA LATE MELT NO CONTAINMENT COOLING	3.85E-09	<0.1
TEFC	TRANSIENT WITH NO COOLING, EARLY MELT	1.29E-06	2.71
TEF	TRANSIENT WITH NO COOLING, EARLY MELT	1.06E-09	<0.1
TEC	TRANSIENT WITH NO COOLING, EARLY MELT	6.17E-07	1.29
TE	TRANSIENT EARLY MELT NO CONTAINMENT COOLING	4.60E-07	.96
V2E	SGTR EARLY MELT	7.71E-07	1.61
V2L	SGTR LATE MELT	3.52E-07	.74
V	INTERFACING SYSTEMS LOCA	2.10E-07	.44
	TOTAL	4.78E-05	100.0

TABLE 4.1-38

INITIATING EVENTS AND THE CORE MELT FREQUENCIES

SYMBOL	DESCRIPTION	CORE MELT FREQUENCY	PERCENT CONTRIBUTION	CONDITIONAL CORE MELT FREQUENCY
1	LARGE LOCA	8.94E-07	1.87	9.51E-04
2	MEDIUM LOCA	8.99E-07	1.88	9.57E-04
3	SMALL LOCA	1.77E-05	37.14	5.01E-04
4	STEAM GENERATOR TUBE RUPTURE	1.07E-06	2.25	2.90E-05
5	STEAM BREAK INSIDE CONTAINMENT	2.01E-08	<0.1	2.14E-05
6	STEAM BREAK OUTSIDE CONTAINMENT	2.01E-08	<0.1	2.14E-05
7	LOSS OF MAIN FEEDWATER	6.19E-06	12.96	2.06E-06
8	CLOSURE OF ONE MSIV	5.19E-07	1.09	2.06E-06
9	LOSS OF RCS FLOW	7.39E-07	1.55	2.06E-06
10	CORE POWER EXCURSION	1.60E-13	<0.1	7.01E-12
11	TURBINE TRIP	8.25E-06	17.28	2.06E-06
12	LOSS OF OFFSITE POWER	4.70E-06	9.84	8.15E-05
13	SPURIOUS SAFETY INJECTION	3.19E-07	.67	3.99E-06
14	REACTOR TRIP	6.19E-06	12.96	2.06E-06
V	INTERFACING SYSTEMS LOCA	2.10E-07	.44	1.00E+00
		4.78E-05	100.0	

TABLE 4.1.3-5

CORE MELT FREQUENCY BY SUPPORT STATE

STATE	1	2.36E-05	49.36
STATE	2	1.94E-05	40.55
STATE	3	2.65E-07	.55
STATE	4	1.00E-08	.02
STATE	5	5.04E-07	1.05
STATE	6	4.04E-06	8.46

TABLE 4.1.3-6

CORE MELT FREQUENCY BY EVENT AND SUPPORT STATE

ET03.01	1.70E-05	ET07.06	3.26E-08	ET09.05	4.80E-10	ET15.04	1.26E-12
ET11.02	6.62E-06	ET14.06	3.26E-08	ET01.06	3.57E-10	ET15.03	1.26E-12
ET14.02	4.96E-06	ET12.01	2.25E-08	ET02.06	3.57E-10	ET05.04	1.55E-13
ET07.02	4.96E-06	ET01.02	1.88E-08	ET08.05	3.36E-10	ET06.04	1.55E-13
ET12.06	3.90E-06	ET02.02	1.88E-08	ET09.03	2.53E-10	ET10.02	1.29E-13
ET11.01	1.58E-06	ET04.06	1.41E-08	ET05.06	1.85E-10	ET15.06	7.98E-14
ET07.01	1.19E-06	ET03.06	1.35E-08	ET06.06	1.85E-10	ET10.01	3.09E-14
ET14.01	1.19E-06	ET06.01	1.02E-08	ET04.03	1.80E-10	ET10.06	8.49E-16
ET02.01	8.80E-07	ET05.01	1.02E-08	ET08.03	1.77E-10	ET10.05	1.04E-16
ET01.01	8.74E-07	ET05.02	9.72E-09	ET02.04	1.18E-10	ET10.03	5.49E-17
ET04.02	7.40E-07	ET06.02	9.72E-09	ET02.03	1.18E-10	ET10.04	1.68E-18
ET03.02	7.08E-07	ET12.04	7.79E-09	ET11.04	8.60E-11	ET16.06	0.00E-01
ET09.02	5.96E-07	ET11.05	5.33E-09	ET07.04	6.45E-11	ET16.05	0.00E-01
ET12.05	4.87E-07	ET07.05	4.00E-09	ET14.04	6.45E-11	ET16.04	0.00E-01
ET08.02	4.17E-07	ET14.05	4.00E-09	ET13.03	5.18E-11	ET16.03	0.00E-01
ET04.01	3.20E-07	ET09.06	3.91E-09	ET01.03	5.07E-11	ET16.02	0.00E-01
ET13.02	2.56E-07	ET13.05	3.04E-09	ET01.04	5.07E-11	ET16.01	0.00E-01
ET12.03	2.54E-07	ET11.03	2.81E-09	ET04.04	1.94E-11	ET15.05	0.00E-01
ET15.01	2.10E-07	ET08.06	2.74E-09	ET09.04	7.74E-12	ET06.05	0.00E-01
ET09.01	1.42E-07	ET03.03	2.35E-09	ET08.04	5.42E-12	ET05.05	0.00E-01
ET08.01	9.93E-08	ET07.03	2.10E-09	ET15.02	4.20E-12	ET04.05	0.00E-01
ET12.02	6.00E-08	ET14.03	2.10E-09	ET05.03	2.35E-12	ET03.05	0.00E-01
ET13.01	5.85E-08	ET03.04	1.79E-09	ET06.03	2.35E-12	ET02.05	0.00E-01
ET13.01	5.85E-08	ET03.04	1.79E-09	ET06.03	2.35E-12	ET02.05	0.00E-01

TABLE 4.1.3-7

EVENT/SUPPORT STATE CONTRIBUTORS TO CORE MELT STATES (PERCENTAGE)

AEFC	99.98	ET02.01	50.21	ET01.01	49.77						
AEF	99.93	ET02.01	50.02	ET01.01	49.64	ET02.04	.13	ET02.03	.13		
AEC	99.88	ET02.02	99.88								
AE	99.99	ET02.06	49.27	ET01.06	49.27	ET02.02	1.45				
ALFC	99.98	ET01.01	49.99	ET02.01	49.99						
ALF	100.00	ET01.01 ET02.03	49.79 .10	ET02.01	49.79	ET01.03	.10	ET01.04	.10	ET02.04	.10
ALC	99.98	ET01.02	99.98								
AL	99.85	ET01.02	99.85								
SEFC	99.79	ET03.01 ET09.01	28.80 2.04	ET11.01 ET13.01	22.72 .45	ET07.01 ET12.01	17.04 .32	ET12.05 ET12.03	15.83 .20	ET14.01	12.37
SEF	99.72	ET03.01 ET09.01	95.91 .13	ET11.01	1.41	ET07.01	1.06	ET14.01	.99	ET12.05	.23
SEC	99.84	ET11.02 ET09.02	33.89 3.05	ET14.02 ET08.02	25.42 2.14	ET07.02 ET13.02	25.42 .68	ET12.06 ET12.02	5.19 .31	ET03.02	3.75
SE	99.64	ET12.06 ET12.05	95.00 .35	ET11.06 ET09.06	1.43 .13	ET14.06 ET11.02	1.07 .12	ET07.06	1.07	ET03.06	.46
SLFC	99.83	ET03.01 ET09.01	83.53 .51	ET11.01 ET08.01	5.67 .36	ET07.01 ET13.01	4.25 .20	ET14.01	4.25	ET12.03	1.07
SLF	99.29	ET03.01 ET12.04	68.57 .57	ET12.03 ET09.01	17.43 .42	ET11.01 ET08.01	4.65 .29	ET07.01 ET11.03	3.49 .19	ET14.01 ET03.03	3.49 .18
SLC	99.72	ET13.02	97.46	ET12.03	2.26						
SL	99.93	ET13.05	76.22	ET13.06	21.08	ET13.02	1.80	ET12.03	.83		
TEFC	99.85	ET11.01 ET12.03	32.45 2.38	ET07.01 ET08.01	24.36 2.05	ET14.01 ET13.01	24.36 1.39	ET12.05 ET12.01	9.50 .46	ET09.01	2.92
TEF	99.06	ET12.03 ET09.01	32.15 1.99	ET11.01 ET08.01	22.10 1.39	ET07.01 ET13.01	16.59 .95	ET14.01 ET12.04	16.59 .47	ET12.05 ET11.03	6.47 .35
TEC	99.83	ET11.02 ET08.02	35.21 2.22	ET07.02 ET13.02	26.41 .70	ET14.02 ET12.02	26.41 .32	ET12.06	5.39	ET09.02	3.17
TE	99.78	ET12.05 ET11.06	75.61 .31	ET12.06 ET07.06	20.50 .23	ET11.05 ET14.06	1.12 .23	ET07.05 ET09.05	.84 .10	ET14.05	.84
V2E	99.71	ET04.02	95.97	ET04.01	1.92	ET04.06	1.82				

TABLE 4.1.3-7 (Continued)

EVENT/SUPPORT STATE CONTRIBUTORS TO CORE MELT STATES (PERCENTAGE)

V2L	99.76	ET04.01 ET11.01	86.73 .94	ET05.01 ET07.01	2.67 .70	ET06.01 ET14.01	2.67 .70	ET02.01	2.67	ET01.01	2.67
V	100.00	ET15.01	100.00								

4.1.4 CALCULATION OF PLANT RISK

In this section the plant risk in terms of the consequence categories

1) early fatalities
2) early injuries
3) thyroid cancer incidences
4) latent cancer fatalities
5) man-rem release

is calculated and the corresponding risk curves are drawn for the 3-day LCO.

The product ϕMC provides the release category frequencies. This quantification is summarized by Table 4.1.4-1.

The product ϕMCS for each consequence category provides the point estimate frequencies for each of the consequence categories, i=1, 2, 3, 4, 5. The results are given by Tables 4.1.4-2 through 4.1.4-6. The same results are also expressed as risk curves by Figures 4.1.4-1 through 4.1.4-5.

TABLE 4.1.4-1

RELEASE CATEGORY DEFINITIONS AND CALCULATED MEAN FREQUENCIES

RELEASE CATEGORY	DESCRIPTION	FREQUENCY / REACTOR YEAR	PERCENT CONTRIBUTION
Z-1	STEAM EXPLOSION WITHOUT CONTAINMENT SPRAY	7.43E-10	<0.1
2	OVERPRESSURE FAILURES WITHOUT SPRAYS	2.15E-07	.45
2R	DELAYED OVERPRESSURE FAILURE WITHOUT SPRAYS	3.38E-06	7.08
Z-3	STEAM EXPLOSIONS WITH SPRAYS	1.93E-10	<0.1
5R	DELAYED OVERPRESSURE WITH SPRAYS	5.59E-09	<0.1
Z-5	EARLY OVERPRESSURE FAILURES WITH SPRAYS	3.73E-09	<0.1
6	BASEMAT MELT-THROUGH WITHOUT SPRAYS	6.45E-10	<0.1
7	BASEMAT MELT-THROUGH WITH SPRAYS	7.49E-09	<0.1
8A	CONTAINMENT INTACT WITHOUT SPRAYS	1.72E-08	<0.1
8B	CONTAINMENT INTACT WITH SPRAYS	4.30E-05	90.05
2R'	SGTR RELEASE	1.12E-06	2.35
	TOTAL	4.78E-05	100.0

TABLE 4.1.4-2

POINT ESTIMATE VECTOR FOR EARLY FATALITIES

NUMBER OF FATALITIES	FREQUENCY OF OCCURRENCE
1.00E+00	1.08E-08
2.00E+00	1.08E-08
3.00E+00	1.08E-08
5.00E+00	1.08E-08
7.00E+00	1.04E-08
1.00E+01	9.14E-09
2.00E+01	8.97E-09
3.00E+01	8.97E-09
5.00E+01	8.97E-09
7.00E+01	8.80E-09
1.00E+02	7.70E-09
2.00E+02	7.70E-09
3.00E+02	5.34E-09
5.00E+02	5.34E-09
7.00E+02	5.04E-09
1.00E+03	4.27E-09
2.00E+03	1.70E-11
3.00E+03	1.49E-11
5.00E+03	0.00E-01

TABLE 4.1.4-3

POINT ESTIMATE VECTOR FOR EARLY INJURIES

NUMBER OF INJURIES	FREQUENCY OF OCCURRENCE
1.00E+00	2.06E-07
2.00E+00	2.06E-07
3.00E+00	2.06E-07
5.00E+00	2.05E-07
7.00E+00	2.00E-07
1.00E+01	1.99E-07
2.00E+01	1.99E-07
3.00E+01	1.98E-07
5.00E+01	1.95E-07
7.00E+01	1.83E-07
1.00E+02	1.82E-07
2.00E+02	1.80E-07
3.00E+02	1.79E-07
5.00E+02	1.72E-07
7.00E+02	1.34E-07
1.00E+03	1.11E-07
2.00E+03	8.15E-08
3.00E+03	6.37E-08
5.00E+03	5.55E-08
7.00E+03	3.73E-08
1.00E+04	3.19E-08
2.00E+04	6.87E-09
3.00E+04	5.83E-09
5.00E+04	5.81E-09
7.00E+04	3.43E-10
1.00E+05	0.00E-01

TABLE 4.1.4-4

POINT ESTIMATE VECTOR FOR THYROID CANCERS

NUMBER OF THY CANCER	FREQUENCY OF OCCURRENCE
1.00E+00	4.22E-06
2.00E+00	3.15E-06
3.00E+00	2.43E-06
5.00E+00	2.07E-06
7.00E+00	1.80E-06
1.00E+01	1.70E-06
2.00E+01	1.69E-06
3.00E+01	1.69E-06
5.00E+01	1.66E-06
7.00E+01	1.64E-06
1.00E+02	1.60E-06
2.00E+02	1.50E-06
3.00E+02	1.45E-06
5.00E+02	1.34E-06
7.00E+02	1.25E-06
1.00E+03	1.13E-06
2.00E+03	9.25E-07
3.00E+03	7.01E-07
5.00E+03	5.01E-07
7.00E+03	4.17E-07
1.00E+04	3.22E-07
2.00E+04	1.41E-07
3.00E+04	7.63E-08
5.00E+04	2.61E-08
7.00E+04	7.65E-09
1.00E+05	3.43E-10
2.00E+05	0.00E-01

TABLE 4.1.4-5

POINT ESTIMATE VECTOR FOR LATENT CANCER FATALITIES (EXCLUDING THYROID)

NUMBER OF LAT CANCER	FREQUENCY OF OCCURRENCE
1.00E+00	2.72E-06
2.00E+00	2.00E-06
3.00E+00	1.91E-06
5.00E+00	1.81E-06
7.00E+00	1.81E-06
1.00E+01	1.81E-06
2.00E+01	1.80E-06
3.00E+01	1.79E-06
5.00E+01	1.75E-06
7.00E+01	1.73E-06
1.00E+02	1.68E-06
2.00E+02	1.56E-06
3.00E+02	1.51E-06
5.00E+02	1.39E-06
7.00E+02	1.29E-06
1.00E+03	1.18E-06
2.00E+03	8.74E-07
3.00E+03	6.08E-07
5.00E+03	2.99E-07
7.00E+03	1.72E-07
1.00E+04	5.69E-08
2.00E+04	7.12E-12
3.00E+04	0.00E-01

TABLE 4.1.4-6

POINT ESTIMATE VECTOR FOR MAN-REMS

NUMBER OF MAN-REM	FREQUENCY OF OCCURRENCE
1.00E+03	8.61E-06
2.00E+03	6.19E-06
3.00E+03	4.58E-06
5.00E+03	4.31E-06
7.00E+03	3.50E-06
1.00E+04	2.97E-06
2.00E+04	2.34E-06
3.00E+04	1.89E-06
5.00E+04	1.80E-06
7.00E+04	1.70E-06
1.00E+05	1.70E-06
2.00E+05	1.69E-06
3.00E+05	1.69E-06
5.00E+05	1.68E-06
7.00E+05	1.65E-06
1.00E+06	1.63E-06
2.00E+06	1.55E-06
3.00E+06	1.47E-06
5.00E+06	1.41E-06
7.00E+06	1.33E-06
1.00E+07	1.22E-06
2.00E+07	9.67E-07
3.00E+07	8.07E-07
5.00E+07	5.16E-07
7.00E+07	2.98E-07
1.00E+08	1.89E-07
2.00E+08	5.92E-09
3.00E+08	0.00E-01

FIGURE 4.1.4-1

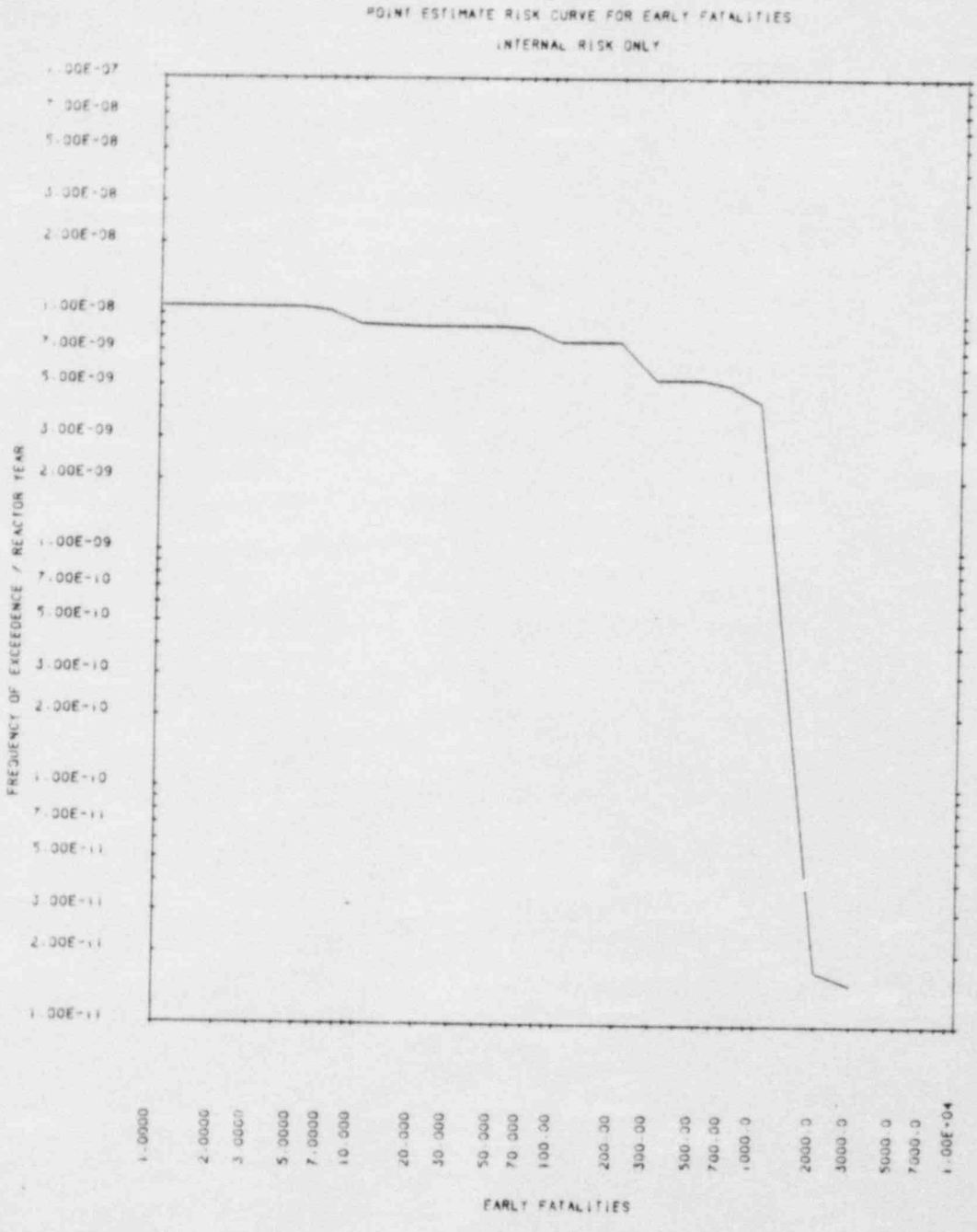

POINT ESTIMATE RISK CURVE FOR EARLY FATALITIES
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
1.00E-07
7.00E-08
5.00E-08
3.00E-08
2.00E-08
1.00E-08
7.00E-09
5.00E-09
3.00E-09
2.00E-09
1.00E-09
7.00E-10
5.00E-10
3.00E-10
2.00E-10
1.00E-10
7.00E-11
5.00E-11
3.00E-11
2.00E-11
1.00E-11
1.0000
2.0000
3.0000
5.0000
7.0000
10.000
20.000
30.000
50.000
70.000
100.00
200.00
300.00
500.00
700.00
1000.0
2000.0
3000.0
5000.0
7000.0
1.00E+04
EARLY FATALITIES

FIGURE 4.1.4-2

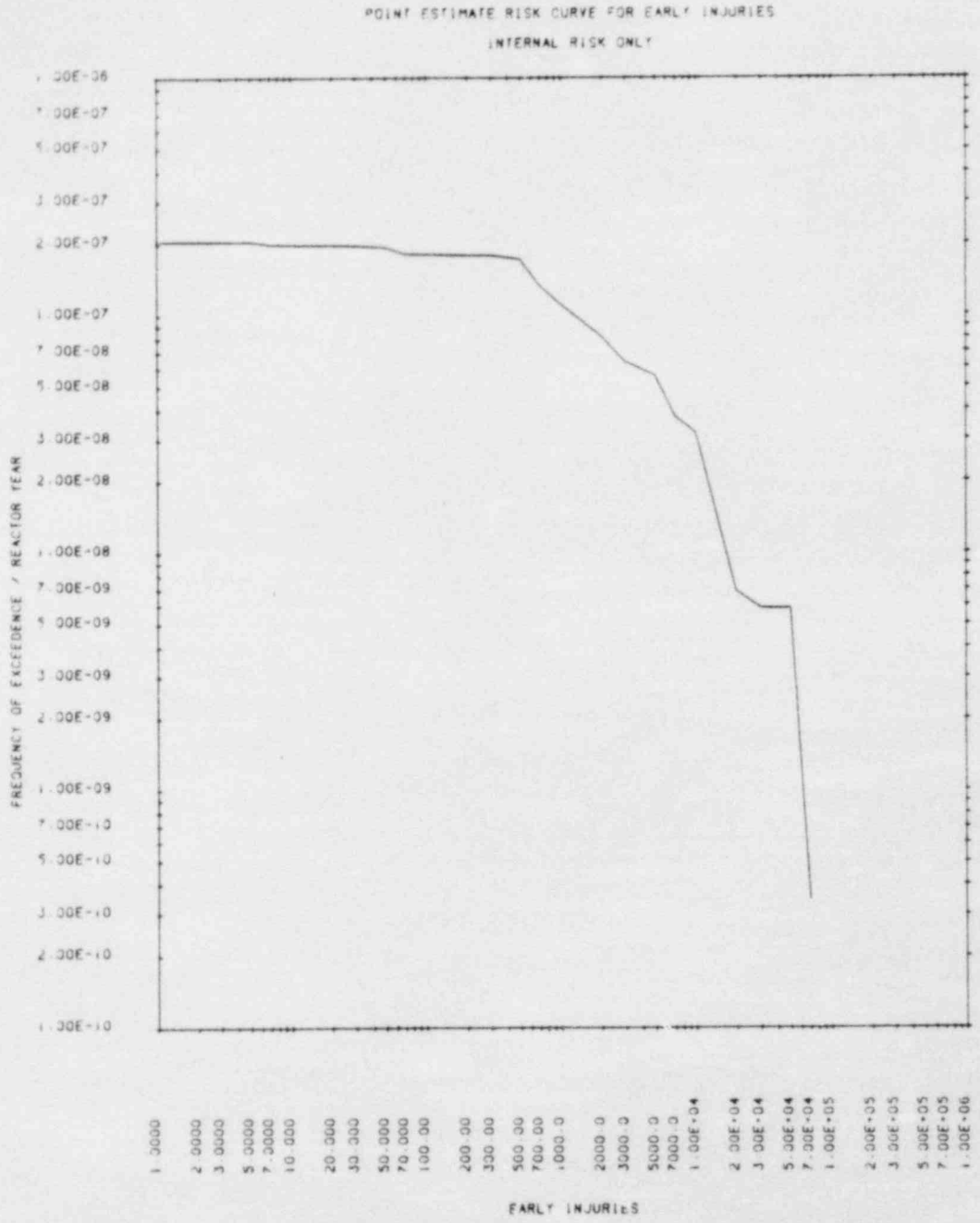

POINT ESTIMATE RISK CURVE FOR EARLY INJURIES
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
1.00E-06
7.00E-07
5.00E-07
3.00E-07
2.00E-07
1.00E-07
7.00E-08
5.00E-08
3.00E-08
2.00E-08
1.00E-08
7.00E-09
5.00E-09
3.00E-09
2.00E-09
1.00E-09
7.00E-10
5.00E-10
3.00E-10
2.00E-10
1.00E-10
1.0000
2.0000
3.0000
5.0000
7.0000
10.000
20.000
30.000
50.000
70.000
100.00
200.00
300.00
500.00
700.00
1000.0
2000.0
3000.0
5000.0
7000.0
1.00E+04
2.00E+04
3.00E+04
5.00E+04
7.00E+04
1.00E+05
2.00E+05
3.00E+05
5.00E+05
7.00E+05
1.00E+06
EARLY INJURIES

FIGURE 4.1.4-3

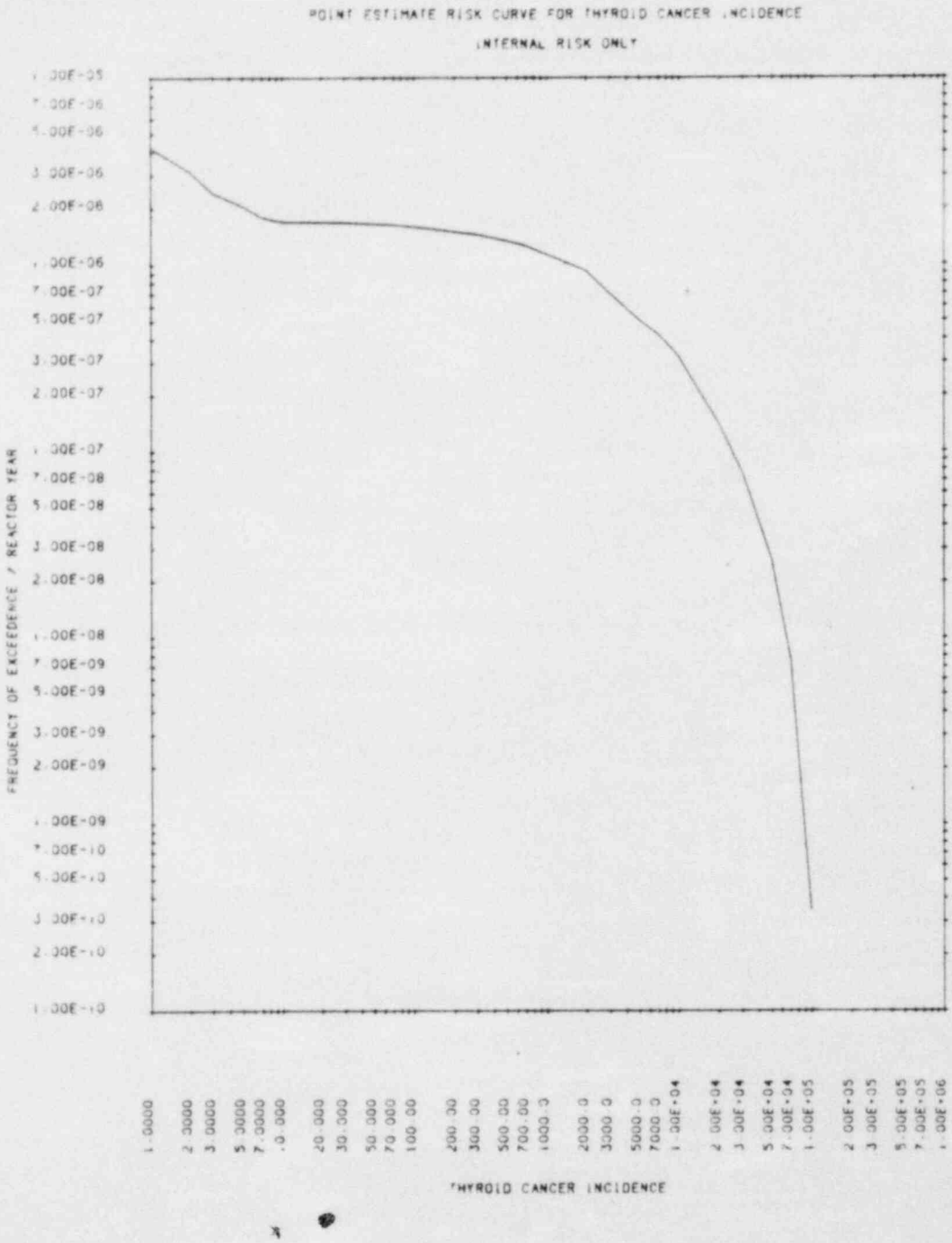
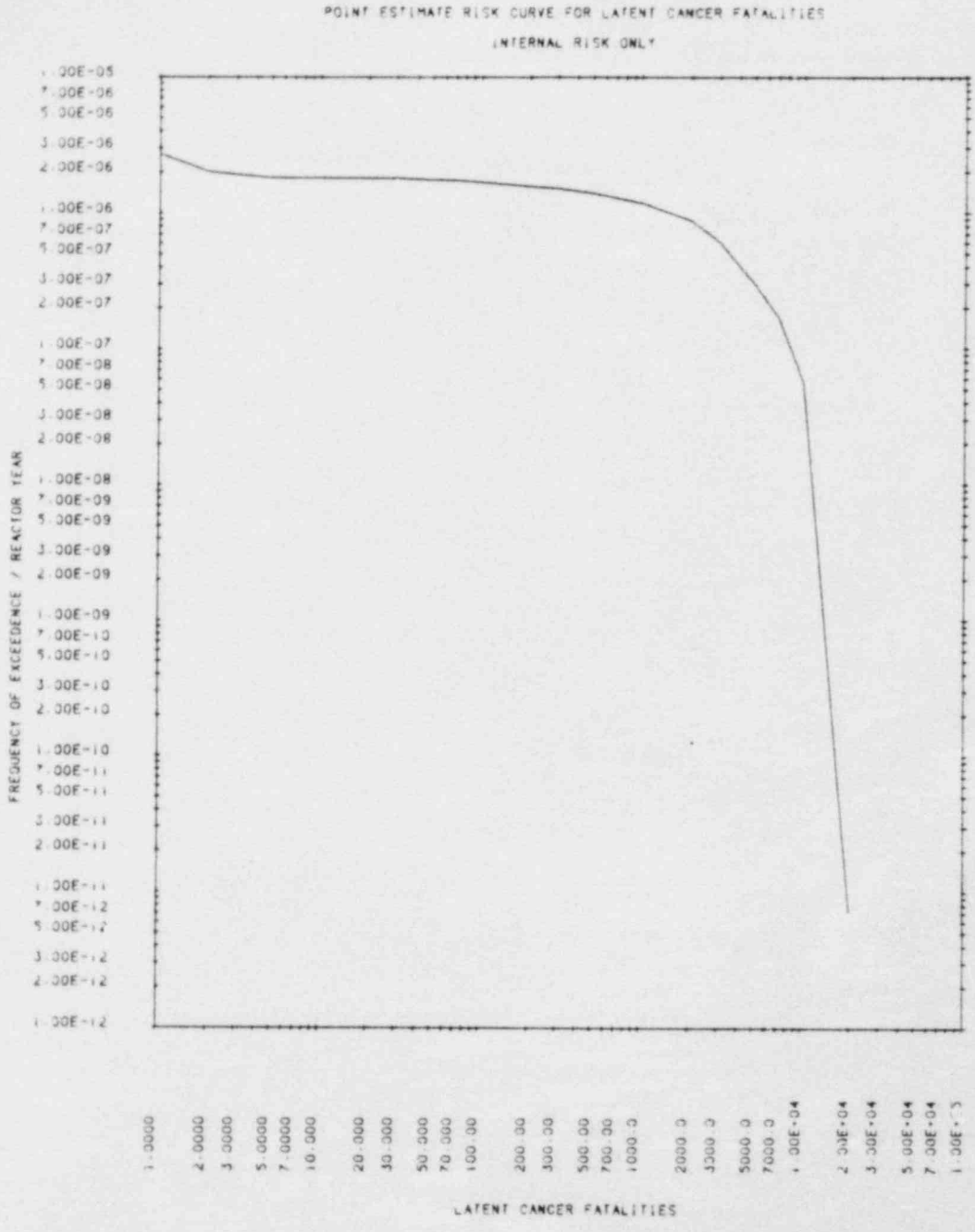

POINT ESTIMATE RISK CURVE FOR THYROID CANCER INCIDENCE
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
THYROID CANCER INCIDENCE

FIGURE 4.1.4-4


POINT ESTIMATE RISK CURVE FOR LATENT CANCER FATALITIES
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
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7.00E-06
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1.00E-06
7.00E-07
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5.0000
7.0000
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30.000
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200.00
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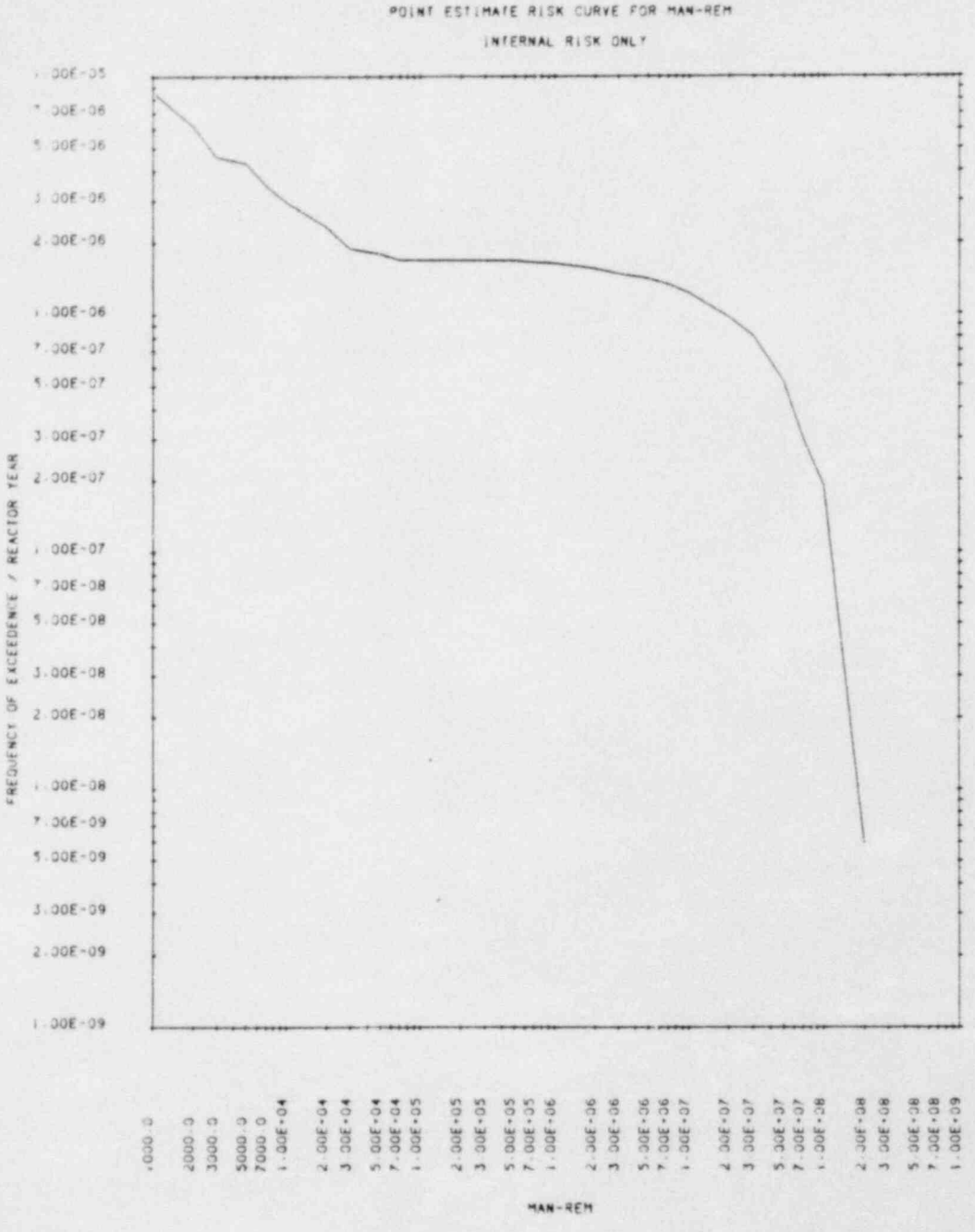
500.00
700.00
1000.0
2000.0
3000.0
5000.0
7000.0
1.00E-04
2.00E-04
3.00E-04
5.00E-04
7.00E-04
1.00E-3
LATENT CANCER FATALITIES

FIGURE 4.1.4-5


POINT ESTIMATE RISK CURVE FOR MAN-REM
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
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5.00E-06
3.00E-06
2.00E-06
1.00E-06
7.00E-07
5.00E-07
3.00E-07
2.00E-07
1.00E-07
7.00E-08
5.00E-08
3.00E-08
2.00E-08
1.00E-08
7.00E-09
5.00E-09
3.00E-09
2.00E-09
1.00E-09
1000.0
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3000.0
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7000.0
1.00E+04
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3.00E+04
5.00E+04
7.00E+04
1.00E+05
2.00E+05
3.00E+05
5.00E+05
7.00E+05
1.00E+06
2.00E+06
3.00E+06
5.00E+06
7.00E+06
1.00E+07
2.00E+07
3.00E+07
5.00E+07
7.00E+07
1.00E+08
2.00E+08
3.00E+08
5.00E+08
7.00E+08
1.00E+09
MAN-REM

4.2 SEVEN DAY LCO PLANT RISK QUANTIFICATION

In this section plant risk is quantified by first calculating core melt frequency using event tree analysis for 7-day LCO. The above information is used to determine the radiological release and exposure to the public to yield total plant risk. In the following three subsections, the event tree nodal probabilities, the core melt frequency and plant risk are calculated.

4.2.1 CALCULATION OF EVENT TREE NODES FOR 7 DAY LCO

The unavailabilities used for each node are contained in the following tables:

Fluid System	-	Table 4.2.1.a
Plant Functions	-	Table 4.2.1.b
Operator Actions	-	Table 4.2.1.c
Consequential Failure Rates	-	Table 4.2.1.d

The unavailabilities in Tables 4.2.1.c and 4.2.1.d for a 7-day LCO are identical to these for a 3-day LCO (Tables 4.1.1.c and 4.1.1.d) and are included here for the reader's convenience.

TABLE 4.2.1.a

FLUID SYSTEM MEAN UNAVAILABILITIES (7 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
CC	Note 4.2.1.a.1	0	0	0	0	0	0
CF	Note 4.2.1.a.2	9.2(-6)	1.0	1.9(-2)	1.9(-2)	1.0	1.0
CS	Note 4.2.1.a.2	5.8(-4)	5.8(-4)	1.2(-2)	1.2(-2)	1.0	1.0
HH1	Section 3.7	8.2(-6)	1.0	1.4(-2)	1.4(-2)	1.0	1.0
HH2	Section 3.7	1.2(-7)	1.0	4.1(-5)	4.1(-5)	1.0	1.0
L-1	Section 3.5	6.0(-4)	3.6(-2)	3.6(-2)	6.0(-4)	3.6(-2)	3.6(-2)
L-2	Section 3.5	6.1(-4)	3.7(-2)	3.7(-2)	6.1(-4)	3.7(-2)	3.7(-2)
LP	Note 4.2.1.a.3	6.7(-4)	6.7(-4)	5.4(-3)	5.4(-3)	1.0	1.0
NA	Note 4.2.1.a.2	1.5(-3)	1.5(-3)	2.4(-2)	2.4(-2)	1.0	1.0
R-1	Section 3.6.2	2.6(-4)	1.0	4.5(-3)	4.5(-3)	1.0	1.0
R-2	Note 4.2.1.a.4	4.9(-4)	1.0	1.2(-2)	9.3(-3)	1.0	1.0

Fluid System Mean Unavailability Notes
(Seven Day LCO)

4.2.1.a.1 CC

The contribution of component cooling water is considered withi the fault tree. Therefore, the unavailability of node CC in the event tree is set equal to zero.

4.2.1.a.2 CF, CS, NA

The unavailability of each of the following systems is taken from the referenced section for all event trees except Loss of Offsite Power (LOOP). For the LOOP tree, an additional unavailability conditional on the recovery of AC power (node 120) is modeled for support state 5.

System	Section	Unavailability in Support State 5
Containment Fan Coolers	3.8	9.2(-6)/demand
Contaiment Spray	3.9.1	5.8(-4)/demand
Sodium Hydroxide Tanks	3.9.2	1.5(-3)/demand

4.2.1.a.3 LP

The unavailability due to the low pressure safety injection and accumulator injection systems are taken from Section 3.6.2 of this report. Although accumulator injection is not required for a medium LOCA, no distinction was made between low pressure safety injection with or without accumulator injection. Low pressure SI with accumulator injection is dominant and is used for both.

4.2.1.a.4 R-2

The unavailability due to the high pressure recirculation system is taken from Section 3.7 of this report. R-2 recirculation applies to event trees where the initiating event leaves the reactor coolant system at a pressure high

enough to require high head recirculation cooling. Although one could develop separate nodes which would apply to non-LOCA transients where "feed and bleed" core cooling is used or to a steam generator tube rupture transient where only long term cooling is required, the unavailability of both of these states is bounded by the unavailability of R-2. Therefore, R-2 applies to small LOCA, steam generator tube rupture, and non-LOCA transients.

TABLE 4.2.1.b

PLANT FUNCTION MEAN UNAVAILABILITIES (7 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
K-2	(1) Tbl. 4.5-4	1.3(-6)	1.3(-6)	1.3(-6)	1.3(-6)	1.3(-6)	1.3(-6)
K-3	(1) Tbl. 4.5-4	1.8(-6)	1.8(-6)	1.8(-6)	1.8(-6)	1.8(-6)	1.8(-6)
K-5	(1) Tbl. 4.5-4	1.0(-3)	1.0(-3)	1.0(-3)	1.0(-3)	1.0(-3)	1.0(-3)
MS-1	(1) Tbl. 4.5-4	1.0(-4)	1.0(-4)	1.0(-4)	1.0(-4)	1.0(-4)	1.0(-4)
MS-2	(1) Tbl. 4.5-4	9.4(-2)	9.4(-2)	9.4(-2)	9.4(-2)	9.4(-2)	9.4(-2)
PL	(1) Tbl. 4.5-4	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)
PR1	(1) Tbl. 4.5-4	1.0(-6)	1.0(-6)	1.0(-6)	1.0(-6)	1.0(-6)	1.0(-6)
PR2	Table 4.1.1.b	1.2(-2)	1.2(-2)	1.2(-2)	1.2(-2)	1.0	1.0
SA1	(1) Tbl. 4.5-4	2.9(-7)	2.9(-7)	2.9(-7)	2.9(-7)	2.9(-7)	2.9(-7)

Reference 1 - Byron Risk Study, February 1983

TABLE 4.2.1.b (Continued)

PLANT FUNCTION MEAN UNAVAILABILITIES (7 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
SA2	Note 4.2.1.b.1	4.1(-7)	1.0	4.1(-5)	4.1(-5)	1.0	1.0
SO	(1) Tbl. 4.5-4	1.0(-2)	1.0(-2)	1.0(-2)	1.0(-2)	1.0(-2)	1.0(-2)
TK	(1) Tbl. 4.5-4	2.4(-8)	2.4(-8)	2.4(-8)	2.4(-8)	2.4(-8)	2.4(-8)
TI1	(1) Tbl. 4.5-4	2.8(-6)	2.8(-6)	2.8(-6)	2.8(-6)	2.8(-6)	2.8(-6)
TI2	(2) Pg. 2.2-51	1.4(-1)	1.4(-1)	1.4(-1)	1.4(-1)	1.4(-1)	1.4(-1)
E60	Table 4.1.1.b	N.A	N/A	N/A	N/A	1.0	1.0
120	Table 4.1.1.b	N/A	N/A	N/A	N/A	7.4(-1)	7.4(-1)
V	Table 4.1.1.b	1.0	1.0	1.0	1.0	1.0	1.0

Reference 1 - Byron Risk Study, February 1983

Reference 2 - Milestone Probabilistic Safety Study, August 1983

Plant Function Mean Unavailability Notes
(Seven Day LCO)

4.2.1.b.1 SA2 SI SIGNAL AND HIGH HEAD PUMPS

Node SA2 signifies the presence of an SI signal and the operation of the high head SI pumps.

$$q(SA2) = q(SA1) + q(HH2) * [1 - q(SA1)] \sim q(SA1) + q(HH2)$$

Support State	SA1	HH2	SA2
1	2.9(-7)	1.2(-7)	4.1(-7)
2	2.9(-7)	1.0	1.0
3	2.9(-7)	4.1(-5)	4.1(-5)
4	2.9(-7)	4.1(-5)	4.1(-5)
5	2.9(-7)	1.0	1.0
6	2.9(-7)	1.0	1.0

Operator Action Mean Unavailability Notes
(Seven Day LCO)

4.2.1.c.1 OP2 FEED AND BLEED

This operator action is similar to OP1 except that it includes an additional step of starting a charging or a safety injection pump and establishing valve lineup, if needed. This action is modeled and quantified in three phases.

A. Diagnosis Phase

It is implicit in this model that 60 minutes are available for diagnosis. A stress factor of 2 is assigned. The equation to calculate failure probability q_D of diagnosis is:

$$q_D = (2q_1)\left(\frac{1+6(2q_1)}{7}\right)$$

Where q_1 is taken from Appendix 3C, Table 3C.4-1, item 4 as 4.4(-4). The result is calculated to be:

$$q_D = 1.3 \times 10^{-4}$$

B. Action Phase

The action phase will be modeled as a selection or omission error associated with each of the main phases of feed and bleed procedures. The omission error from Table 3C.4-1 item 15 is:

$$q_3 = 3.6 \times 10^{-3}$$

The selection error from the same table, item 21 is:

$$q_4 = 1.2 \times 10^{-3}$$

The total human error q_A with a stress factor of 2 is calculated as:

$$q_A = (2q_3) + (2q_4) + (2q_3) + (2q_4)$$
$$= 1.9 \times 10^{-2}$$

Note that this value includes both action for feed and action for bleed.

C. Recovery Phase

If the action phase fails, operators have recovery mechanisms in the form of:

1. observation of increasing plant parameters, such as temperature and pressure;

2. flow indicators;

3. procedural steps for verification.

The recovery is modeled as failure of checking involving active participation (Table 3C.4-1 item 37).

$$q_5 = 1.5 \times 10^{-3}$$

With a stress factor of 2, the recovery probability q_R is calculated as:

$$q_R = 3.0 \times 10^{-3}$$

D. Quantification of Nodal Probability

The nodal failure probability is calculated as:

$$q_{OP2} = q_D + q_A\, q_R + q_{HH2} + q_{PORV}$$

where q_{HH2} is the hardware failure probability of injection as calculated by fault tree analysis, and labeled as node HH2, and q_{PORV} is calculated in OP1 for one and two PORVs.

The results of the calculation for each support state is given below.

Support State	$q_{HH2} + q_{PORV}$	$q_O + q_A\, q_R$	q_{OP2}
1	1.6×10^{-5}	1.9×10^{-4}	2.1×10^{-4}
2	1.0	1.9×10^{-4}	1.0
3	1.4×10^{-3}	1.9×10^{-4}	1.6×10^{-3}
4	1.4×10^{-3}	1.9×10^{-4}	1.6×10^{-3}
5	1.0	-	1.0
6	1.0	-	1.0

TABLE 4.2.1.c

OPERATOR ACTION MEAN UNAVAILABILITIES (7 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
OP1	Table 4.1.1.c	1.5(-4)	1.5(-4)	1.5(-3)	1.5(-3)	1.0	1.0
OP2	Note 4.2.1.c.1	2.1(-4)	1.0	1.6(-3)	1.6(-3)	1.0	1.0
OP3	Table 4.1.1.c	4.5(-4)	1.0	4.5(-4)	4.5(-4)	1.0	1.0
OP4	Table 4.1.1.c	1.0(-5)	1.0(-5)	1.0	1.0	1.0	1.0
OP5 (SA2 and MT success)	Table 4.1.1.c	7.8(-4)	7.8(-4)	7.8(-4)	7.8(-4)	1.0	1.0
OP5 (SA2 Fails)	Table 4.1.1.c	1.0	1.0	1.0	1.0	1.0	1.0
OP5 (MT Fails)	Table 4.1.1.c	7.8(-3)	7.8(-3)	7.8(-3)	7.8(-3)	1.0	1.0
OP6	Table 4.1.1.c	2.2(-1)	2.2(-1)	2.2(-1)	2.2(-1)	2.2(-1)	2.2(-1)
OP7	Table 4.1.1.c	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)	5.0(-1)

TABLE 4.2.1.c (con't)

OPERATOR ACTION MEAN UNAVAILABILITIES (7 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
OP8 (OP5, SA2, and MT Success)	Table 4.1.1.c	4.5(-4)	1.0	4.5(-4)	4.5(-4)	1.0	1.0
OP8 (OP5 Fails)	Table 4.1.1.c	1.3(-2)	1.0	1.3(-2)	1.3(-2)	1.0	1.0
OP8 (SA2 Fails)	Table 4.1.1.c	1.0	1.0	1.0	1.0	1.0	1.0
OP8 (MT Fails)	Table 4.1.1.c	1.0(-1)	1.0	1.0(-1)	1.0(-1)	1.0	1.0
OP9	Table 4.1.1.c	3.4(-3)	3.4(-3)	3.4(-3)	3.4(-3)	3.4(-3)	3.4(-3)

TABLE 4.1.1.d

CONSEQUENTIAL MEAN VALUE FAILURE RATES (7 DAY LCO)

SUPPORT STATE

Node	Source	Buses 141 & 142 & ESW	Buses 141 & 142 No ESW	Bus 142 Only & ESW	Bus 141 Only & ESW	No Buses ESW Only	No Buses No ESW
LK (OP5 Success)	(1) Tbl 4.5-6	4.5 (-3)	4.5 (-3)	4.5 (-3)	4.5 (-3)	1.2 (-1)	1.2 (-1)
LK (OP5 Fails)	Table 4.1.1.d	1.0	1.0	1.0	1.0	1.0	1.0
MT	(1) Tbl 4.5-6	1.0 (-1)	1.0 (-1)	1.0 (-1)	1.0 (-1)	1.0 (-1)	1.0 (-1)
S2	Table 4.1.1.d	1.0 (-4)	5.0 (-1)	1.0 (-3)	1.0 (-3)	1.0 (-3)	5.0 (-1)
TR1	Table 4.1.1.d	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)
TR2	Table 4.1.1.d	1.0 (-4)	1.0 (-4)	1.0 (-4)	1.0 (-4)	1.0 (-4)	1.0 (-4)
TR3	Table 4.1.1.d	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)	1.0 (-5)

Reference 1 - Byron Risk Study, February 1983.

4.2.2 CALCULATION OF SUPPORT STATE SPLIT FRACTIONS FOR 7 DAY LCO

4.2.2.1 DESCRIPTION

The performance of the event tree analysis for this study required the establishment of electric power and service water split fractions for these types of events: LOCA, LOOP, and transients. The support states are identified as follows:

1. Both 4160 V AC busses and service water at the unit 1 header available;

2. Both busses available and no service water at the unit 1 header;

3. Bus 142 and service water available;

4. Bus 141 and service water available;

5. Neither bus available but service water (from unit 2) available;

6. Neither bus nor service water available.

4.2.2.2 ASSUMPTIONS

The basic assumptions for the establishment of these support states are as follows:

1. The loss of power to any one bus follows loss of offsite AC and the failure of the onsite diesel generator associated with that bus; (this is the result of the minimal probability that a bus will deenergize following a transient or LOCA compared to a loss of the grid to the whole station).

2. Service water from unit 2 is only available for transient and LOOP events where the operators have sufficient time to align the SX005 crosstie valves. This is considered proper due to the need for

service water flow (to the High Pressure Safety Injection and charging pumps following an SI signal) within several minutes of pump start to prevent damage to the pumps.

3. The loss of service water following a loss of offsite power will result in diesel generator failure, the split fraction for this support state includes these secondary events due to the grouping of support states as shown in Figure 4.2.2-1.

4.2.2.3 CALCULATIONS

The calculation of support state split fractions for 7-day LCO are carried out on Figures 4.2.2-2 through 4.2.2-4, with the summary of results presented in Table 4.2.2-1.

TABLE 4.2.2-1

7 DAY LCO - RESULTS

Support State	LOCA	Transient	LOOP
1	.999	.999	.973
2	2.7(-5)	5.5(-6)	3.4(-6)
3	7.6(-6)	2.0(-6)	1.3(-2)
4	7.6(-6)	2.0(-6)	1.3(-2)
5	0.0	5.1(-8)	3.2(-4)
6	5.5(-7)	3.0(-8)	1.9(-4)

SEVEN DAY LCO SUPPORT STATE SPLIT FRACTIONS

Event Tree	LOCA	Transient	LOOP
1	X		
2	X		
3	X		
4	X		
5	X		
6	X		
7		X	
8		X	
9		X	
10		X	
11		X	
12			X
13		X	
14		X	
15	X		
16	X		

Figure 4.2.2-1

FIGURE 4.2.2-2

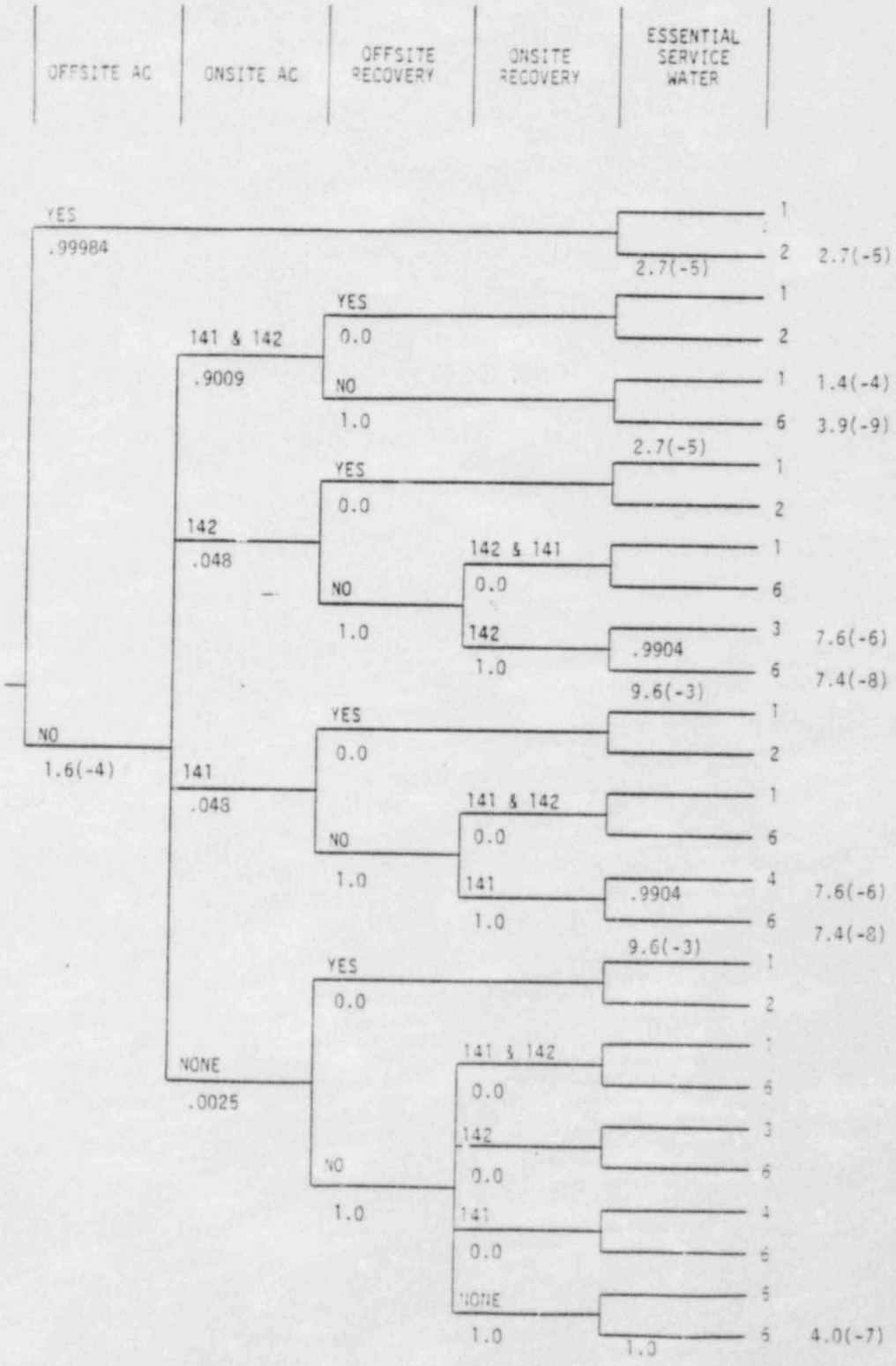

OFFSITE AC
ONSITE AC
OFFSITE RECOVERY
ONSITE RECOVERY
ESSENTIAL SERVICE WATER
YES
.99984
NO
1.6(-4)
141 & 142
.9009
142
.048
141
.048
NONE
.0025
YES
0.0
NO
1.0
142 & 141
141 & 142
141
NONE
.9904
2.7(-5)
9.6(-3)
1.4(-4)
3.9(-9)
7.6(-6)
7.4(-8)
4.0(-7)

FIGURE 4.2.2-3

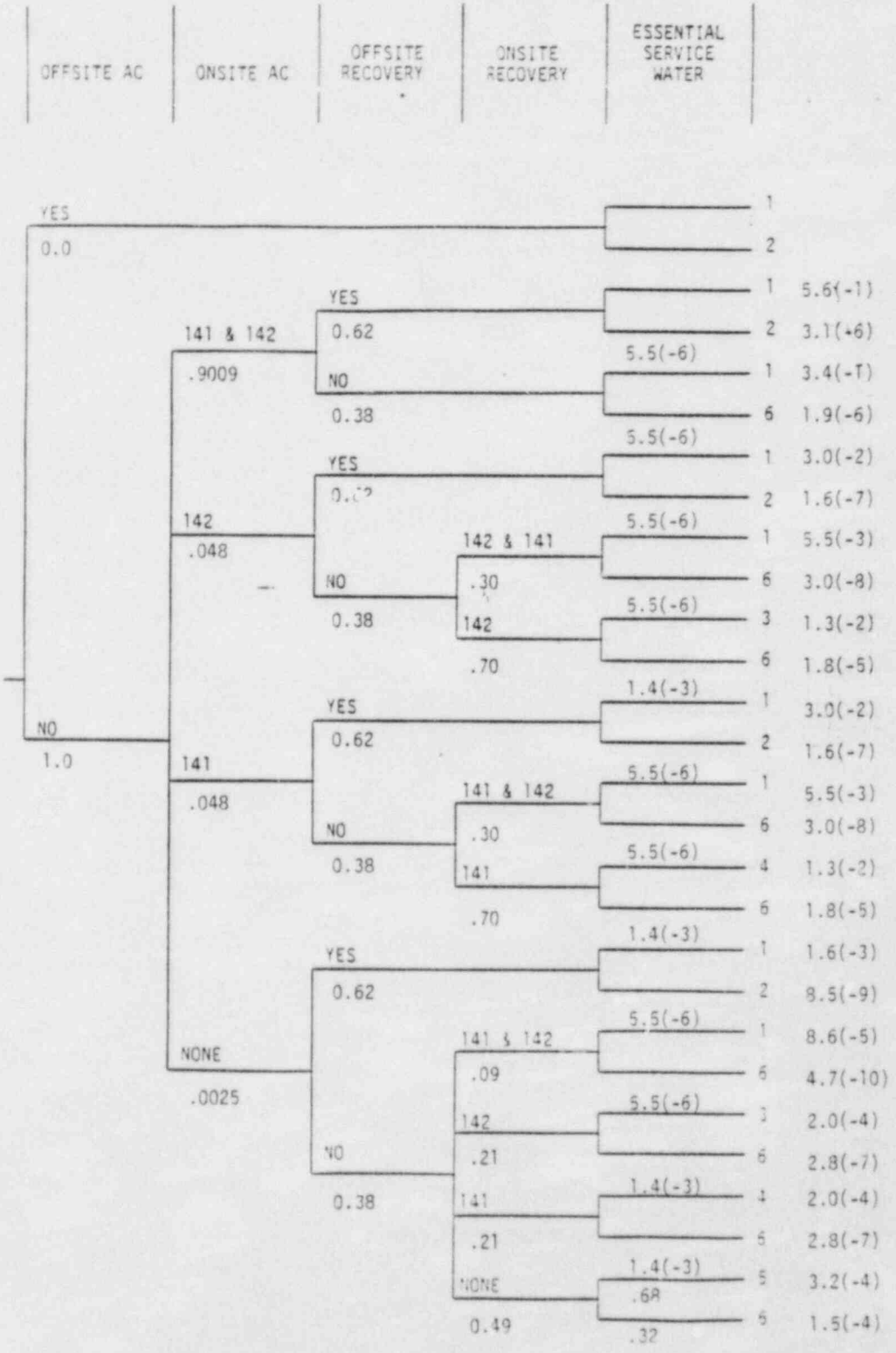
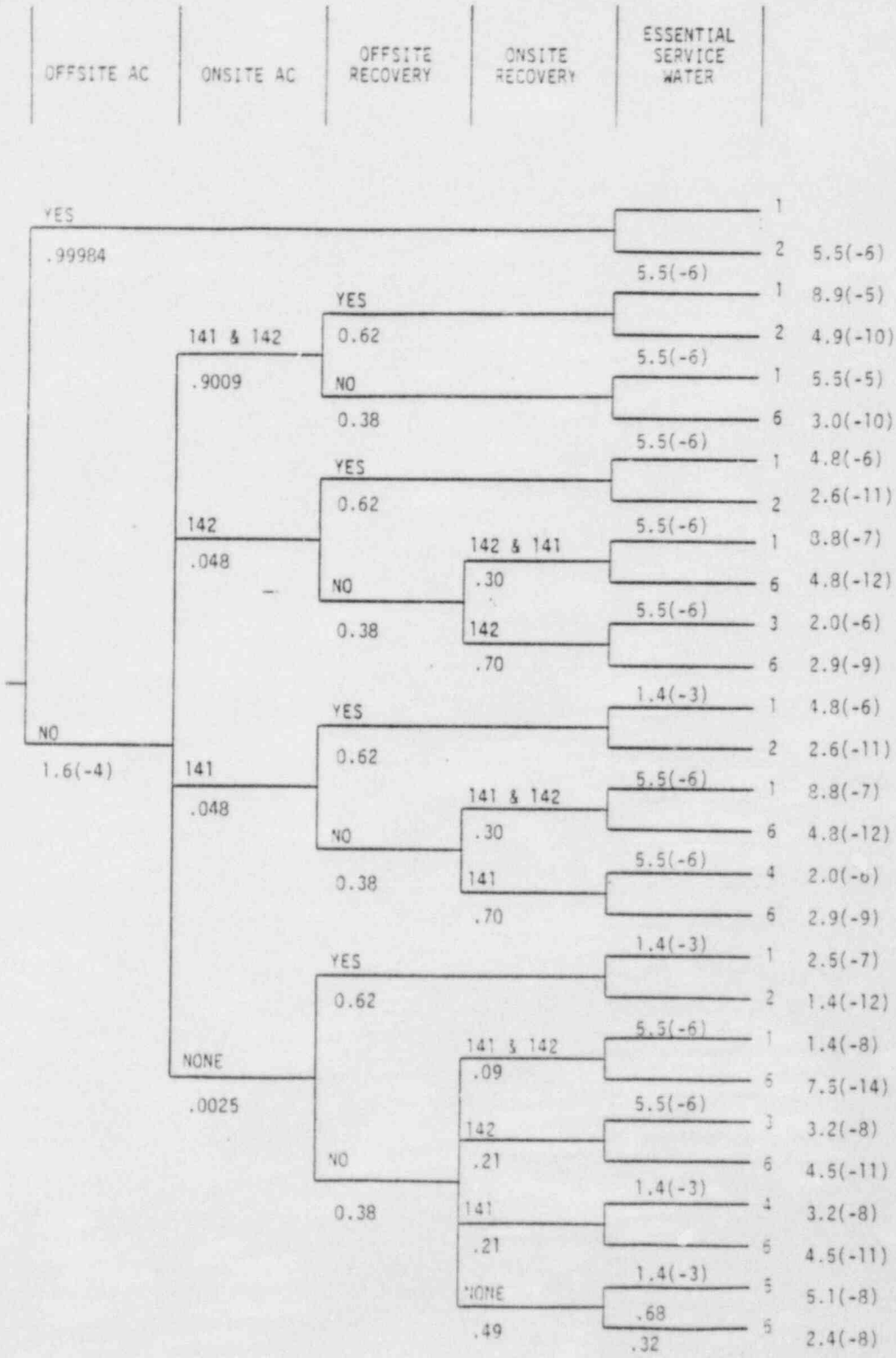

OFFSITE AC
ONSITE AC
OFFSITE RECOVERY
ONSITE RECOVERY
ESSENTIAL SERVICE WATER
YES
0.0
NO
1.0
141 & 142
.9009
142
.048
141
.048
NONE
.0025
YES
0.62
NO
0.38
142 & 141
.30
142
.70
141 & 142
.30
141
.70
.09
.21
.21
.68
.32
0.49
5.5(-6)
1.4(-3)
5.6(-1)
3.1(+6)
3.4(-1)
1.9(-6)
3.0(-2)
1.6(-7)
5.5(-3)
3.0(-8)
1.3(-2)
1.8(-5)
1.6(-3)
8.5(-9)
8.6(-5)
4.7(-10)
2.0(-4)
2.8(-7)
3.2(-4)
1.5(-4)

FIGURE 4.2.2-4


OFFSITE AC
ONSITE AC
OFFSITE RECOVERY
ONSITE RECOVERY
ESSENTIAL SERVICE WATER
YES
.99984
NO
1.6(-4)
141 & 142
.9009
142
.048
141
.048
NONE
.0025
YES
0.62
NO
0.38
142 & 141
.30
142
.70
141 & 142
.30
141
.70
141 & 142
.09
142
.21
141
.21
NONE
.49
.68
.32
1
2
5.5(-6)
1
2
5.5(-6)
1
6
3.0(-10)
1
2
2.6(-11)
1
6
4.8(-12)
3
6
2.9(-9)
1
2
2.6(-11)
1
6
4.8(-12)
4
6
2.9(-9)
1
2
1.4(-12)
1
6
7.5(-14)
3
6
4.5(-11)
4
6
4.5(-11)
5
6
2.4(-8)
5.5(-6)
8.9(-5)
4.9(-10)
5.5(-5)
4.8(-6)
3.8(-7)
2.0(-6)
1.4(-3)
4.8(-6)
2.8(-7)
2.0(-6)
2.5(-7)
1.4(-8)
3.2(-8)
3.2(-8)
5.1(-8)

4.2.3 CALCULATION OF CORE DAMAGE FOR 7 DAY LCO

In this section, the plant core melt frequency from the internal initiating events is calculated.

To calculate the plant matrix, **M**, and the plant core melt frequency, the event trees of section 2 are quantified for each of the six support states, using nodal probabilities calculated in Section 4.2.1. The plant matrix generated is given by Table 4.2.3-1.

The internal initiating event frequency vector (ϕ) is taken from the section 1 and is repeated as Table 4.2.3-2.

The product ϕ**M** provides the frequencies of damage states given by Table 4.2.3-3.

The contribution of each initiating event category to the total internal core melt frequency is calculated and is displayed by Table 4.2.3-4. The contribution of each support state to the total core melt frequency is given by Table 4.2.3-5.

The ranking of initiating event-support state cases by their contribution to core melt is displayed on Table 4.2.3-6. Finally, Table 4.2.3-7 contains the percent contributions to each core melt state by initiating event-support state case.

TABLE 4.2.3-1

PLANT MATRIX (M MATRIX)

	AEFC SEC V2E	AEF SE V2L	AEC SLFC V	AE SLF	ALFC SLC	ALF SL	ALC TEFC	AL TEF	SEFC TEC	SEF TE
1	6.70E-04 0.00E-01 6.70E-09	4.14E-07 0.00E-01 9.99E-06	2.58E-08 0.00E-01 0.00E-01	5.50E-07 0.00E-01	2.60E-04 0.00E-01	1.51E-07 0.00E-01	2.70E-05 0.00E-01	1.57E-08 0.00E-01	0.00E-01 0.00E-01	0.00E-01 0.00E-01
2	6.78E-04 0.00E-01 7.06E-09	4.21E-07 0.00E-01 9.99E-06	2.70E-05 0.00E-01 0.00E-01	5.66E-07 0.00E-01	2.60E-04 0.00E-01	1.51E-07 0.00E-01	3.65E-09 0.00E-01	1.68E-11 0.00E-01	0.00E-01 0.00E-01	0.00E-01 0.00E-01
3	0.00E-01 2.73E-05 0.00E-01	0.00E-01 5.66E-07 0.00E-01	0.00E-01 4.90E-04 0.00E-01	0.00E-01 2.86E-07	0.00E-01 7.54E-09	0.00E-01 3.95E-11	0.00E-01 4.44E-11	0.00E-01 2.58E-14	2.12E-07 6.37E-12	2.42E-08 1.33E-13
4	0.00E-01 6.41E-12 2.80E-05	0.00E-01 1.79E-13 9.39E-06	0.00E-01 8.78E-17 0.00E-01	0.00E-01 8.44E-20	0.00E-01 5.69E-20	0.00E-01 6.82E-22	0.00E-01 1.84E-17	0.00E-01 1.32E-20	5.27E-16 6.37E-12	3.18E-19 1.33E-13
5	0.00E-01 1.35E-05 2.74E-10	0.00E-01 2.83E-07 1.00E-05	0.00E-01 6.15E-07 0.00E-01	0.00E-01 3.97E-10	0.00E-01 7.26E-11	0.00E-01 9.05E-13	0.00E-01 3.15E-07	0.00E-01 1.84E-10	1.30E-09 4.87E-07	3.18E-12 1.02E-08
6	0.00E-01 1.35E-05 2.74E-10	0.00E-01 2.83E-07 1.00E-05	0.00E-01 6.15E-07 0.00E-01	0.00E-01 3.97E-10	0.00E-01 7.26E-11	0.00E-01 9.05E-13	0.00E-01 3.15E-07	0.00E-01 1.84E-10	1.30E-09 4.87E-07	3.18E-12 1.02E-08
7	0.00E-01 2.75E-06 3.23E-10	0.00E-01 1.66E-08 9.39E-10	0.00E-01 3.44E-07 0.00E-01	0.00E-01 2.10E-10	0.00E-01 2.12E-11	0.00E-01 2.21E-13	0.00E-01 1.26E-07	0.00E-01 7.46E-11	1.30E-09 9.90E-08	3.17E-12 2.43E-09
8	0.00E-01 2.75E-06 3.23E-10	0.00E-01 1.66E-08 9.39E-10	0.00E-01 3.44E-07 0.00E-01	0.00E-01 2.10E-10	0.00E-01 2.12E-11	0.00E-01 2.21E-13	0.00E-01 1.26E-07	0.00E-01 7.45E-11	2.14E-11 9.89E-08	2.42E-12 2.43E-09
9	0.00E-01 2.75E-06 3.23E-10	0.00E-01 1.66E-08 9.39E-10	0.00E-01 3.44E-07 0.00E-01	0.00E-01 2.10E-10	0.00E-01 2.12E-11	0.00E-01 2.21E-13	0.00E-01 1.26E-07	0.00E-01 7.46E-11	1.30E-09 9.90E-08	3.17E-12 2.43E-09
10	0.00E-01 9.34E-12 1.10E-15	0.00E-01 5.66E-14 3.19E-15	0.00E-01 1.17E-12 0.00E-01	0.00E-01 7.15E-16	0.00E-01 7.21E-17	0.00E-01 7.51E-19	0.00E-01 4.29E-13	0.00E-01 2.53E-16	4.43E-15 3.36E-13	1.08E-17 8.27E-15
11	0.00E-01 2.75E-06 3.23E-10	0.00E-01 1.66E-08 9.39E-10	0.00E-01 3.44E-07 0.00E-01	0.00E-01 2.10E-10	0.00E-01 2.12E-11	0.00E-01 2.21E-13	0.00E-01 1.26E-07	0.00E-01 7.45E-11	1.30E-09 9.90E-08	3.17E-12 2.43E-09

TABLE 4.2.3-1 (Continued)

PLANT MATRIX (M MATRIX)

12	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	8.63E-08	8.17E-11
	2.64E-05	7.06E-05	6.10E-06	7.02E-08	1.12E-07	1.36E-09	3.85E-06	1.08E-08	9.64E-07	1.10E-05
	3.16E-10	2.12E-09	0.00E-01							
13	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.30E-09	3.17E-12
	2.75E-06	1.66E-08	5.64E-07	3.38E-10	2.65E-06	6.51E-08	2.70E-07	1.57E-10	9.89E-08	2.43E-09
	3.23E-10	9.39E-10	0.00E-01							
14	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	9.47E-10	2.96E-12
	2.75E-06	1.66E-08	3.44E-07	2.10E-10	2.12E-11	2.21E-13	1.26E-07	7.46E-11	9.90E-08	2.43E-09
	3.23E-10	9.39E-10	0.00E-01							
V	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	1.00E+00							

TABLE 4.2.3-2

INITIATING EVENT DEFINITIONS AND MEAN FREQUENCIES

EVENT SYMBOL	EVENT DESCRIPTION	FREQUENCY / REACTOR YEAR
1	LARGE LOCA	9.40E-04
2	MEDIUM LOCA	9.40E-04
3	SMALL LOCA	3.54E-02
4	STEAM GENERATOR TUBE RUPTURE	3.70E-02
5	STEAM BREAK INSIDE CONTAINMENT	9.40E-04
6	STEAM BREAK OUTSIDE CONTAINMENT	9.40E-04
7	LOSS OF MAIN FEEDWATER	3.00E+00
8	CLOSURE OF ONE MSIV	2.52E-01
9	LOSS OF RCS FLOW	3.58E-01
10	CORE POWER EXCURSION	2.28E-02
11	TURBINE TRIP	4.00E+00
12	LOSS OF OFFSITE POWER	5.76E-02
13	SPURIOUS SAFETY INJECTION	8.00E-02
14	REACTOR TRIP	3.00E+00
V	INTERFACING SYSTEMS LOCA	2.10E-07

TABLE 4.2.3-3

CORE MELT STATE DEFINITIONS AND CALCULATED MEAN FREQUENCIES

SYMBOL	DESCRIPTION	FREQUENCY / REACTOR YEAR	PERCENT CONTRIBUTION
AEFC	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.27E-06	1.96
AEF	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	7.85E-10	<0.1
AEC	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	2.54E-08	<0.1
AE	LARGE LOCA EARLY NO CONTAINMENT COOLING	1.05E-09	<0.1
ALFC	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	4.88E-07	.76
ALF	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.85E-10	<0.1
ALC	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.54E-08	<0.1
AL	LARGE LOCA LATE MELT NO CONTAINMENT COOLING	1.47E-11	<0.1
SEFC	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	2.50E-08	<0.1
SEF	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	8.94E-10	<0.1
SEC	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	3.19E-05	49.35
SE	SMALL LOCA EARLY MELT NO CONTAINMENT COOLING	4.26E-06	6.60
SLFC	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.14E-05	33.10
SLF	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	1.64E-08	<0.1
SLC	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.19E-07	.34
SL	SMALL LOCA LATE MELT NO CONTAINMENT COOLING	5.29E-09	<0.1
TEFC	TRANSIENT WITH NO COOLING, EARLY MELT	1.58E-06	2.45
TEF	TRANSIENT WITH NO COOLING, EARLY MELT	1.42E-09	<0.1
TEC	TRANSIENT WITH NO COOLING, EARLY MELT	1.11E-06	1.72
TE	TRANSIENT EARLY MELT NO CONTAINMENT COOLING	6.62E-07	1.02
V2E	SGTR EARLY MELT	1.04E-06	1.61
V2L	SGTR LATE MELT	3.95E-07	.61
V	INTERFACING SYSTEMS LOCA	2.10E-07	.32
	TOTAL	6.46E-05	100.0

TABLE 4.2.3-4

INITIATING EVENTS AND THE CORE MELT FREQUENCIES

SYMBOL	DESCRIPTION	CORE MELT FREQUENCY	PERCENT CONTRIBUTION	CONDITIONAL CORE MELT FREQUENCY
1	LARGE LOCA	9.10E-07	1.41	9.68E-04
2	MEDIUM LOCA	9.18E-07	1.42	9.76E-04
3	SMALL LOCA	1.83E-05	28.39	5.18E-04
4	STEAM GENERATOR TUBE RUPTURE	1.38E-06	2.14	3.74E-05
5	STEAM BREAK INSIDE CONTAINMENT	2.37E-08	<0.1	2.52E-05
6	STEAM BREAK OUTSIDE CONTAINMENT	2.37E-08	<0.1	2.52E-05
7	LOSS OF MAIN FEEDWATER	1.00E-05	15.50	3.34E-06
8	CLOSURE OF ONE MSIV	8.41E-07	1.30	3.34E-06
9	LOSS OF RCS FLOW	1.20E-06	1.85	3.34E-06
10	CORE POWER EXCURSION	2.59E-13	<0.1	1.14E-11
11	TURBINE TRIP	1.34E-05	20.67	3.34E-06
12	LOSS OF OFFSITE POWER	6.86E-06	10.62	1.19E-04
13	SPURIOUS SAFETY INJECTION	5.13E-07	.79	6.42E-06
14	REACTOR TRIP	1.00E-05	15.50	3.34E-06
V	INTERFACING SYSTEMS LOCA	2.10E-07	.32	1.00E+00
		6.46E-05	100.0	

TABLE 4.2.3-5

CORE MELT FREQUENCY BY SUPPORT STATE

STATE	1	2.48E-05	38.39
STATE	2	3.28E-05	50.73
STATE	3	3.92E-07	.61
STATE	4	1.51E-08	.02
STATE	5	7.10E-07	1.10
STATE	6	5.92E-06	9.15

TABLE 4.2.3-6

CORE MELT FREQUENCY BY EVENT AND SUPPORT STATE

ET03.01	1.74E-05	ET07.06	4.66E-08	ET09.05	6.80E-10	ET15.04	1.60E-12
ET11.02	1.14E-05	ET14.06	4.66E-08	ET01.06	5.17E-10	ET15.03	1.60E-12
ET07.02	8.55E-06	ET12.01	2.65E-08	ET02.06	5.17E-10	ET10.02	2.23E-13
ET14.02	8.55E-06	ET02.02	2.54E-08	ET08.05	4.76E-10	ET06.04	2.17E-13
ET12.06	5.71E-06	ET01.02	2.54E-08	ET09.03	3.78E-10	ET05.04	2.17E-13
ET11.01	1.89E-06	ET04.06	2.04E-08	ET05.06	2.68E-10	ET15.06	1.16E-13
ET07.01	1.41E-06	ET03.06	1.95E-08	ET06.06	2.68E-10	ET10.01	3.69E-14
ET14.01	1.41E-06	ET05.02	1.31E-08	ET08.03	2.65E-10	ET10.06	1.22E-15
ET09.02	1.03E-06	ET06.02	1.31E-08	ET04.03	2.55E-10	ET10.05	1.48E-16
ET04.02	9.99E-07	ET12.04	1.20E-08	ET02.04	1.70E-10	ET10.03	8.22E-17
ET03.02	9.56E-07	ET06.01	1.03E-08	ET02.03	1.70E-10	ET10.04	2.61E-18
ET02.01	8.91E-07	ET05.01	1.03E-08	ET11.04	1.33E-10	ET16.06	0.00E-01
ET01.01	8.84E-07	ET11.05	7.56E-09	ET07.04	1.00E-10	ET16.05	0.00E-01
ET08.02	7.18E-07	ET07.05	5.67E-09	ET14.04	1.00E-10	ET16.04	0.00E-01
ET12.05	6.86E-07	ET14.05	5.67E-09	ET13.03	7.81E-11	ET16.03	0.00E-01
ET13.02	4.40E-07	ET09.06	5.59E-09	ET01.03	7.06E-11	ET16.02	0.00E-01
ET12.03	3.77E-07	ET11.03	4.20E-09	ET01.04	7.06E-11	ET16.01	0.00E-01
ET04.01	3.62E-07	ET13.05	4.08E-09	ET04.04	3.04E-11	ET15.05	0.00E-01
ET15.01	2.10E-07	ET08.06	3.92E-09	ET09.04	1.20E-11	ET06.05	0.00E-01
ET09.01	1.70E-07	ET03.03	3.25E-09	ET08.04	8.41E-12	ET05.05	0.00E-01
ET08.01	1.18E-07	ET07.03	3.15E-09	ET15.02	5.67E-12	ET04.05	0.00E-01
ET12.02	1.02E-07	ET14.03	3.15E-09	ET05.03	3.41E-12	ET03.05	0.00E-01
ET13.01	6.69E-08	ET03.04	2.51E-09	ET06.03	3.41E-12	ET02.05	0.00E-01
ET13.01	6.69E-08	ET03.04	2.51E-09	ET06.03	3.41E-12	ET02.05	0.00E-01

TABLE 4.2.3-7

EVENT/SUPPORT STATE CONTRIBUTORS TO CORE MELT STATES (PERCENTAGE)

AEFC	99.97	ETO2.01	50.29	ETO1 01	49.68						
AEF	99.88	ETO2.01	50.00	ETO1.01	49.47	ETO2.04	.21	ETO2.03	.21		
AEC	99.86	ETO2.02	99.86								
AE	99.99	ETO2.06	49.29	ETO1.06	49.29	ETO2.02	1.40				
ALFC	99.97	ETO1.01	49.99	ETO2.01	49.99						
ALF	100.00	ETO1.01 ETO2.03	49.74 .13	ETO2.01	49.74	ETO1.03	.13	ETO1.04	.13	ETO2.04	.13
ALC	99.97	ETO1.02	99.97								
AL	99.78	ETO1.02	99.78								
SEFC	99.82	ETO3.01 ETO9.01	29.81 1.87	ET11.01 ET13.01	20.80 .42	ET12.05 ET12.01	19.28 .29	ETO7.01 ET12.03	15.60 .28	ET14.01 ET12.04	11.34 .13
SEF	99.76	ETO3.01 ET12.03	95.70 .15	ET11.01 ETO9.01	1.42 .13	ETO7.01	1.06	ET14.01	.99	ET12.05	.31
SEC	99.89	ET11.02 ETO3.02	34.45 2.99	ET14.02 ETO8.02	25.84 2.17	ETO7.02 ET13.02	25.84 .69	ET12.06 ET12.02	4.49 .31	ETO9.02	3.10
SE	99.82	ET12.06 ET12.05	95.05 .32	ET11.06 ET11.02	1.40 .15	ET14.06 ETO9.06	1.05 .13	ETO7.06 ETO7.02	1.05 .11	ETO3.06 ET14.02	.45 .11
SLFC	99.78	ETO3.01 ETO9.01	81.04 .58	ET11.01 ETO8.01	6.41 .40	ETO7.01 ET13.01	4.81 .21	ET14.01	4.81	ET12.03	1.51
SLF	99 12	ETO3.01 ET12.04	61.12 .80	ET12.03 ETO9.01	23.88 .44	ET11.01 ETO8.01	4.83 .30	ETO7.01 ET11.03	3.63 .27	ET14.01 ETO3.03	3.63 .23
SLC	99.68	ET13.02	96.81	ET12.03	2.86						
SL	99.88	ET13.05	74.25	ET13.06	21.86	ET13.02	2.32	ET12.03	1.44		
TEFC	99.84	ET11.01 ET12.03	31.81 2.65	ETO7.01 ETO8.01	23.87 2.00	ET14.01 ET13.01	23.87 1.36	ET12.05 ET12.01	10.95 .45	ETO9.01	2.86
TEF	99.01	ET12.03 ETO9.01	35.76 1.84	ET11.01 ETO8.01	20.47 1.29	ETO7.01 ET13.01	15.36 .88	ET14.01 ET12.04	15.36 .60	ET12.05 ET11.03	7.05 .40
TEC	99.84	ET11.02 ETO8.02	35.50 2.24	ETO7.02 ET13.02	26.63 .71	ET14.02 ET12.02	26.63 .32	ET12 06	4.62	ETO9.02	3.20
TE	99.66	ET12.05 ET11.06	74.08 .32	ET12.06 ETO7.06	22.02 .24	ET11.05 ET14.06	1.10 .24	ETO7.05	.83	ET14.05	.83
V2E	99.77	ETO4.02	96.24	ETO4.06	1.96	ETO4.01	1.46	ET11.02	.11		

TABLE 4.2.3-7 (Continued)

EVENT/SUPPORT STATE CONTRIBUTORS TO CORE MELT STATES (PERCENTAGE)

V2L	99.74	ET04.01	87.85	ET05.01	2.38	ET06.01	2.38	ET02.01	2.38	ET01.01	2.38
		ET11.01	.95	ET07.01	.71	ET14.01	.71				
V	100.00	ET15.01	100.00								

4.2.4 CALCULATION OF PLANT RISK

In this section the plant risk in terms of the consequence categories

1) early fatalities
2) early injuries
3) thyroid cancer incidences
4) latent cancer fatalities
5) man-rem release

is calculated and the corresponding risk curves are drawn for the 7-day LCO.

The product ϕMC provides the release category frequencies. This quantification is summarized by Table 4.2.4-1.

The product ϕMCS for each consequence category provides the point estimate frequencies for each of the consequence categories, i=1, 2, 3, 4, 5. The results are given by Tables 4.2.4-2 through 4.2.4-6. The same results are also expressed as risk curves by Figures 4.2.4-1 through 4.2.4-5.

TABLE 4.2.4-1

RELEASE CATEGORY DEFINITIONS AND CALCULATED MEAN FREQUENCIES

RELEASE CATEGORY	DESCRIPTION	FREQUENCY / REACTOR YEAR	PERCENT CONTRIBUTION
Z-1	STEAM EXPLOSION WITHOUT CONTAINMENT SPRAY	1.07E-09	<0.1
2	OVERPRESSURE FAILURES WITHOUT SPRAYS	2.17E-07	.34
2R	DELAYED OVERPRESSURE FAILURE WITHOUT SPRAYS	4.93E-06	7.63
Z-3	STEAM EXPLOSIONS WITH SPRAYS	2.06E-10	<0.1
5R	DELAYED OVERPRESSURE WITH SPRAYS	7.53E-09	<0.1
Z-5	EARLY OVERPRESSURE FAILURES WITH SPRAYS	5.08E-09	<0.1
6	BASEMAT MELT-THROUGH WITHOUT SPRAYS	9.40E-10	<0.1
7	BASEMAT MELT-THROUGH WITH SPRAYS	1.01E-08	<0.1
8A	CONTAINMENT INTACT WITHOUT SPRAYS	2.03E-08	<0.1
8B	CONTAINMENT INTACT WITH SPRAYS	5.80E-05	89.75
2R'	SGTR RELEASE	1.43E-06	2.22
	TOTAL	6.46E-05	100.0

TABLE 4.2.4-2

POINT ESTIMATE VECTOR FOR EARLY FATALITIES

NUMBER OF FATALITIES	FREQUENCY OF OCCURRENCE
1.00E+00	1.48E-08
2.00E+00	1.48E-08
3.00E+00	1.48E-08
5.00E+00	1.48E-08
7.00E+00	1.45E-08
1.00E+01	1.27E-08
2.00E+01	1.26E-08
3.00E+01	1.25E-08
5.00E+01	1.25E-08
7.00E+01	1.24E-08
1.00E+02	1.10E-08
2.00E+02	1.10E-08
3.00E+02	7.51E-09
5.00E+02	7.51E-09
7.00E+02	7.21E-09
1.00E+03	6.11E-09
2.00E+03	2.19E-11
3.00E+03	1.98E-11
5.00E+03	0.00E-01

TABLE 4.2.4-3

POINT ESTIMATE VECTOR FOR EARLY INJURIES

NUMBER OF INJURIES	FREQUENCY OF OCCURRENCE
1.00E+00	2.88E-07
2.00E+00	2.88E-07
3.00E+00	2.88E-07
5.00E+00	2.88E-07
7.00E+00	2.80E-07
1.00E+01	2.79E-07
2.00E+01	2.79E-07
3.00E+01	2.78E-07
5.00E+01	2.75E-07
7.00E+01	2.58E-07
1.00E+02	2.57E-07
2.00E+02	2.55E-07
3.00E+02	2.54E-07
5.00E+02	2.45E-07
7.00E+02	1.89E-07
1.00E+03	1.56E-07
2.00E+03	1.14E-07
3.00E+03	8.87E-08
5.00E+03	7.80E-08
7.00E+03	5.23E-08
1.00E+04	4.44E-08
2.00E+04	9.38E-09
3.00E+04	8.33E-09
5.00E+04	8.31E-09
7.00E+04	3.46E-10
1.00E+05	0.00E-01

TABLE 4.2.4-4

POINT ESTIMATE VECTOR FOR THYROID CANCERS

NUMBER OF THY CANCER	FREQUENCY OF OCCURRENCE
1.00E+00	5.83E-06
2.00E+00	4.38E-06
3.00E+00	3.41E-06
5.00E+00	2.92E-06
7.00E+00	2.55E-06
1.00E+01	2.42E-06
2.00E+01	2.42E-06
3.00E+01	2.41E-06
5.00E+01	2.37E-06
7.00E+01	2.35E-06
1.00E+02	2.29E-06
2.00E+02	2.14E-06
3.00E+02	2.07E-06
5.00E+02	1.91E-06
7.00E+02	1.79E-06
1.00E+03	1.61E-06
2.00E+03	1.32E-06
3.00E+03	9.97E-07
5.00E+03	7.11E-07
7.00E+03	5.92E-07
1.00E+04	4.56E-07
2.00E+04	2.00E-07
3.00E+04	1.07E-07
5.00E+04	3.62E-08
7.00E+04	1.02E-08
1.00E+05	3.46E-10
2.00E+05	0.00E-01

TABLE 4.2.4-5

POINT ESTIMATE VECTOR FOR LATENT CANCER FATALITIES (EXCLUDING THYROID)

NUMBER OF LAT CANCER	FREQUENCY OF OCCURRENCE
1.00E+00	3.79E-06
2.00E+00	2.83E-06
3.00E+00	2.71E-06
5.00E+00	2.57E-06
7.00E+00	2.57E-06
1.00E+01	2.57E-06
2.00E+01	2.55E-06
3.00E+01	2.54E-06
5.00E+01	2.47E-06
7.00E+01	2.46E-06
1.00E+02	2.38E-06
2.00E+02	2.21E-06
3.00E+02	2.14E-06
5.00E+02	1.97E-06
7.00E+02	1.82E-06
1.00E+03	1.67E-06
2.00E+03	1.24E-06
3.00E+03	8.61E-07
5.00E+03	4.23E-07
7.00E+03	2.43E-07
1.00E+04	8.07E-08
2.00E+04	1.03E-11
3.00E+04	0.00E-01

TABLE 4.2.4-6

POINT ESTIMATE VECTOR FOR MAN-REMS

NUMBER OF MAN-REM	FREQUENCY OF OCCURRENCE
1.00E+03	1.17E-05
2.00E+03	8.49E-06
3.00E+03	6.31E-06
5.00E+03	5.95E-06
7.00E+03	4.86E-06
1.00E+04	4.13E-06
2.00E+04	3.29E-06
3.00E+04	2.68E-06
5.00E+04	2.56E-06
7.00E+04	2.42E-06
1.00E+05	2.42E-06
2.00E+05	2.41E-06
3.00E+05	2.40E-06
5.00E+05	2.40E-06
7.00E+05	2.35E-06
1.00E+06	2.33E-06
2.00E+06	2.21E-06
3.00E+06	2.10E-06
5.00E+06	2.01E-06
7.00E+06	1.90E-06
1.00E+07	1.74E-06
2.00E+07	1.38E-06
3.00E+07	1.15E-06
5.00E+07	7.36E-07
7.00E+07	4.24E-07
1.00E+08	2.70E-07
2.00E+08	8.45E-09
3.00E+08	0.00E-01

FIGURE 4.2.4-1

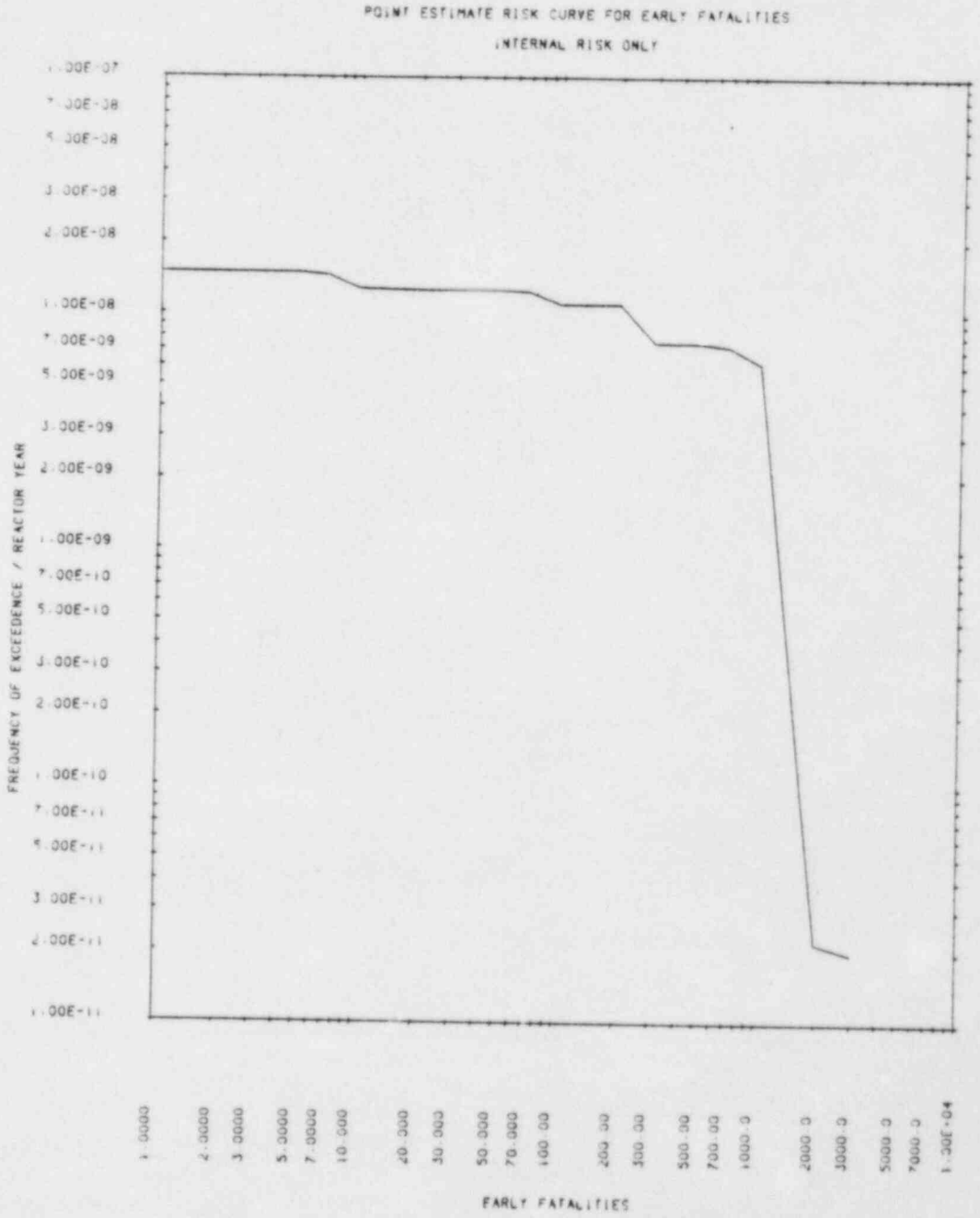

POINT ESTIMATE RISK CURVE FOR EARLY FATALITIES
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
EARLY FATALITIES

FIGURE 4.2.4-2

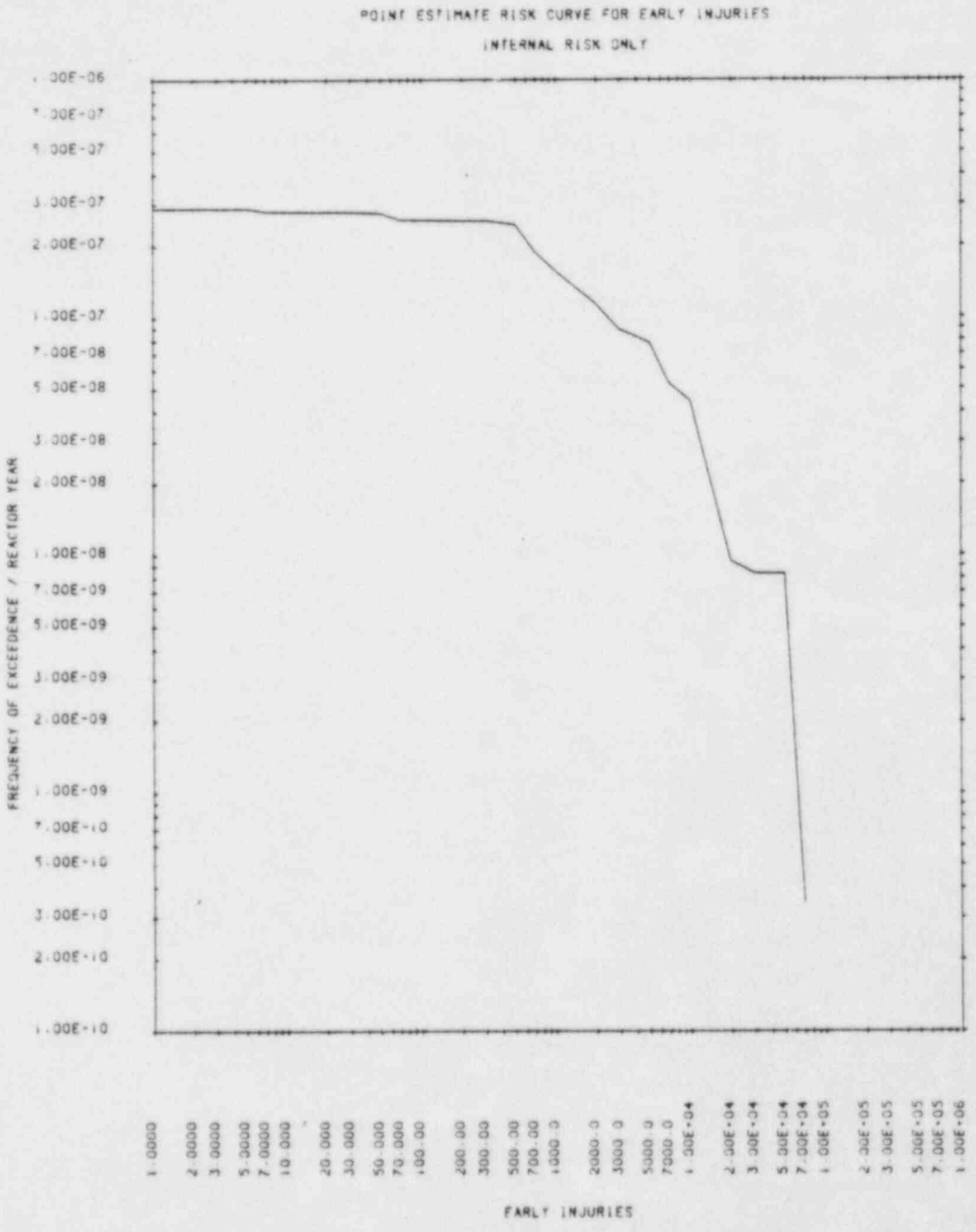

POINT ESTIMATE RISK CURVE FOR EARLY INJURIES
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
1.00E-06
7.00E-07
5.00E-07
3.00E-07
2.00E-07
1.00E-07
7.00E-08
5.00E-08
3.00E-08
2.00E-08
1.00E-08
7.00E-09
5.00E-09
3.00E-09
2.00E-09
1.00E-09
7.00E-10
5.00E-10
3.00E-10
2.00E-10
1.00E-10
1.0000
2.0000
3.0000
5.0000
7.0000
10.000
20.000
30.000
50.000
70.000
100.00
200.00
300.00
500.00
700.00
1000.0
2000.0
3000.0
5000.0
7000.0
1.00E+04
2.00E+04
3.00E+04
5.00E+04
7.00E+04
1.00E+05
2.00E+05
3.00E+05
5.00E+05
7.00E+05
1.00E+06
EARLY INJURIES

FIGURE 4.2.4-3

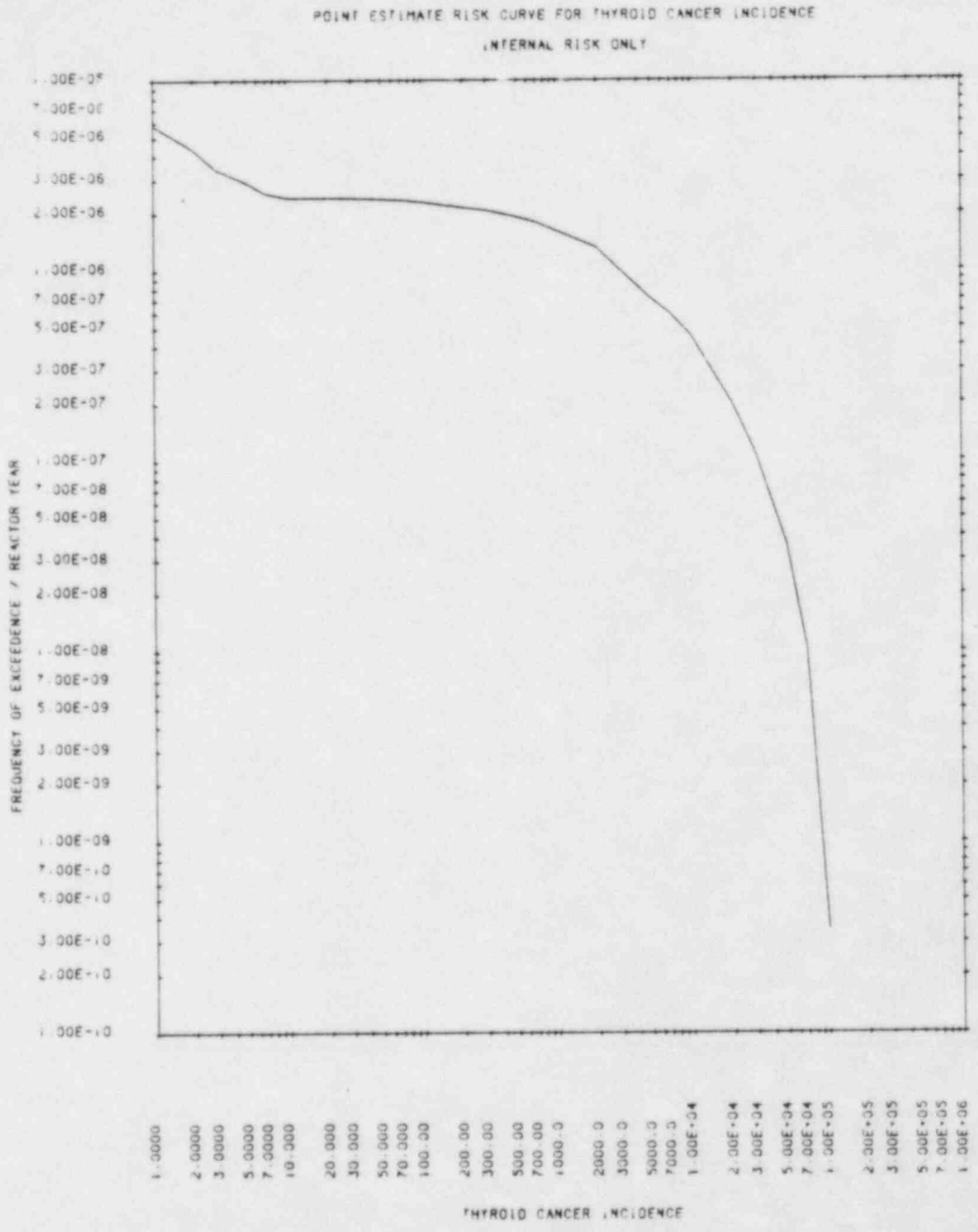
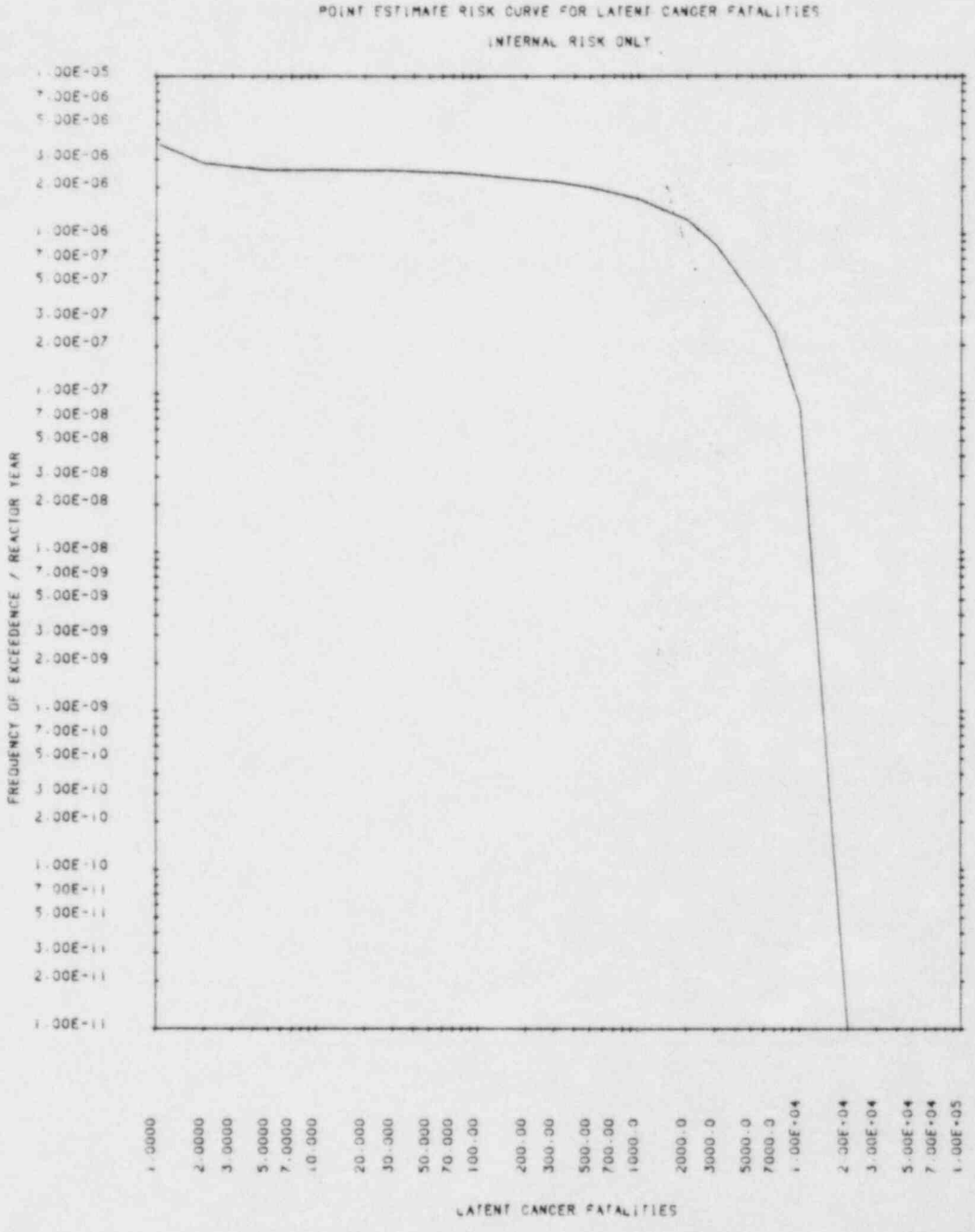

POINT ESTIMATE RISK CURVE FOR THYROID CANCER INCIDENCE
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
THYROID CANCER INCIDENCE

FIGURE 4.2.4-4


POINT ESTIMATE RISK CURVE FOR LATENT CANCER FATALITIES
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
1.00E-05
7.00E-06
5.00E-06
3.00E-06
2.00E-06
1.00E-06
7.00E-07
5.00E-07
3.00E-07
2.00E-07
1.00E-07
7.00E-08
5.00E-08
3.00E-08
2.00E-08
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7.00E-09
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1.00E-10
7.00E-11
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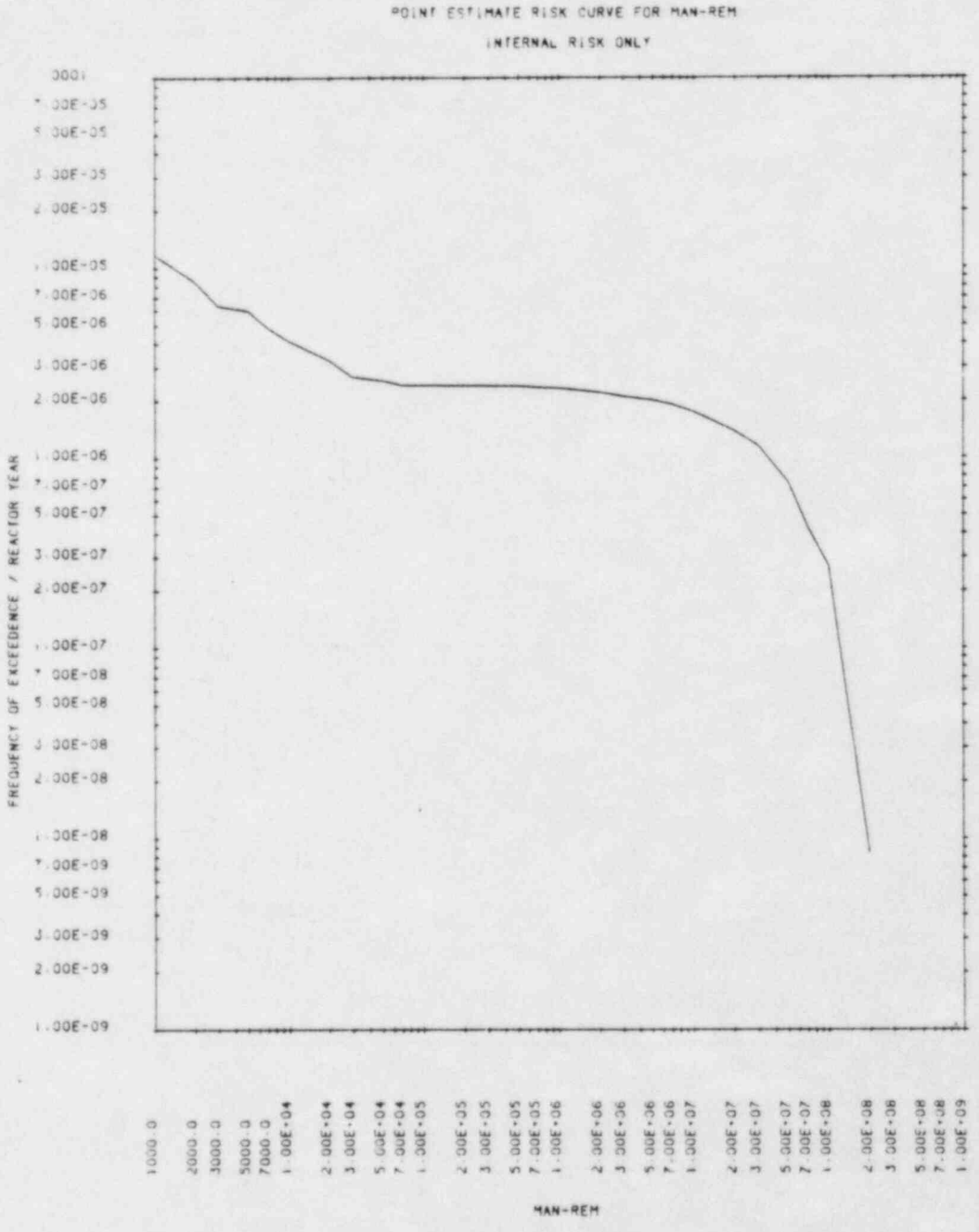
3.00E-11
2.00E-11
1.00E-11
1.0000
2.0000
3.0000
5.0000
7.0000
10.000
20.000
30.000
50.000
70.000
100.00
200.00
300.00
500.00
700.00
1000.0
2000.0
3000.0
5000.0
7000.0
1.00E+04
2.00E+04
3.00E+04
5.00E+04
7.00E+04
1.00E+05
LATENT CANCER FATALITIES

FIGURE 4.2.4-5


POINT ESTIMATE RISK CURVE FOR MAN-REM
INTERNAL RISK ONLY
FREQUENCY OF EXCEEDENCE / REACTOR YEAR
MAN-REM

APPENDIX 4A

CONTAINMENT RESPONSE MODEL

4A.1 INTRODUCTION AND SUMMARY

A comparison of the Byron and Zion station containment systems was performed. This evaluation was performed to determine the applicability of the Zion Containment Event Tree (CET) structure and quantification to the present Byron station setup. Differences between the two stations were identified and a qualitative assessment was made as to the effect these differences would make on the structure, timing and quantification of the Zion CET. The results of this comparison showed no significant differences between the Byron and Zion containment systems. Where differences were identified, these differences would generally affect the timing of events and have little impact on either the structure or quantification of the CET. This result is due to structural and functional simularities between the two containment systems and reactor coolant systems. The containment analysis results are summarized in the C-Matrix which is given by Table 4A-4.

4A.2 Zion Containment Event Tree

The Containment Event Tree as developed and described in the Zion Probabilistic Safety Study (PSS) is an event tree structure which is used by the risk analyst to trace the progression of an accident through its numerous possible scenarios to a conclusion. This conclusion may be a successful recovery from the accident or a type and amount of release of radioactivity to the environment. The Zion CET methodology is comprised of three separate parts: Entry states which describe the initial state of the reactor and containment, Event questions which ask various phenomenological questions relevant to the scenarios stemming from the plant entry states, and Release categories which quantify the amount and timing of radioactivity releases for each end point of the CET. All of these parts will be discussed in Section 5.

The six entry states used as input to the Zion CET are shown in Table 4A-1. Each entry state typifies a set of accidents whose characteristics with regard

to containment response are similar. The Event questions used in Zion CET are given in Table 4A-2. These questions address the state of the containment and its response to various phenomena related to core melt (e.g., Is containment pressure within the containment pressure limit, Is water present in the reactor cavity at the time of vessel failure). These questions are asked in an approximately chronological order A release category is assigned to each path of the tree, out of study of the physical processes represented by that path. These release categories are essentially those given in the WASH-1400 release categories. Modifications were made for some categories to account for new assessments of phenomenology. These modifications are discussed in Section 5 of the Zion PSS.

4A.3 Byron Containment and Primary System Comparison

The comparison of the Byron and Zion containment and primary systems was divided into the three parts: Containment Structure, Containment Safeguards, and Primary Systems. Under the heading of Containment Structure the capability of the Byron containment building to perform its prime function (i.e., provide a barrier to fission product release) was compared with Zion. This includes the capacity of the containment to withstand the pressures and temperatures expected following a severe accident. Under Containment Safeguards, the capabilities of the containment spray systems, containment fan coolers, and passive heat sinks were compared with Zion. These systems act in a containment transient to remove energy and provide an inventory of cooling water for recirculation cooling. The primary systems comparison examined the systems which affect the timing and magnitude of mass and energy release to the containment. This includes both water inventory introduction to the containment and core debris deposition following vessel failure.

4A.3.1. Containment Structure

Pressure Capacity

The primary function of a reactor containment building during and after an accident, is to act as a barrier to fission product release to the environment. This function is dependent upon the containments ability to

withstand the pressures experienced during the course of an accident. In the Zion PSS the ultimate capacity of the Zion containment was conservatively estimated to be 134 psig. This was based on an analysis which calculated the yield point of the containment structure. The yield point was defined as a one percent strain in prestressing steel tendons. Actual containment failure would occur at some pressure above 134 psig. The failure mode at this pressure was determined to be by hoop tendon yielding. The Zion CET addresses the containment pressurization at several questions (i.e., Questions A, C, E, G, N, P, and R) since pressurization rate, timing, and magnitude depend on how an accident progresses.

A detailed determination of the ultimate capacity of the Byron containment was beyond the scope of this work, however a lower bound estimate of 125 psig has been reported in the Byron FSAR (Response to Q130.52). This result is supported by basic similarities between the two containment buildings as discussed below.

Construction

Both containment structures were designed by Sargent and Lundy Const. and are prestressed concrete shell structures made up of a cylinder with a shallow dome roof and flat foundation slab. The cylindrical portions of both containments are prestressed by a post-tensioning system consisting of horizontal and vertical tendons. For Byron the horizontal post-tensioning consists of three buttresses equally spaced around the containment and each of 201 horizontal tendons is anchored at buttresses 240° apart, bypassing the intermediate buttress. For Zion, the horizontal post-tensioning consists of 555 horizontal tendons distributed and anchored between six buttresses. The vertical post-tensioning system for both containments consists of vertical tendons anchored at the top surface of the dome ring and the bottom of the base slab. Zion contains 216 tendons compared with 162 for Byron. Three groups of dome tendons make up the dome post-tensioning system for both containments. Zion contains 63 dome tendons/group while Byron contains 40 dome tendons/group. Each group is oriented at 120° to each other and are anchored at the vertical face of the dome ring grid. The entire structure for both containments is lined on the inside with 1/4" steel plate which acts

as a leak tight membrane. The overall dimensions of the two containments are essentially identical with the Byron containment being approximately 10 ft. higher in total height. This contributes to a slightly larger free volume for Byron (~ 3 percent). The slightly larger containment volume will cause the containment to pressurize at a slower rate, and provide accomodation for more hydrogen prior to reaching the combustible level. A comparison of containment dimension is given in Table 4A-3.

The containment sump and reactor cavity regions play a significant role in postulated core melt scenarios. This is due to the fact that vessel failure following a core melt is predicted to occur at the bottom head portion of the vessel. At the time of vessel failure the core debris is ejected into the reactor cavity region of containment. The events which occur following this drop depend on the configuration of the cavity and whether or not the cavity contains water. The presence of water in the cavity during or after debris dispersal acts to cool the core debris with the energy removed by steam formation acting to pressurize the containment. Absence of water increases core debris attack on the underlying concrete pad. The sources of cavity water are water from the vessel at the time of vessel failure and spillover from the sump region of containment. The geometry and size of the reactor cavity influences the disposition and ultimate coolability of the core debris material following vessel failure. Zion CET questions J, K, L, M, N, O, P, and Q address the events which occur in the containment following vessel failure.

The design of the reactor cavity area for Byron and Zion are essentially the same. The geometry of the two cavities areas is comprised of a circular cavity directly under the reactor vessel which is the low point in the containment. This area is connected to the sump area by the instrumentation tunnel. In both plants, the tunnel/cavity configuration offers no flow path singularities or obstructions to prevent debris dispersion or cavity flooding. The Byron reactor cavity is larger than the Zion cavity due to a longer and wider tunnel region. This increase in size provides a larger area over which debris in the cavity could be cooled. The concrete slab directly under the reactor cavity for Byron is again essentially the same as Zion.

Both slabs are comprised of a limestone based concrete approximately equal in thickness. Figure 4A-1 provides a schematic the Byron cavity area. The reactor cavity area parameters for both plants are given in Table 4A-3.

The net effect of these containment design similarities in the reactor cavity region is that the important phenomenological arguments relating to debris dispersion and coolability presented in the Zion PSS do not change. Namely that:

- debris will be dispersed for the high pressure core melt scenarios

- the debris will be coolable whether it is dispersed or not if water is present in the reactor cavity area and if containment safeguards are operational.

4A.3.2 Containment Safeguards

The containment safeguard systems (i.e., containment sprays, containment fan coolers, and passive heat sinks) act during a containment transient to remove energy from the containment atmosphere. The containment sprays perform this function by injecting subcooled water droplets into the containment atmosphere from spray headers located at the top of the containment. The source of this water can be either the Refueling Water Storage Tank (RWST) or the containment sump. The containment fan coolers act during transient conditions to remove energy from the containment by recirculating containment air past cooling coils and moisture separators which provide for steam condensation and gas cooling. Both the fan cooler and spray system provide atmospheric mixing. Although the containment safeguards systems are not modeled explicitly in the Zion CET, their effectiveness was evaluated in detailed analysis of containment transients. The results of these analysis are implicitly modeled in Zion CET questions which address the pressure in the containment (questions A, C, E, G, N, P, and R), and the operability or inoperability of the containment safeguards systems are included in the definition of the class sequences.

Containment Spray System

The containment spray systems for the Zion and Byron plants have fundamental differences in design, primarily in the implementation of the recirculation phase of spray injection which are considered in detail in the analyses of system reliability (Section 3), however these differences have little effect on the heat removal capacities of the systems which are essentially equal. The Zion spray system consists of 3 spray pumps, 1 diesel driven (DD) and 2 motor driven (MD), each delivering to 2 spray rings. The spray pumps take injection from the RWST. During the recirculation phase of spray injection, spray flow is provided by Recirculation Heat Removal (RHR) pumps which take suction from the containment sump. The Byron spray system consists of 2 MD pumps which operate during both injection and recirculation phases of a transient. Suction to the spray pumps is provided by the RWST during the injection phase and the containment sump during the recirculation phase. The spray flow capacity of the Byron spray system is about 10 percent higher than that for Zion which would tend to increase heat removal and thus reduce pressure. A comparison of system parameters is given in Table 4A-3.

Containment Fan Coolers

The containment fan cooler systems for Zion and Byron were compared on the basis of heat removal capacity per fan cooler assembly during accident conditions as well as total heat removal capacity. This comparison (Table 4A-3) shows that the Byron fan cooler system has a higher capacity (i.e., about 25 percent higher) than that for the Zion system. This will result in a lower containment pressure following degraded core accidents both during the longterm and prior to any pressure spikes due to steam release or generation, or hydrogen burns.

Containment Passive Heat Sinks

The walls and structures in the containment building which act as passive heat sinks were compared for Zion and Byron using information presented in their respective FSARs. This FSAR information was originally used in the determination of maximum containment pressure following loss of coolant

accidents and should represent conservatively low assessments of containment passive heat sink areas. For comparison purposes these heat sinks were collapsed into three types: steel lined concrete, unlined concrete, and steel. The heat sinks were then compared on the basis of total heat transfer surface available. This comparison (Table 4A-3) shows that Byron containment has considerably larger area available to act as a heat sink. Based on this information the Byron containment heat sinks should perform as well or better than Zion in relieving the heat load and thus pressure experienced by the containment.

4A.3.3 Primary Systems

The response of the primary system during an accident is very dependent on the accident which is being analyzed and the support systems and operator actions which are modeled. However, a comparison of key systems and parameters allows conclusions to be drawn as to the effect differences between the Byron and Z . primary systems will have on the Zion CET. These systems and parameters are:

a) Emergency Core Coolant Injection System (ECCS),
b) Primary Pressure Relief,
c) Core Parameters.

ECCS

The ECCS system is designed to provide cooling and inventory replacement during a Loss of Coolant Accident. These systems include the High Head Charging System, Medium Head Safety Injection, Residual Heat Removal System, Accumulators, and RWST. These systems were compared on the basis of total cooling water delivery capacity. This comparison is given in Table 4A-3. There is essentially no difference between the Byron and Zion designs with regard to cooling flow injection capacity, however Byron has a larger inventory of cooling water available in the RWST. This increased RWST size could possibly extend the time to switch over to recirculation injection, but increased spray flow capacity for Byron which also draws suction from the RWST, makes this uncertain. Overall system performance is essentially the same.

Primary Pressure Relief

Primary pressure relief is provided by the pressurizer PORVs and safety valves. The capacities of these valves are the same for Byron and Zion as shown in Table 4A-3.

Core Parameters

Table 4A-3 gives a comparison of key core parameters for Byron and Zion. The Byron and Zion designs were compared on the basis of parameters which would be expected to affect the progression of a core degradation process. Because of difficulty in modeling and predicting core melt progression a large amount of conservatism exists in modeling used in the Zion PSS. Because of this uncertainty and conservatism the small differences identified in the comparison of the Byron and Zion core parameters are not considered significant. These differences include a 5 percent higher total core heat flux, ~ 10 percent higher core specific power and a 5 percent lower metallic content for Byron.

4A.4 Summary of Containment / Primary Systems Comparison

The Zion and Byron containments, containment safeguard systems and primary systems are very similar. The differences between the plant layout and geometry and the capacity of the safeguards systems are conservative with respect to those for Byron. In particular

1. Byron's volume is about 2 percent greater than Zion's.

2. Byron's spray system has a more than 10 percent greater flowrate.

3. Byron's fan coolers have a 25 percent greater heat removal capacity than Zion's.

4. Byron has greater passive heat sink capability.

This would suggest that for a given accident sequence in which safeguards are operating the pressure and temperature would stabilize at lower values for

Byron than for Zion, and that the rate of containment pressurization for Byron given that containment safeguards are not operational would be slightly slower.

This is tempered by the fact the Byron containment failure pressure used in this analysis is slightly lower than that for the Zion Plant. This difference is minor however when it is noted that the containment transients, including sensitivity study runs, which can realistically generate pressures which are above the Byron failure pressure are the same set of transients that generate pressures above the Zion failure pressure. Those transients which would not fail Zion will not fail Byron.

Therefore no identifiable differences exist in the containment and containment safeguards systems which would make the Zion CET probabilities inapplicable. Thus in this study the Zion CET probability values were used.

TABLE 4A-1

CONTAINMENT RESPONSE CLASS SEQUENCES

Class Sequence No.	Reference Definitions
Class I	Initiating event is typically a large break LOCA without safety injection but with minimum containment safeguards operating throughout transient.
Class II	Same as Class I except that safety injection and the containment safeguards are initiated but only operate until switchover to recirculation is attempted, at which time they become inoperative for the remainder of the transient.
Class III	Same as Class I except that the initiating event is typically a small break LOCA. Note that the containment sprays do not turn on until later in the transient due to the pressure setpoint for the sprays not being reached until later in the transient.
Class IV	Same as Class II except that the initiating event is typically a small break LOCA. Note that the containment sprays would not be actuated throughout the transient since containment pressure would never exceed the spray setpoint until after vessel failure.
Class V	The initiating event is typically a transient in which all power is lost and a complete loss of all A.C. power. There would therefore be no safety injection and no containment safeguards initiation at any time during the transient.
Class VI	Same as Class V except that containment safeguards are available.

TABLE 4A-2

CONTAINMENT EVENT TREE NODAL QUESTIONS

A.	(P<CL)	Is the containment pressure resulting from the initiating transient prior to any core degradation within the containment pressure limit
B.	(H_2burn)	Is sufficient hydrogen generated and released prior to core slump and do the conditions for ignition of this hydrogen exist
C.	(P<CL)	Is the containment pressure within the containment pressure limit
D.	(Non-coherent)	Does the postulated fuel melting progress non-coherently
E.	(P<Comp)	Is the pressure generated from core debris-water interaction within the reactor vessel within the pressure boundary failure limits
F.	(H_2burn)	Is sufficient hydrogen generated and released prior to vessel failure and do conditions for ignition of this hydrogen exist
G.	(P<CL)	Is the containment pressure within the containment pressure limit
H.	(In-vessel cooling)	Do the conditions for in-vessel cooling of the core debris exist
I.	(Debris dispersion)	Is the majority of the core debris forcibly ejected subsequent to vessel failure

TABLE 4A-2 (continued)

CONTAINMENT EVENT TREE NODAL QUESTIONS

J.	(Cavity water)	Is water present in the reactor cavity at the time of vessel failure
K.	(Basemat perforation)	Is the basemat penetrated immediately following vessel failure
L.	(Accumulator discharge)	Do the accumulators discharge or does water return to the cavity following vessel failure
M.	(Steam pressure)	Does the containment pressure exceed 70 psia in the transient immediately after vessel failure
N.	(P<CL)	Is the containment pressure within the containment pressure limit
O.	(H_2burn)	Is sufficient hydrogen available immediately following vessel failure and do conditions for ignition of this hydrogen exist
P.	(P<CL)	Is the containment pressure within the containment pressure limit
Q.	(Coolable debris bed)	Does a coolable debris bed form initially
R.	(No late overpressure)	Does the containment pressure remain within the containment pressure limit
S.	(No basemat penetration)	Is basemat failure prevented

TABLE 4A-3

BYRON/ZION CET PARAMETER

Containment Dimensions	Byron	Zion
Approximate Free Volume (ft^3)	2.75E06	2.72E06
Base Slab Thickness (ft)	12	9
Base Slab Diameter (ft)	157	157
Inside Diam. of Cont. (ft)	140	140
Inside Ht. of Cont. (ft)	222	212
Cont. Wall Thickness (ft)	3	2.67
Reactor Cavity		
Wall Thickness (ft)	9	16
Diameter (ft)	21	21
Slab Thickness (ft)	9	9
Volume (ft3)	~8000	7692
Concrete Type	limestone	limestone
Containment Spray System		
Pump Flow Rate (gpm)		
Injection: 1 pump	3285	3000
2 pumps	7080	6000
Recirculation: 1 pump	4200	~3000
2 pumps	8700	~6000
Integrated Flow to Switchover	410,000	<350,000
Containment Fan Coolers		
Number	4	5
Heat Removal Capacity (Accident mode)		
Per assembly (10^6 BTU/hr)	132	81
Total (106 BTU/hr)	528	405
Passive Heat Sinks		
Steel Lined Concrete Area (ft^2)	~120,000	~115,000
Unlined Concrete Area (ft^2)	~98,000	~58,000
ECCS System		
Safety Injection Pumps		
Number	2	2
Cutoff Pressure (psig)	~1500	1520
Max Flow (gpm)	650	650

TABLE 4A-3 (Continued)

	Byron	Zion
Charging Pumps		
Number	2	2
Cutoff Pressure (psig)	~2500	2670
Max Flow Rate (gpm)	550	550
RHR Pumps		
Number	2	2
Cutoff Pressure (psig)		4500
Max Flow Rate (gpm)		170
Accumulators		
Number	4	4
Min Operating Pressure (psig)	600	600
Min Water Volume (ft^3 each)	935	850
Core		
Core Power (MW_{th})	3411	3250
Specific Power (kW/kg UO_2)	36.8	33.1
Fuel Wt (lb UO_2)	204,236	221,564
Zirc Wt (lb)	45,352	47,671
Control Rod Matl	Hafnium	AG-IN-CD
Pressure Relief		
Pressurizer PORV		
Number	2	2
Capacity Each (lbm/hr)	210,000	210,000
Set Point (psig)	2335	2335
Safety Valves		
Number	3	3
Capacity Each (lbm/hr)	420,000	420,000
Set Point (psig)	2485	2485

TABLE 4A-4

CONTAINMENT MATRIX (C MATRIX)

	Z-1 2R'	2	2R	Z-3	5R	Z-5	6	7	8A	8B
AEFC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	1.98E-06	1.50E-04	2.00E-10	0.00E-01	1.50E-04	0.00E-01	1.00E+00
AEF	1.98E-06 0.00E-01	1.00E-04	1.50E-04	0.00E-01	0.00E-01	0.00E-01	1.50E-04	0.00E-01	1.00E+00	0.00E-01
AEC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	1.98E-06	1.50E-04	2.00E-10	0.00E-01	1.50E-04	0.00E-01	1.00E+00
AE	1.00E+00 0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
ALFC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	1.98E-06	1.00E-04	2.20E-10	0.00E-01	1.90E-04	0.00E-01	1.00E+00
ALF	1.98E-06 0.00E-01	1.00E-04	1.00E-04	0.00E-01	0.00E-01	0.00E-01	1.90E-04	0.00E-01	1.00E+00	0.00E-01
ALC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	1.98E-06	1.00E-04	2.20E-10	0.00E-01	1.90E-04	0.00E-01	1.00E+00
AL	1.00E+00 0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
SEFC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	1.78E-07	1.31E-04	8.99E-05	0.00E-01	1.74E-04	0.00E-01	1.00E+00
SEF	1.78E-07 0.00E-01	1.90E-04	1.31E-04	0.00E-01	0.00E-01	0.00E-01	1.74E-04	0.00E-01	1.00E+00	0.00E-01
SEC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	1.78E-07	1.31E-04	8.99E-05	0.00E-01	1.74E-04	0.00E-01	1.00E+00
SE	2.19E-06 0.00E-01	2.00E-04	1.00E+00	0.00E-01	0.00E-01	0.00E-01	1.90E-04	0.00E-01	1.00E-04	0.00E-01
SLFC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	9.08E-06	1.31E-04	8.99E-05	0.00E-01	1.74E-04	0.00E-01	9.99E-01
SLF	9.08E-06 0.00E-01	1.90E-04	1.31E-04	0.00E-01	0.00E-01	0.00E-01	1.74E-04	0.00E-01	9.99E-01	0.00E-01

TABLE 4A-4 (Continued)

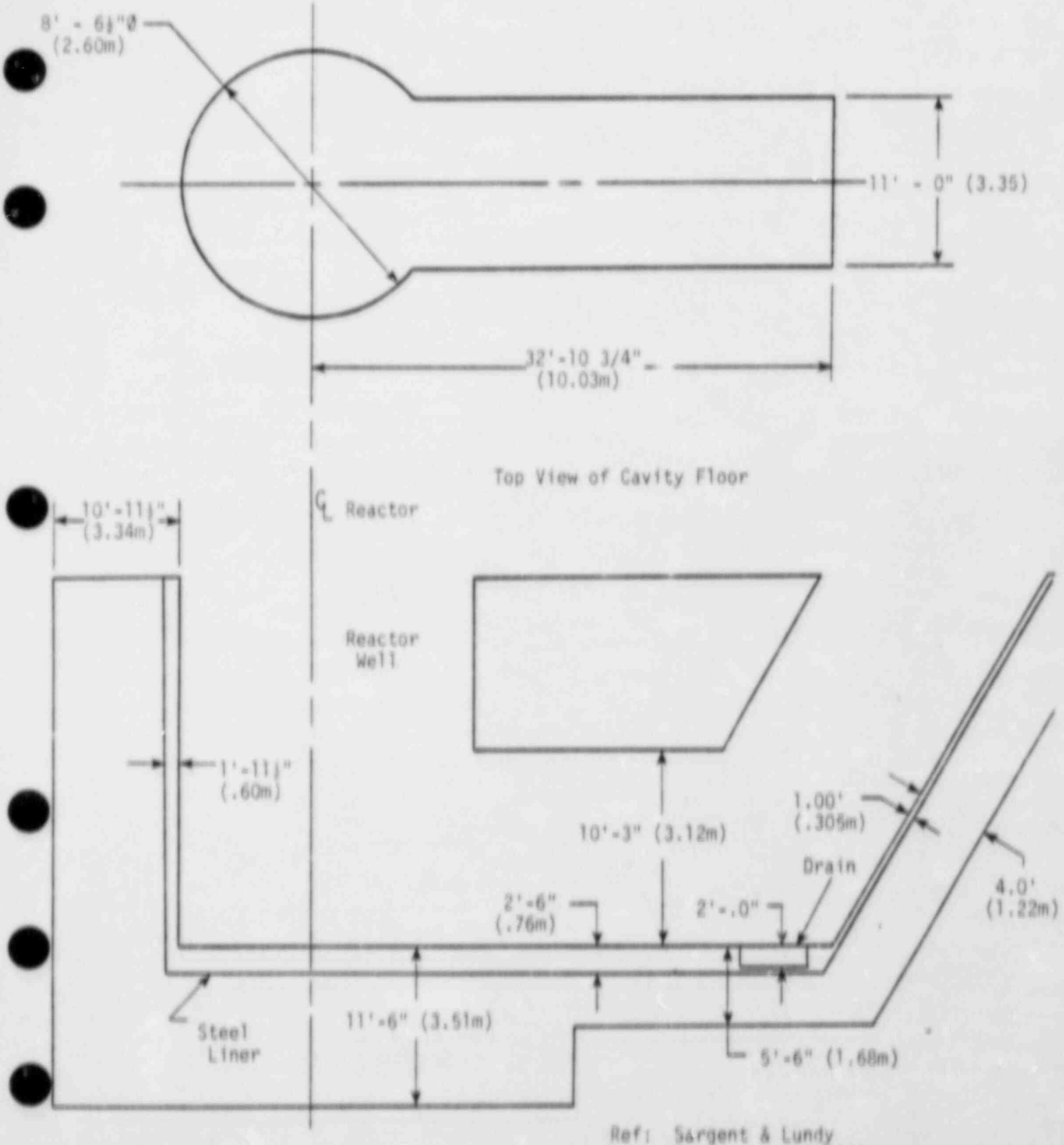
CONTAINMENT MATRIX (C MATRIX)

SLC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	9.08E-06	1.31E-04	8.99E-05	0.00E-01	1.74E-04	0.00E-01	9.99E-01
SL	2.19E-06 0.00E-01	2.00E-04	1.00E+00	0.00E-01	0.00E-01	0.00E-01	1.90E-04	0.00E-01	1.00E-04	0.00E-01
TEFC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	9.80E-08	1.03E-04	9.98E-05	0.00E-01	1.90E-04	0.00E-01	9.99E-01
TEF	9.80E-08 0.00E-01	2.00E-04	1.03E-04	0.00E-01	0.00E-01	0.00E-01	1.90E-04	0.00E-01	9.99E-01	0.00E-01
TEC	0.00E-01 0.00E-01	1.00E-04	0.00E-01	9.80E-08	1.03E-04	9.98E-05	0.00E-01	1.90E-04	0.00E-01	9.99E-01
TE	2.19E-06 0.00E-01	2.00E-04	1.00E+00	0.00E-01	0.00E-01	0.00E-01	1.90E-04	0.00E-01	1.00E-04	0.00E-01
V2E	0.00E-01 1.00E+00	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
V2L	0.00E-01 1.00E+00	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
V	0.00E-01 0.00E-01	1.00E+00	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01

FIGURE 4A-1

BYRON CAVITY SCHEMATIC

Floor Area = 503.86 ft^2 = 46.81m^2



Ref: Sargent & Lundy
Drawing No. S-1067

APPENDIX 4B

SITE CONSEQUENCE MODEL

4B.1 INTRODUCTION

Each of the major postulated accident scenarios identified in this study has a release of radioactive material associated with its occurrence. Each scenario was assigned to one of several "release categories" based on the core and containment responses to the accident conditions. The objective of the consequence portion of this analysis is to estimate the potential for health effect impact on the surrounding population due to exposure to the releases assigned to each release category.

Assuming that a release occurs at any random time, there are a number of factors that would cause the consequences to vary. One of the more important factors affecting this variation are the weather conditions that exist during the release. Wind speed, wind direction, atmospheric turbulence, and rainfall dictate the area contaminated and the amount of radioactive material in the plume. Once the distribution of airborne and deposited radioactive material is defined in the environment as a function of time, an estimate of health effects can proceed. A large number of individual weather condition scenarios can be studied and statistically weighted from meteorological data to determine the probability that selected health effects would occur. In order to compute the health impact to individuals or population groups, information related to their locations and travel paths (during evacuation) with respect to the radioactive plume location must be characterized. The degree of radiation exposure is not only dependent on the time exposure to the plume or deposited material on the ground but also on the shielding provided by dwellings and/or other protective measures taken.

Once the frequency of occurrence of selected health effects has been established for each release category, these results are combined with the frequency of occurrence of the release category itself to determine the overall potential impact on health (expressed as risk curves) due to operation of the plant.

4B.2 METHOD OF ANALYSIS

The calculation of consequences due to a radioactive release requires a probabilistic treatment due to the large variability in possible conditions during and after the release. Such a probabilistic approach was utilized in the Zion PSS to compute consequences in terms of, for example, early death, early injury, and long-term mortality from given hypothetical releases. Meteorological data measured at the Zion site and in the region were input along with population distribution and evacuation information. Assumed accident start dates were selected randomly in sets stratified so that start times were uniformly distributed over all months, and each month having the same number of day and night samples.

The principle model used was CRACIT, an extensively modified version of the CRAC (calculation of Reactor Accident Consequences) computer program developed by the U.S. Nuclear Regulatory Commission during the Reactor Safety Study (RSS) reported in WASH-1400 (NUREG-75/014). A complete description of CRACIT can be found in Section 6.0 of the Zion PSS.

In lieu of detailed consequence calculations as were performed for Zion, a more simplistic approach was taken for Byron. This approach involved recognizing the major contributors to site specific consequence results thus allowing approximate scaling factors to be developed which could then be used to transform consequence results for one plant (Zion) into representative consequences results for a second plant (Byron). To this end, use was made of results and conclusions reached in a study performed by Sandia National Laboratories for the U.S. Nuclear Regulatory Commission. In this study, NUREG/CR-2239, an evaluation of the effect of site specific characteristics on accident consequences was made. This study looked at the impact on consequences of source term magnitude, meteorology, population distribution and emergency response. The principal results and conclusions of this study are summarized below.

- The number of early fatalities resulting from a large release is very sensitive to source term magnitude. A one order of magnitude decrease in source term magnitude for large releases resulted in a two order of magnitude decrease in mean early fatalities.

- The weather conditions at the time of a release have a substantial impact on health effects, however the mean health effects when averaged over the range of meteorological conditions which could exist at the plant site are relatively insensitive to meteorology.

- The distance away from the plant site to which consequences occur depends primarily on source term magnitude and meteorology. For the largest source terms used in the Sandia study (SST-1 and SST-2) it was found that the mean, 99 percent confidence and maximum calculated distances for early fatalities and early injuries were:

		Effective Distance (Miles)		
Source Term	Consequence	Mean	99 Percent	Maximum
SST-1	Early Fatalities	<5	≤15	< 25
	Early Injuries	~10	~30	≤ 50
SST-2	Early Fatalities	~0.5	< 2	< 2
	Early Injuries	<2	< 5	~5

- Consequence results are very sensitive to the population distribution around a site, with mean results being sensitive to the average population density and peaks sensitive to the distance to and size of exposed population centers.

- Emergency response actions can significantly reduce early fatalities and early injuries.

The effect of each of these conclusions and their impact on Byron site consequences was addressed in this study.

4B.3 SOURCE TERM SENSITIVITY

4B.3.1 SOURCE TERM BASIS

The source terms for environmental release used in this study for Byron are the same as those developed in the Zion PSS with the exception of the source term used for steam generator tube rupture events which lead to core melt.

This source term is discussed in Section 4B.3.2. The Zion source terms are used because of similarity between the Zion and Byron system as discussed in Section 4A, thus the core melt phenomena and radioactivity retention characteristics used in the development of the Zion release categories are expected to be applicable to Byron. These release categories and a short description of each are given in Table 4B-1. A more comprehensive evaluation of the release categories along with the rationale for their development can be found in Section 4A of the Zion PSS.

4B.3.2 STEAM GENERATOR TUBE RUPTURE SOURCE TERMS

Radionuclide releases associated with steam generator tube rupture accidents range in severity from inconsequential releases (from a public risk standpoint) of coolant activity to releases of significant fractions of core nuclide fractions following core melt.

For steam generator tube rupture accidents, if core melt occurs, it occurs relatively late in time (i.e., about 3 to 4 hours or longer after accident initiation). The most severe progression to core melt, in terms of source term considerations, will involve loss of secondary water through boil-off before sufficient primary inventory is lost to permit core melt. Thus, radionuclides released during core melt may not encounter secondary fluid upon leakage across the ruptured tube. Source terms for an accident where the radionuclides, released as a result of core melt, encounter secondary water will be discussed at the end of this subsection.

Source terms for a steam generator tube rupture with a dry secondary system during fission product transport were developed by analogy to the WASH-1400

(RSS) source terms. The flow path for the radionuclides upon release will be from the core into the hot leg (because of the cold leg water seal in the bottom of the vessel), into the steam generator, across the ruptured tube to the secondary side of the generator and then through the steam separators and dryers, and out the steamline to the break location (likely a stuck open relief valve). Release at this point is direct to the environment.

With respect to source terms in the RSS, there is an obvious parallel in transport paths to BWR containment bypass sequence (main steamline rupture with MSIV failure) or a BWR TC or TW sequence with the suppression pool drained (transient initiated event with loss of core cooling capability and failure of containment before core melt). Source terms in the RSS for such sequences are generally similar to those for the RSS PWR-2; the source terms are generally regarded as very conservative since potential for deposition in the BWR steam separator region is not accounted for in the RSS. Capability to account for deposition in the steam separator region, in detail, is not yet available although it is being developed.

From the standpoint of source terms for Byron, a conservative estimate has been developed by utilizing RSS Release Category 2. In the RSS and in the Zion study, RSS Category PWR-2 was utilized for the transient initiated TMLB' sequence. Current scoping calculations indicate that the Category 2 source term is particularly conservative when applied to a TMLB' sequence. For TMLB', pressure in the system will be relatively high and steam flow relatively low at the time of radionuclide release. The long residence time in the upper plenum can lead to significant deposition of vapor phase and particulate species. Further, significant retention in the relief line downstream of the relief valves is likely since this line will be cool and condensation in the line is likely. An analogous and even more favorable situation exists in a steam generator tube rupture accident since the radionuclides entering the steam generator must pass through the cooled steam separator region before being released to the environs. Thus, retention in the case of SGTR sequence should be at least as large as that experienced during reactor system transport for a TMLB sequence with discharge through the pressurizer relief valves.

Likely source term reductions relative to the RSS point estimate values have recently been developed for a PWR, with subtantial analytical support, as part of the Sizewell-B PRA study. The values are reported in terms of discrete probability distributions (DPD) in the British Report SRD R256, November, 1982. The DPD's are suppported by retention calculations performed with computer codes where available but largely by hand calculations. The DPD for the transient initiated event is contained in Table 3.4 of the report and lists a probability of 0.5 that release to the containment will be 0.1 that of the RSS Category 2 release and 0.5 that the source term will be no larger than 0.05 of the Category 2 source term. Use of this distribution was applied to the RSS Category 2 source (identical in radionuclide magnitude to the Zion Point estimate values for Category 2R) for Byron for sequences with a dry SG secondary side upon fission product release and is designated category 2R'.

If there is water in the steam generator covering the rupture location as fission products are released, retention of fission product iodine and particulates by the water will be very effective. Recent GE data for retention by water at saturation temperature indicates a pool DF of at least 80. Therefore a reduction of source terms by approximately an additional 2 decades (except of course for noble gases) is appropriate for sequences where the tubes are covered by secondary water at the time of fission product release.

In considering site consequences from category, 2R' releases, results from NUREG/CR-2239 were used. Table 2.3.2-2 of the report shows the sensitivity of mean consequences to reductions in SST-1 (high consequence release category) release fractions. This table shows that a 0.1 reduction in SST-1 release fractions (excluding noble gases) results in a 0.01 reduction in early fatalities, .04 reduction in early injuries, 0.32 reduction in latent cancers, and a 0.10 reduction in thyroid cancers. Thus the site consequences for 2R' releases were determined by reducing the category 2R site consequence values from Zion for each consequence category in the same proportions as reported in NUREG/CR-2239 (e.g., the consequence values for 2R' releases for early fatalities is 0.01 the Zion 2R consequence values). The consequences for Man Rems for 2R'releases were reduced by 0.1 (same as reduction in thyroid cancers).

4B.3.3 SOURCE TERM UNCERTAINTY

In the Zion PSS, it was recognized that the magnitude of the release categories which were used as input to the consequence calculation were very conservative and ignored many depletion mechanisms which may significantly reduce the source term for release. The uncertainity in these source terms was addressed in the Zion Study as well as uncertainty in the plant and site matrices.

4B.4 METEOROLOGY

Meterological differences between the Zion and Byron sites were not considered in this study. This is due primarily to the insensitivity of meteorology on mean consequences as is discussed in the Sandia study. In the Sandia sensitivity studies, metorological data from climatically diverse areas were applied to a single site with a resulting insensitivity to mean consequence results. Secondly, it was felt that the Zion and Byron sites were geographically close enough to each other such that only small meteorological differences would be expected.

4B.5 POPULATION

Site consequences are very sensitive to population distributions as discussed in NUREG/CR 2239. Because of this, a method was needed to compare the population distribution of Zion with that of Byron in a manner which would be applicable to the scaling of Zion consequence results to reflect Byron site characteristics. The method which was chosen was the application of Site Population Factors (SPF). The SPF was developed by the NRC[1] to provide a

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1. WASH-1235, The Site Population Factor: A Technique for Consideration of Population in Site Comparison, U.S.A.E.C., Oct. 1974.

way to compare populations around different sites. The factors are intended to be dimensionless measures of the total sensitivity to the population within a specified radial distance and are defined by:

$$SPF = \frac{\sum_{i=1}^{m} P_i / r_i^{1.5}}{\sum_{i=1}^{m} \bar{P}_i / r_i^{1.5}}$$

where r_i = the outer radius of annulus i of m concentric annuli ($r_o = 0$, $r_m = n$).

n = the outer radius of the outermost annulus, annulus m.

$\bar{P}_i$ = the population of annulus i assuming a uniform population density of 1000 people per sq. mile;
i.e., $P_i = 10^3 \Pi (r_i^2 - r_{i-1}^2)$

P_i = the actual population of annulus i.

Population information from NUREG/CR 2239 for the Zion and Byron plants were used. The mean distance of effect is dependent upon both the release category and the consequence of interest, thus different SPF factors were used to scale the Zion consequence results. To account for population differences a population scaling factor (Fp) was defined as:

$$F_p \text{ (Release Category, Consequence)} = \frac{SPF_{\text{Byron (Population, Distance)}}}{SPF_{\text{Zion (Population, Distance)}}}$$

Two scaling factors were used. For high consequence releases in which the effective range of the release is large (greater than 50 miles) the scaling factor was based on population data out to 200 miles from the respective plant sites. The resulting scaling factor of 0.46 was applied to category Z-1, 2, 2R, 2R', Z-3, Z-5, and 5R releases. For the low consequence releases, the limit of effective range is less than 20 miles from the plant site. A scaling factor of 0.2 was calculated for 20 miles and was applied to category 6, 7, 8A and 8B releases.

These factors were calculated and applied to the Zion consequence S-matrices for all consequence categories except early fatalities. In these cases the application of a "mean" correction factor is inadequate due to threshold effects which are more properly addressed using a correction factor which is a function of the frequency of the effect. To account for this threshold effect on early fatalities, results from NUREG/CR-2239 were again used. This study presents conditional early fatality consequence curves for Zion and Byron for high consequence release category SST-1 (comparable to categories Z-1, 2, and 2R). By simply ratioing these consequence results and applying the results to the comparable Zion consequence curves the Byron results were estimated.

This resulted in an effective reduction of 0.25 in the probability of exceedance for 1 fatality, 0.2 for 100 fatalities, and 0.17 for 1000 fatalities. No correction for early fatalities was made to category Z-3, Z-5, and 5R releases due to the small risk contribution of these categories to early fatalities.

The population scaling factors are given in Table 4B-2 and the Byron S-matrices are presented in Table 4B-3 through 4B-7.

4B.6 EMERGENCY RESPONSE

Possible differences in Emergency Response procedures between Zion and Byron such as evacuation plans were not addressed. The Byron emergency plans are being formulated and are not expected to be any less effective than those in place for Zion. In any event, the evacuation details are of second order importance compared to the basic effect of evacuation itself.

4B.7 RESULTS

The results of modifying the Zion consequence analysis as discussed above are reflected in a series of point estimate, conditional consequence matrices. One such matrix is employed for each health effect or damage index employed. Tables 4B-3 through 4B-7 present these results.

TABLE 4B-1

SUMMARY OF RELEASE CATEGORY RATIONALE AND NOMENCLATURE

Category	Description
Z-1	This release category is used for overpressure failure events with a steam explosion like source in which containment sprays are not functioning. This release category is parallel to Reactor Safety Study (RSS) release Category 1. However, the sources were adjusted for 25 percent of the core being introduced in the containment atmosphere as fine particles by the steam explosion rather than the 50 percent assumed in RSS. Tellurium and ruthenium are the only radioactive species whose release fractions to the environment are enhanced by the steam explosion process. Values for these species were then appropriately adjusted.
2, 2R	This release category is used for overpressure failures without sprays operating. Both the dispersive and gravity drop cases are included when they lead to failure. Sources for this release category are taken to be the same as those utilized in the RSS. Also a delayed release condition from long-term overpressure failure is considered and is designated Condition 2-R. Isolation failures associated with interfacing check valve failure are placed in this release category.
2R'	This release category is used for core melts with direct bypass of the containment associated with steam generator tube rupture events. The source terms in this category are essentially 0.1 that of Category 2R.

TABLE 4B-1 (Continued)

SUMMARY OF RELEASE CATEGORY RATIONALE AND NOMENCLATURE

Category	Description
Z-3	This release category is used for overpressure failure events with a steam explosion like source in which the spray system is functioning at the time the steam explosion occurs. The release category is parallel to RSS release Category 3. However, sources were adjusted for 25 percent of the core being introduced into the containment atmosphere as fine particles rather than the 50 percent assumed in the RSS. Tellurium and ruthenium are the only species whose release fraction to the containment and environment are enhanced by the steam explosion event. Values for these species were appropriately adjusted. Only a low energy release condition is considered for this release category.
Z-5	This release category is used for overpressure failures where sprays have only a short time to reduce the source term before containment failure permits release to the environment. The source term is intemediate between Category 2 and Category 5 of the RSS. This category is used for containment failures which occur at or shortly after reactor vessel failure as a result of a rapid pressure spike which, in addition, have the spray system operating.

TABLE 4B-1 (Continued)

SUMMARY OF RELEASE CATEGORY RATIONALE AND NOMENCLATURE

Category	Description
5, 5R	These release categories are used for delayed overpressure failures and for containment isolation failures which occur with the spray system operating. The source term used for this release category is the same as that in the RSS. Only low energy source release conditions are considered. However, a delayed release condition, from long-term overpressure failure, is considered and is designated Condition 5-R.
6	This release category is used for for melt-through of the basemat without spray system operation. It is assumed that a core melt source term is released through the basemat and surrounding soil to the environment. The source term for this release category is taken to be the same as for the RSS release Category 6.
7	This release category is used for melt-through of the basemat with spray system operation. It is assumed that a core melt source term is released through the basemat and surrounding soil to the environment. The source term for this release category is taken to be the same as the RSS release Category 7.

TABLE 4B-1 (Continued)

SUMMARY OF RELEASE CATEGORY RATIONALE AND NOMENCLATURE

Category	Description
8A and 8B	These release categories are used for all degraded or core melt accidents in which the containment remains intact. Radioactivity released to the environment would be small, corresponding to that associated with normal levels of containment leakage. Source terms for these release categories were generated with the CORRAL code. Category 8-A is for a core melt event without spravs. operating and Category. 8-B is for a core melt event with sprays operating.

TABLE 4B-2

POPULATION SCALING FACTORS, F_P

Release Category	Z-1 /2 / 2R / 2R'	Z-3 / Z-5 / 5R	6 / 7 / 8A / 8B
Early Fatalities	scaled to NUREG/ CR-2239 results	1	1
Early Injuries	.46	.46	.2
Thyroid Cancers	.46	.46	.2
Latent Cancers	.46	.46	.2
Man Rems	.46	.46	.2

TABLE 4B-3

TRANSPOSED SITE MATRIX (S MATRIX) FOR EARLY FATALITIES

	Z-1 2R'	2	2R	Z-3	5R	Z-5	6	7	8A	8B
1.00E+00	4.17E-02 2.60E-05	8.68E-03	2.61E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+00	3.91E-02 2.60E-05	8.68E-03	2.61E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+00	3.91E-02 2.60E-05	8.68E-03	2.61E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+00	3.64E-02 2.60E-05	8.68E-03	2.61E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+00	3.64E-02 2.60E-05	6.94E-03	2.61E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+01	2.98E-02 2.29E-05	6.11E-03	2.29E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+01	2.52E-02 2.29E-05	5.35E-03	2.29E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+01	2.06E-02 2.29E-05	5.35E-03	2.29E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+01	1.83E-02 2.29E-05	5.35E-03	2.29E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+01	1.38E-02 2.29E-05	4.58E-03	2.29E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+02	1.25E-02 2.08E-05	2.78E-03	2.08E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+02	8.33E-03 2.08E-05	2.78E-03	2.08E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+02	8.33E-03 1.39E-05	2.78E-03	1.39E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+02	6.25E-03 1.39E-05	2.78E-03	1.39E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01

TABLE 48-3 (Cont.)

TRANSPOSED SITE MATRIX (S MATRIX) FOR EARLY FATALITIES

7.00E+02	6.25E-03 1.39E-05	1.39E-03	1.39E-03	2.08E-02	0.00E-01	6.94E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+03	3.54E-03 1.18E-05	1.18E-03	1.18E-03	2.08E-02	0.00E-01	3.47E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+03	0.00E-01 0.00E-01	0.00E-01	0.00E-01	2.08E-02	0.00E-01	3.47E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+03	0.00E-01 0.00E-01	0.00E-01	0.00E-01	1.04E-02	0.00E-01	3.47E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+03	0.00E-01 0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01

TABLE 4B-4

TRANSPOSED SITE MATRIX (S MATRIX) FOR EARLY INJURIES

	Z-1 2R'	2	2R	Z-3	5R	Z-5	6	7	8A	8B
1.00E+00	1.39E-01 2.11E-03	1.15E-01	5.27E-02	4.31E-02	0.00E-01	3.51E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+00	1.39E-01 2.11E-03	1.15E-01	5.27E-02	4.31E-02	0.00E-01	3.35E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+00	1.39E-01 2.11E-03	1.15E-01	5.27E-02	4.31E-02	0.00E-01	3.35E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+00	1.39E-01 2.11E-03	1.13E-01	5.27E-02	4.31E-02	0.00E-01	3.35E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+00	1.39E-01 2.04E-03	1.13E-01	5.11E-02	4.31E-02	0.00E-01	3.35E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+01	1.34E-01 2.04E-03	1.10E-01	5.11E-02	4.31E-02	0.00E-01	3.35E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+01	1.34E-01 2.04E-03	1.09E-01	5.11E-02	4.31E-02	0.00E-01	3.35E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+01	1.29E-01 2.04E-03	1.05E-01	5.11E-02	3.83E-02	0.00E-01	2.87E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+01	1.25E-01 2.04E-03	9.10E-02	5.11E-02	3.83E-02	0.00E-01	2.72E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+01	1.25E-01 1.92E-03	8.46E-02	4.79E-02	3.35E-02	0.00E-01	2.72E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+02	1.25E-01 1.92E-03	8.15E-02	4.79E-02	3.35E-02	0.00E-01	2.72E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+02	1.15E-01 1.92E-03	7.19E-02	4.79E-02	2.40E-02	0.00E-01	2.24E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+02	1.10E-01 1.92E-03	7.05E-02	4.79E-02	2.40E-02	0.00E-01	2.08E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+02	1.01E-01 1.92E-03	6.23E-02	4.63E-02	1.44E-02	0.00E-01	1.76E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01

TABLE 4B-4 (Cont.)

TRANSPOSED SITE MATRIX (S MATRIX) FOR EARLY INJURIES

7.00E+02	8.63E-02 1.41E-03	6.07E-02	3.51E-02	1.44E-02	0.00E-01	1.60E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+03	7.67E-02 1.15E-03	5.91E-02	2.87E-02	1.44E-02	0.00E-01	1.12E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+03	7.19E-02 8.30E-04	4.79E-02	2.08E-02	9.58E-03	0.00E-01	7.99E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+03	6.71E-02 6.39E-04	4.15E-02	1.60E-02	4.79E-03	0.00E-01	4.79E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+03	5.27E-02 5.75E-04	2.87E-02	1.44E-02	0.00E-01	0.00E-01	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+03	4.79E-02 3.83E-04	2.08E-02	9.58E-03	0.00E-01	0.00E-01	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+04	4.31E-02 3.19E-04	2.08E-02	7.99E-03	0.00E-01	0.00E-01	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+04	2.40E-02 6.39E-05	6.39E-03	1.60E-03	0.00E-01	0.00E-01	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+04	2.40E-02 6.39E-05	1.60E-03	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+04	0.00E-01 6.39E-05	1.60E-03	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+04	0.00E-01 0.00E-01	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+05	0.00E-01 0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01

TABLE 4B-5

TRANSPOSED SITE MATRIX (S MATRIX) FOR THYROID CANCER

	Z-1 2R'	2	2R	Z-3	5R	Z-5	6	7	8A	8B
1.00E+00	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.55E-01	4.60E-01	1.90E-01	4.58E-02	1.85E-01	5.83E-02
2.00E+00	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.55E-01	4.60E-01	1.77E-01	1.88E-02	1.69E-01	3.33E-02
3.00E+00	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.50E-01	4.58E-01	1.69E-01	6.25E-03	1.56E-01	1.67E-02
5.00E+00	4.60E-01 4.58E-02	4.58E-01	4.58E-01	4.60E-01	4.46E-01	4.58E-01	1.50E-01	2.08E-03	1.50E-01	8.33E-03
7.00E+00	4.55E-01 4.58E-02	4.58E-01	4.58E-01	4.60E-01	4.36E-01	4.58E-01	1.37E-01	0.00E-01	1.44E-01	2.08E-03
1.00E+01	4.55E-01 4.57E-02	4.58E-01	4.57E-01	4.50E-01	4.07E-01	4.57E-01	1.19E-01	0.00E-01	1.37E-01	0.00E-01
2.00E+01	4.50E-01 4.55E-02	4.57E-01	4.55E-01	4.41E-01	3.69E-01	4.49E-01	7.92E-02	0.00E-01	1.04E-01	0.00E-01
3.00E+01	4.50E-01 4.54E-02	4.54E-01	4.54E-01	4.41E-01	3.59E-01	4.47E-01	5.63E-02	0.00E-01	8.75E-02	0.00E-01
5.00E+01	4.41E-01 4.47E-02	4.49E-01	4.47E-01	4.12E-01	3.21E-01	4.31E-01	3.75E-02	0.00E-01	5.00E-02	0.00E-01
7.00E+01	4.41E-01 4.42E-02	4.44E-01	4.42E-01	4.02E-01	3.02E-01	4.17E-01	2.71E-02	0.00E-01	4.17E-02	0.00E-01
1.00E+02	4.22E-01 4.31E-02	4.36E-01	4.31E-01	3.88E-01	2.73E-01	4.06E-01	1.04E-02	0.00E-01	2.71E-02	0.00E-01
2.00E+02	4.02E-01 4.04E-02	4.07E-01	4.04E-01	3.55E-01	1.73E-01	3.83E-01	2.08E-03	0.00E-01	1.25E-02	0.00E-01
3.00E+02	3.93E-01 3.90E-02	3.95E-01	3.90E-01	3.26E-01	1.44E-01	3.59E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+02	3.78E-01 3.59E-02	3.72E-01	3.59E-01	2.83E-01	1.05E-01	3.19E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01

TABLE 4B-5 (Cont.)

TRANSPOSED SITE MATRIX (S MATRIX) FOR THYROID CANCER

7.00E+02	3.59E-01 3.37E-02	3.51E-01	3.37E-01	2.44E-01	8.15E-02	2.89E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+03	3.35E-01 3.03E-02	3.27E-01	3.03E-01	2.30E-01	4.79E-02	2.62E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+03	2.97E-01 2.48E-02	2.76E-01	2.48E-01	1.39E-01	9.58E-03	1.74E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+03	2.44E-01 1.87E-02	2.20E-01	1.87E-01	1.15E-01	4.79E-03	1.36E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+03	1.68E-01 1.33E-02	1.73E-01	1.33E-01	9.10E-02	0.00E-01	9.43E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+03	1.49E-01 1.10E-02	1.49E-01	1.10E-01	7.67E-02	0.00E-01	7.35E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+04	1.29E-01 8.46E-03	1.21E-01	8.46E-02	6.71E-02	0.00E-01	5.43E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+04	7.67E-02 3.67E-03	6.07E-02	3.67E-02	9.58E-03	0.00E-01	1.60E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+04	5.27E-02 1.92E-03	4.31E-02	1.92E-02	4.79E-03	0.00E-01	4.79E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+04	2.87E-02 6.39E-04	1.76E-02	6.39E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+04	1.44E-02 1.60E-04	9.58E-03	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+05	0.00E-01 0.00E-01	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+05	0.00E-01 0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01

TABLE 4B-6

TRANSPOSED SITE MATRIX (S MATRIX) FOR LATENT CANCER FATALITIES

	Z-1 2R'	2	2R	Z-3	5R	Z-5	6	7	8A	8B
1.00E+00	4.60E-01 1.47E-01	4.60E-01	4.60E-01	4.60E-01	4.50E-01	4.60E-01	1.81E-01	2.08E-02	7.50E-02	2.08E-02
2.00E+00	4.60E-01 1.47E-01	4.60E-01	4.60E-01	4.60E-01	4.31E-01	4.60E-01	1.63E-01	2.08E-03	5.63E-02	4.17E-03
3.00E+00	4.60E-01 1.47E-01	4.60E-01	4.60E-01	4.60E-01	4.12E-01	4.58E-01	1.50E-01	0.00E-01	4.38E-02	2.08E-03
5.00E+00	4.55E-01 1.46E-01	4.58E-01	4.57E-01	4.60E-01	3.98E-01	4.57E-01	1.27E-01	0.00E-01	3.33E-02	0.00E-01
7.00E+00	4.50E-01 1.46E-01	4.57E-01	4.57E-01	4.60E-01	3.83E-01	4.55E-01	1.19E-01	0.00E-01	2.08E-02	0.00E-01
1.00E+01	4.50E-01 1.46E-01	4.57E-01	4.57E-01	4.50E-01	3.64E-01	4.55E-01	1.10E-01	0.00E-01	1.46E-02	0.00E-01
2.00E+01	4.41E-01 1.45E-01	4.54E-01	4.54E-01	4.50E-01	3.31E-01	4.50E-01	7.50E-02	0.00E-01	0.00E-01	0.00E-01
3.00E+01	4.41E-01 1.45E-01	4.52E-01	4.52E-01	4.31E-01	3.16E-01	4.42E-01	4.58E-02	0.00E-01	0.00E-01	0.00E-01
5.00E+01	4.31E-01 1.41E-01	4.41E-01	4.41E-01	3.98E-01	2.63E-01	4.27E-01	3.33E-02	0.00E-01	0.00E-01	0.00E-01
7.00E+01	4.31E-01 1.40E-01	4.38E-01	4.38E-01	3.83E-01	2.30E-01	4.17E-01	1.88E-02	0.00E-01	0.00E-01	0.00E-01
1.00E+02	4.27E-01 1.35E-01	4.25E-01	4.23E-01	3.74E-01	1.87E-01	4.06E-01	6.25E-03	0.00E-01	0.00E-01	0.00E-01
2.00E+02	3.93E-01 1.26E-01	3.98E-01	3.95E-01	3.55E-01	1.20E-01	3.83E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+02	3.88E-01 1.22E-01	3.85E-01	3.82E-01	3.12E-01	7.67E-02	3.55E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+02	3.64E-01 1.12E-01	3.59E-01	3.51E-01	2.73E-01	5.27E-02	3.19E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01

TABLE 4B-6 (Cont.)

TRANSPOSED SITE MATRIX (S MATRIX) FOR LATENT CANCER FATALITIES

7.00E+02	3.50E-01 1.04E-01	3.32E-01	3.24E-01	2.40E-01	1.92E-02	2.81E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+03	3.31E-01 9.51E-02	3.08E-01	2.97E-01	1.97E-01	9.58E-03	2.49E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+03	2.59E-01 7.05E-02	2.30E-01	2.20E-01	9.10E-02	0.00E-01	1.52E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+03	1.92E-01 4.91E-02	1.61E-01	1.53E-01	6.23E-02	0.00E-01	8.94E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+03	1.15E-01 2.40E-02	8.46E-02	7.51E-02	2.87E-02	0.00E-01	4.63E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+03	8.63E-02 1.38E-02	4.79E-02	4.31E-02	1.44E-02	0.00E-01	2.08E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+04	5.27E-02 4.60E-03	1.44E-02	1.44E-02	0.00E-01	0.00E-01	3.19E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+04	9.58E-03 0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+04	0.00E-01 0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01

TABLE 4B-7

TRANSPOSED SITE MATRIX (S MATRIX) FOR MAN-REM

	Z-1 2R'	2	2R	Z-3	5R	Z-5	6	7	8A	8B
1.00E+00	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.60E-01	4.60E-01	2.00E-01	1.35E-01	1.83E-01	1.60E-01
2.00E+00	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.60E-01	4.60E-01	2.00E-01	1.13E-01	1.65E-01	1.04E-01
3.00E+00	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.55E-01	4.60E-01	1.94E-01	9.17E-02	1.48E-01	6.67E-02
5.00E+00	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.55E-01	4.60E-01	1.90E-01	7.29E-02	1.33E-01	6.04E-02
7.00E+00	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.55E-01	4.60E-01	1.90E-01	5.83E-02	1.21E-01	4.17E-02
1.00E+01	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.55E-01	4.60E-01	1.85E-01	4.17E-02	8.75E-02	2.92E-02
2.00E+01	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.46E-01	4.60E-01	1.71E-01	8.33E-03	7.08E-02	1.46E-02
3.00E+01	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.41E-01	4.60E-01	1.63E-01	2.08E-03	5.83E-02	4.17E-03
5.00E+01	4.60E-01 4.60E-02	4.60E-01	4.60E-01	4.60E-01	4.07E-01	4.58E-01	1.44E-01	0.00E-01	4.38E-02	2.08E-03
7.00E+01	4.55E-01 4.57E-02	4.58E-01	4.57E-01	4.60E-01	3.98E-01	4.57E-01	1.31E-01	0.00E-01	3.54E-02	0.00E-01
1.00E+02	4.50E-01 4.57E-02	4.57E-01	4.57E-01	4.60E-01	3.93E-01	4.57E-01	1.21E-01	0.00E-01	2.08E-02	0.00E-01
2.00E+02	4.46E-01 4.55E-02	4.57E-01	4.55E-01	4.50E-01	3.50E-01	4.52E-01	9.58E-02	0.00E-01	8.33E-03	0.00E-01
3.00E+02	4.41E-01 4.54E-02	4.54E-01	4.54E-01	4.50E-01	3.31E-01	4.52E-01	7.50E-02	0.00E-01	0.00E-01	0.00E-01
5.00E+02	4.41E-01 4.52E-02	4.52E-01	4.52E-01	4.27E-01	3.07E-01	4.41E-01	4.58E-02	0.00E-01	0.00E-01	0.00E-01

TABLE 4B-7 (Cont.)

TRANSPOSED SITE MATRIX (S MATRIX) FOR MAN-REM

7.00E+02	4.31E-01 4.44E-02	4.44E-01	4.44E-01	4.07E-01	2.78E-01	4.36E-01	3.75E-02	0.00E-01	0.00E-01	0.00E-01
1.00E+03	4.31E-01 4.39E-02	4.39E-01	4.39E-01	3.83E-01	2.40E-01	4.22E-01	1.88E-02	0.00E-01	0.00E-01	0.00E-01
2.00E+03	4.12E-01 4.17E-02	4.17E-01	4.17E-01	3.74E-01	1.53E-01	3.96E-01	2.08E-03	0.00E-01	0.00E-01	0.00E-01
3.00E+03	3.93E-01 3.96E-02	3.99E-01	3.96E-01	3.55E-01	1.20E-01	3.87E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+03	3.88E-01 3.78E-02	3.83E-01	3.78E-01	2.97E-01	7.67E-02	3.43E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+03	3.69E-01 3.58E-02	3.66E-01	3.58E-01	2.73E-01	5.75E-02	3.21E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+04	3.50E-01 3.29E-02	3.35E-01	3.29E-01	2.40E-01	2.40E-02	2.86E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+04	3.07E-01 2.60E-02	2.63E-01	2.60E-01	1.77E-01	4.79E-03	2.20E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+04	2.20E-01 2.17E-02	2.20E-01	2.17E-01	9.10E-02	0.00E-01	1.55E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
5.00E+04	1.29E-01 1.39E-02	1.42E-01	1.39E-01	6.23E-02	0.00E-01	7.99E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
7.00E+04	6.71E-02 7.99E-03	8.79E-02	7.99E-02	3.35E-02	0.00E-01	5.11E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
1.00E+05	2.87E-02 5.11E-03	4.95E-02	5.11E-02	1.44E-02	0.00E-01	2.56E-02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
2.00E+05	0.00E-01 1.60E-04	1.60E-03	1.60E-03	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
3.00E+05	0.00E-01 0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01

APPENDIX 4C

RECAPITULATION OF THE ASSEMBLY PROCESS

This section describes the analytical techniques used to compile and assemble the results of previous sections into risk diagrams. The structure of the assembly process is based on a "pinch point" concept, as shown in Figure 4C-1. There are four pinch points: initiating events, plant states, release categories, and damage states. The transition between each pinch point can be summarized as a matrix whose elements are the conditional frequencies of reaching a subsequent pinch point state given an entry state from the previous pinch point.

In Section 1, 15 initiating event categories have been defined to characterize the possible internal initiating events for the plant. These initiating event categories are listed in Table 4C-1.

For each of these initiating event categories, the frequency of occurrence has been developed in Section 1. Let the index i stand for any of these categories and let ϕ_i stand for the frequency of occurrence of the ith initiating event category. Then, a row matrix of initiating event category frequencies is defined:

$$\phi^I = [\phi_1^I, \phi_2^I, \cdots \phi_{11c}^I, \phi_{12}^I, \phi_{13}^I, \phi_V^I]. \qquad (4C\text{-}1)$$

The next step in the process is the determination of the plant response to the various initiating event categories. As described in Section 2, individual event trees (which identify the branching chains of events) have been developed to represent the plant system responses to the various initiating event categories. At the end of each path through a tree, there is either no significant core damage or there is degraded core initiation with varying core and containment initial conditions.

To represent these varying conditions, a set of "plant states" (or "plant damage categories") is defined in Section 2 and is listed in Table 4C-2. In

the event trees, the split fractions at each node are developed largely from the Zion systems analyses with appropriate modifications to ensure applicability to the Byron plant design. The split fractions along each event tree path are then combined to obtain the conditional frequency of that path. All of the event tree paths which lead from any given initiating event category (i) to a plant damage state (j) are summed to yield a quantity, m_{ij}, which is defined as the conditional frequency of reaching plant damage state j given initiating event category i. This process is repeated for all initiating event categories and all plant damage categories. These m_{ij} are aggregated into a matrix, M, called the plant matrix:

$$M = \begin{matrix} m_{11} & m_{12} & \cdots \\ m_{21} & & \\ \vdots & & \end{matrix} \qquad (4C\text{-}2)$$

which express the transition frequencies between the initiating event categories and the plant damage categories.

Define ϕ_j^y to represent the frequency of occurrence of plant damage state j. Then the following relationship exists:

$$\phi_i^y = \Sigma_i \ \phi_i^I \ m_{ij} \qquad (4C\text{-}3)$$

Thus, if the ϕ_j^y are arranged into a row vector, ϕ^y, then (4C-3) can be concisely stated as a conventional matrix multiplication,

$$\phi^y = \phi^I M. \qquad (4C\text{-}4)$$

ϕ^I represents the frequency of initiating event categories, ϕ^y represents the frequency of plant damage states, and M represents the conditional frequencies of reaching any given damage state given an initiating event category.

An identical process results in the definition of a containment matrix C, whose elements are the conditional frequencies of reaching any given release category given the occurrence of a plant damage state. As described in Section 4A, a containment event tree has been constructed. The end points of each path through the containment event tree are release categories. The release categories are shown in Table 4C-3. The plant damage state (the output of a plant event tree) is an input state for the containment tree. The split fractions in the containment event tree are based primarily on the analyses and phenomenological evaluations presented in ZPSS Sections 4 and 3, respectively. By summing the frequencies of all containment tree paths leading to a release category from a plant damage state j, we obtain the elements (c_{ij}). These are aggregated into a matrix, C, called the containment matrix,

$$C = \begin{matrix} c_{11} & c_{12} \cdots \\ c_{12} \end{matrix} . \qquad (4C\text{-}5)$$

Define $$\phi_k^{\rho} - \sum_j \phi_j^{y} c_{jk} \qquad (4C\text{-}6)$$

If the ϕ_k^{ρ} are arranged in a row vector, ϕ_j^{ρ}, the following matrix equation holds:

$$\phi^{\rho} - \phi^{y} C - \phi^{I} MC. \qquad (4C\text{-}7)$$

ϕ^{y} represents the frequencies of plant damage states, ϕ^{ρ} represents the frequencies of release categories, and C represents the conditional frequencies of reaching any given release category given a plant damage state.

Finally, if there is a release of category k, then there will be various possible levels of damage delivered to the surrounding population. "Damage" is measured in this study by the following five damage indices:

1. Early Fatalities
2. Injuries
3. Thyroid Cancers

4. Cancer Fatalities (not including fatalities from thyroid cancers)
5. Total Man Rem.

These are defined more fully in Section 6 of the ZPSS. Let x represent one of these damage indices and let x_ℓ denote a particular level of this type of damage (e.g., 50 fatalities, 10,000 man rem, etc.). Next, let Φ^x_ℓ denote the frequency with which this level of damage, or greater, occurs.* The site model calculations then determine the numbers, $s_{k\ell}$, defined as:

$s_{k\ell}$ = the conditional likelihood that damage level x_ℓ or greater will result given that a release of type k has occurred.

Assembling the $s_{k\ell}$ into a rectangular "site matrix,"

$$S = \begin{matrix} s_{11}, & s_{12} & \cdots \\ s_{21} & \ddots & \\ \vdots & & \end{matrix} \qquad (4C\text{-}8)$$

and the Φ^x_ℓ into a row vector

$$\Phi^x = \Phi^x_1, \; {}^x_2\Phi \; \cdots \qquad (4C\text{-}9)$$

we have the relationship

$$\Phi^x = \phi^P S \qquad (4C\text{-}10)$$

between damage frequencies and release frequencies. Subsituting in Equation (4C-10) yields:

$$\Phi^x = \phi^I MCS. \qquad (4C\text{-}11)$$

---

* The use of the upper case phi in Φ^x_ℓ denotes the "or greater" definition.

The row vector Φ^X may be plotted directly as a risk curve. Since the risk curves are calculated from the initiating event frequencies and the results of the plant, containment, and site models, this equation is called the master assembly equation.

The information contained in the vectors (initiating event, plant state, release, and damage) and the matrices (plant, containment, and site) can be supplemented by the intermediate product matrices (MC, CS, and MCS) and by constructing further matrices based on use of the diagonal matrices of the vectors as described below.

If the initiating event vector ϕ^I is written as a diagonal matrix

$$\Phi_D^I = \Phi_1^I \quad \Phi_2^I \quad \cdot \quad \cdot \quad \Phi_{16}^I \qquad (4C\text{-}12)$$

then the element ij of the product matrix, $\Phi_D^I M$, is the frequency of occurrence of a plant state, j, as a result of an initiating event, i. Comparison of this element with element j of ϕ^y shows the fraction of the total frequency of plant state j attributable to initiating event i. Furtheremore, the vector ϕ^y is the columnar sum of the product matrix.

Similarly, the product matrices, $\Phi_D^I MC$ and $\Phi_D^I MCS$, show the contributors of the initiating events to the release category and damage level frequencies respectively.

If Φ_D^y and Φ_D^ρ are defined as diagonal matrices and the products $\Phi_D^y C$, $\Phi_D^y CS$, and $\Phi^\rho S$ are formed, the contributions of the plant states to release categories or damage levels and of the release categories to damage levels are generated.

TABLE 4C-1

INITIATING EVENT DEFINITIONS

Event Symbol	Event Description
1	Large LOCA
2	Medium LOCA
3	Small LOCA
4	Steam Generator Tube Rupture
5	Steam Break Inside Containment
6	Steam Break Outside Containment
7	Loss of Main Feedwater
8	Closure of One MSIV
9	Loss of RCS Flow
10	Core Power Excursion
11	Turbine Trip
12	Loss of Offsite Power
13	Spurious Safety Injection
14	Reactor Trip
V	Interfacing Systems LOCA

TABLE 4C-2

CORE MELT STATE DEFINITIONS

Symbol	Description
AEFC	Large LOCA Early Melt ECCS Failure at Injection
AEF	Large LOCA Early Melt ECCS Failure at Injection
AEC	Large LOCA Early Melt ECCS Failure at Injection
AE	Large LOCA Early No Containment Cooling
ALFC	Large LOCA Late Melt ECCS Failure on Recirculation
ALF	Large LOCA Late Melt ECCS Failure on Recirculation
ALC	Large LOCA Late Melt ECCS Failure on Recirculation
AL	Large LOCA Late Melt No Containment Cooling
SEFC	Small LOCA Early Melt ECCS Failure at Injection
SEF	Small LOCA Early Melt ECCS Failure at Injection
SEC	Small LOCA Early Melt ECCS Failure at Injection
SE	Small LOCA Early Melt No Containment Cooling
SLFC	Small LOCA Late Melt ECCS Failure on Recirculation
SLF	Small LOCA Late Melt ECCS Failure on Recirculation
SLC	Small LOCA Late Melt ECCS Failure on Recirculation
SL	Small LOCA Late Melt No Containment Cooling
TEFC	Transient With No Cooling, Early Melt
TEF	Transient With No Cooling, Early Melt
TEC	Transient With No Cooling, Early Melt
TE	Transient Early Melt No Containment Cooling
V2E	SGTR Early Melt
VZL	SGTR Late Melt
V	Interfacing Systems LOCA

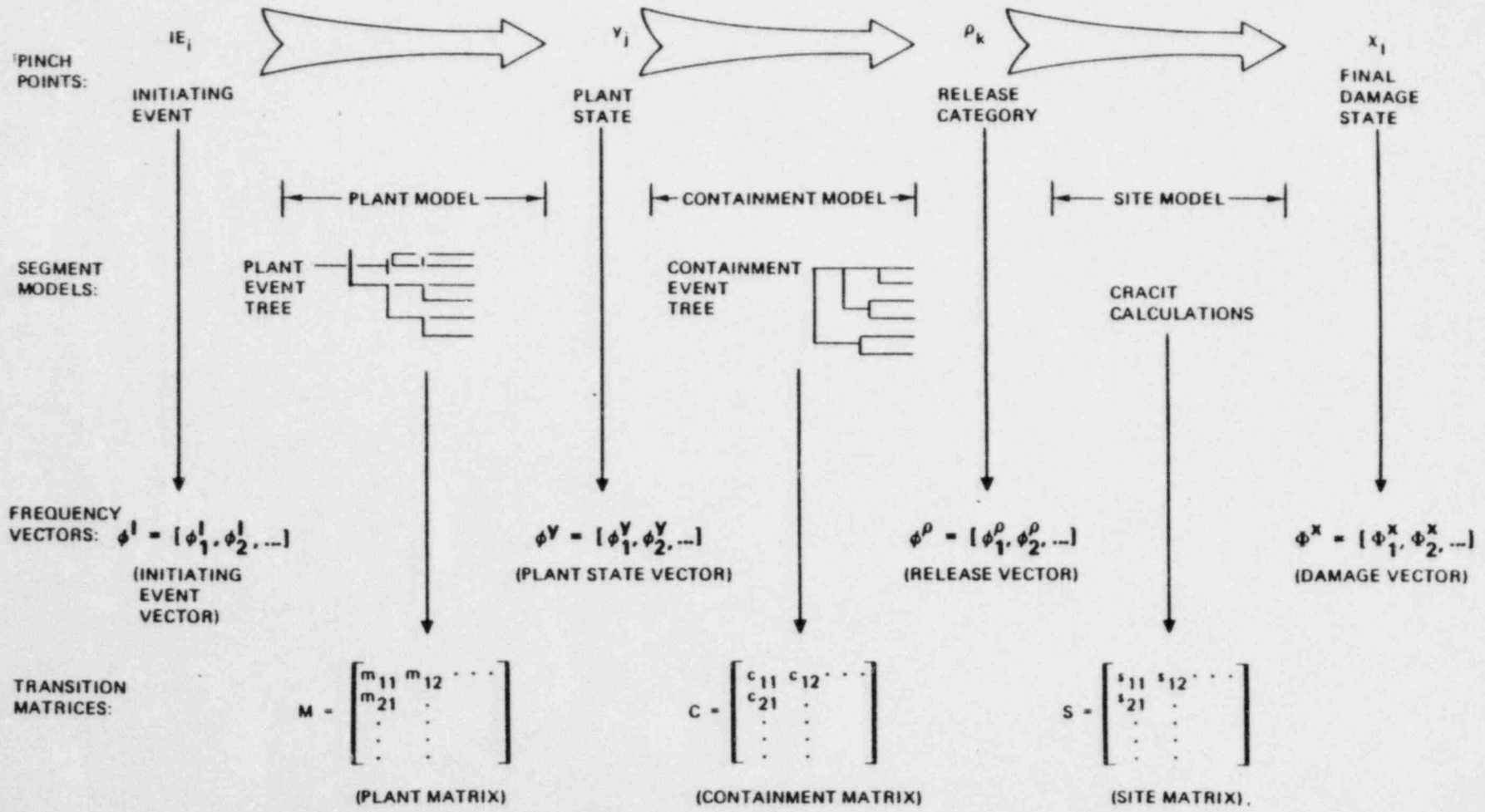
TABLE 4C-3

RELEASE CATEGORY DEFINITIONS

Release Catetory	Description
Z-1	Steam Explosion Without Containment Spray
2	Overpressure Failures Without Sprays
2R	Delayed Overpressure Failure Without Sprays
Z-3	Steam Explosions With Sprays
5R	Delayed Overpressure With Sprays
Z-5	Early Overpressure Failures With Sprays
6	Basemat Melt-Through Without Sprays
7	Basemat Melt-Through With Sprays
8A	Containment Intact Without Sprays
8B	Containment Intact With Sprays
2R'	SGTR Release

FIGURE 4C-1

OVERVIEW OF THE ASSEMBLY PROCESS, SHOWING RELATIONSHIP OF PINCH POINTS, FREQUENCY VECTORS, EVENT TREES, AND TRANSITION MATRICES



ASSEMBLY PROCESS:

$\phi^Y = \phi^I M$

$\phi^\rho = \phi^Y C = \phi^I MC$

$\Phi^X = \phi^\rho S = \phi^Y CS = \phi^I MCS$

5.0 CONCLUSIONS AND DISCUSSION OF ANALYSIS RESULTS

This section presents the results of the analysis and provides a discussion of the major contributors to plant risk. A sensitivity analysis of risk to various system alignments is presented in Section 5.2.

5.1 RESULTS AND CONCLUSIONS

The results of the analysis are presented in Figures 5-1 through 5-4, presenting 3-day and 7-day LCO consequence curves for comparison. the risk categories addressed are:

1. Early fatalities;
2. Latent fatalities;
3. Thyroid cancers; and
4. Early injuries.

The results of the analysis show a statistically insignificant increase in the relative risk of the Byron facility due to the projected increase in the LCO for all fluid systems. It is noted that the increase is well within the 10 and 90 percent confidence limits of previous risk assessments performed with the same techniques on similar Westinghouse NSSS reactors. The largest impact on plant risk from a change in the LCO is noted, as expected, in the support systems, especially the diesel generators and the Essential Service Water System. The Component Cooling Water System is not important due to the inclusion of a maintenance spare pump in the design.

The increased outage time of the Auxiliary Feedwater System pumps does not lead to a noticeable increase in plant risk due to the overall reliability of the system and of backup feed and bleed function. Likewise, the reliability of the high pressure safety injection function, due to the design of four pumps (two HPSI and two charging), is not impacted by the change. The Residual Heat Removal System reliability is impacted by the proposed change, but there is a negligible total impact on plant risk.

Special consideration to the Diesel Generators and the Essential Service Water System are being given. An analysis of past diesel generator maintenance events, presented in NUREG/CR-1362 (1980), with an assumption of a log-normal distribution and categorical mean times to restore of 1, 4, 8, 24 and 72 hours for the discrete distributions of reported maintenance times, yields a mean time to restore of about 7 hours, much less than the analyzed 19 and 34 hours. While not specifically addressing the frequency of this data set, the frequency used is justified by the Zion study, and some plant flexibility in control of the frequency of maintenance is noted, such that significant variation from that analyzed would be an indicator of skewed component behavior, flagging the equipment for management attention.

The ESWS susceptibility to maintenance is caused by the design of one pump per train, combined with the normally operating status of the system. In single unit operation, this becomes more dominant with the presence of only two (of two necessary) ultimate heat sink forced draft cooling tower fans, where the construction of the Unit 2 components have not been completed. Due to the shared nature of this system and the CCWS, the completion of the Unit 2 portion of the system will yield a noticeable increase in overall system reliability, with concommitant decrease in plant risk.

The curves therefore show that the proposed increase in the allowed maintenance outage time does not result in a significant increase in plant risk. This result must be taken in the light of the conservative modeling assumptions used in the analysis, especially that: 1) mean maintenance duration is a function of LCO; and 2) maintenance frequency is a constant, independent of changes in the LCO. Westinghouse believes these results support the proposed changes to the Byron Technical Specifications.

5.2 SENSITIVITY ANALYSIS

This section presents the results of two analyses made to assess the dependence of plant risk on the differences in particular systems' reliabilities.

Particular attention has been drawn to the Auxiliary Feedwater System (AFWS) since the Three Mile Island-2 incident. The NRCs own assessment of the Byron AFWS showed that the system reliability just met their qualitative guidelines for the two-pump system. To better assess the impact of maintenance, the analysis model used was developed to analyze a 7-day LCO on only the AFWS, learning all other plant fluid systems at 3 days. This resulted in a change in internal core melt frequency from 4.78(-5) to 4.86(-5). The risk curves for this analysis show no perceivable change on the given scale, but are nontheless presented in Figures 5-5 through 5-8 for the four risk indices.

To better assess which systems impacted the plant risk to the largest extent, analysis was made of the support systems, i.e., Diesel Generators and Essential Service Water System. The support systems were maintained at the 3-day LCO, and all other plant systems were shifted to the 7-day reliability values. This resulted in a change in the internal core melt frequency from 4.78(-5) to 4.91(-5). Again, the risk curves were superimposed, with no perceivable difference in results. Therefore, these curves have not been presented.

This analysis supports the conclusions drawn above, in that the overall increase in plant risk due to the proposed LCO changes is dominated by the support systems. Since the magnitude of that change is statistically insignificant, the proposed changes are justified for all systems.

FIGURE 5-1

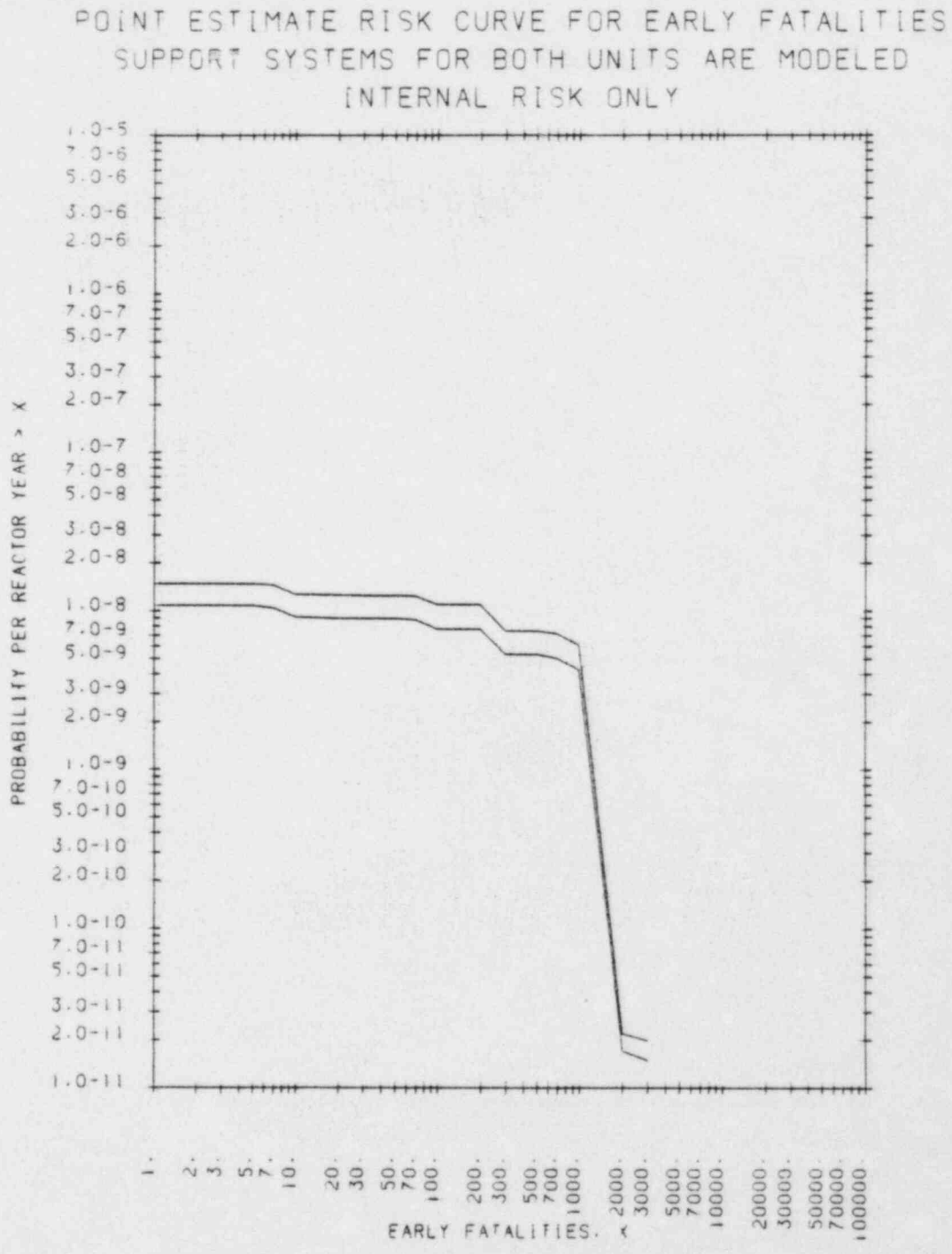

POINT ESTIMATE RISK CURVE FOR EARLY FATALITIES
SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED
INTERNAL RISK ONLY
PROBABILITY PER REACTOR YEAR > X
1.0-5
7.0-6
5.0-6
3.0-6
2.0-6
1.0-6
7.0-7
5.0-7
3.0-7
2.0-7
1.0-7
7.0-8
5.0-8
3.0-8
2.0-8
1.0-8
7.0-9
5.0-9
3.0-9
2.0-9
1.0-9
7.0-10
5.0-10
3.0-10
2.0-10
1.0-10
7.0-11
5.0-11
3.0-11
2.0-11
1.0-11
1.
2.
3.
5.
7.
10.
20.
30.
50.
70.
100.
200.
300.
500.
700.
1000.
2000.
3000.
5000.
7000.
10000.
20000.
30000.
50000.
70000.
100000.
EARLY FATALITIES, X

FIGURE 5-2

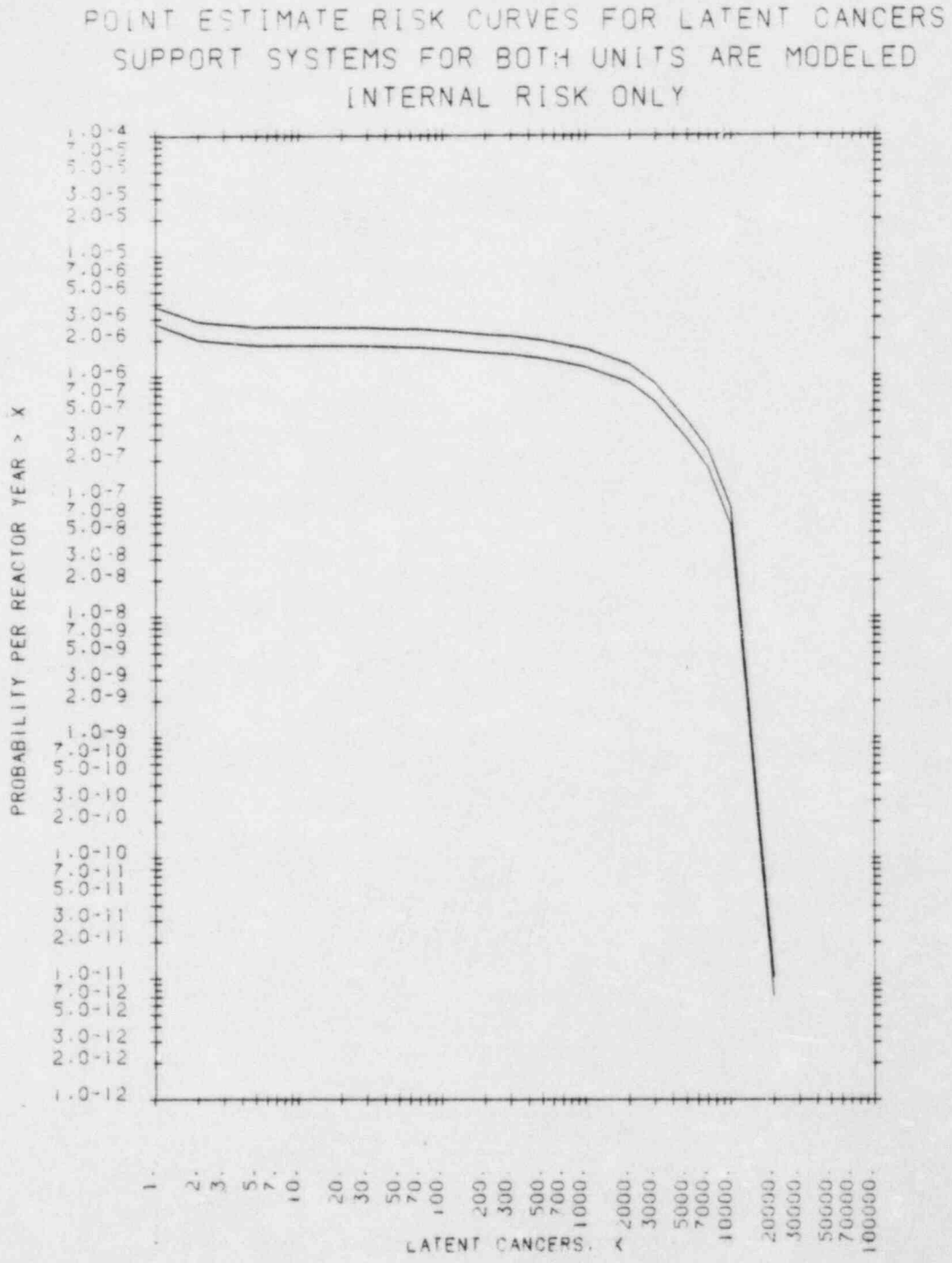

POINT ESTIMATE RISK CURVES FOR LATENT CANCERS
SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED
INTERNAL RISK ONLY
PROBABILITY PER REACTOR YEAR > X
1.0-4
7.0-5
5.0-5
3.0-5
2.0-5
1.0-5
7.0-6
5.0-6
3.0-6
2.0-6
1.0-6
7.0-7
5.0-7
3.0-7
2.0-7
1.0-7
7.0-8
5.0-8
3.0-8
2.0-8
1.0-8
7.0-9
5.0-9
3.0-9
2.0-9
1.0-9
7.0-10
5.0-10
3.0-10
2.0-10
1.0-10
7.0-11
5.0-11
3.0-11
2.0-11
1.0-11
7.0-12
5.0-12
3.0-12
2.0-12
1.0-12
1.
2.
3.
5.
7.
10.
20.
30.
50.
70.
100.
200.
300.
500.
700.
1000.
2000.
3000.
5000.
7000.
10000.
20000.
30000.
50000.
70000.
100000.
LATENT CANCERS, X

FIGURE 5-3

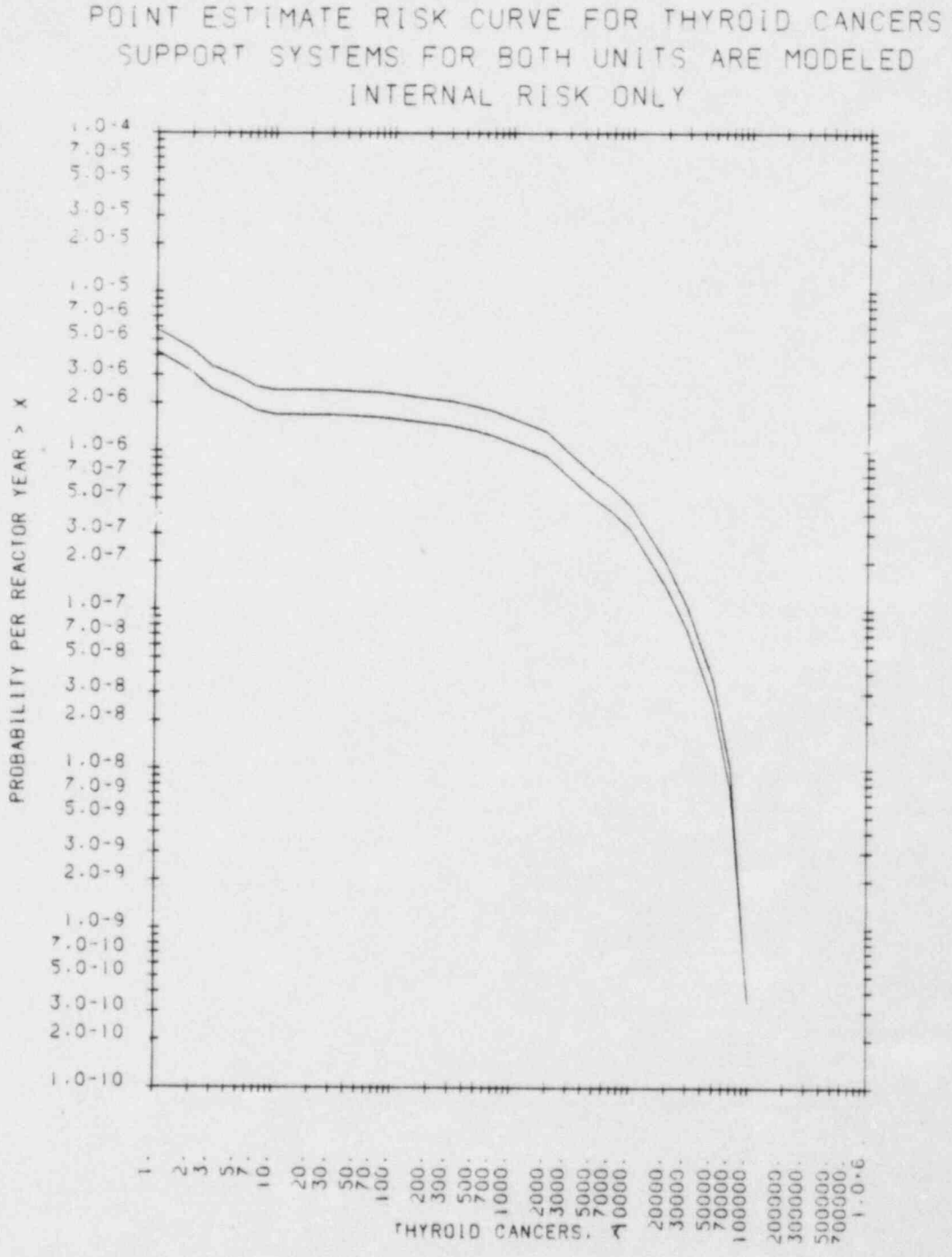

POINT ESTIMATE RISK CURVE FOR THYROID CANCERS
SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED
INTERNAL RISK ONLY
PROBABILITY PER REACTOR YEAR > X
1.0-4
7.0-5
5.0-5
3.0-5
2.0-5
1.0-5
7.0-6
5.0-6
3.0-6
2.0-6
1.0-6
7.0-7
5.0-7
3.0-7
2.0-7
1.0-7
7.0-8
5.0-8
3.0-8
2.0-8
1.0-8
7.0-9
5.0-9
3.0-9
2.0-9
1.0-9
7.0-10
5.0-10
3.0-10
2.0-10
1.0-10
1.
2.
3.
5.
7.
10.
20.
30.
50.
70.
100.
200.
300.
500.
700.
1000.
2000.
3000.
5000.
7000.
10000.
20000.
30000.
50000.
70000.
100000.
200000.
300000.
500000.
700000.
1.0+6
THYROID CANCERS.

FIGURE 5-4

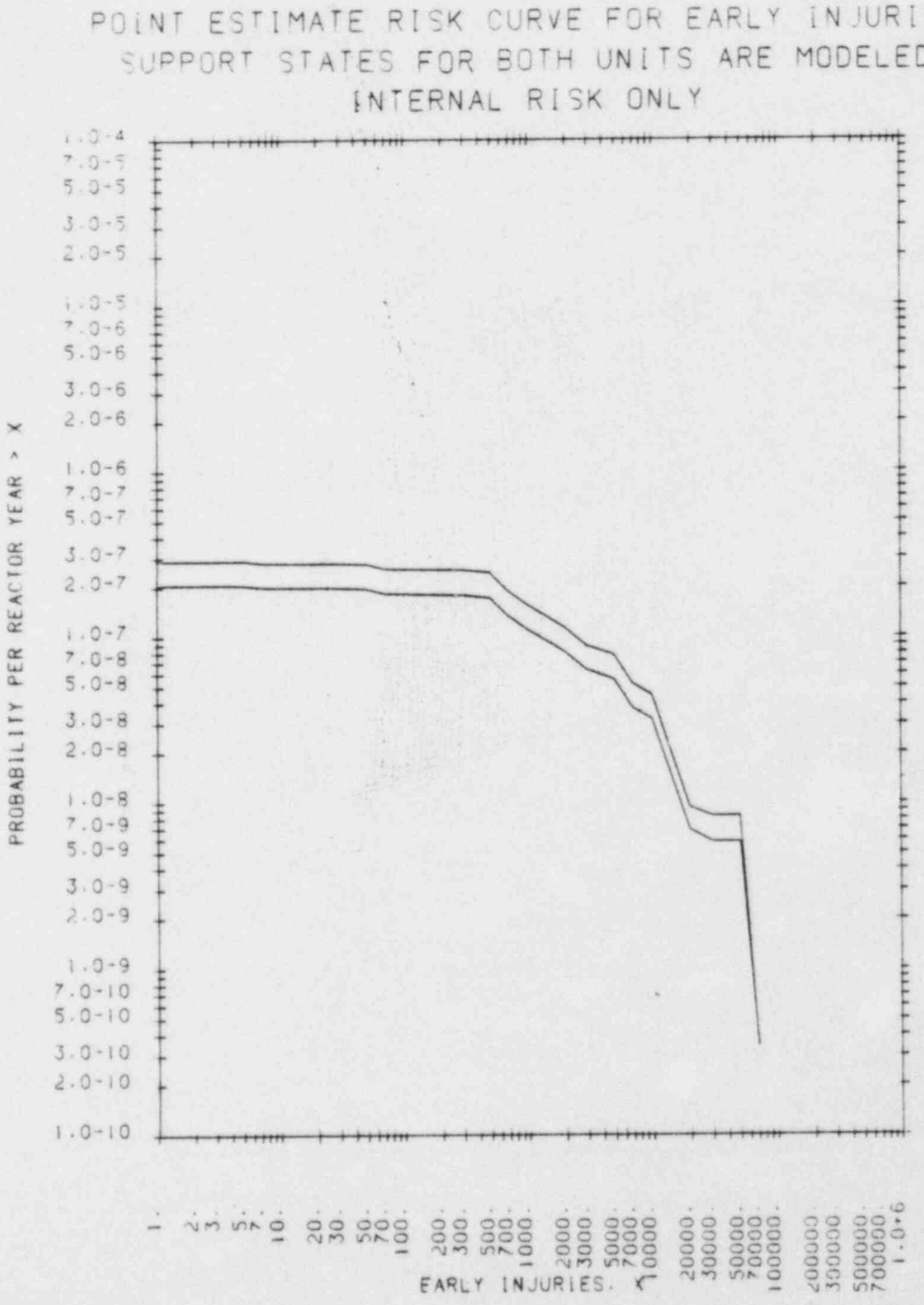

POINT ESTIMATE RISK CURVE FOR EARLY INJURIES
SUPPORT STATES FOR BOTH UNITS ARE MODELED
INTERNAL RISK ONLY
PROBABILITY PER REACTOR YEAR > X
1.0-4
7.0-5
5.0-5
3.0-5
2.0-5
1.0-5
7.0-6
5.0-6
3.0-6
2.0-6
1.0-6
7.0-7
5.0-7
3.0-7
2.0-7
1.0-7
7.0-8
5.0-8
3.0-8
2.0-8
1.0-8
7.0-9
5.0-9
3.0-9
2.0-9
1.0-9
7.0-10
5.0-10
3.0-10
2.0-10
1.0-10
1.
2.
3.
5.
7.
10.
20.
30.
50.
70.
100.
200.
300.
500.
700.
1000.
2000.
3000.
5000.
7000.
10000.
20000.
30000.
50000.
70000.
100000.
200000.
300000.
500000.
700000.
1.0+6
EARLY INJURIES. X

FIGURE 5-5

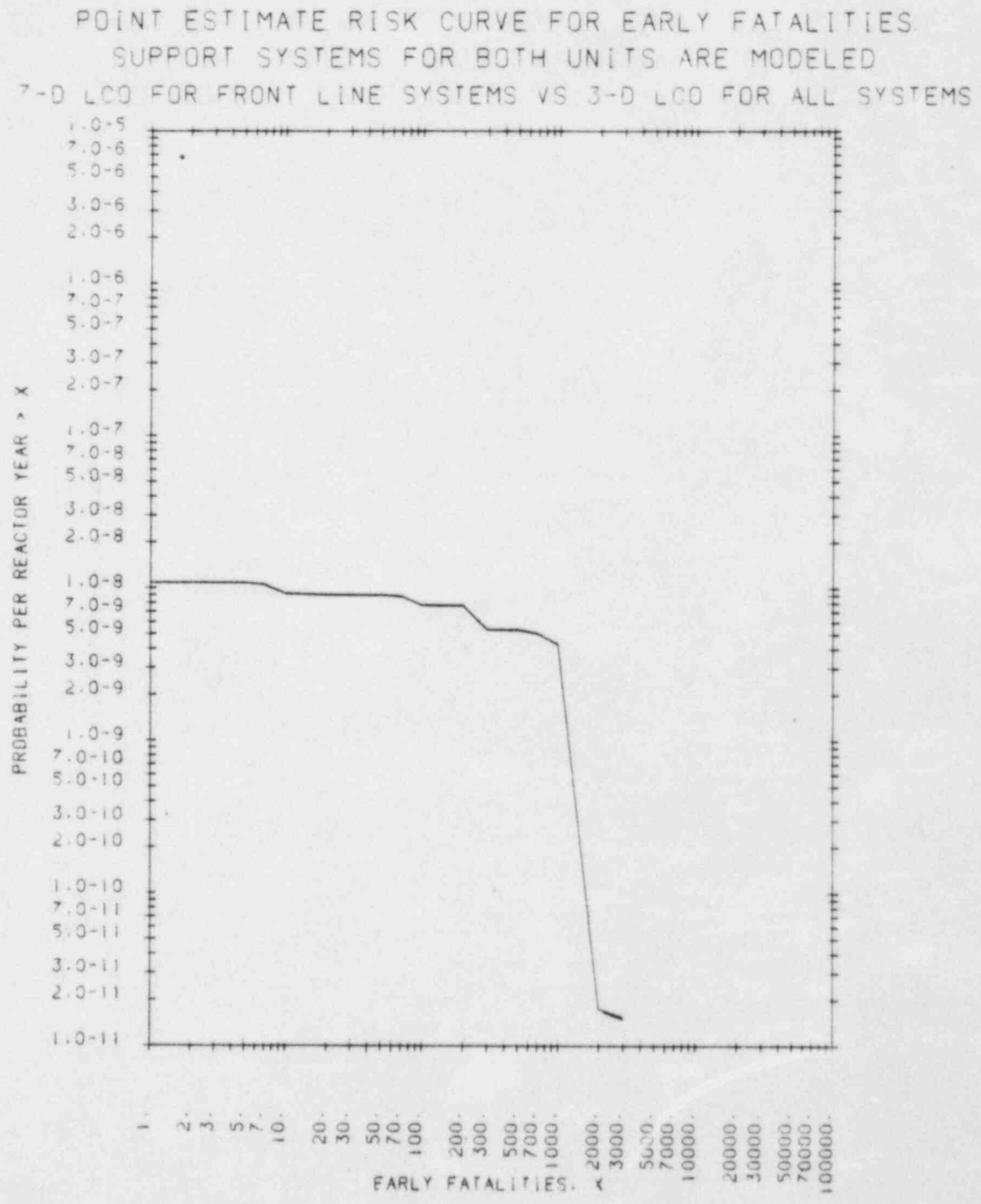

POINT ESTIMATE RISK CURVE FOR EARLY FATALITIES
SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED
7-D LCO FOR FRONT LINE SYSTEMS VS 3-D LCO FOR ALL SYSTEMS
PROBABILITY PER REACTOR YEAR > X
1.0-5
7.0-6
5.0-6
3.0-6
2.0-6
1.0-6
7.0-7
5.0-7
3.0-7
2.0-7
1.0-7
7.0-8
5.0-8
3.0-8
2.0-8
1.0-8
7.0-9
5.0-9
3.0-9
2.0-9
1.0-9
7.0-10
5.0-10
3.0-10
2.0-10
1.0-10
7.0-11
5.0-11
3.0-11
2.0-11
1.0-11
1.
2.
3.
5.
7.
10.
20.
30.
50.
70.
100.
200.
300.
500.
700.
1000.
2000.
3000.
5000.
7000.
10000.
20000.
30000.
50000.
70000.
100000.
EARLY FATALITIES, X

FIGURE 5-6

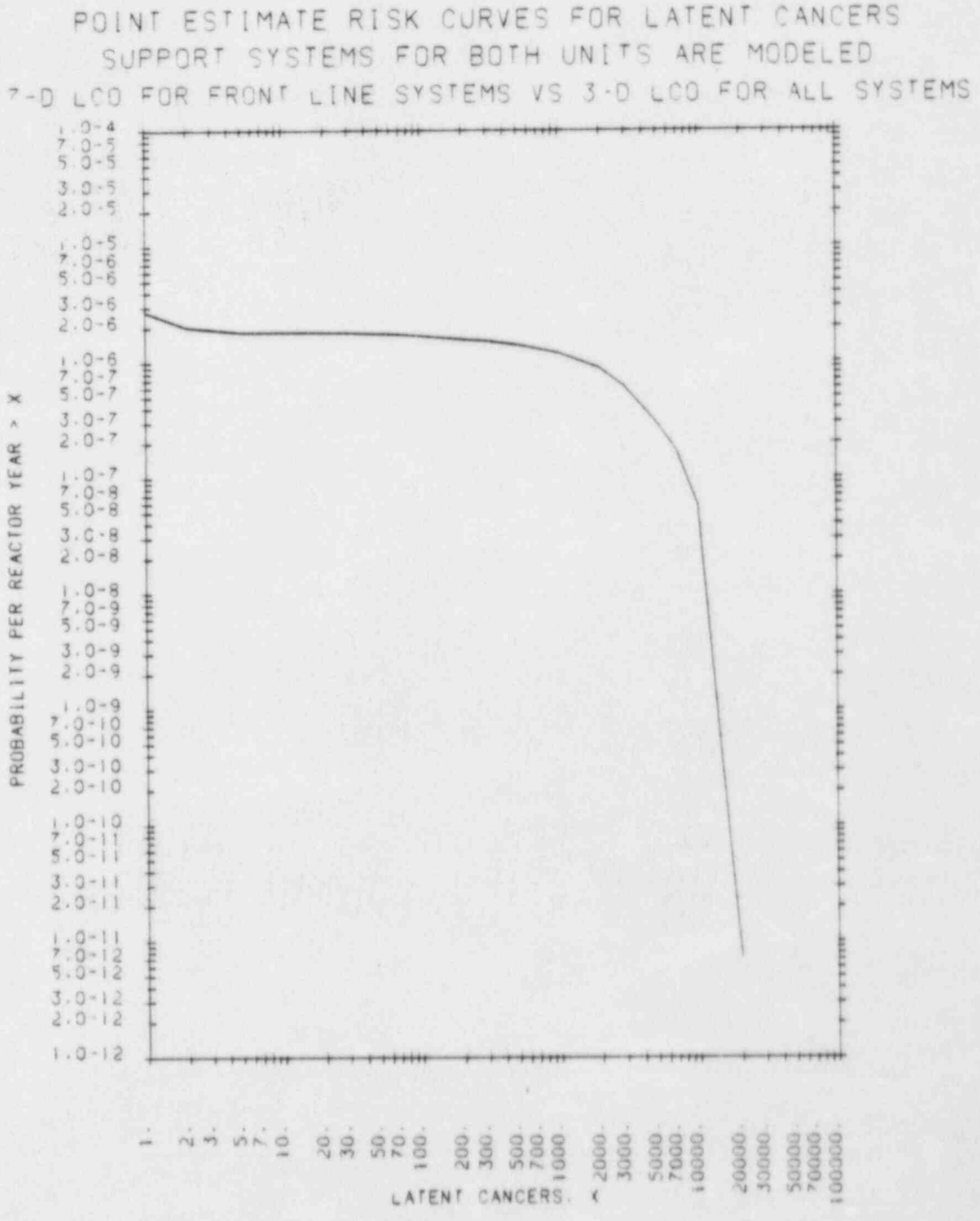

POINT ESTIMATE RISK CURVES FOR LATENT CANCERS
SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED
7-D LCO FOR FRONT LINE SYSTEMS VS 3-D LCO FOR ALL SYSTEMS
PROBABILITY PER REACTOR YEAR > X
1.0-4
7.0-5
5.0-5
3.0-5
2.0-5
1.0-5
7.0-6
5.0-6
3.0-6
2.0-6
1.0-6
7.0-7
5.0-7
3.0-7
2.0-7
1.0-7
7.0-8
5.0-8
3.0-8
2.0-8
1.0-8
7.0-9
5.0-9
3.0-9
2.0-9
1.0-9
7.0-10
5.0-10
3.0-10
2.0-10
1.0-10
7.0-11
5.0-11
3.0-11
2.0-11
1.0-11
7.0-12
5.0-12
3.0-12
2.0-12
1.0-12
1.
2.
3.
5.
7.
10.
20.
30.
50.
70.
100.
200.
300.
500.
700.
1000.
2000.
3000.
5000.
7000.
10000.
20000.
30000.
50000.
70000.
100000.
LATENT CANCERS, X

FIGURE 5-7

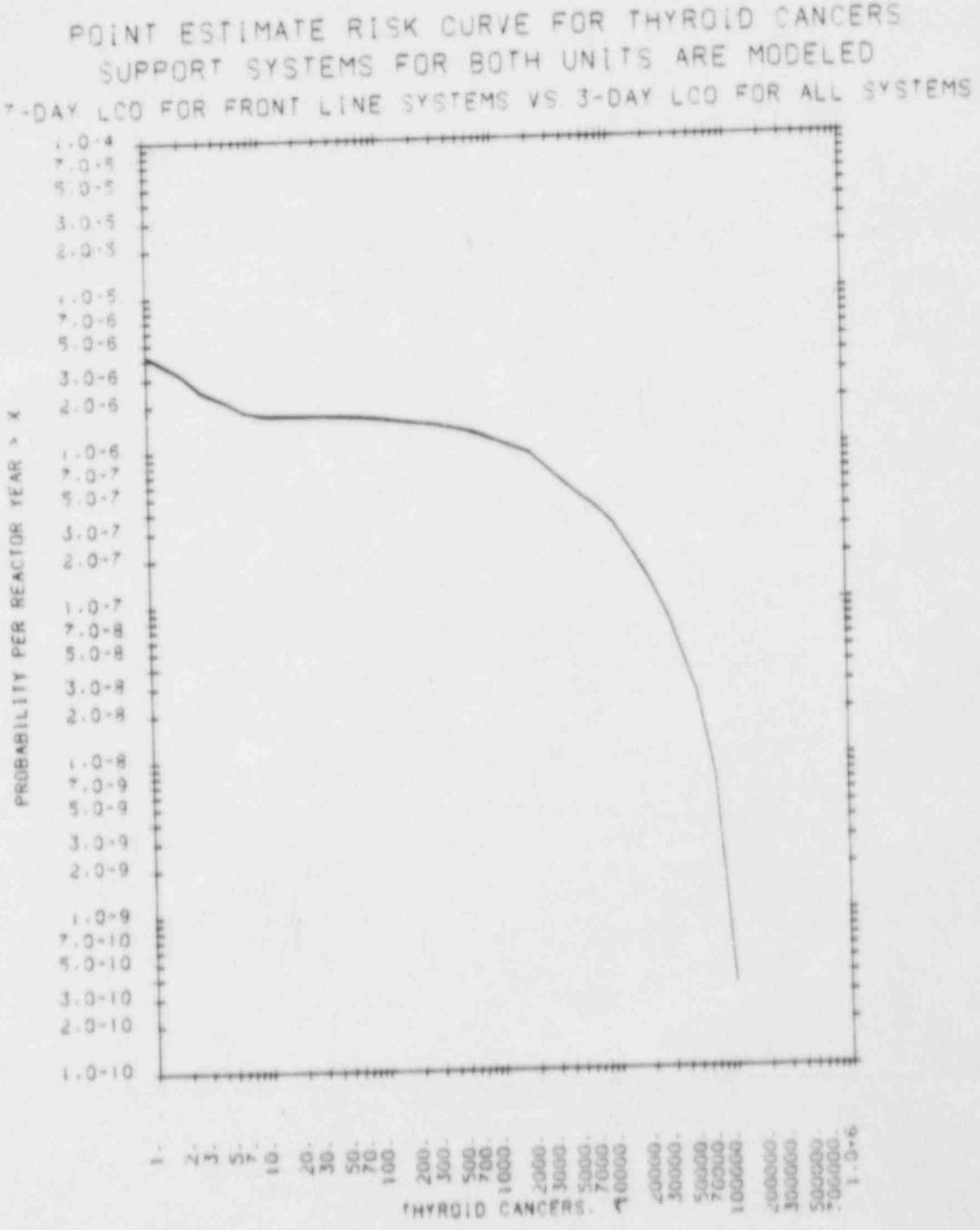
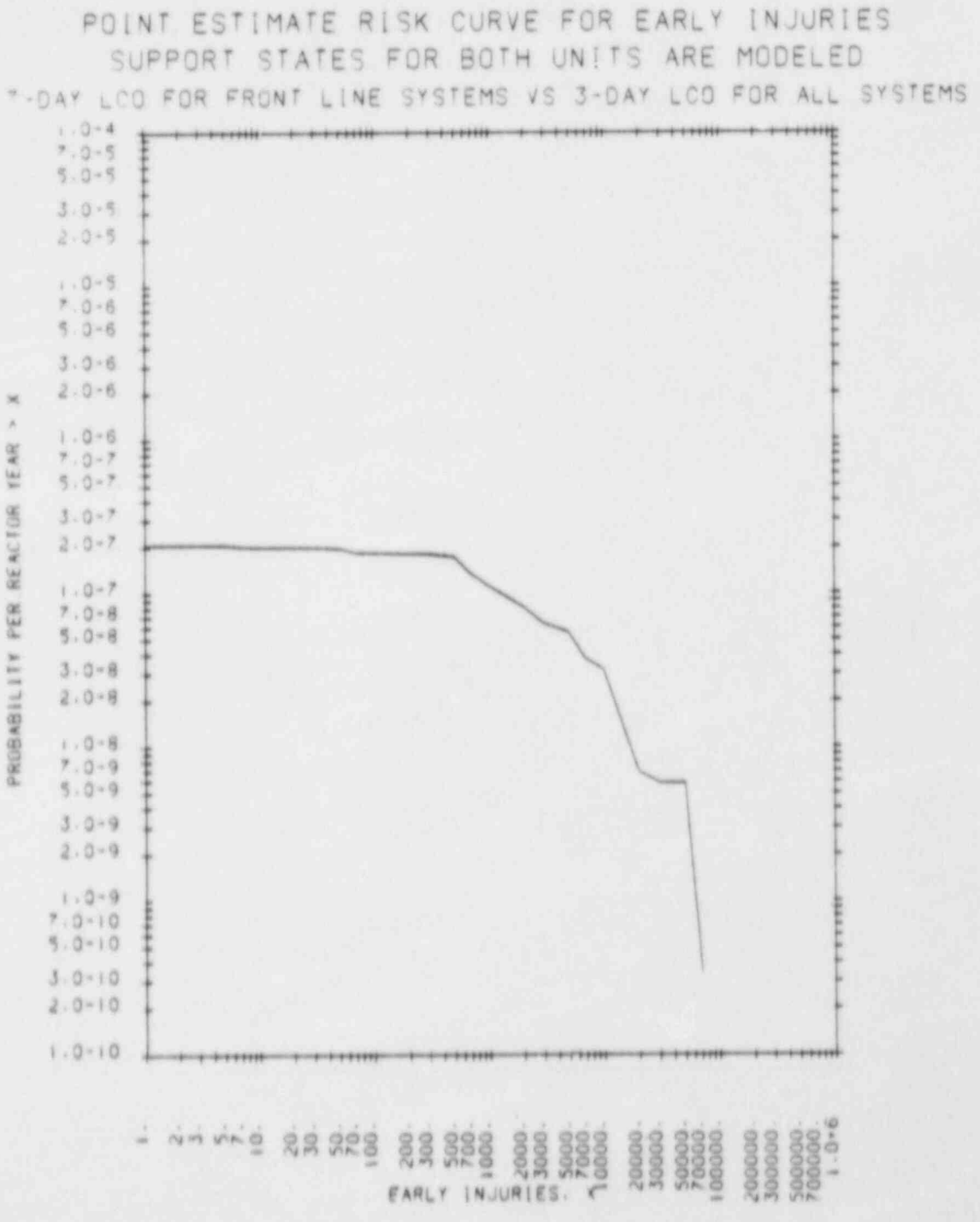

POINT ESTIMATE RISK CURVE FOR THYROID CANCERS
SUPPORT SYSTEMS FOR BOTH UNITS ARE MODELED
7-DAY LCO FOR FRONT LINE SYSTEMS VS 3-DAY LCO FOR ALL SYSTEMS
PROBABILITY PER REACTOR YEAR > K
1.0-4
7.0-5
5.0-5
3.0-5
2.0-5
1.0-5
7.0-6
5.0-6
3.0-6
2.0-6
1.0-6
7.0-7
5.0-7
3.0-7
2.0-7
1.0-7
7.0-8
5.0-8
3.0-8
2.0-8
1.0-8
7.0-9
5.0-9
3.0-9
2.0-9
1.0-9
7.0-10
5.0-10
3.0-10
2.0-10
1.0-10
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
2000
3000
5000
7000
10000
20000
30000
50000
70000
100000
200000
300000
500000
700000
1.0-6
THYROID CANCERS

FIGURE 5-8


POINT ESTIMATE RISK CURVE FOR EARLY INJURIES
SUPPORT STATES FOR BOTH UNITS ARE MODELED
7-DAY LCO FOR FRONT LINE SYSTEMS VS 3-DAY LCO FOR ALL SYSTEMS
PROBABILITY PER REACTOR YEAR > X
1.0-4
7.0-5
5.0-5
3.0-5
2.0-5
1.0-5
7.0-6
5.0-6
3.0-6
2.0-6
1.0-6
7.0-7
5.0-7
3.0-7
2.0-7
1.0-7
7.0-8
5.0-8
3.0-8
2.0-8
1.0-8
7.0-9
5.0-9
3.0-9
2.0-9
1.0-9
7.0-10
5.0-10
3.0-10
2.0-10
1.0-10
1 2 3 5 7 10 20 30 50 70 100 200 300 500 700 1000 2000 3000 5000 7000 10000 20000 30000 50000 70000 100000 200000 300000 500000 700000 1.0+6
EARLY INJURIES, X

6. SINGLE UNIT OPERATION

6.1 INTRODUCTION

This chapter presents the systems analysis and quantification of core melt and plant risk for the operation of Unit 1 only. The difference in systems lineup for single unit operation is comprised of isolation of those components of the shared safety systems, the Component Cooling Water and Essential Service Water Systems, that are part of Unit 2. These systems are analyzed in Sections 6.2.1 and 6.2.2, respectively. Due to changes in the unreliability of the essential service water system, the support state split fractions will change. The calculation of single unit support states is presented in Section 6.2.3.

In addition, the resultant changes in Component Cooling Water System unavailability impact the unavailabilities of the Low Pressure Recirculation and High Pressure Recirculation Systems. Requantification of the fault trees for these two systems are presented in Sections 6.1.4 and 6.1.5, respectively.

The results of the systems analyses are used for requantification of core melt frequencies and attendant plant risk. This analysis is presented in Section 6.3.

Conclusions derived from this analysis are presented in Section 6.4.

This chapter is not intended to be a stand-alone document. As such, reference to the appropriate sections of the main report (Chapters 1 through 6) is made where applicable.

6.2 PLANT SYSTEMS ANALYSIS

6.2.1 COMPONENT COOLING WATER SYSTEM

6.2.1.1 Discussion

The Component Cooling Water System provides cooling water flow to the Residual Heat Removal pump and to the shell side of the RHR heat exchanger in the

recirculation phase of LOCA mitigation. The system alignment in single unit operation differs from that analyzed for Unit 2 operation, analyzed in Section 3.4, since all Unit 2 equipment is isolated. A simplified flow diagram of the system in this operating mode is presented in Figure 6.2.1-1.

6.2.1.2 Fault Tree Analysis

The fault tree for this system in the single unit operating mode is presented in Figure 6.2.1-2. Refer to Section 3.4 for a detailed description of the success criteria and assumptions used in this analysis, and for the calculations of component common cause failure probabilities.

6.2.1.2.1 Input Data

The input to the quantification of the fault tree for 3 day LCO, all AC power available, is presented in Table 6.2.1-1. This is a listing of the component identifiers from the fault tree basic events and associated failure probabilities. This input differs for power states 2 and 3 by utilizing busses 141 and 142, respectively, as switches. Assigning a value of 1.0 to each switch effectively turns off the subject part of the tree, which is equivalent to removing power from subject pumps and valves. For 7 day LCO analysis, quantification of the fault tree is duplicated as above with the mean duration of maintenance set equal to 34 hours.

6.2.1.2.2 Results

The results of the quantification of the CCW fault tree are presented in Table 6.2.1-2. Note that a distinction is drawn between the probabilities of failure of cooling flow to the Train A RHR heat exchanger and the Train B RHR heat exchanger. This is due to a lack of symmetry in the system design. The common element is comprised of those failures leading to loss of flow to both heat exchangers. This model is required for input of system unavailability to the low and high pressure recirculation system fault trees.

The difference noted between power states 2 and 3 is a result of the loss of electric power to the Essential Service Water valves SX-005 and SX-146 at the inlet and discharge, respectively, of the "O" CCW heat exchanger, both of which must open.

The dominant cutsets for each power state (i.e., power state one, both busses available; power state two, bus 142 available only; and power state three, bus 141 only) are presented in Tables 6.2.1-3, 4, and 5.

TABLE 6.2.1-1 (Sheet 1 of 2)

CCW UNIT 1 SYSTEM COMPONENT FAULTS 1,3

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
1MOVSX004C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC9460AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC9460BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9466AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC9466BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVC19470BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OXVSX007C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
XVCC9471BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
1MOVSX007C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC9471AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVCC9509C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVC19467CC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVC19458C	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
XVC19470AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVC19467BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVC19470BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVC19459BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVC19467AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
XVC19459AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09

TABLE 6.2.1-1 (Sheet 2 of 2)

CCW UNIT 1 SYSTEM COMPONENT FAULTS 1,3

MVC19473AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MVC19473BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	6.570E+03	0.000E-01	3.47E-04	1.22E-07
MOVSX146D	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
1SX005D	MOV	FAIL TO OPERATE	1.550E-03	6.300E-08	ZPSS	0.000E-01	0.000E-01	1.55E-03	6.30E-08
CVCC9463AC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
CVCC9463BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
OCCO1PM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
1CCO1PAM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
1CCO1PBM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
BUS132D	BUS	NO POWER-4 HR DETECT	7.640E-08	0.000E-01	C1	0.000E-01	0.000E-01	7.64E-08	0.00E-01
PCCO1PBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCCO1PAFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
PCCO1PAFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
PCCO1PBFR	MDP	FAIL DURING OPERATIO	1.760E-06	9.620E-12	ZPSS	2.400E+01	0.000E-01	4.22E-05	5.54E-09
CCCCWPA	CC	CC RUNNING CCW TRAIN	4.590E-06	0.000E-01	CCW	0.000E-01	0.000E-01	4.59E-06	0.00E-01
CCCCWPB	CC	COMMON CAUSE STANDBY	7.160E-05	0.000E-01	CC2	0.000E-01	0.000E-01	7.16E-05	0.00E-01

TABLE 6.2.1-2

COMPONENT COOLING WATER SYSTEM SINGLE UNIT OPERATION

SUMMARY OF RESULTS

Power State	Train	3-Day LCO	7-Day LCO
1	Common	8.6 (-7)	9.4 (-7)
	Train A	2.2 (-6)	2.3 (-6)
	Train B	9.3 (-7)	1.0 (-6)
2	Common	1.0 (-3)	1.1 (-3)
	Train A	1.1 (-3)	1.1 (-3)
	Train B	1.0 (-3)	1.1 (-3)
3	Common	8.4 (-4)	8.8 (-4)
	Train A	8.4 (-4)	8.9 (-4)
	Train B	2.6 (-3)	2.7 (-3)

TABLE 6.2.1-3

CCW DOMINANT CUTSETS - ALL AC POWER

Component Failures and Modes	Relative Contribution (%) 3-Day	7-Day
CCW Pumps A and B fail to start	60.	55.
CCW Pumps A fails to start and any one valve (1CC9466B, 9460B, or 9463B) transfes closed	13.	12.
CCW Pump A (B) fails to start and Pump B (A) fails to run	7.	6.
CCW Pump A fails to start and common cause failure of Pump B	6.	5.
One pump fails to start and other pump (and Pump OC) in maintenance	3.	10.

TABLE 6.2.1-4

CCW DOMINANT CUTSETS - POWER STATE 2

Component Failures and Modes	Relative Contribution (%) 3-Day	7-Day
Pump B fails to start	72.	66.
Pump B fails - common cause	7.	7.
One valve (1CC9466B, 9460B, or 9463B) transfer closed	16.	14.
Pump B fails to run	4.	4.
Pump B (and Pump OC) maintenance	2.	6.

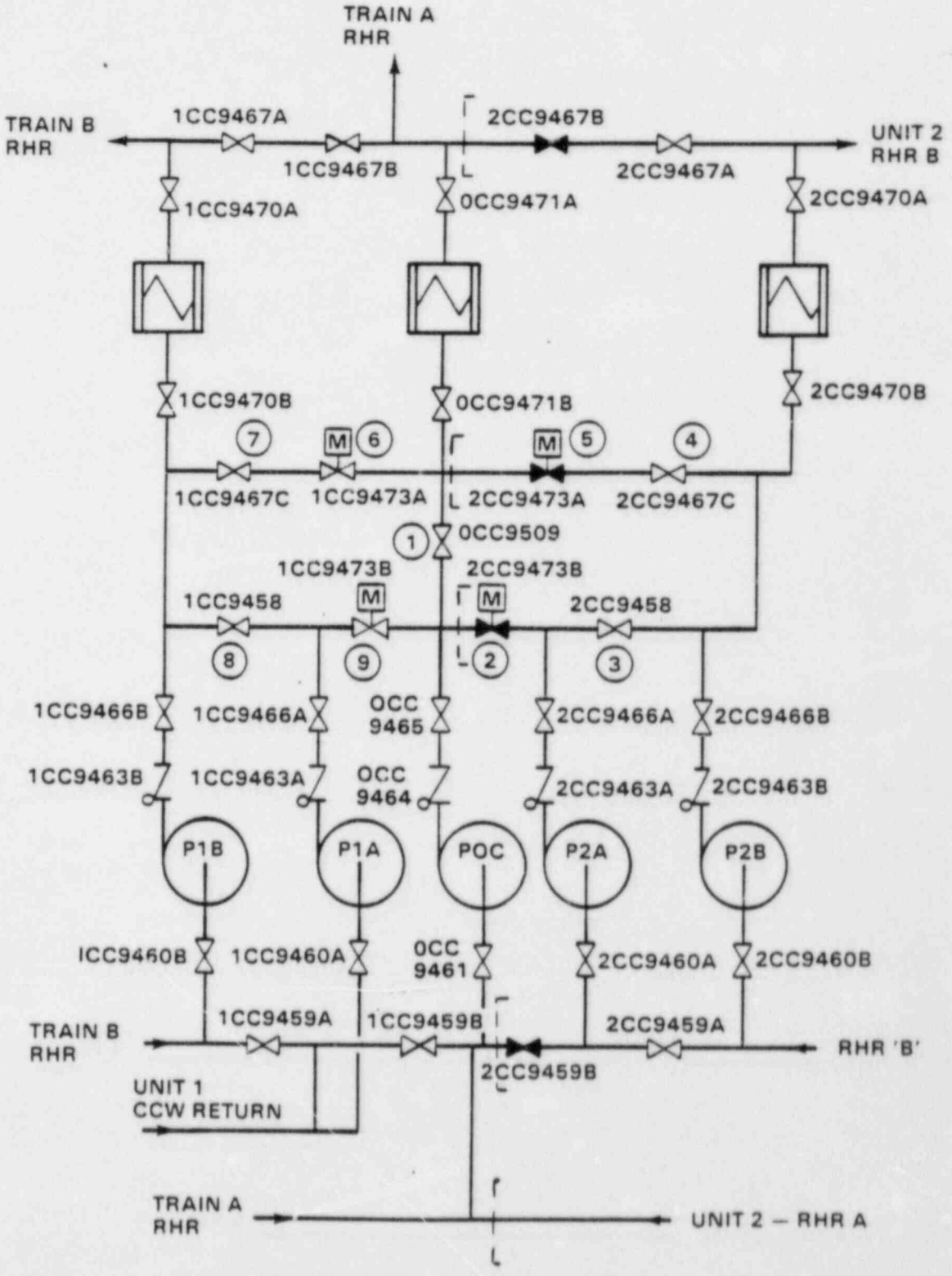
TABLE 6.2.1-5

CCW DOMINANT CUTSETS - POWER STATE 3

Component Failures and Modes	Relative Contribution (%) 3-Day	7-Day
Pump A fails to start	86.	82.
Pump A fails to run	5.	5.
Check valve 9463A fails closed	6.	5.
Pump A maintenance (and Pump OC)	2.	7.

FIGURE 6.2.1-1

COMPONENT COOLING WATER SYSTEM
ALIGNED FOR SINGLE UNIT OPERATION



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6.2.2 ESSENTIAL SERVICE WATER SYSTEM

6.2.2.1 Discussion

The Essential Service Water System provides cooling water flow to the component cooling water heat exchangers and to the high head safety injection and charging pumps and room coolers, to the diesel driven auxiliary feedwater pump, and to the Containment Fan Coolers. Due to the dependence of many plant systems on the ESWS, the system has been modeled into the support states of this analysis.

The ESWS used for single unit operation differs from that analyzed in Section 3.3 in that no Unit 2 equipment is available to provide flow or cooling. A simplified flow diagram of the Unit 1 ESWS is presented in Figure 6.2.2-1.

6.2.2.2 Fault Tree Analysis

The fault tree for the ESWS in the single unit operating mode is presented in Figure 6.2.2-2. Refer to Section 3.3 for a detailed description of the success criteria and assumptions used in this analysis, and for the calculations of component common cause failure probabilities.

6.2.2.2.1 Input Data

The input to the quantification of the fault tree for 3 day LCO, all AC power available, is presented in Table 6.2.2-1. This is a listing of the component identifiers from the fault tree basic events and associated failure probabilities. This input differs for power states 2 and 3 by utilizing busses 141 and 142, respectively, as switches. Assigning a value of 1.0 to each switch effectively turns off the subject part of the tree, which is equivalent to removing power from subject pumps, fans, and valves. For 7 day LCO analysis, quantification of the fault tree is duplicated as above with the mean duration of maintenance set equal to 34 hours.

6.2.2.2.2 Results

The results of the quantification of the ESW fault tree are presented in Table 6.2.2-2. The difference noted between power states 2 and 3 is a result of the maintenance of Train B components only, since Train A is assumed operational during plant operation, and therefore, cannot be placed in maintenance.

The dominant cutsets for each power state (i.e., power state one, both busses available; power state two, bus 142 available only; and power state three, bus 141 only) are presented in Tables 6.2.2-3, 4, and 5.

TABLE 6.2.2-1 (Sheet 1 of 2)

ESSENTIAL SERVICE WATER SYSTEM 3 DAY LCO POWER STATE 1

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	VARIANCE	PROBABILITY	VARIANCE
OMVSX162AO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	2.400E+01	0.000E-01	7.54E-07	8.99E-12
OMVSX162CO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	2.400E+01	0.000E-01	7.54E-07	8.99E-12
OMVSX162BO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	2.400E+01	0.000E-01	7.54E-07	8.99E-12
OMVSX162DO	MOV	TRANSFER OPEN/EXCESS	3.140E-08	1.560E-14	ZPSS	2.400E+01	0.000E-01	7.54E-07	8.99E-12
OMVSX163AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163EC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OMVSX163FC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
FSXO3CAFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
FSXO3CBFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
FSXO3CEFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FSXO3CFFS	CFC	FAIL TO START	1.170E-03	7.600E-07	ZPSS	0.000E-01	0.000E-01	1.17E-03	7.60E-07
FSXO3CAFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CBFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CEFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
FSXO3CFFR	CFC	FAIL DURING OPERATIO	3.530E-06	1.330E-11	ZPSS	2.400E+01	0.000E-01	8.47E-05	7.66E-09
BUS131ZD	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
BUS132ZD	BUS	OPEN CIRCUIT	1.910E-08	2.220E-15	ZPSS	2.800E+01	0.000E-01	5.35E-07	1.74E-12
JBS141D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01

TABLE 6.2.2-1 (Sheet 2 of 2)

ESSENTIAL SERVICE WATER SYSTEM 3 DAY LCO POWER STATE 1

JBS142D	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
OXVSX138AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
OXVSX138BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
1MVSX001AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
1MVSX001BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
1CVSX002AC	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
1CVSX002BC	CV	FAILURE TO OPEN ON D	4.320E-05	2.410E-09	ZPSS	0.000E-01	0.000E-01	4.32E-05	2.41E-09
1SSX01FAQ	STR	STRAINER FAILURE	2.400E-04	1.400E-05	BRS	0.000E-01	0.000E-01	2.40E-04	1.40E-05
1SSX01FBQ	STR	STRAINER FAILURE	2.400E-04	1.400E-05	BRS	0.000E-01	0.000E-01	2.40E-04	1.40E-05
1XVSX143AC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	2.400E+01	0.000E-01	1.27E-06	1.62E-12
1XVSX143BC	X,MV	TRANSFER CLOSED	5.280E-08	2.820E-15	ZPSS	1.095E+03	0.000E-01	5.78E-05	3.38E-09
1PSX01PAFS	SWT-	SWITCH OFF	0.000E-01	0.000E-01	NONE	0.000E-01	0.000E-01	0.00E-01	0.00E-01
1PSX01PBFS	MDP	FAIL TO START	7.210E-04	1.910E-07	ZPSS	0.000E-01	0.000E-01	7.21E-04	1.91E-07
1PSX01PAFR	MDP	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.400E+01	0.000E-01	3.17E-05	2.15E-09
1PSX01PBFR	MDP	FAIL DURING OPERATIO	1.320E-06	3.740E-12	ZPSS	2.400E+01	0.000E-01	3.17E-05	2.15E-09
1SSX01FBM	STR	STRAINER MAINT. FREQ	1.000E-05	0.000E-01	ES1	1.900E+01	0.000E-01	1.90E-04	0.00E-01
1PSX01PBM	MDP	CCW PUMP MAINT. FREQ	2.360E-04	0.000E-01	CC1	1.900E+01	0.000E-01	4.48E-03	0.00E-01
CCESWHXA	ESWH	COMMON CAUSE HEAT EX	8.920E-05	0.000E-01	ES2	0.000E-01	0.000E-01	8.92E-05	0.00E-01
CCESWHXB	ESWH	COMMON CAUSE HEAT EX	8.920E-05	0.000E-01	ES2	0.000E-01	0.000E-01	8.92E-05	0.00E-01
CCESWU1	ESWU	CC ESW BETWEEN UNITS	1.200E-05	0.000E-01	ES5	0.000E-01	0.000E-01	1.20E-05	0.00E-01
FSX03CEM	FANS	UHS FAN MAINT. FREQ.	5.850E-05	0.000E-01	ESW	1.900E+01	0.000E-01	1.11E-03	0.00E-01
FSX03CEM	FANS	UHS FAN MAINT. FREQ	5.850E-05	0.000E-01	ESW	1.900E+01	0.000E-01	1.11E-03	0.00E-01

TABLE 6.2.2-2

ESSENTIAL SERVICE WATER SYSTEM SINGLE UNIT OPERATION

SUMMARY OF RESULTS

Power State	3-Day LCO	7-Day LCO
1	1.8 (-5)	2.1 (-5)
2	1.1 (-2)	1.6 (-2)
3	3.6 (-3)	3.6 (-3)

TABLE 6.2.2-3

ESW DOMINANT CUTSETS - ALL AC POWER

Component Failures and Modes	Relative Contribution (%) 3-Day	7-Day
Common Cause Failure of both Pumps	67.	57.
Pump B maintenance and: Fans A or B fail to run, or Common cause failure of UHS fans on Train A, or Pump A fails to run, or Strainer A plugs	7.	20.
Strainer A plugs and: Fans E or F fail to start, or Pump B fails to run	4.	4.
Fans E or F in maintenance and: Strainer A plugs, or Fans A or B fail to run, or Common cause failure of UHS fans.	3.	9.

TABLE 6.2.2-4

ESW DOMINANT CUTSETS - POWER STATE 2

Component Failures and Modes	Relative Contribution (%) 3-Day	7-Day
Pump B in maintenance	41.	50.
Fans E or F fail to start	21.	15.
Fans E or F in maintenance	10.	25.
Pump B fails to start	7.	5.

TABLE 6.2.2-5

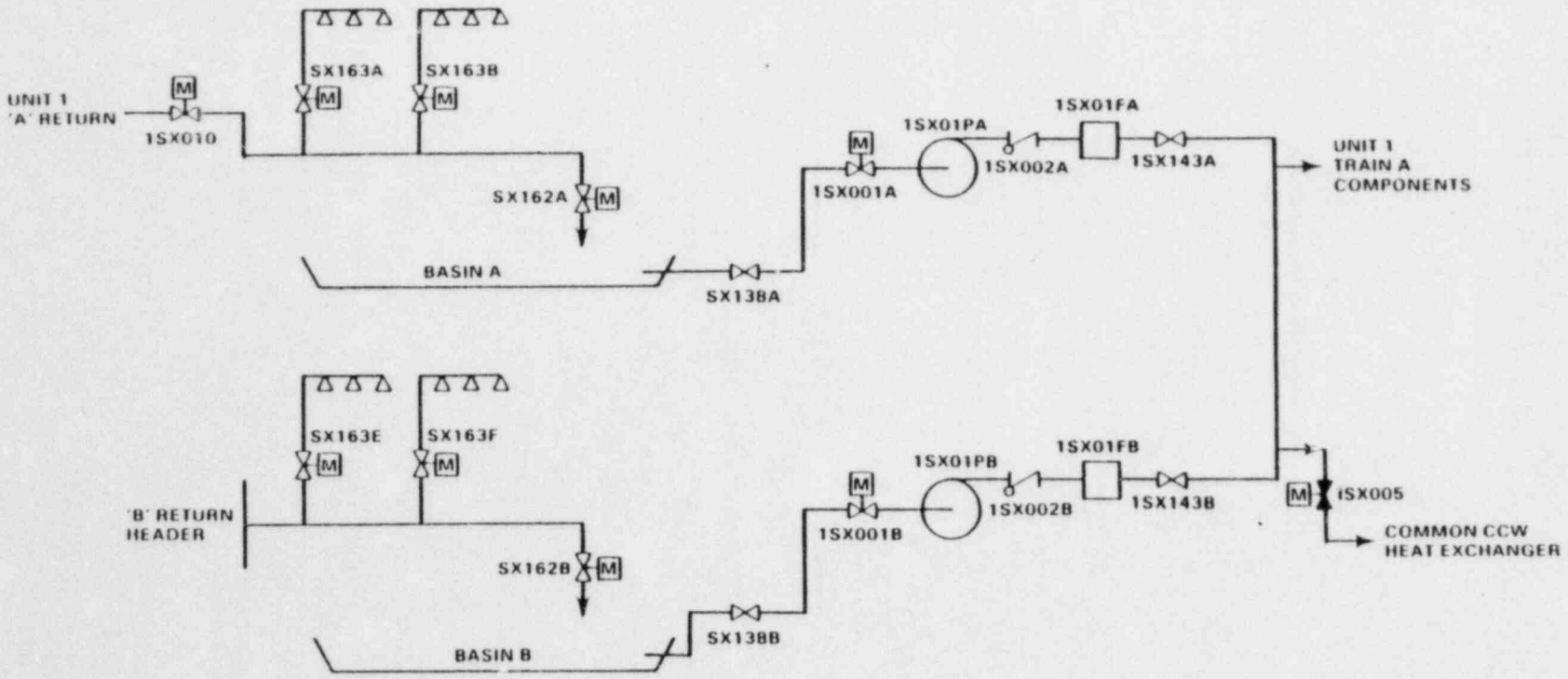
ESW DOMINANT CUTSETS - POWER STATE 3

Component Failures and Modes	Relative Contribution (%) 3-Day	7-Day
Fans A or B fail to start	65.	65.
Pump A fails to start	20.	20.
Strain A plug	7.	7.

FIGURE 6.2.2-1

ESSENTIAL SERVICE WATER SYSTEM

SIMPLIFIED FLOW DIAGRAM - SINGLE UNIT OPERATION



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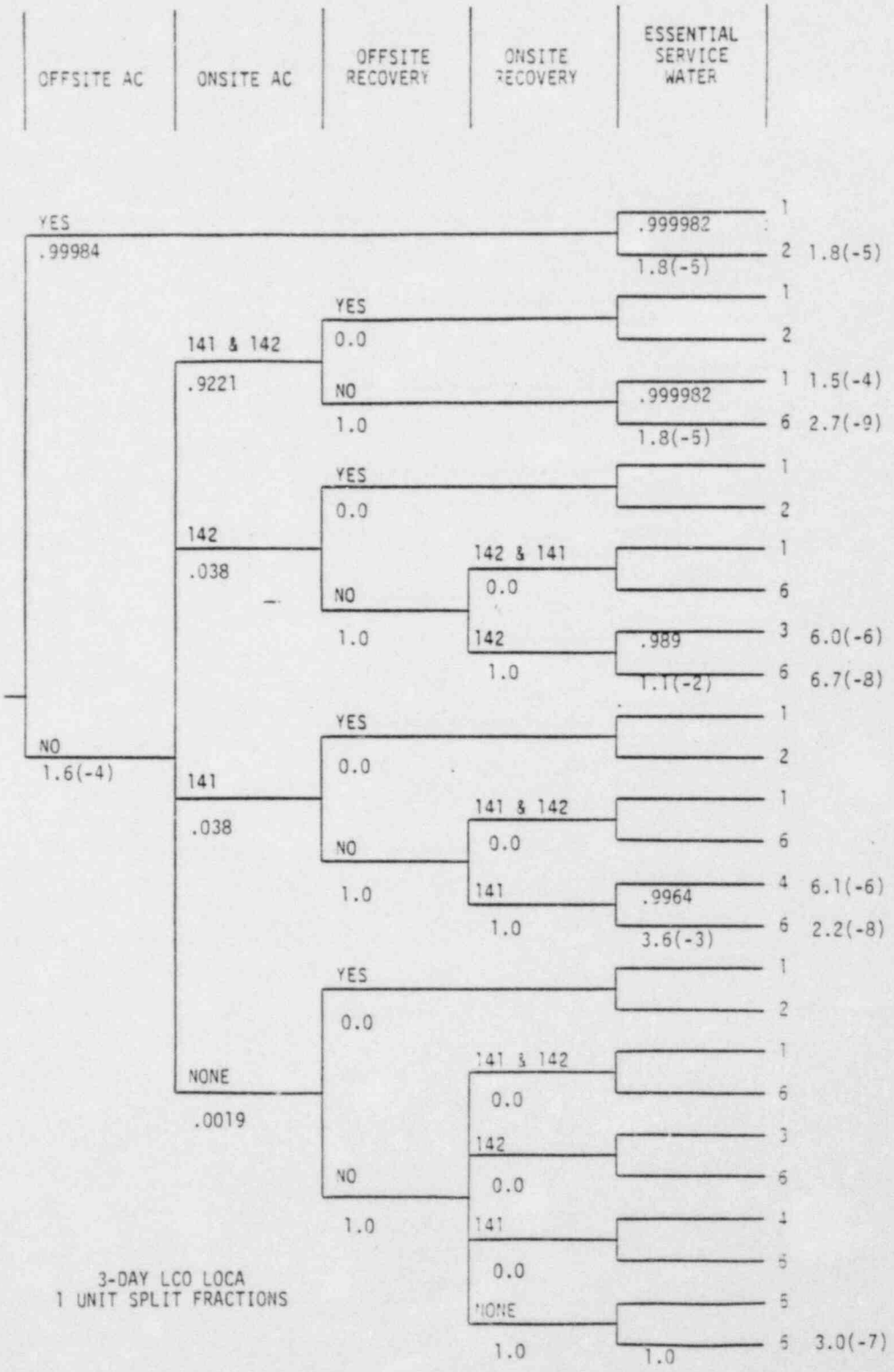
6.2.3 SUPPORT STATE SPLIT FRACTIONS

The calculation of the support state split fractions follows the methodology presented in Appendix 2C. The electric power state split fractions are calculated and presented in Section 3.2. The calculations are presented on Tables 6.2.3-1, 2, and 3 for 3-Day LCO and Tables 6.2.3-5, 6, and 7 for 7-Day LCO. Summaries of split fractions are presented in Tables 6.2.3-4 (3-Day) and 6.2.3-8 (7-Day).

TABLE 6.2.3-1



3-DAY LCO LOCA
1 UNIT SPLIT FRACTIONS

TABLE 6.2.3-2

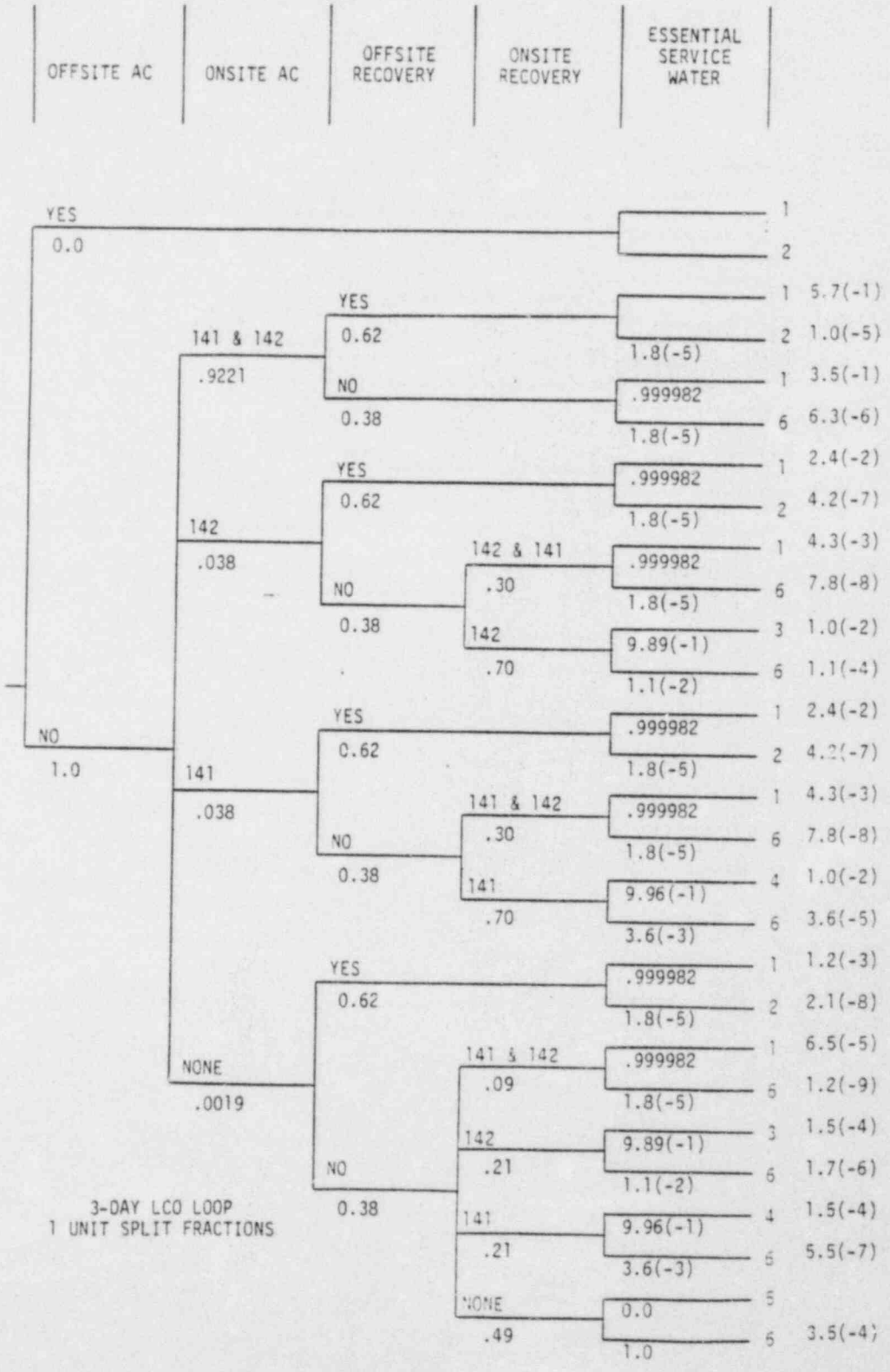
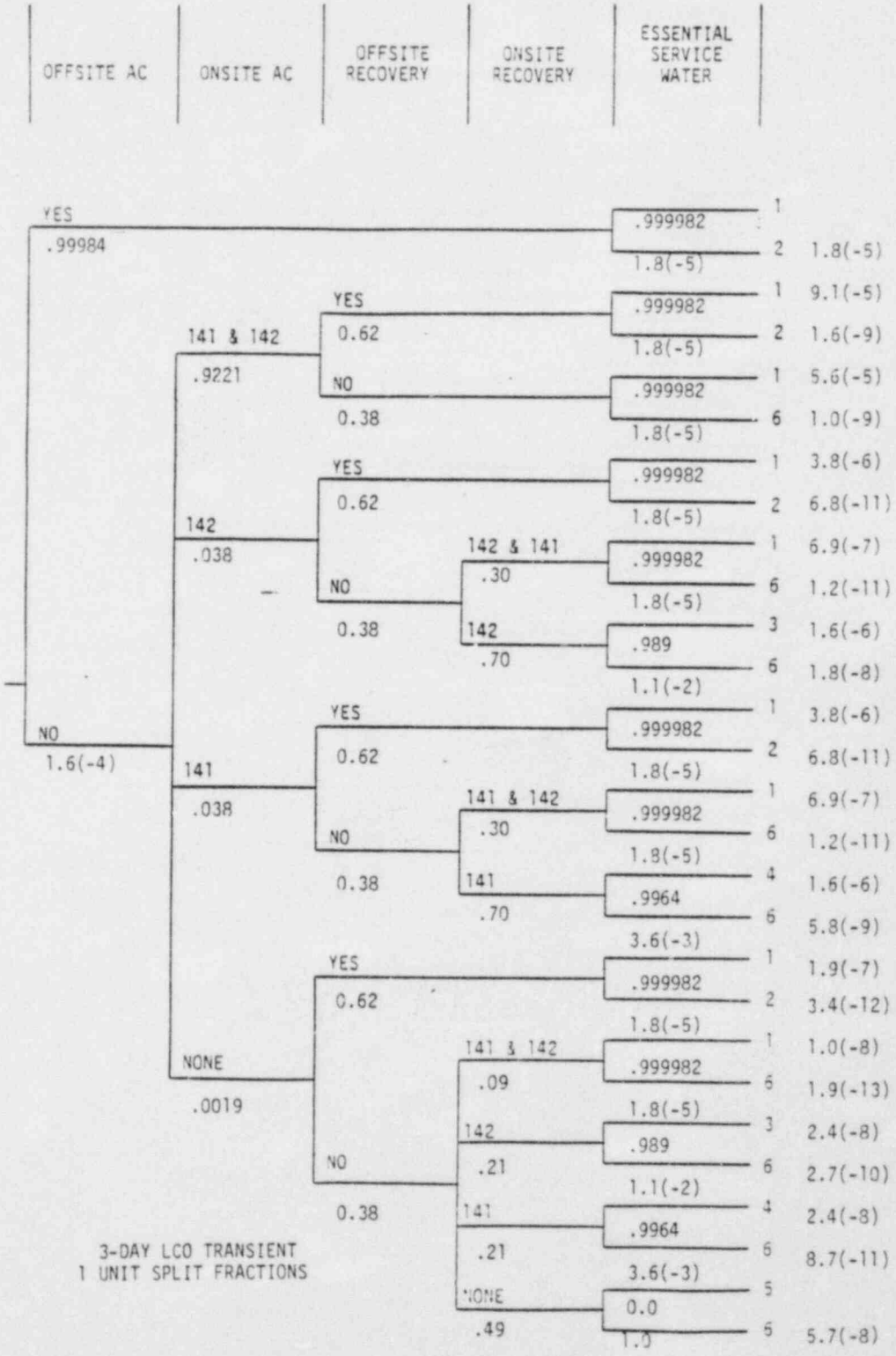

OFFSITE AC
ONSITE AC
OFFSITE RECOVERY
ONSITE RECOVERY
ESSENTIAL SERVICE WATER
YES
0.0
1
2
NO
1.0
141 & 142
.9221
YES
0.62
1.8(-5)
1
2
5.7(-1)
1.0(-5)
NO
0.38
.999982
1.8(-5)
1
6
3.5(-1)
6.3(-6)
142
.038
YES
0.62
.999982
1.8(-5)
1
2
2.4(-2)
4.2(-7)
NO
0.38
142 & 141
.30
.999982
1.8(-5)
1
6
4.3(-3)
7.8(-8)
142
.70
9.89(-1)
1.1(-2)
3
6
1.0(-2)
1.1(-4)
141
.038
YES
0.62
.999982
1.8(-5)
1
2
2.4(-2)
4.2(-7)
NO
0.38
141 & 142
.30
.999982
1.8(-5)
1
6
4.3(-3)
7.8(-8)
141
.70
9.96(-1)
3.6(-3)
4
6
1.0(-2)
3.6(-5)
NONE
.0019
YES
0.62
.999982
1.8(-5)
1
2
1.2(-3)
2.1(-8)
NO
0.38
141 & 142
.09
.999982
1.8(-5)
1
6
6.5(-5)
1.2(-9)
142
.21
9.89(-1)
1.1(-2)
3
6
1.5(-4)
1.7(-6)
141
.21
9.96(-1)
3.6(-3)
4
6
1.5(-4)
5.5(-7)
NONE
.49
0.0
1.0
5
6
3.5(-4)
3-DAY LCO LOOP
1 UNIT SPLIT FRACTIONS

TABLE 6.2.3-3



3-DAY LCO TRANSIENT
1 UNIT SPLIT FRACTIONS

TABLE 6.2.3-4

SUMMARY OF RESULTS - 3 DAY LCO
SUPPORT STATE SPLIT FRACTIONS

Support State	LOCA	Loop	Transient
1	.99997	.97948	.99998
2	1.8 (-5)	1.1 (-5)	1.8 (-5)
3	6.0 (-6)	1.0 (-2)	1.6 (-6)
4	6.0 (-6)	1.0 (-2)	1.6 (-6)
5	0.0	0.0	0.0
6	4.0 (-7)	5.1 (-4)	8.2 (-8)

TABLE 6.2.3-5

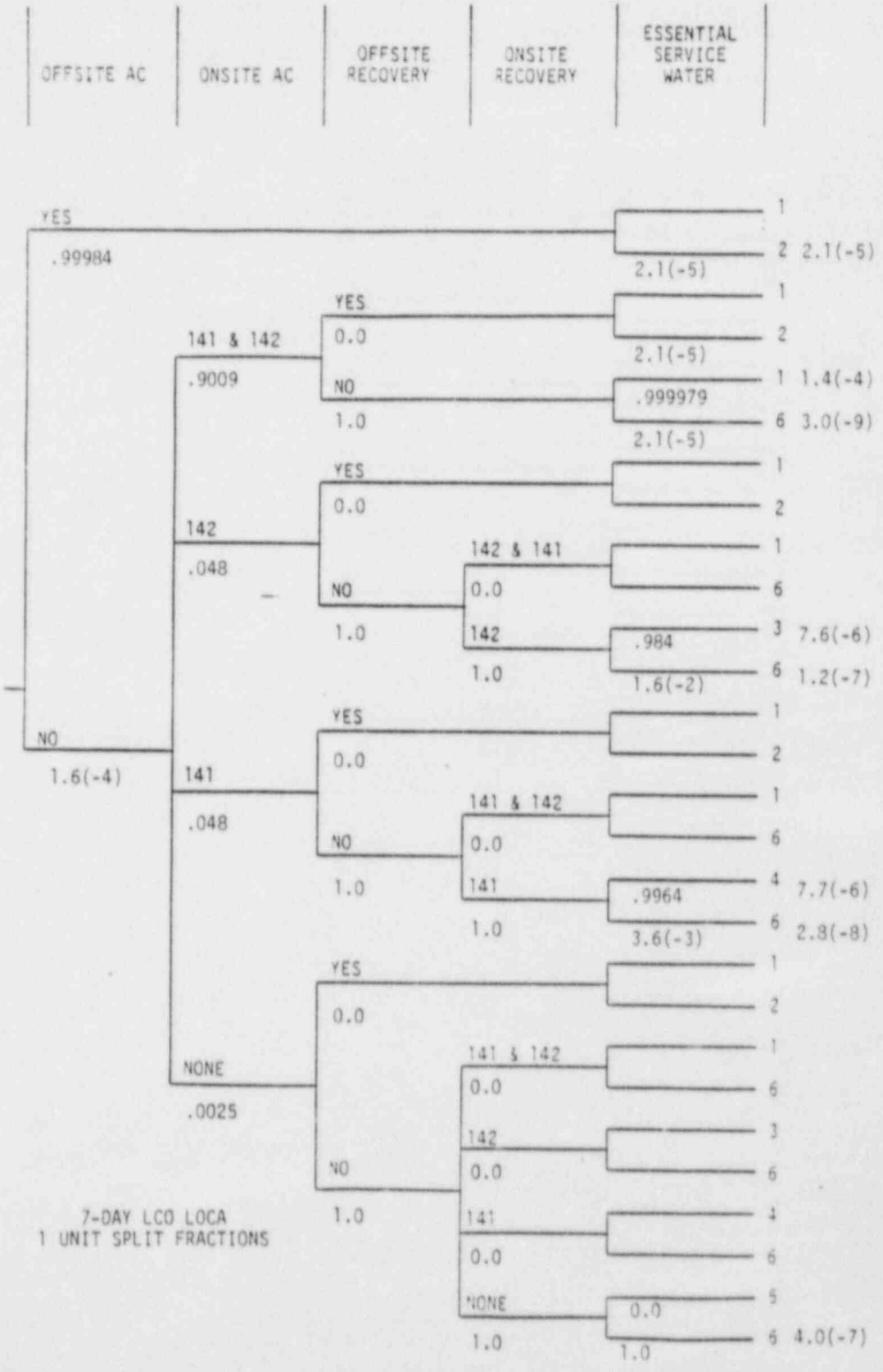

OFFSITE AC
ONSITE AC
OFFSITE RECOVERY
ONSITE RECOVERY
ESSENTIAL SERVICE WATER
YES
.99984
1
2 2.1(-5)
2.1(-5)
141 & 142
.9009
YES
0.0
1
2
2.1(-5)
NO
1.0
.999979
1 1.4(-4)
6 3.0(-9)
2.1(-5)
142
.048
YES
0.0
1
2
142 & 141
0.0
1
6
NO
1.0
142
1.0
.984
3 7.6(-6)
1.6(-2)
6 1.2(-7)
NO
1.6(-4)
141
.048
YES
0.0
1
2
141 & 142
0.0
1
6
NO
1.0
141
1.0
.9964
4 7.7(-6)
3.6(-3)
6 2.8(-8)
NONE
.0025
YES
0.0
1
2
141 & 142
0.0
1
6
142
0.0
3
6
NO
1.0
141
0.0
4
6
NONE
1.0
0.0
1.0
5
6 4.0(-7)
7-DAY LCO LOCA
1 UNIT SPLIT FRACTIONS

TABLE 6.2.3-6

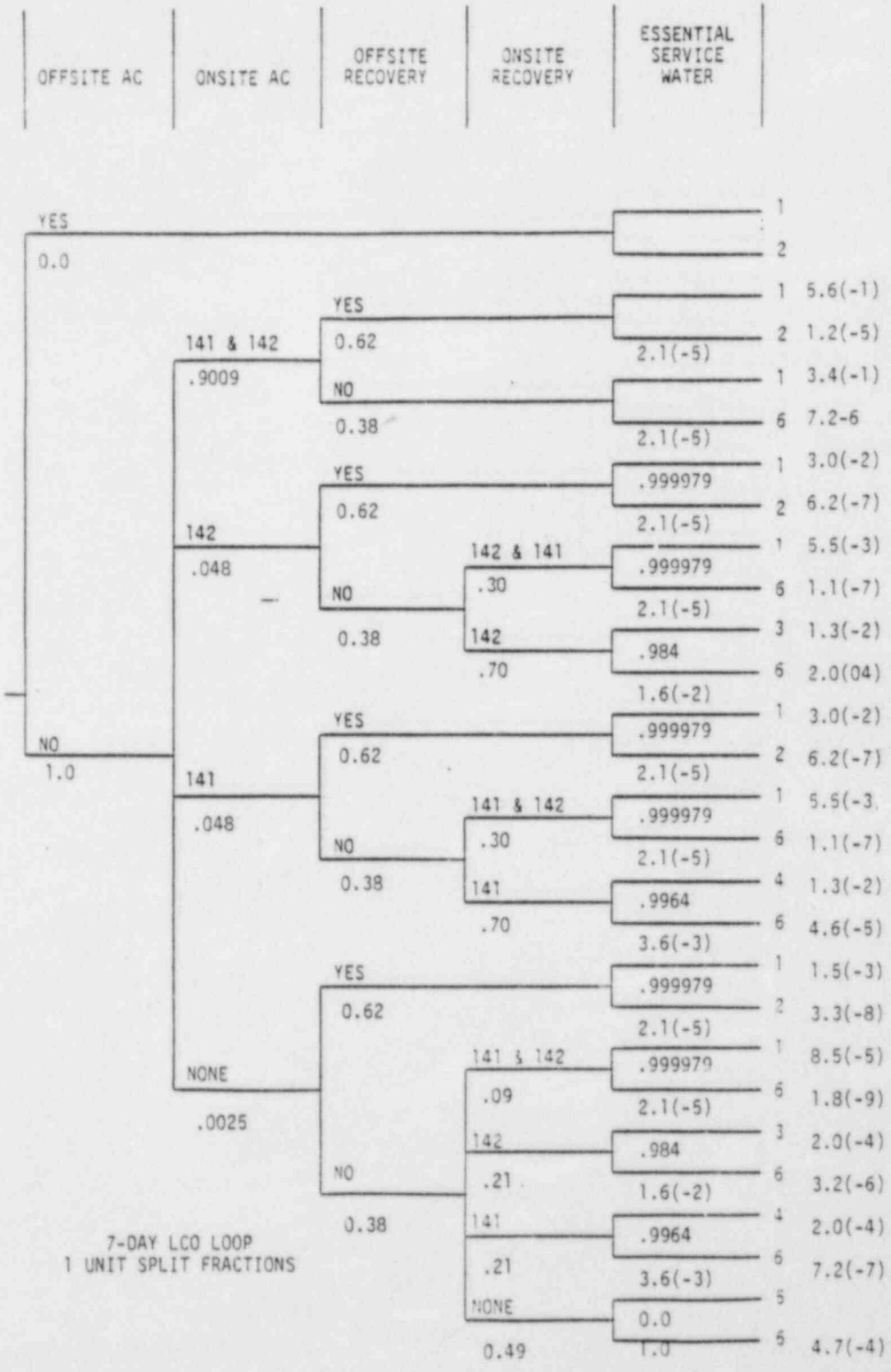

OFFSITE AC
ONSITE AC
OFFSITE RECOVERY
ONSITE RECOVERY
ESSENTIAL SERVICE WATER
YES
0.0
NO
1.0
141 & 142
.9009
142
.048
141
.048
NONE
.0025
YES
0.62
NO
0.38
142 & 141
.30
142
.70
141 & 142
.30
141
.70
.09
.21
.21
NONE
0.49
.999979
.984
.9964
0.0
1.0
2.1(-5)
1.6(-2)
3.6(-3)
1
2
3
4
5
6
5.6(-1)
1.2(-5)
3.4(-1)
7.2-6
3.0(-2)
6.2(-7)
5.5(-3)
1.1(-7)
1.3(-2)
2.0(04)
1.5(-3)
3.3(-8)
8.5(-5)
1.8(-9)
2.0(-4)
3.2(-6)
2.0(-4)
7.2(-7)
4.7(-4)
7-DAY LCO LOOP
1 UNIT SPLIT FRACTIONS

TABLE 6.2.3-7

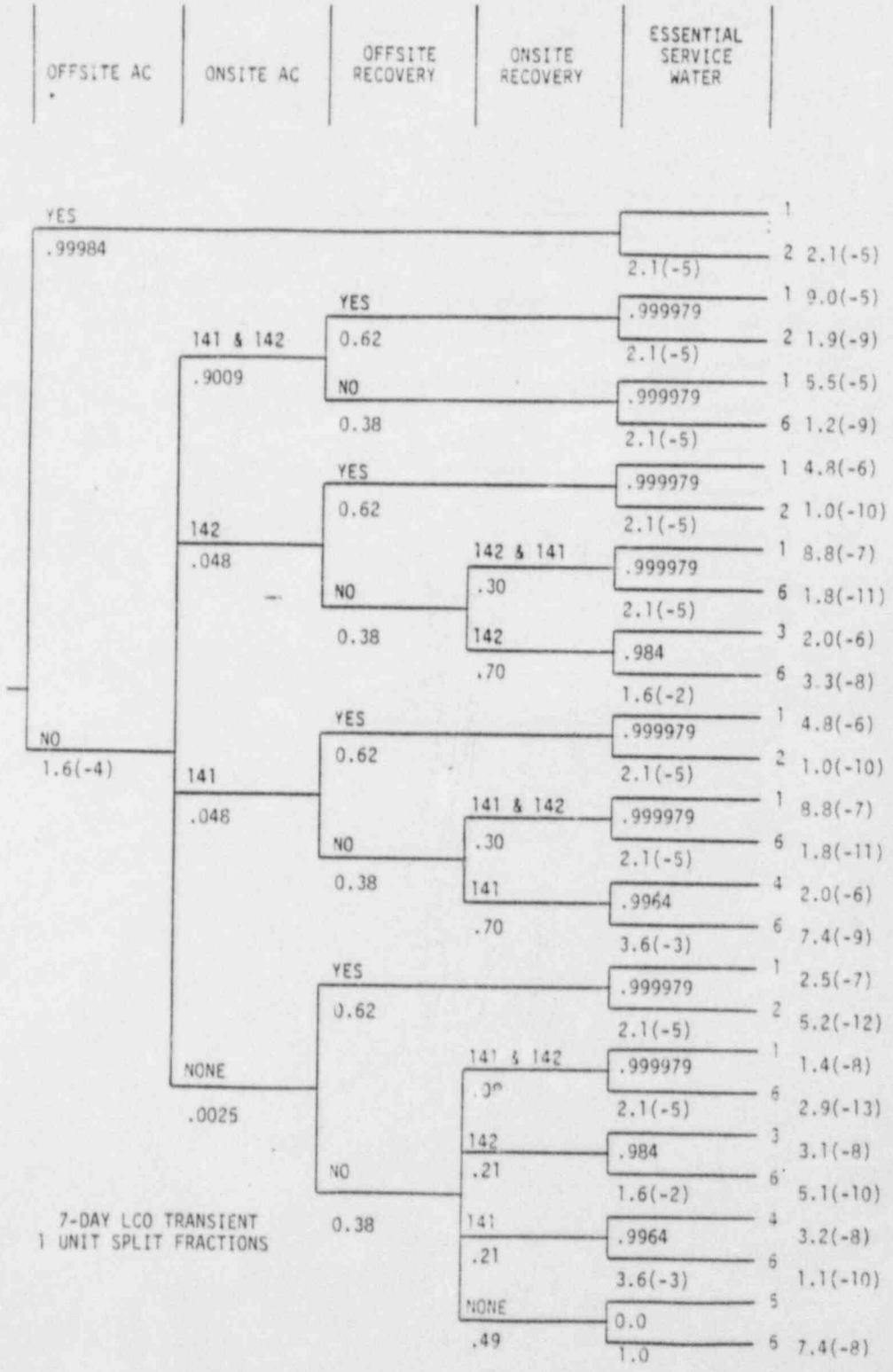

OFFSITE AC
ONSITE AC
OFFSITE RECOVERY
ONSITE RECOVERY
ESSENTIAL SERVICE WATER
YES
.99984
NO
1.6(-4)
2.1(-5)
1 2.1(-5)
141 & 142
.9009
YES
0.62
.999979
2.1(-5)
1 9.0(-5)
2 1.9(-9)
NO
0.38
.999979
2.1(-5)
1 5.5(-5)
6 1.2(-9)
142
.048
YES
0.62
.999979
2.1(-5)
1 4.8(-6)
2 1.0(-10)
NO
0.38
142 & 141
.30
.999979
2.1(-5)
1 8.8(-7)
6 1.8(-11)
142
.70
.984
1.6(-2)
3 2.0(-6)
6 3.3(-8)
141
.048
YES
0.62
.999979
2.1(-5)
1 4.8(-6)
2 1.0(-10)
NO
0.38
141 & 142
.30
.999979
2.1(-5)
1 8.8(-7)
6 1.8(-11)
141
.70
.9964
3.6(-3)
4 2.0(-6)
6 7.4(-9)
NONE
.0025
YES
0.62
.999979
2.1(-5)
1 2.5(-7)
2 5.2(-12)
NO
0.38
141 & 142
.30
.999979
2.1(-5)
1 1.4(-8)
6 2.9(-13)
142
.21
.984
1.6(-2)
3 3.1(-8)
6 5.1(-10)
141
.21
.9964
3.6(-3)
4 3.2(-8)
6 1.1(-10)
NONE
.49
0.0
1.0
5
6 7.4(-8)
7-DAY LCO TRANSIENT
1 UNIT SPLIT FRACTIONS

TABLE 6.2.3-8

SUMMARY OF RESULTS - 7 DAY LCO
SUPPORT STATE SPLIT FRACTIONS

Support State	LOCA	Loop	Transient
1	.99996	.97326	.99997
2	2.1 (-5)	1.3 (-5)	2.1 (-5)
3	7.6 (-6)	1.3 (-2)	2.0 (-6)
4	7.6 (-6)	1.3 (-2)	2.0 (-6)
5	0.0	0.0	0.0
6	5.5 (-7)	7.3 (-4)	1.2 (-7)

6.2.4 LOW PRESSURE RECIRCULATION

6.2.4.1 Discussion

Single unit operation for the low pressure recirculation system is reflected in the dependence or the Component Cooling Water system (CCW). Component Cooling Water data for a single operating unit was input into the tree and the fault tree was analyzed with these values.

6.2.4.2 Fault Tree Analysis

The fault tree analysis for the low pressure recirculation system for single unit operation is consistent with Section 3.6.2. The RHR pumps and the RHR heat exchangers are dependent on the CCW system for cooling.

6.2.4.2.1 Input Data

The only difference between the input data for the low pressure recirculation system for two unit operation and the input data for single unit operation is the failure rate values for the CCW system. The input data for CCW that are used to quantify the fault tree for 3 day and 7 day LCO are listed in Table 6.2.4.1.

6.2.4.2.2 Results

The fault tree was analyzed using the WAMBAM computer code to determine system unavailability. The unavailability results for 3 day and 7 day LCO are listed in Table 6.2.5-2. The dominant cutsets for the low pressure system are listed in Section 3.6.2 (Table 3.6.2-10) for two unit operation. There is no significant change in the percent contribution of each cutset for single unit operation.

TABLE 6.2.4-1

INPUT FOR LOW RECIRCULATION FOR SINGLE UNIT OPERATION

UNAVAILABILITY, 3 DAY LCO

Support State

Identifier	1	2	3	4	5	6
CCWAU	2.2(-06)	1.0	1.1(-03)	8.4(-04)	0.0	1.0
CCWBU	9.3(-07)	1.0	1.0(-03)	2.6(-03)	0.0	1.0
CCCCW	8.6(-07)	1.0	1.0(-03)	8.4(-04)	0.0	1.0

UNAVAILABILITY, 7 DAY LCO

Support State

Identifier	1	2	3	4	5	6
CCWAU	2.3(-06)	1.0	1.1(-03)	8.9(-04)	0.0	1.0
CCWBU	1.0(-06)	1.0	1.1(-03)	2.7(-03)	0.0	1.0
CCCCW	9.4(-07)	1.0	1.1(-03)	8.8(-04)	0.0	1.0

NOTE:

CCWAU - CCW Train A
CCWBU - CCW Train B
CCCCW - CCW Common

TABLE 6.2.4-2

NODE DATA FROM FAULT QUANTIFICATION
FOR LOW PRESSURE RECIRCULATION FOR
SINGLE UNIT OPERATION

Support State	3-Day LCO R-1	7-Day LCO R-1
1	2.5(-04)	2.6(-04)
2	1.0	1.0
3	6.4(-03)	6.7(-03)
4	6.1(-03)	6.2(-03)
5	1.0	1.0
6	1.0	1.0

6.2.5 HIGH PRESSURE RECIRCULATION

6.2.5.1 Discussion

Single unit operation for the high pressure recirculation system is reflected in the dependence of the high pressure recirculation system on the Component Cooling Water System (CCW). Component cooling water data for a single operating unit was input and the fault tree was analyzed with these valves.

6.2.5.2 Fault Tree Analysis

The fault tree analysis for the high pressure recirculation system for single unit operation is consistent with Section 3.7.1. The RHR pumps and the RHR heat exchangers are dependent on the CCW system for cooling.

6.2.5.2.1 Input Data

The only difference between the input data for the high pressure recirculation system for two unit operation and the input data for single unit operation is the failure rate values for the CCW system. The input data for CCW that are used to quantify the fault tree for 3 day and 7 day LCO are listed in Table 6.2.5-1.

6.2.5.2.2 Results

The fault tree was analyzed using the WAMBAM computer code to determine system unavailability and the WAMCUT computer code to obtain cutsets for the high pressure recirculation system. The unavailability results for 3 day and 7 day LCO are listed in Table 6.2.5-2. The dominant cutsets for the system with percent contribution are listed in Table 6.2.5-3.

TABLE 6.2.5-1

INPUT FOR HIGH RECIRCULATION FOR SINGLE UNIT OPERATION

UNAVAILABILITY, 3 DAY LCO

Support State

Identifier	1	2	3	4	5	6
CCWAU	2.2(-06)	1.0	1.1(-03)	8.4(-04)	0.0	1.0
CCWBU	9.3(-07)	1.0	1.0(-03)	8.4(-04)	0.0	1.0
CCWCC	8.6(-07)	1.0	1.0(-03)	8.4(-04)	0.0	1.0

UNAVAILABILITY, 7 DAY LCO

Support State

Identifier	1	2	3	4	5	6
CCWAU	2.3(-06)	1.0	1.1(-03)	8.9(-04)	0.0	1.0
CCWBU	1.0(-06)	1.0	1.1(-03)	2.7(-03)	0.0	1.0
CCWCC	9.4(-07)	1.0	1.1(-03)	8.8(-04)	0.0	1.0

NOTE:

CCWAU - CCW Train A
CCWBU - CCW Train B
CCCCW - CCW Common

TABLE 6.2.5-2

SUMMARY OF RESULTS FROM FAULT TREE QUANTIFICATION
FOR HIGH PRESSURE RECIRCULATION FOR
SINGLE UNIT OPERATION

Power State	3-Day LCO R-2	7-Day LCO R-2
1	4.8(-04)	4.9(-04)
2	1.0	1.0
3	1.3(-02)	1.4(-02)
4	1.0(-02)	1.1(-02)
5	1.0	1.0
6	1.0	1.0

TABLE 6.2.5-3

CUTSETS FOR TOTAL HIGH PRESSURE TREE
FOR SINGLE UNIT OPERATION

Cutset Description	Percent of unavailability for Support State 1 3 day	7 day
Two RHR pumps fail to start due to common cause	46	45
Operator error-failure to open motor operated valve to RHR heat exchanger cooling	20	19
Motor operated valves to recirculation sumps or two motor operated valves to RHR heat exchanger cooling trains fail to open due to common cause	19	19
Failure to open of two motor operated valves to heat exchanger cooling on both trains or two sump valves on both trains or a sump valve on one train and a heat exchanger cooling valve on the other	2	2
Two RHR pumps fail to run due to common cause	2	2
One RHR pump out for maintenance and a motor operated heat exchanger cooling valve or a motor operated sump valve on the other train fails to open	1	3
One RHR pump out for test and a motor operated heat exchanger cooling valve or a motor operated sump valve on the other train fails to open	1	1
Air operated valve RH0607 or RH0608 transfers closed on one RHR train and a motor operated heat exchanger cooling valve or a motor operated sump valve on the other train fails to open	1	1
One RHR pump fails to start and a motor operated heat exchanger cooling valve or a motor operated sump valve on the other train fails to open	1	1

6.3 PLANT RISK QUANTIFICATION FOR 3-DAY LCO

6.3.1 CALCULATION OF EVENT TREE NODES FOR 3-DAY LCO

The recalculation of event tree nodes for single unit operation was comprised of changes to the recirculation nodes R1 and R2, see Sections 6.2.4 and 6.2.5. These data changes to Table 4.1.1.a are delimited below.

	Support State					
	1	2	3	4	5	6
R-1	2.5(-4)	1.0	6.4(-3)	6.1(-3)	1.0	1.0
R-2	4.8(-4)	1.0	1.3(-2)	1.0(-2)	1.0	1.0

6.3.2 CALCULATION OF CORE DAMAGE FOR 1-UNIT 3 DAY LCO

In this section, the plant core melt frequency from the internal initiating events is calculated.

To calculate the plant matrix, M, and the plant core melt frequency, the event trees of section 2 are quantified for each of the six support states, using nodal probabilities calculated in Section 6.2.1. The plant matrix generated is given by Table 6.3.2-1.

The internal initiating event frequency vector (ϕ) is taken from the section 1 and is repeated as Table 6.3.2-2.

The product ϕM provides the frequencies of damage states given by Table 6.3.2-3.

The contribution of each initiating event category to the total internal core melt frequency is calculated and is displayed by Table 6.3.2-4. The contribution of each support state to the total core melt frequency is given by Table 6.3.2-5.

The ranking of initiating event-support state cases by their contribution to core melt is displayed on Table 6.3.2-6. Finally, Table 6.3.2-7 contains the percent contributions to each core melt state by initiating event-support state case.

TABLE 6.3.2-1 (Sheet 1 of 2)

PLANT MATRIX (M MATRIX)

	AEFC SEC V2E	AEF SE V2L	AEC SLFC V	AE SLF	ALFC SLC	ALF SL	ALC TEFC	AL TEF	SEFC TEC	SEF TE
1	6.70E-04 0.00E-01 6.71E-09	4.03E-07 0.00E-01 9.99E-06	1.98E-08 0.00E-01 0.00E-01	4.00E-07 0.00E-01	2.50E-04 0.00E-01	1.44E-07 0.00E-01	1.80E-05 0.00E-01	1.01E-08 0.00E-01	0.00E-01 0.00E-01	0.00E-01 0.00E-01
2	6.77E-04 0.00E-01 6.95E-09	4.15E-07 0.00E-01 9.99E-06	1.80E-05 0.00E-01 0.00E-01	4.10E-07 0.00E-01	2.50E-04 0.00E-01	1.44E-07 0.00E-01	6.80E-09 0.00E-01	5.02E-11 0.00E-01	0.00E-01 0.00E-01	0.00E-01 0.00E-01
3	0.00E-01 1.83E-05 0.00E-01	0.00E-01 4.10E-07 0.00E-01	0.00E-01 4.81E-04 0.00E-01	0.00E-01 2.78E-07	0.00E-01 1.36E-08	0.00E-01 1.22E-10	0.00E-01 4.44E-11	0.00E-01 2.51E-14	1.91E-07 4.22E-12	2.42E-08 9.62E-14
4	0.00E-01 4.25E-12 1.88E-05	0.00E-01 1.29E-13 8.30E-06	0.00E-01 9.18E-17 0.00E-01	0.00E-01 1.64E-19	0.00E-01 1.41E-19	0.00E-01 1.57E-21	0.00E-01 1.84E-17	0.00E-01 1.74E-20	5.15E-16 4.22E-12	2.22E-19 9.62E-14
5	0.00E-01 8.99E-06 1.84E-10	0.00E-01 2.05E-07 1.00E-05	0.00E-01 5.79E-07 0.00E-01	0.00E-01 6.11E-10	0.00E-01 3.61E-10	0.00E-01 4.10E-12	0.00E-01 2.71E-07	0.00E-01 1.62E-10	1.30E-09 3.07E-07	3.23E-12 6.99E-09
6	0.00E-01 8.99E-06 1.84E-10	0.00E-01 2.05E-07 1.00E-05	0.00E-01 5.79E-07 0.00E-01	0.00E-01 6.11E-10	0.00E-01 3.61E-10	0.00E-01 4.10E-12	0.00E-01 2.71E-07	0.00E-01 1.62E-10	1.30E-09 3.07E-07	3.23E-12 6.99E-09
7	0.00E-01 8.99E-06 9.44E-10	0.00E-01 4.60E-08 8.24E-10	0.00E-01 2.89E-07 0.00E-01	0.00E-01 1.70E-10	0.00E-01 1.13E-11	0.00E-01 1.08E-13	0.00E-01 1.05E-07	0.00E-01 5.98E-11	1.30E-09 3.06E-07	3.14E-12 1.57E-09
8	0.00E-01 8.99E-06 9.44E-10	0.00E-01 4.60E-08 8.24E-10	0.00E-01 2.89E-07 0.00E-01	0.00E-01 1.69E-10	0.00E-01 1.13E-11	0.00E-01 1.08E-13	0.00E-01 1.05E-07	0.00E-01 5.98E-11	1.88E-11 3.06E-07	2.42E-12 1.57E-09
9	0.00E-01 8.99E-06 9.44E-10	0.00E-01 4.60E-08 8.24E-10	0.00E-01 2.89E-07 0.00E-01	0.00E-01 1.70E-10	0.00E-01 1.13E-11	0.00E-01 1.08E-13	0.00E-01 1.05E-07	0.00E-01 5.98E-11	1.30E-09 3.06E-07	3.14E-12 1.57E-09
10	0.00E-01 3.06E-11 3.21E-15	0.00E-01 1.57E-13 2.80E-15	0.00E-01 9.81E-13 0.00E-01	0.00E-01 5.76E-16	0.00E-01 3.86E-17	0.00E-01 3.68E-19	0.00E-01 3.57E-13	0.00E-01 2.03E-16	4.42E-15 1.04E-12	1.07E-17 5.32E-15
11	0.00E-01 8.99E-06 9.44E-10	0.00E-01 4.60E-08 8.24E-10	0.00E-01 2.89E-07 0.00E-01	0.00E-01 1.69E-10	0.00E-01 1.13E-11	0.00E-01 1.08E-13	0.00E-01 1.05E-07	0.00E-01 5.98E-11	1.30E-09 3.06E-07	3.14E-12 1.57E-09

TABLE 6.3.2-1 (Sheet 2 of 2)

PLANT MATRIX (M MATRIX)

12	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	2.35E-09	2.21E-11
	7.17E-05	1.89E-04	4.86E-06	5.11E-08	6.03E-08	6.70E-10	6.41E-07	6.04E-09	2.45E-06	6.42E-06
	6.45E-10	1.74E-09	0.00E-01							
13	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.30E-09	3.14E-12
	8.99E-06	4.60E-08	5.05E-07	2.91E-10	8.69E-06	4.45E-08	2.25E-07	1.26E-10	3.06E-07	1.57E-09
	9.44E-10	8.24E-10	0.00E-01							
14	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	9.44E-10	2.94E-12
	8.99E-06	4.60E-08	2.89E-07	1.70E-10	1.13E-11	1.08E-13	1.05E-07	5.98E-11	3.06E-07	1.57E-09
	9.44E-10	8.24E-10	0.00E-01							
V	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	1.00E+00							

TABLE 6.3.2-2

INITIATING EVENT DEFINITIONS AND MEAN FREQUENCIES

EVENT SYMBOL	EVENT DESCRIPTION	FREQUENCY / REACTOR YEAR
1	LARGE LOCA	9.40E-04
2	MEDIUM LOCA	9.40E-04
3	SMALL LOCA	3.54E-02
4	STEAM GENERATOR TUBE RUPTURE	3.70E-02
5	STEAM BREAK INSIDE CONTAINMENT	9.40E-04
6	STEAM BREAK OUTSIDE CONTAINMENT	9.40E-04
7	LOSS OF MAIN FEEDWATER	3.00E+00
8	CLOSURE OF ONE MSIV	2.52E-01
9	LOSS OF RCS FLOW	3.58E-01
10	CORE POWER EXCURSION	2.28E-02
11	TURBINE TRIP	4.00E+00
12	LOSS OF OFFSITE POWER	5.76E-02
13	SPURIOUS SAFETY INJECTION	8.00E-02
14	REACTOR TRIP	3.00E+00
V	INTERFACING SYSTEMS LOCA	2.10E-07

TABLE 6.3.2-3

CORE MELT STATE DEFINITIONS AND CALCULATED MEAN FREQUENCIES

SYMBOL	DESCRIPTION	FREQUENCY / REACTOR YEAR	PERCENT CONTRIBUTION
AEFC	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.27E-06	.90
AEF	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	7.68E-10	<0.1
AEC	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.69E-08	<0.1
AE	LARGE LOCA EARLY NO CONTAINMENT COOLING	7.62E-10	<0.1
ALFC	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	4.70E-07	.33
ALF	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.72E-10	<0.1
ALC	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	1.69E-08	<0.1
AL	LARGE LOCA LATE MELT NO CONTAINMENT COOLING	9.58E-12	<0.1
SEFC	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.94E-08	<0.1
SEF	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	8.92E-10	<0.1
SEC	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.01E-04	71.36
SE	SMALL LOCA EARLY MELT NO CONTAINMENT COOLING	1.14E-05	8.04
SLFC	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.04E-05	14.42
SLF	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	1.46E-08	<0.1
SLC	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	6.99E-07	.49
SL	SMALL LOCA LATE MELT NO CONTAINMENT COOLING	3.60E-09	<0.1
TEFC	TRANSIENT WITH NO COOLING, EARLY MELT	1.17E-06	.83
TEF	TRANSIENT WITH NO COOLING, EARLY MELT	9.93E-10	<0.1
TEC	TRANSIENT WITH NO COOLING, EARLY MELT	3.41E-06	2.41
TE	TRANSIENT EARLY MELT NO CONTAINMENT COOLING	3.86E-07	.27
V2E	SGTR EARLY MELT	7.06E-07	.50
V2L	SGTR LATE MELT	3.53E-07	.25
V	INTERFACING SYSTEMS LOCA	2.10E-07	.15
	TOTAL	1.41E-04	100.0

TABLE 6.3.2-4

INITIATING EVENTS AND THE CORE MELT FREQUENCIES

SYMBOL	DESCRIPTION	CORE MELT FREQUENCY	PERCENT CONTRIBUTION	CONDITIONAL CORE MELT FREQUENCY
1	LARGE LOCA	8.92E-07	.63	9.49E-04
2	MEDIUM LOCA	8.99E-07	.64	9.56E-04
3	SMALL LOCA	1.77E-05	12.50	5.00E-04
4	STEAM GENERATOR TUBE RUPTURE	1.00E-06	.71	2.71E-05
5	STEAM BREAK INSIDE CONTAINMENT	1.91E-08	<0.1	2.04E-05
6	STEAM BREAK OUTSIDE CONTAINMENT	1.91E-08	<0.1	2.04E-05
7	LOSS OF MAIN FEEDWATER	2.92E-05	20.67	9.75E-06
8	CLOSURE OF ONE MSIV	2.46E-06	1.74	9.74E-06
9	LOSS OF RCS FLOW	3.49E-06	2.47	9.75E-06
10	CORE POWER EXCURSION	7.55E-13	<0.1	3.31E-11
11	TURBINE TRIP	3.90E-05	27.55	9.75E-06
12	LOSS OF OFFSITE POWER	1.58E-05	11.20	2.75E-04
13	SPURIOUS SAFETY INJECTION	1.51E-06	1.06	1.88E-05
14	REACTOR TRIP	2.92E-05	20.66	9.74E-06
V	INTERFACING SYSTEMS LOCA	2.10E-07	.15	1.00E+00
		1.41E-04	100.0	

TABLE 6.3.2-5

CORE MELT FREQUENCY BY SUPPORT STATE

STATE	1	2.36E-05	16.66
STATE	2	1.02E-04	71.95
STATE	3	3.35E-07	.24
STATE	4	1.18E-08	.01
STATE	5	0.00E-01	.00
STATE	6	1.58E-05	11.14

TABLE 6.3.2-6

CORE MELT FREQUENCY BY EVENT AND SUPPORT STATE

ET11.02	3.72E-05	ET13.01	5.85E-08	ET09.03	2.93E-10	ET10.06	3.32E-15
ET14.02	2.79E-05	ETO3.03	2.78E-08	ETO8.03	2.05E-10	ET10.03	6.36E-17
ETO7.02	2.79E-05	ET12.01	2.25E-08	ETO5.06	1.94E-10	ET10.04	1.98E-18
ETO3.01	1.70E-05	ETO1.02	1.69E-08	ETO6.06	1.94E-10	ET16.06	0.00E-01
ET12.06	1.53E-05	ETO2.02	1.69E-08	ETO2.04	1.29E-10	ET16.05	0.00E-01
ETO9.02	3.35E-06	ETO9.06	1.53E-08	ET11.04	1.01E-10	ET16.04	0.00E-01
ETO8.02	2.35E-06	ETO4.06	1.48E-08	ETO7.04	7.60E-11	ET16.03	0.00E-01
ET11.01	1.58E-06	ETO3.06	1.42E-08	ET14.04	7.60E-11	ET16.02	0.00E-01
ET13.02	1.44E-06	ETO8.06	1.07E-08	ET13.03	6.09E-11	ET16.01	0.00E-01
ETO7.01	1.19E-06	ETO5.01	1.02E-08	ETO1.04	6.07E-11	ET15.05	0.00E-01
ET14.01	1.19E-06	ETO6.01	1.02E-08	ETO5.03	2.75E-11	ET14.05	0.00E-01
ETO2.01	8.80E-07	ET12.04	9.18E-09	ETO6.03	2.75E-11	ET13.05	0.00E-01
ETO1.01	8.74E-07	ETO5.02	8.75E-09	ETO4.04	2.21E-11	ET12.05	0.00E-01
ETO4.02	6.66E-07	ETO6.02	8.75E-09	ET15.03	1.26E-11	ET11.05	0.00E-01
ETO3.02	6.37E-07	ET13.06	6.56E-09	ETO9.04	9.12E-12	ET10.05	0.00E-01
ET12.02	3.30E-07	ET11.03	3.25E-09	ETO8.04	6.38E-12	ETO9.05	0.00E-01
ETO4.01	3.20E-07	ETO7.03	2.44E-09	ET15.02	3.78E-12	ETO8.05	0.00E-01
ET12.03	2.95E-07	ET14.03	2.44E-09	E113.04	2.53E-12	ETO7.05	0.00E-01
ET15.01	2.10E-07	ETO3.04	2.17E-09	ET15.04	1.28E-12	ETO6.05	0.00E-01
ET11.06	1.70E-07	ETO4.03	1.98E-09	ET10.02	7.28E-13	ETO5.05	0.00E-01
ETO9.01	1.42E-07	ETO2.03	1.28E-09	ETO5.04	1.77E-13	ETO4.05	0.00E-01
ETO7.06	1.27E-07	ETO1.03	6.14E-10	ETO6.04	1.77E-13	ETO3.05	0.00E-01
ET14.06	1.27E-07	ETO2.06	3.76E-10	ET15.06	8.40E-14	ETO2.05	0.00E-01
ET14.06	1.27E-07	ETO2.06	3.76E-10	ET15.06	8.40E-14	ETO2.05	0.00E-01

TABLE 6.3.2-7 (Sheet 1 of 2)

EVENT/SUPPORT STATE CONTRIBUTORS TO CORE MELT STATES (PERCENTAGE)

AEFC	99.90	ETO2.01	50.17	ETO1.01	49.73						
AEF	99.96	ETO2.01	49.27	ETO1.01	48.89	ETO2.03	1.31	ETO1.03	.36	ETO2.04	.13
AEC	99.79	ETO2.02	99.79								
AE	99.97	ETO2.06	49.37	ETO1.06	49.37	ETO2.02	1.24				
ALFC	99.84	ETO1.01	49.92	ETO2.01	49.92						
ALF	100.00	ETO1.01 ETO2.04	48.43 .14	ETO2.01	48.43	ETO1.03	1.44	ETO2.03	1.42	ETO1.04	.14
ALC	99.92	ETO1.02	99.92								
AL	99.88	ETO1.02	98.81	ETO1.03	.54	ETO2.03	.53				
SEFC	99.83	ETO3.01 ETO3.03	33.96 .84	ET11.01 ET13.01	26.79 .54	ETO7.01 ET12.01	20.09 .38	ET14.01 ET12.03	14.59 .23	ETO9.01	2.41
SEF	99.85	ETO3.01 ETO9.01	95.81 .13	ET11.01 ET12.03	1.41 .10	ETO7.01	1.05	ET14.01	.99	ETO3.03	.36
SEC	99.97	ET11.02 ETO8.02	35.62 2.24	ET14.02 ET13.02	26.72 .71	ETO7.02 ETO3.02	26.72 .63	ET12.06 ET12.02	3.80 .32	ETO9.02	3.21
SE	99.84	ET12.06 ETO7.02	95.57 .13	ET11.06 ET14.02	1.43 .13	ET14.06 ETO9.06	1.07 .13	ETO7.06 ETO3.06	1.07 .12	ET11.02	.18
SLFC	99.82	ETO3.01 ETO9.01	83.25 .51	ET11.01 ETO8.01	5.65 .36	ETO7.01 ET13.01	4.24 .20	ET14.01 ETO3.03	4.24 .13	ET12.03	1.26
SLF	99.23	ETO3.01 ETO3.03	65.07 2.05	ET12.03 ET12.04	19.54 .65	ET11.01 ETO9.01	4.41 .40	ETO7.01 ETO8.01	3.31 .28	ET14.01 ET11.03	3.31 .22
SLC	99.90	ET13.02	99.41	ET12.03	.48						
SL	99.92	ET13.06	87.96	ET13.02	10.81	ET12.03	1.04	ETO3.03	.11		
TEFC	99.84	ET11.01 ETO8.01	35.85 2.26	ETO7.01 ET13.01	26.91 1.54	ET14.01 ET12.01	26.91 .51	ETO9.01	3.23	ET12.03	2.63
TEF	99.33	ET12.03 ETO8.01	34.38 1.49	ET11.01 ET13.01	23.63 1.01	ETO7.01 ET12.04	17.73 .51	ET14.01 ET11.03	17.73 .38	ETO9.01 ET12.01	2.13 .34
TEC	99.97	ET11.02 ETO8.02	35.85 2.26	ETO7.02 ET13.02	26.89 .72	ET14.02 ET12.02	26.89 .32	ET12.06	3.83	ETO9.02	3.23
TE	99.84	ET12.06 ETO7.02	95.69 .13	ET11.06 ET14.02	1.43 .13	ETO7.06 ETO9.06	1.08 .13	ET14.06	1.08	ET11.02	.18

TABLE 6.3.2-7 (Sheet 2 of 2)

EVENT/SUPPORT STATE CONTRIBUTORS TO CORE MELT STATES (PERCENTAGE)

V2E	99.83	ET04.02 ET07.02	94.36 .38	ET04.06	2.10	ET04.01	2.10	ET11.02	.51	ET14.02	.38
V2L	99.80	ET04.01 ET11.01	86.30 .93	ET05.01 ET07.01	2.66 .70	ET06.01 ET14.01	2.66 .70	ET02.01 ET04.03	2.66 .54	ET01.01	2.66
V	99.99	ET15.01	99.99								

6.3.3 CALCULATION OF PLANT RISK FOR 1-UNIT 3-DAY LCO

In this section the plant risk in terms of the consequence categories:

1) Early fatalities
2) Early injuries
3) Thyroid cancer incidences
4) Latent cancer fatalities
5) Man-rem release

is calculated and the corresponding risk curves are drawn for the 3-day LCO.

The product ϕMC provides the release category frequencies. This quantification is summarized by Table 6.3.3-1.

The product ϕMCS for each consequence category provides the point estimate frequencies for each of the consequence categories, i=1, 2, 3, 4, 5. The results are given by Tables 6.3.3-2 through 6.3.3-6. The same results are also expressed as risk curves by Figures 6.3.3-1 through 6.3.3-5.

TABLE 6.3.3-1

RELEASE CATEGORY DEFINITIONS AND CALCULATED MEAN FREQUENCIES

RELEASE CATEGORY	DESCRIPTION	FREQUENCY / REACTOR YEAR	PERCENT CONTRIBUTION
Z-1	STEAM EXPLOSION WITHOUT CONTAINMENT SPRAY	7.97E-10	<0.1
2	OVERPRESSURE FAILURES WITHOUT SPRAYS	2.25E-07	.16
2R	DELAYED OVERPRESSURE FAILURE WITHOUT SPRAYS	1.18E-05	8.32
Z-3	STEAM EXPLOSIONS WITH SPRAYS	2.14E-10	<0.1
5R	DELAYED OVERPRESSURE WITH SPRAYS	1.67E-08	<0.1
Z-5	EARLY OVERPRESSURE FAILURES WITH SPRAYS	1.14E-08	<0.1
6	BASEMAT MELT-THROUGH WITHOUT SPRAYS	2.24E-09	<0.1
7	BASEMAT MELT-THROUGH WITH SPRAYS	2.24E-08	<0.1
8A	CONTAINMENT INTACT WITHOUT SPRAYS	1.87E-08	<0.1
8B	CONTAINMENT INTACT WITH SPRAYS	1.28E-04	90.73
2R'	SGTR RELEASE	1.06E-06	.75
	TOTAL	1.41E-04	100.0

TABLE 6.3.3-2

POINT ESTIMATE VECTOR FOR EARLY FATALITIES

NUMBER OF FATALITIES	FREQUENCY OF OCCURRENCE
1.00E+00	3.27E-08
2.00E+00	3.27E-08
3.00E+00	3.27E-08
5.00E+00	3.27E-08
7.00E+00	3.24E-08
1.00E+01	2.85E-08
2.00E+01	2.83E-08
3.00E+01	2.83E-08
5.00E+01	2.83E-08
7.00E+01	2.81E-08
1.00E+02	2.53E-08
2.00E+02	2.53E-08
3.00E+02	1.71E-08
5.00E+02	1.71E-08
7.00E+02	1.67E-08
1.00E+03	1.42E-08
2.00E+03	4.41E-11
3.00E+03	4.19E-11
5.00E+03	0.00E-01

TABLE 6.3.3-3

POINT ESTIMATE VECTOR FOR EARLY INJURIES

NUMBER OF INJURIES	FREQUENCY OF OCCURRENCE
1.00E+00	6.49E-07
2.00E+00	6.49E-07
3.00E+00	6.49E-07
5.00E+00	6.48E-07
7.00E+00	6.29E-07
1.00E+01	6.29E-07
2.00E+01	6.28E-07
3.00E+01	6.28E-07
5.00E+01	6.24E-07
7.00E+01	5.85E-07
1.00E+02	5.85E-07
2.00E+02	5.82E-07
3.00E+02	5.82E-07
5.00E+02	5.61E-07
7.00E+02	4.29E-07
1.00E+03	3.53E-07
2.00E+03	2.56E-07
3.00E+03	1.98E-07
5.00E+03	1.76E-07
7.00E+03	1.18E-07
1.00E+04	9.90E-08
2.00E+04	2.03E-08
3.00E+04	1.92E-08
5.00E+04	1.92E-08
7.00E+04	3.60E-10
1.00E+05	0.00E-01

TABLE 6.3.3-4

POINT ESTIMATE VECTOR FOR THYROID CANCERS

NUMBER OF THY CANCER	FREQUENCY OF OCCURRENCE
1.00E+00	1.31E-05
2.00E+00	9.86E-06
3.00E+00	7.72E-06
5.00E+00	6.63E-06
7.00E+00	5.83E-06
1.00E+01	5.54E-06
2.00E+01	5.52E-06
3.00E+01	5.50E-06
5.00E+01	5.42E-06
7.00E+01	5.36E-06
1.00E+02	5.23E-06
2.00E+02	4.90E-06
3.00E+02	4.72E-06
5.00E+02	4.36E-06
7.00E+02	4.08E-06
1.00E+03	3.68E-06
2.00E+03	3.00E-06
3.00E+03	2.27E-06
5.00E+03	1.61E-06
7.00E+03	1.34E-06
1.00E+04	1.03E-06
2.00E+04	4.50E-07
3.00E+04	2.37E-07
5.00E+04	7.98E-08
7.00E+04	2.11E-08
1.00E+05	3.60E-10
2.00E+05	0.00E-01

TABLE 6.3.3-5

POINT ESTIMATE VECTOR FOR LATENT CANCER FATALITIES (EXCLUDING THYROID)

NUMBER OF LAT CANCER	FREQUENCY OF OCCURRENCE
1.00E+00	8.36E-06
2.00E+00	6.22E-06
3.00E+00	5.95E-06
5.00E+00	5.65E-06
7.00E+00	5.64E-06
1.00E+01	5.64E-06
2.00E+01	5.60E-06
3.00E+01	5.58E-06
5.00E+01	5.44E-06
7.00E+01	5.40E-06
1.00E+02	5.23E-06
2.00E+02	4.87E-06
3.00E+02	4.71E-06
5.00E+02	4.34E-06
7.00E+02	4.00E-06
1.00E+03	3.67E-06
2.00E+03	2.72E-06
3.00E+03	1.89E-06
5.00E+03	9.28E-07
7.00E+03	5.33E-07
1.00E+04	1.77E-07
2.00E+04	7.64E-12
3.00E+04	0.00E-01

TABLE 6.3.3-6

POINT ESTIMATE VECTOR FOR MAN-REMS

NUMBER OF MAN-REM	FREQUENCY OF OCCURRENCE
1.00E+03	2.62E-05
2.00E+03	1.90E-05
3.00E+03	1.41E-05
5.00E+03	1.33E-05
7.00E+03	1.09E-05
1.00E+04	9.32E-06
2.00E+04	7.45E-06
3.00E+04	6.11E-06
5.00E+04	5.85E-06
7.00E+04	5.54E-06
1.00E+05	5.54E-06
2.00E+05	5.52E-06
3.00E+05	5.50E-06
5.00E+05	5.48E-06
7.00E+05	5.38E-06
1.00E+06	5.32E-06
2.00E+06	5.05E-06
3.00E+06	4.80E-06
5.00E+06	4.58E-06
7.00E+06	4.33E-06
1.00E+07	3.98E-06
2.00E+07	3.15E-06
3.00E+07	2.63E-06
5.00E+07	1.68E-06
7.00E+07	9.68E-07
1.00E+08	6.18E-07
2.00E+08	1.93E-08
3.00E+08	0.00E-01

FIGURE 6.3.3-1

POINT ESTIMATE RISK CURVE FOR EARLY FATALITIES

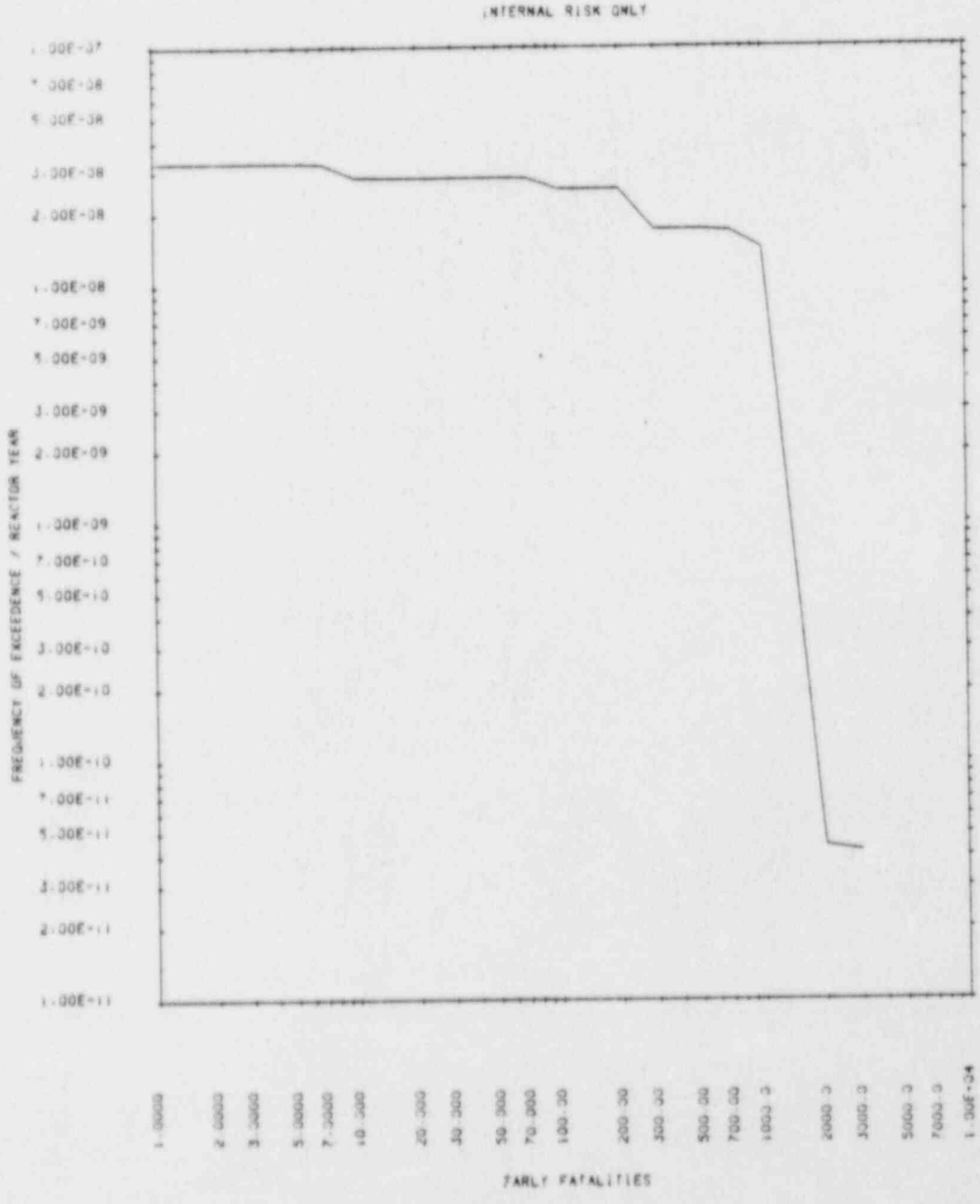


FIGURE 6.3.3-2

POINT ESTIMATE RISK CURVE FOR EARLY INJURIES

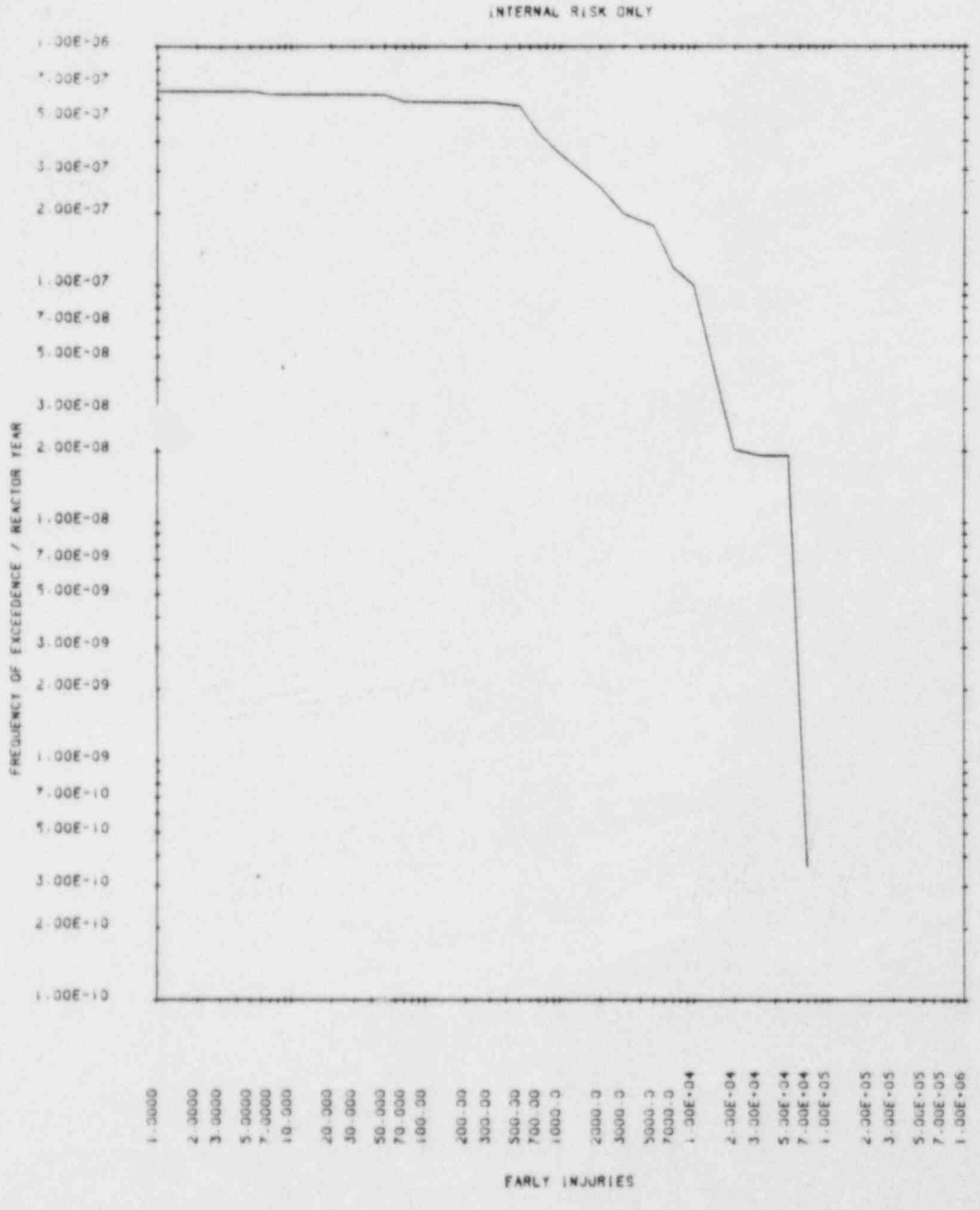


FIGURE 6.3.3-3

POINT ESTIMATE RISK CURVE FOR THYROID CANCER INCIDENCE

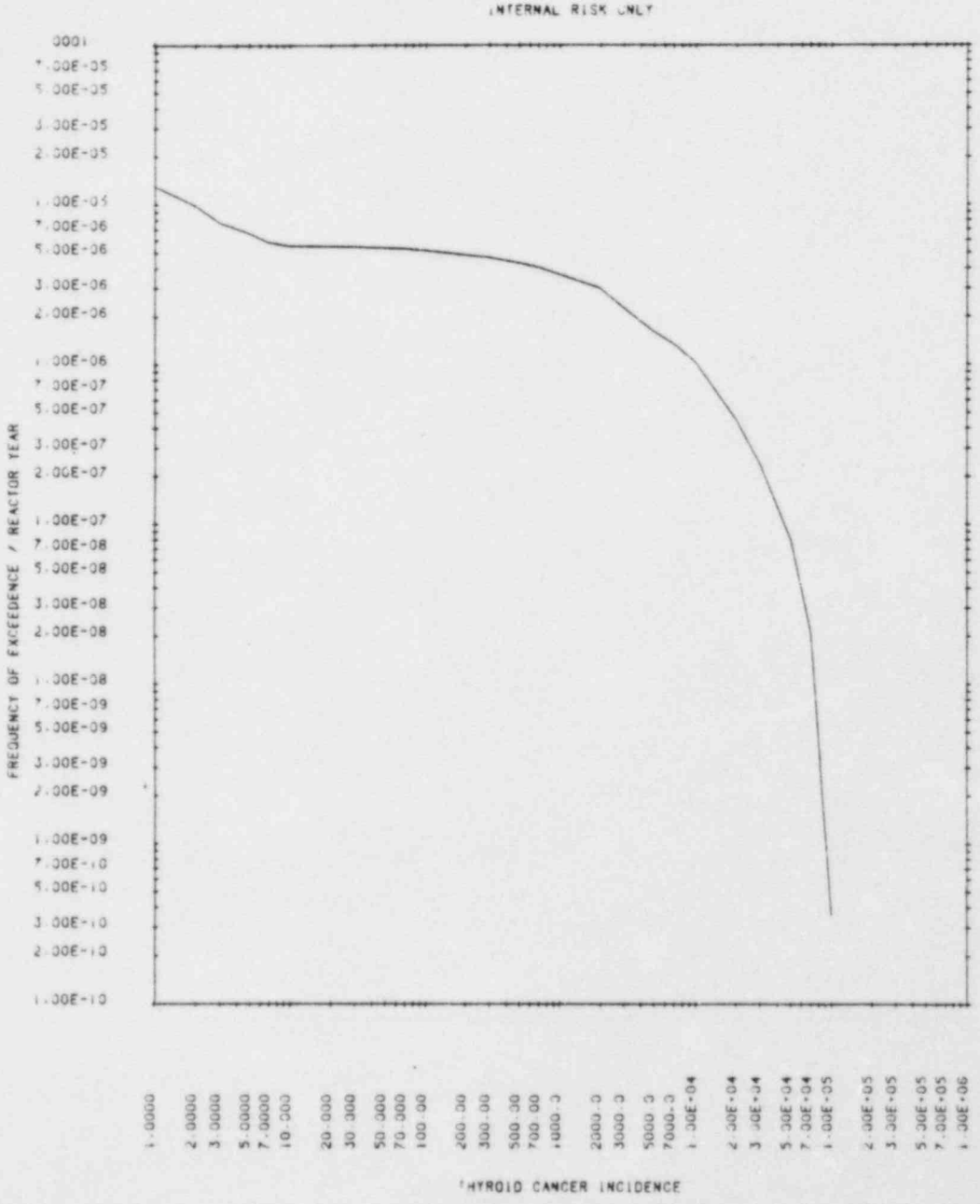


FIGURE 6.3.3-4

POINT ESTIMATE RISK CURVE FOR LATENT CANCER FATALITIES

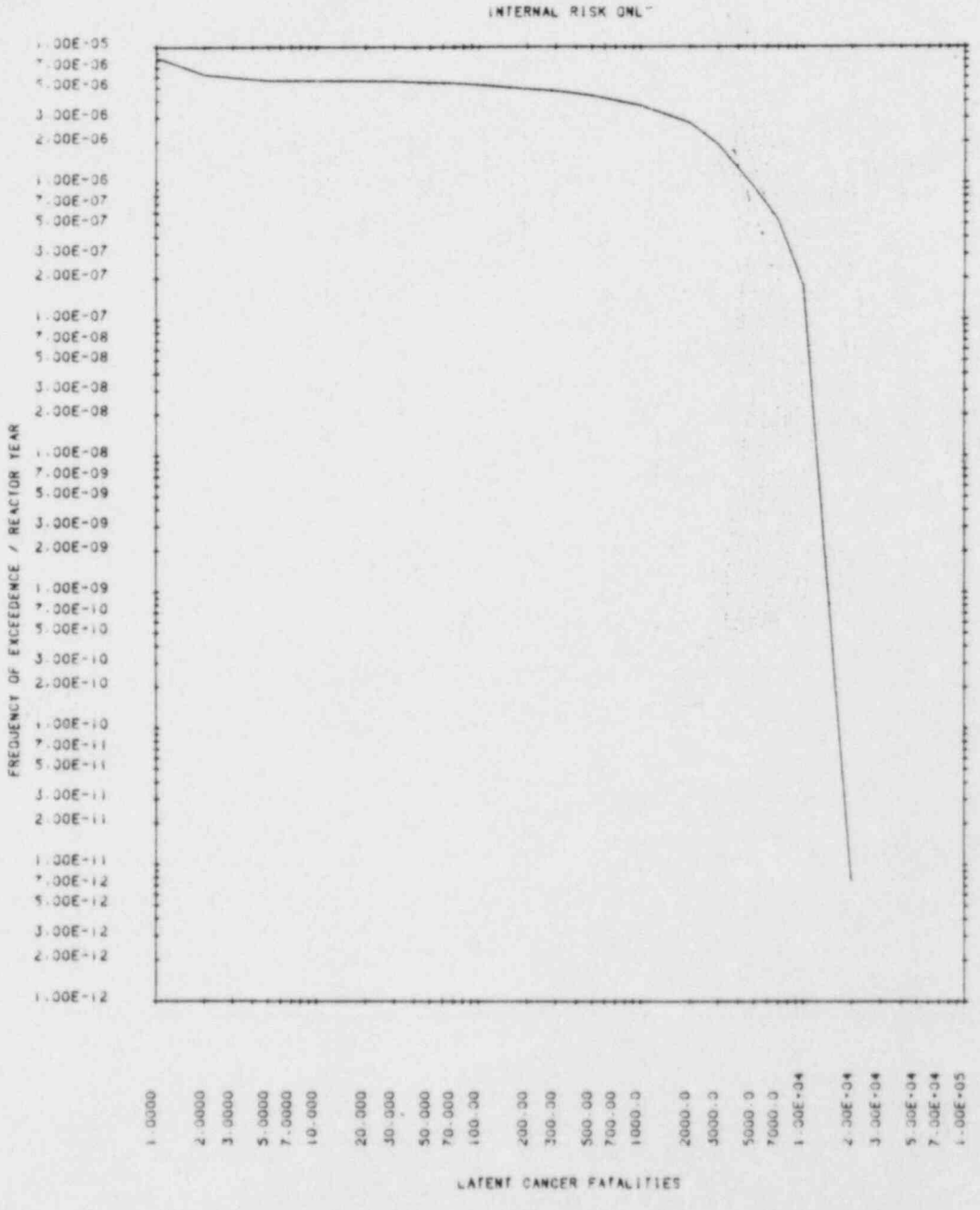
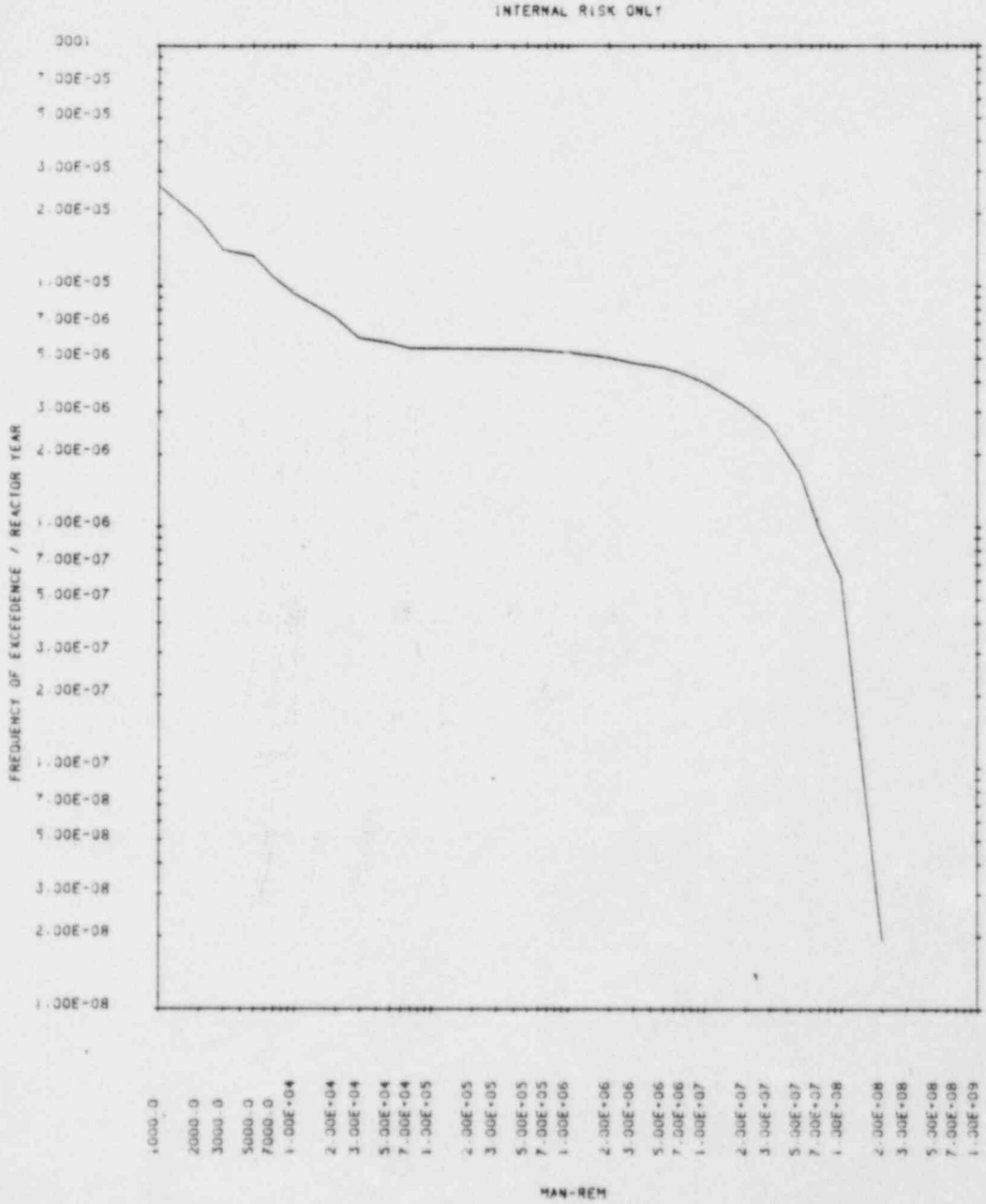


FIGURE 6.3.3-5

POINT ESTIMATE RISK CURVE FOR MAN-REM



6.4 PLANT RISK QUANITIFICATION FOR 7-DAY LCO

6.4.1 CALCULATION OF EVENT TREE NODES FOR 7-DAY LCO

The recalculation of event tree nodes for single unit operation was comprised of changes to the recirculation nodes R1 and R2, see Sections 6.2.4 and 6.2.5. These data changes to Table 4.2.1.a are delimited below.

	Support State					
	1	2	3	4	5	6
R-1	2.6(-4)	1.0	6.7(-3)	6.2(-3)	1.0	1.0
R-2	4.9(-4)	1.0	1.4(-2)	1.1(-2)	1.0	1.0

6.4.2 CALCULATION OF CORE DAMAGE FOR 1-UNIT 7 DAY LCO

In this section, the plant core melt frequency from the internal initiating events is calculated.

To calculate the plant matrix, M, and the plant core melt frequency, the event trees of section 2 are quantified for each of the six support states, using nodal probabilities calculated in Section 6.4.1. The plant matrix generated is given by Table 6.4.2-1.

The internal initiating event frequency vector (ϕ) is taken from the section 1 and is repeated as Table 6.4.2-2.

The product ϕM provides the frequencies of damage states given by Table 6.4.2-3.

The contribution of each initiating event category to the total internal core melt frequency is calculated and is displayed by Table 6.4.2-4. The contribution of each support state to the total core melt frequency is given by Table 6.4.2-5. The composition of core melt by plant core melt states is given by Table 6.4.2-6.

The ranking of initiating event-support state cases by their contribution to core melt is displayed on Table 6.4.2-7. Finally, Table 6.4.2-8 contains the percent contributions to each core melt state by initiating event-support state case.

TABLE 6.4.2-1 (Sheet 1 of 2)

PLANT MATRIX (M MATRIX)

	AEFC SEC V2E	AEF SE V2L	AEC SLFC V	AE SLF	ALFC SLC	ALF SL	ALC TEFC	AL TEF	SEFC TEC	SEF TE
1	6.70E-04 0.00E-01 6.70E-09	4.14E-07 0.00E-01 9.99E-06	2.18E-08 0.00E-01 0.00E-01	5.50E-07 0.00E-01	2.60E-04 0.00E-01	1.52E-07 0.00E-01	2.10E-05 0.00E-01	1.22E-08 0.00E-01	0.00E-01 0.00E-01	0.00E-01 0.00E-01
2	6.78E-04 0.00E-01 7.00E-09	4.21E-07 0.00E-01 9.99E-06	2.10E-05 0.00E-01 0.00E-01	5.62E-07 0.00E-01	2.60E-04 0.00E-01	1.52E-07 0.00E-01	4.20E-09 0.00E-01	2.35E-11 0.00E-01	0.00E-01 0.00E-01	0.00E-01 0.00E-01
3	0.00E-01 2.13E-05 0.00E-01	0.00E-01 5.62E-07 0.00E-01	0.00E-01 4.90E-04 0.00E-01	0.00E-01 2.86E-07	0.00E-01 8.09E-09	0.00E-01 4.62E-11	0.00E-01 4.44E-11	0.00E-01 2.58E-14	2.12E-07 4.95E-12	2.42E-08 1.33E-13
4	0.00E-01 4.99E-12 2.20E-05	0.00E-01 1.78E-13 9.39E-06	0.00E-01 8.83E-17 0.00E-01	0.00E-01 9.07E-20	0.00E-01 6.69E-20	0.00E-01 8.04E-22	0.00E-01 1.84E-17	0.00E-01 1.32E-20	5.27E-16 4.95E-12	3.18E-19 1.33E-13
5	0.00E-01 1.05E-05 2.14E-10	0.00E-01 2.81E-07 1.00E-05	0.00E-01 6.16E-07 0.00E-01	0.00E-01 4.04E-10	0.00E-01 8.39E-11	0.00E-01 1.04E-12	0.00E-01 3.15E-07	0.00E-01 1.84E-10	1.30E-09 3.79E-07	3.18E-12 1.01E-08
6	0.00E-01 1.05E-05 2.14E-10	0.00E-01 2.81E-07 1.00E-05	0.00E-01 6.16E-07 0.00E-01	0.00E-01 4.04E-10	0.00E-01 8.39E-11	0.00E-01 1.04E-12	0.00E-01 3.15E-07	0.00E-01 1.84E-10	1.30E-09 3.79E-07	3.18E-12 1.01E-08
7	0.00E-01 1.05E-05 1.10E-09	0.00E-01 6.61E-08 9.39E-10	0.00E-01 3.44E-07 0.00E-01	0.00E-01 2.12E-10	0.00E-01 2.32E-11	0.00E-01 2.46E-13	0.00E-01 1.26E-07	0.00E-01 7.45E-11	1.30E-09 3.78E-07	3.17E-12 2.38E-09
8	0.00E-01 1.05E-05 1.10E-09	0.00E-01 6.61E-08 9.39E-10	0.00E-01 3.44E-07 0.00E-01	0.00E-01 2.12E-10	0.00E-01 2.32E-11	0.00E-01 2.46E-13	0.00E-01 1.26E-07	0.00E-01 7.45E-11	2.14E-11 3.78E-07	2.42E-12 2.38E-09
9	0.00E-01 1.05E-05 1.10E-09	0.00E-01 6.61E-08 9.39E-10	0.00E-01 3.44E-07 0.00E-01	0.00E-01 2.12E-10	0.00E-01 2.32E-11	0.00E-01 2.46E-13	0.00E-01 1.26E-07	0.00E-01 7.45E-11	1.30E-09 3.78E-07	3.17E-12 2.38E-09
10	0.00E-01 3.57E-11 3.73E-15	0.00E-01 2.25E-13 3.19E-15	0.00E-01 1.17E-12 0.00E-01	0.00E-01 7.19E-16	0.00E-01 7.90E-17	0.00E-01 8.36E-19	0.00E-01 4.29E-13	0.00E-01 2.53E-16	4.43E-15 1.28E-12	1.08E-17 8.09E-15
11	0.00E-01 1.05E-05 1.10E-09	0.00E-01 6.61E-08 9.39E-10	0.00E-01 3.44E-07 0.00E-01	0.00E-01 2.12E-10	0.00E-01 2.32E-11	0.00E-01 2.46E-13	0.00E-01 1.26E-07	0.00E-01 7.45E-11	1.30E-09 3.78E-07	3.17E-12 2.38E-09

TABLE 6.4.2-1 (Sheet 2 of 2)

PLANT MATRIX (M MATRIX)

12	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	3.02E-09	3.48E-11
	1.01E-04	2.70E-04	7.06E-06	8.19E-08	1.30E-07	1.58E-09	8.59E-07	9.02E-09	3.66E-06	9.72E-06
	7.96E-10	2.25E-09	0.00E-01							
13	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.30E-09	3.17E-12
	1.05E-05	6.61E-08	5.64E-07	3.40E-10	1.01E-05	6.37E-08	2.70E-07	1.57E-10	3.78E-07	2.38E-09
	1.10E-09	9.39E-10	0.00E-01							
14	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	9.47E-10	2.96E-12
	1.05E-05	6.61E-08	3.44E-07	2.12E-10	2.32E-11	2.46E-13	1.26E-07	7.45E-11	3.78E-07	2.38E-09
	1.10E-09	9.39E-10	0.00E-01							
V	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
	0.00E-01	0.00E-01	1.00E+00							

TABLE 6.4.2-2

INITIATING EVENT DEFINITIONS AND MEAN FREQUENCIES

EVENT SYMBOL	EVENT DESCRIPTION	FREQUENCY / REACTOR YEAR
1	LARGE LOCA	9.40E-04
2	MEDIUM LOCA	9.40E-04
3	SMALL LOCA	3.54E-02
4	STEAM GENERATOR TUBE RUPTURE	3.70E-02
5	STEAM BREAK INSIDE CONTAINMENT	9.40E-04
6	STEAM BREAK OUTSIDE CONTAINMENT	9.40E-04
7	LOSS OF MAIN FEEDWATER	3.00E+00
8	CLOSURE OF ONE MSIV	2.52E-01
9	LOSS OF RCS FLOW	3.58E-01
10	CORE POWER EXCURSION	2.28E-02
11	TURBINE TRIP	4.00E+00
12	LOSS OF OFFSITE POWER	5.76E-02
13	SPURIOUS SAFETY INJECTION	8.00E-02
14	REACTOR TRIP	3.00E+00
V	INTERFACING SYSTEMS LOCA	2.10E-07

TABLE 6.4.2-3

CORE MELT STATE DEFINITIONS AND CALCULATED MEAN FREQUENCIES

SYMBOL	DESCRIPTION	FREQUENCY / REACTOR YEAR	PERCENT CONTRIBUTION
AEFC	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.27E-06	.76
AEF	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	7.85E-10	<0.1
AEC	LARGE LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.98E-08	<0.1
AE	LARGE LOCA EARLY NO CONTAINMENT COOLING	1.05E-09	<0.1
ALFC	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	4.88E-07	.29
ALF	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.85E-10	<0.1
ALC	LARGE LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	1.97E-08	<0.1
AL	LARGE LOCA LATE MELT NO CONTAINMENT COOLING	1.15E-11	<0.1
SEFC	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	2.02E-08	<0.1
SEF	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	8.91E-10	<0.1
SEC	SMALL LOCA EARLY MELT ECCS FAILURE AT INJECTION	1.19E-04	71.19
SE	SMALL LOCA EARLY MELT NO CONTAINMENT COOLING	1.63E-05	9.76
SLFC	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	2.14E-05	12.85
SLF	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	1.71E-08	<0.1
SLC	SMALL LOCA LATE MELT ECCS FAILURE ON RECIRCULATION	8.17E-07	.49
SL	SMALL LOCA LATE MELT NO CONTAINMENT COOLING	5.19E-09	<0.1
TEFC	TRANSIENT WITH NO COOLING, EARLY MELT	1.41E-06	.84
TEF	TRANSIENT WITH NO COOLING, EARLY MELT	1.32E-09	<0.1
TEC	TRANSIENT WITH NO COOLING, EARLY MELT	4.25E-06	2.55
TE	TRANSIENT EARLY MELT NO CONTAINMENT COOLING	5.86E-07	.35
V2E	SGTR EARLY MELT	8.24E-07	.49
V2L	SGTR LATE MELT	3.95E-07	.24
V	INTERFACING SYSTEMS LOCA	2.10E-07	.13
	TOTAL	1.67E-04	100.0

TABLE 6.4.2-4

INITIATING EVENTS AND THE CORE MELT FREQUENCIES

SYMBOL	DESCRIPTION	CORE MELT FREQUENCY	PERCENT CONTRIBUTION	CONDITIONAL CORE MELT FREQUENCY
1	LARGE LOCA	9.04E-07	.54	9.62E-04
2	MEDIUM LOCA	9.12E-07	.55	9.70E-04
3	SMALL LOCA	1.81E-05	10.87	5.12E-04
4	STEAM GENERATOR TUBE RUPTURE	1.16E-06	.70	3.14E-05
5	STEAM BREAK INSIDE CONTAINMENT	2.08E-08	<0.1	2.21E-05
6	STEAM BREAK OUTSIDE CONTAINMENT	2.08E-08	<0.1	2.21E-05
7	LOSS OF MAIN FEEDWATER	3.42E-05	20.52	1.14E-05
8	CLOSURE OF ONE MSIV	2.88E-06	1.72	1.14E-05
9	LOSS OF RCS FLOW	4.09E-06	2.45	1.14E-05
10	CORE POWER EXCURSION	8.85E-13	<0.1	3.88E-11
11	TURBINE TRIP	4.57E-05	27.36	1.14E-05
12	LOSS OF OFFSITE POWER	2.26E-05	13.57	3.93E-04
13	SPURIOUS SAFETY INJECTION	1.76E-06	1.05	2.20E-05
14	REACTOR TRIP	3.42E-05	20.52	1.14E-05
V	INTERFACING SYSTEMS LOCA	2.10E-07	.13	1.00E+00
		1.67E-04	100.0	

TABLE 6.4.2-5

CORE MELT FREQUENCY BY EVENT AND SUPPORT STATE

ET11.02	4.35E-05	ET13.01	6.69E-08	ET05.06	2.68E-10	ET10.06	4.86E-15
ET07.02	3.26E-05	ET12.01	2.65E-08	ET06.06	2.68E-10	ET10.03	8.98E-17
ET14.02	3.26E-05	ET09.06	2.24E-08	ET02.03	1.85E-10	ET10.04	3.05E-18
ET12.06	2.19E-05	ET04.06	2.04E-08	ET02.04	1.84E-10	ET16.06	0.00E-01
ET03.01	1.74E-05	ET02.02	1.97E-08	ET11.04	1.56E-10	ET16.05	0.00E-01
ET09.02	3.92E-06	ET01.02	1.97E-08	ET07.04	1.17E-10	ET16.04	0.00E-01
ET08.02	2.74E-06	ET03.06	1.95E-08	ET14.04	1.17E-10	ET16.03	0.00E-01
ET11.01	1.89E-06	ET08.06	1.57E-08	ET13.03	8.63E-11	ET16.02	0.00E-01
ET13.02	1.68E-06	ET12.04	1.40E-08	ET01.03	8.63E-11	ET16.01	0.00E-01
ET07.01	1.41E-06	ET06.01	1.03E-08	ET01.04	8.38E-11	ET15.05	0.00E-01
ET14.01	1.41E-06	ET05.01	1.03E-08	ET04.04	3.40E-11	ET14.05	0.00E-01
ET02.01	8.91E-07	ET05.02	1.02E-08	ET09.04	1.41E-11	ET13.05	0.00E-01
ET01.01	8.84E-07	ET06.02	1.02E-08	ET08.04	9.84E-12	ET12.05	0.00E-01
ET04.02	7.77E-07	ET13.06	9.60E-09	ET15.02	4.41E-12	ET11.05	0.00E-01
ET03.02	7.43E-07	ET11.03	4.60E-09	ET06.03	3.95E-12	ET10.05	0.00E-01
ET12.03	4.33E-07	ET03.03	3.79E-09	ET05.03	3.95E-12	ET09.05	0.00E-01
ET12.02	3.91E-07	ET07.03	3.45E-09	ET13.04	3.84E-12	ET08.05	0.00E-01
ET04.01	3.62E-07	ET14.03	3.45E-09	ET15.04	1.62E-12	ET07.05	0.00E-01
ET11.06	2.49E-07	ET03.04	3.01E-09	ET15.03	1.60E-12	ET06.05	0.00E-01
ET15.01	2.10E-07	ET01.06	5.17E-10	ET10.02	8.51E-13	ET05.05	0.00E-01
ET07.06	1.86E-07	ET02.06	5.17E-10	ET05.04	2.46E-13	ET04.05	0.00E-01
ET14.06	1.86E-07	ET09.03	4.14E-10	ET06.04	2.46E-13	ET03.05	0.00E-01
ET09.01	1.70E-07	ET08.03	2.90E-10	ET15.06	1.16E-13	ET02.05	0.00E-01
ET09.01	1.70E-07	ET08.03	2.90E-10	ET15.06	1.16E-13		

TABLE 6.4.2-6

CORE MELT FREQUENCY BY SUPPORT STATE

STATE	1	2.48E-05	14.86
STATE	2	1.19E-04	71.30
STATE	3	4.50E-07	.27
STATE	4	1.78E-08	.01
STATE	5	0.00E-01	.00
STATE	6	2.26E-05	13.56

TABLE 6.4.2-7 (Sheet 1 of 2)

EVENT/SUPPORT STATE CONTRIBUTORS TO CORE MELT STATES (PERCENTAGE)

AEFC	99.97	ETO2.01	50.29	ETO1.01	49.68						
AEF	99.88	ETO2.01	50.00	ETO1.01	49.46	ETO2.04	.21	ETO2.03	.21		
AEC	99.84	ETO2.02	99.84								
AE	99.99	ETO2.06	49.45	ETO1.06	49.45	ETO2.02	1.10				
ALFC	99.96	ETO1.01	49.98	ETO2.01	49.98						
ALF	100.00	ETO1.01 ETO2.04	49.62 .18	ETO2.01	49.62	ETO1.03	.20	ETO2.03	.19	ETO1.04	.18
ALC	99.96	ETO1.02	99.96								
AL	99.61	ETO1.02	99.61								
SEFC	99.89	ETO3.01 ET13.01	36.93 .52	ET11.01 ET12.01	25.77 .36	ETO7.01 ET12.03	19.33 .35	ET14.01 ET12.04	14.04 .16	ETO9.01 ETO3.03	2.32 .12
SEF	99.76	ETO3.01 ETO9.01	95.99 .13	ET11.01	1.42	ETO7.01	1.06	ET14.01	1.00	ET12.03	.16
SEC	99.97	ET11.02 ETO8.02	35.32 2.23	ETO7.02 ET13.02	26.49 .71	ET14.02 ETO3.02	26.49 .63	ET12.06 ET12.02	4.63 .32	ETO9.02	3.18
SE	99.85	ET12.06 ETO9.06	95.56 .13	ET11.06 ETO3.06	1.46 .12	ET14.06 ETO7.02	1.10 .11	ETO7.06 ET14.02	1.10 .11	ET11.02	.15
SLFC	99.76	ETO3.01 ETO9.01	80.83 .58	ET11.01 ETO8.01	6.39 .40	ETO7.01 ET13.01	4.80 .21	ET14.01	4.80	ET12.03	1.76
SLF	99.07	ETO3.01 ET12.04	58.61 .91	ET12.03 ETO9.01	26.71 .42	ET11.01 ETO8.01	4.64 .29	ETO7.01 ET11.03	3.48 .28	ET14.01 ETO3.03	3.48 .26
SLC	99.90	ET13.02	99.01	ET12.03	.89						
SL	99.86	ET13.06	89.11	ET13.02	9.04	ET12.03	1.71				
TEFC	99.82	ET11.01 ETO8.01	35.72 2.25	ETO7.01 ET13.01	26.81 1.53	ET14.01 ET12.01	26.81 .50	ETO9.01	3.22	ET12.03	2.98
TEF	99.28	ET12.03 ETO8.01	38.49 1.39	ET11.01 ET13.01	22.04 .94	ETO7.01 ET12.04	16.54 .64	ET14.01 ET11.03	16.53 .41	ETO9.01 ET12.01	1.98 .31
TEC	99.96	ET11.02 ETO8.02	35.54 2.24	ETO7.02 ET13.02	26.65 .71	ET14.02 ET12.02	26.65 .32	ET12.06	4.66	ETO9.02	3.20
TE	99.85	ET12.06 ETO9.06	95.68 .13	ET11.06 ETO7.02	1.47 .11	ETO7.06 ET14.02	1.10 .11	ET14.06	1.10	ET11.02	.15
V2E	99.84	ETO4.02 ETO7.02	94.26 .38	ETO4.06	2.47	ETO4.01	1.84	ET11.02	.51	ET14.02	.38

TABLE 6.4.2-7 (Sheet 2 of 2)

EVENT/SUPPORT STATE CONTRIBUTORS TO CORE MELT STATES (PERCENTAGE)

V2L	99.73	ET04.01 ET11.01	87.85 .95	ET05.01 ET07.01	2.38 .71	ET06.01 ET14.01	2.38 .71	ET02.01	2.38	ET01.01	2.38
V	100.00	ET15.01	100.00								

6.4.3 CALCULATION OF PLANT RISK FOR 1-UNIT 7-DAY LCO

In this section the plant risk in terms of the consequence categories:

1) Early fatalities
2) Early injuries
3) Thyroid cancer incidences
4) Latent cancer fatalities
5) Man-rem release

is calculated and the corresponding risk curves are drawn for the 7-day LCO.

The product ϕMC provides the release category frequencies. This quantification is summarized by Table 6.4.3-1.

The product ϕMCS for each consequence category provides the point estimate frequencies for each of the consequence categories, i=1, 2, 3, 4, 5. The results are given by Tables 6.4.3-2 through 6.4.3-6. The same results are also expressed as risk curves by Figures 6.4.3-1 through 6.4.3-5.

TABLE 6.4.3-1

RELEASE CATEGORY DEFINITIONS AND CALCULATED MEAN FREQUENCIES

RELEASE CATEGORY	DESCRIPTION	FREQUENCY / REACTOR YEAR	PERCENT CONTRIBUTION
Z-1	STEAM EXPLOSION WITHOUT CONTAINMENT SPRAY	1.09E-09	<0.1
2	OVERPRESSURE FAILURES WITHOUT SPRAYS	2.28E-07	.14
2R	DELAYED OVERPRESSURE FAILURE WITHOUT SPRAYS	1.69E-05	10.11
Z-3	STEAM EXPLOSIONS WITH SPRAYS	2.27E-10	<0.1
5R	DELAYED OVERPRESSURE WITH SPRAYS	1.93E-08	<0.1
Z-5	EARLY OVERPRESSURE FAILURES WITH SPRAYS	1.32E-08	<0.1
6	BASEMAT MELT-THROUGH WITHOUT SPRAYS	3.21E-09	<0.1
7	BASEMAT MELT-THROUGH WITH SPRAYS	2.59E-08	<0.1
8A	CONTAINMENT INTACT WITHOUT SPRAYS	2.21E-08	<0.1
8B	CONTAINMENT INTACT WITH SPRAYS	1.48E-04	88.97
2R'	SGTR RELEASE	1.22E-06	.73
	TOTAL	1.67E-04	100.0

TABLE 6.4.3-2

POINT ESTIMATE VECTOR FOR EARLY FATALITIES

NUMBER OF FATALITIES	FREQUENCY OF OCCURRENCE
1.00E+00	4.61E-08
2.00E+00	4.61E-08
3.00E+00	4.61E-08
5.00E+00	4.61E-08
7.00E+00	4.57E-08
1.00E+01	4.02E-08
2.00E+01	4.00E-08
3.00E+01	4.00E-08
5.00E+01	4.00E-08
7.00E+01	3.99E-08
1.00E+02	3.59E-08
2.00E+02	3.59E-08
3.00E+02	2.42E-08
5.00E+02	2.42E-08
7.00E+02	2.39E-08
1.00E+03	2.02E-08
2.00E+03	5.07E-11
3.00E+03	4.83E-11
5.00E+03	0.00E-01

TABLE 6.4.3-3

POINT ESTIMATE VECTOR FOR EARLY INJURIES

NUMBER OF INJURIES	FREQUENCY OF OCCURRENCE
1.00E+00	9.19E-07
2.00E+00	9.19E-07
3.00E+00	9.19E-07
5.00E+00	9.19E-07
7.00E+00	8.91E-07
1.00E+01	8.91E-07
2.00E+01	8.90E-07
3.00E+01	8.89E-07
5.00E+01	8.86E-07
7.00E+01	8.31E-07
1.00E+02	8.30E-07
2.00E+02	8.28E-07
3.00E+02	8.28E-07
5.00E+02	7.98E-07
7.00E+02	6.09E-07
1.00E+03	5.00E-07
2.00E+03	3.62E-07
3.00E+03	2.80E-07
5.00E+03	2.50E-07
7.00E+03	1.67E-07
1.00E+04	1.40E-07
2.00E+04	2.85E-08
3.00E+04	2.74E-08
5.00E+04	2.74E-08
7.00E+04	3.64E-10
1.00E+05	0.00E-01

TABLE 6.4.3-4

POINT ESTIMATE VECTOR FOR THYROID CANCERS

NUMBER OF THY CANCER	FREQUENCY OF OCCURRENCE
1.00E+00	1.66E-05
2.00E+00	1.29E-05
3.00E+00	1.04E-05
5.00E+00	9.15E-06
7.00E+00	8.22E-06
1.00E+01	7.89E-06
2.00E+01	7.86E-06
3.00E+01	7.83E-06
5.00E+01	7.72E-06
7.00E+01	7.63E-06
1.00E+02	7.44E-06
2.00E+02	6.97E-06
3.00E+02	6.72E-06
5.00E+02	6.20E-06
7.00E+02	5.81E-06
1.00E+03	5.24E-06
2.00E+03	4.27E-06
3.00E+03	3.23E-06
5.00E+03	2.29E-06
7.00E+03	1.91E-06
1.00E+04	1.47E-06
2.00E+04	6.39E-07
3.00E+04	3.36E-07
5.00E+04	1.13E-07
7.00E+04	2.93E-08
1.00E+05	3.64E-10
2.00E+05	0.00E-01

TABLE 6.4.3-5

POINT ESTIMATE VECTOR FOR LATENT CANCER FATALITIES (EXCLUDING THYROID)

NUMBER OF LAT CANCER	FREQUENCY OF OCCURRENCE
1.00E+00	1.12E-05
2.00E+00	8.68E-06
3.00E+00	8.37E-06
5.00E+00	8.01E-06
7.00E+00	8.01E-06
1.00E+01	8.00E-06
2.00E+01	7.95E-06
3.00E+01	7.92E-06
5.00E+01	7.72E-06
7.00E+01	7.66E-06
1.00E+02	7.41E-06
2.00E+02	6.91E-06
3.00E+02	6.69E-06
5.00E+02	6.15E-06
7.00E+02	5.68E-06
1.00E+03	5.20E-06
2.00E+03	3.86E-06
3.00E+03	2.68E-06
5.00E+03	1.32E-06
7.00E+03	7.56E-07
1.00E+04	2.52E-07
2.00E+04	1.05E-11
3.00E+04	0.00E-01

TABLE 6.4.3-6

POINT ESTIMATE VECTOR FOR MAN-REMS

NUMBER OF MAN-REM	FREQUENCY OF OCCURRENCE
1.00E+03	3.18E-05
2.00E+03	2.34E-05
3.00E+03	1.78E-05
5.00E+03	1.69E-05
7.00E+03	1.41E-05
1.00E+04	1.23E-05
2.00E+04	1.01E-05
3.00E+04	8.56E-06
5.00E+04	8.25E-06
7.00E+04	7.88E-06
1.00E+05	7.88E-06
2.00E+05	7.85E-06
3.00E+05	7.83E-06
5.00E+05	7.80E-06
7.00E+05	7.66E-06
1.00E+06	7.58E-06
2.00E+06	7.19E-06
3.00E+06	6.83E-06
5.00E+06	6.53E-06
7.00E+06	6.17E-06
1.00E+07	5.67E-06
2.00E+07	4.49E-06
3.00E+07	3.74E-06
5.00E+07	2.40E-06
7.00E+07	1.38E-06
1.00E+08	8.80E-07
2.00E+08	2.75E-08
3.00E+08	0.00E-01

FIGURE 6.4.3-1

POINT ESTIMATE RISK CURVE FOR EARLY FATALITIES

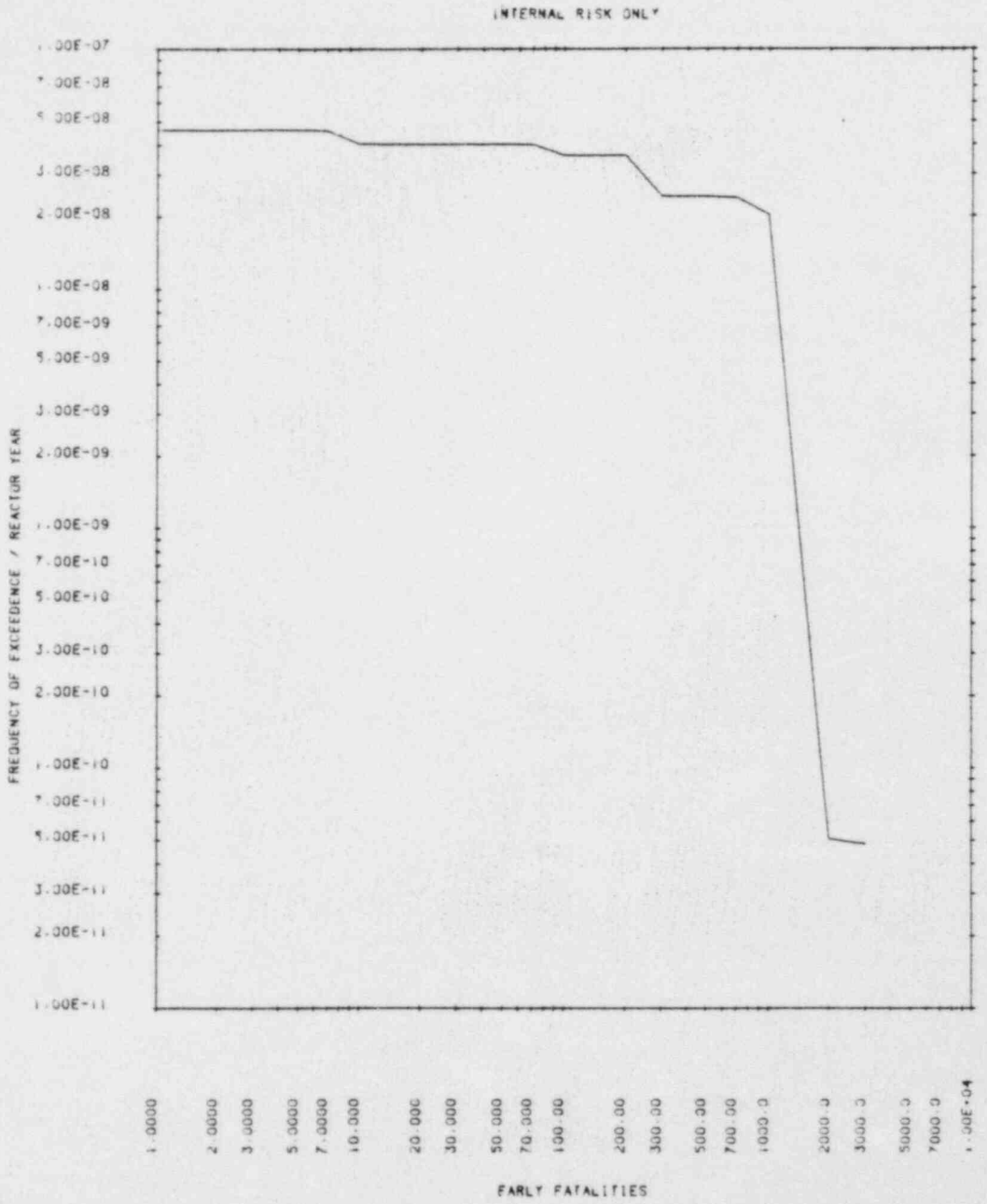


FIGURE 6.4.3-2

POINT ESTIMATE RISK CURVE FOR EARLY INJURIES

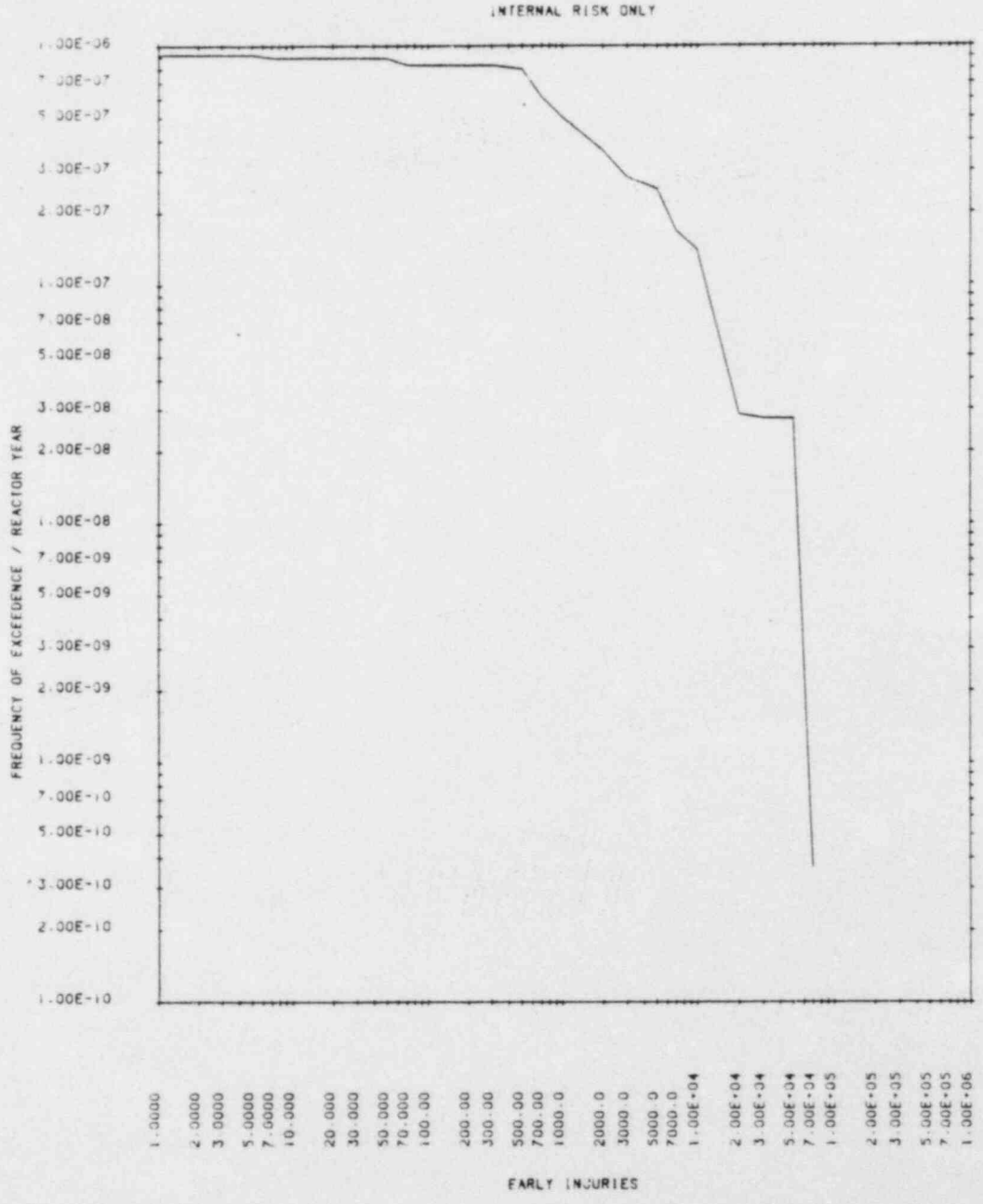


FIGURE 6.4.3-3

POINT ESTIMATE RISK CURVE FOR THYROID CANCER INCIDENCE

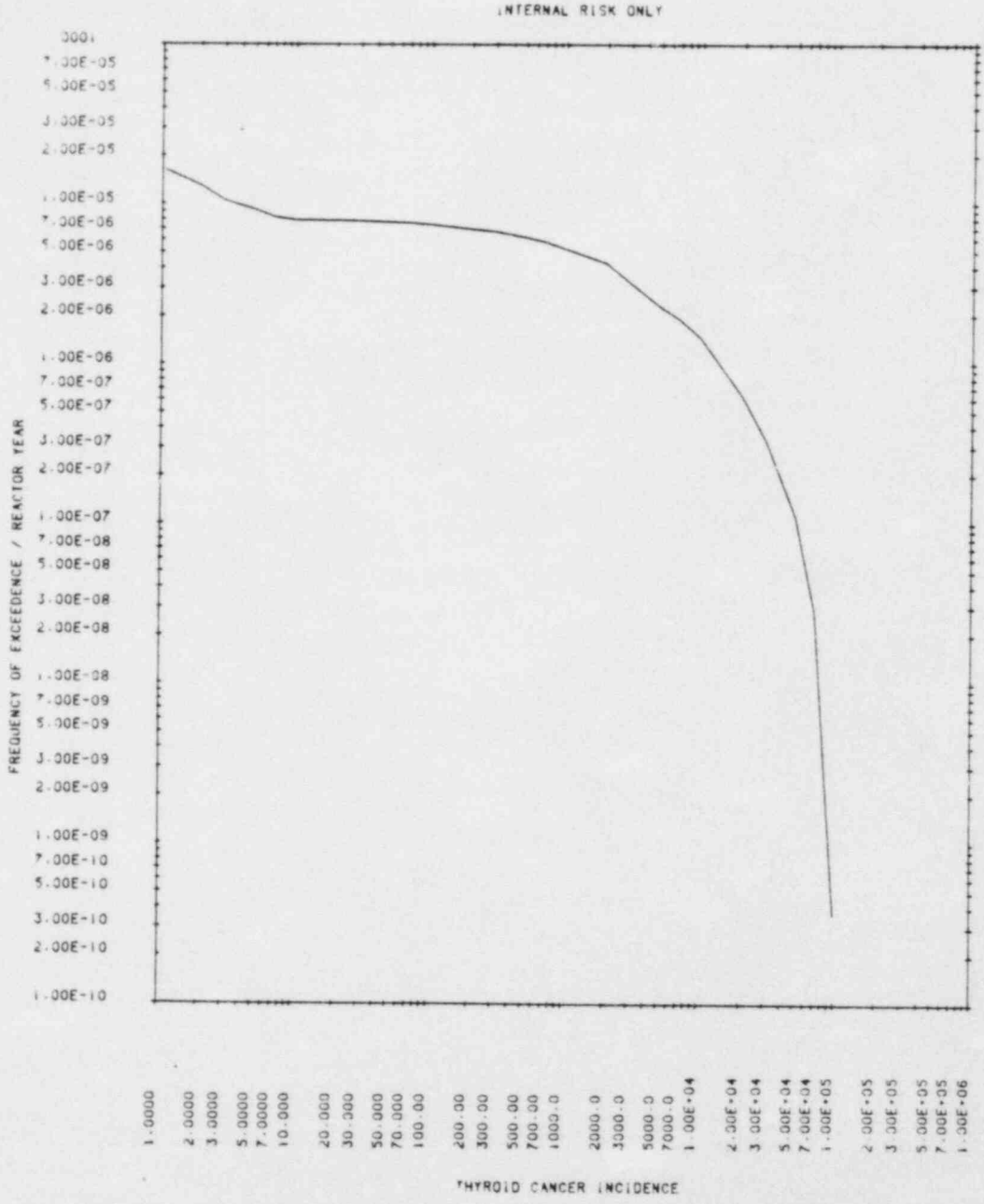


FIGURE 6.4.3-4

POINT ESTIMATE RISK CURVE FOR LATENT CANCER FATALITIES

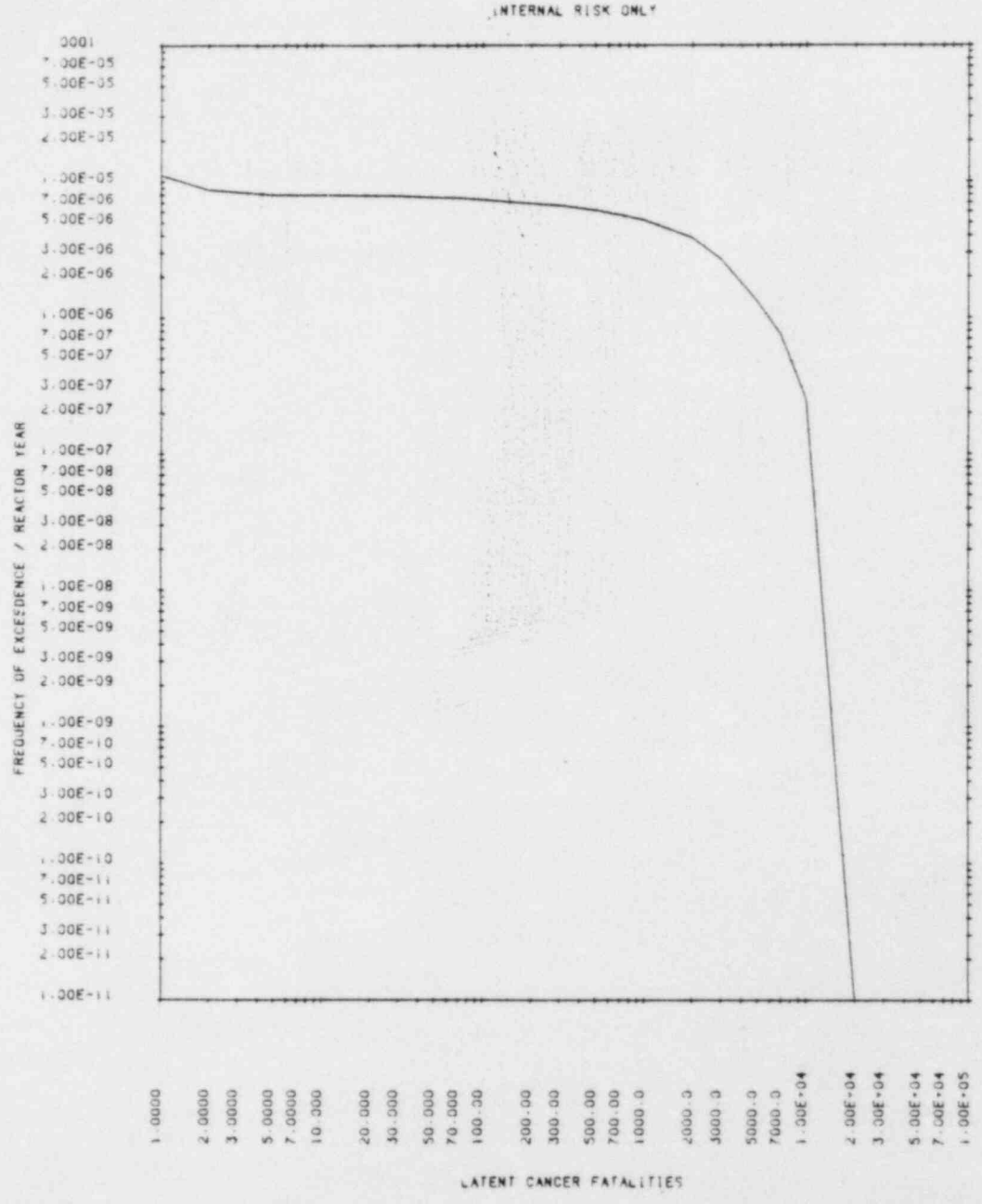
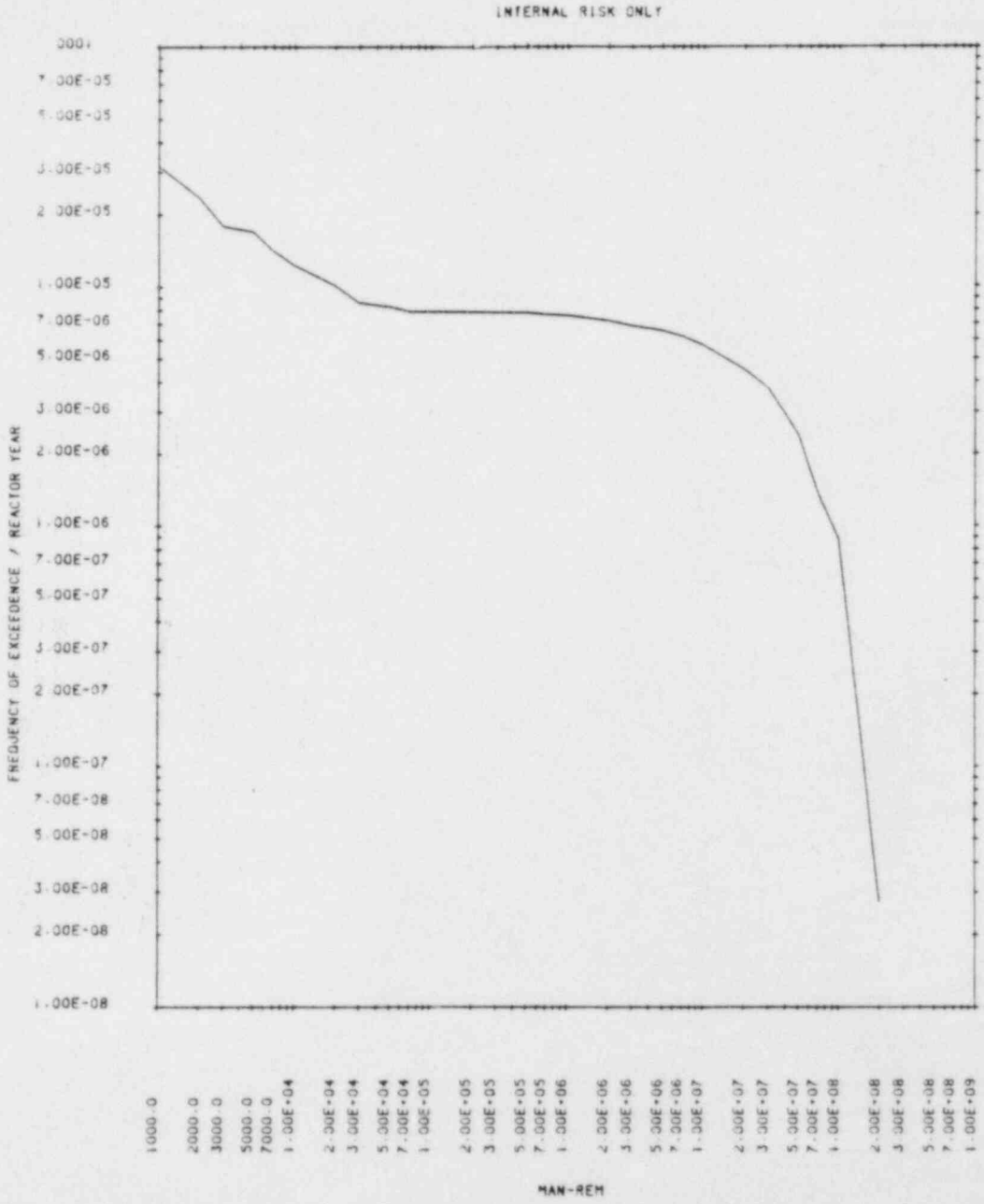


FIGURE 6.4.3-5

POINT ESTIMATE RISK CURVE FOR MAN-REM



6.6 SUMMARY OF RESULTS AND CONCLUSIONS

The results of the Unit 1, single unit operation are similar to those attained in analysis of both units, showing a small increase in the relative risk of the plant. The increase noted in the absolute value of the risk is attributable to the dependence of the plant on essential service water. The limitations placed on system reliability from the present design of two trains, each having one pump and 2 UHS fans (both of which are needed for LOCA recovery), are significant. However, overall external consequences are impacted to only a small extent, and the difference between 3-day and 7-day LCO is, as in two unit operation, statistically insignificant.

The results are presented in Figures 6.6-1 through 6.6-4, showing the same risk parameters as in Section 5.

FIGURE 6.6-1

POINT ESTIMATE RISK CURVE FOR EARLY FATALITIES
SUPPORT SYSTEMS FOR ONE UNIT ARE MODELED
INTERNAL RISK ONLY

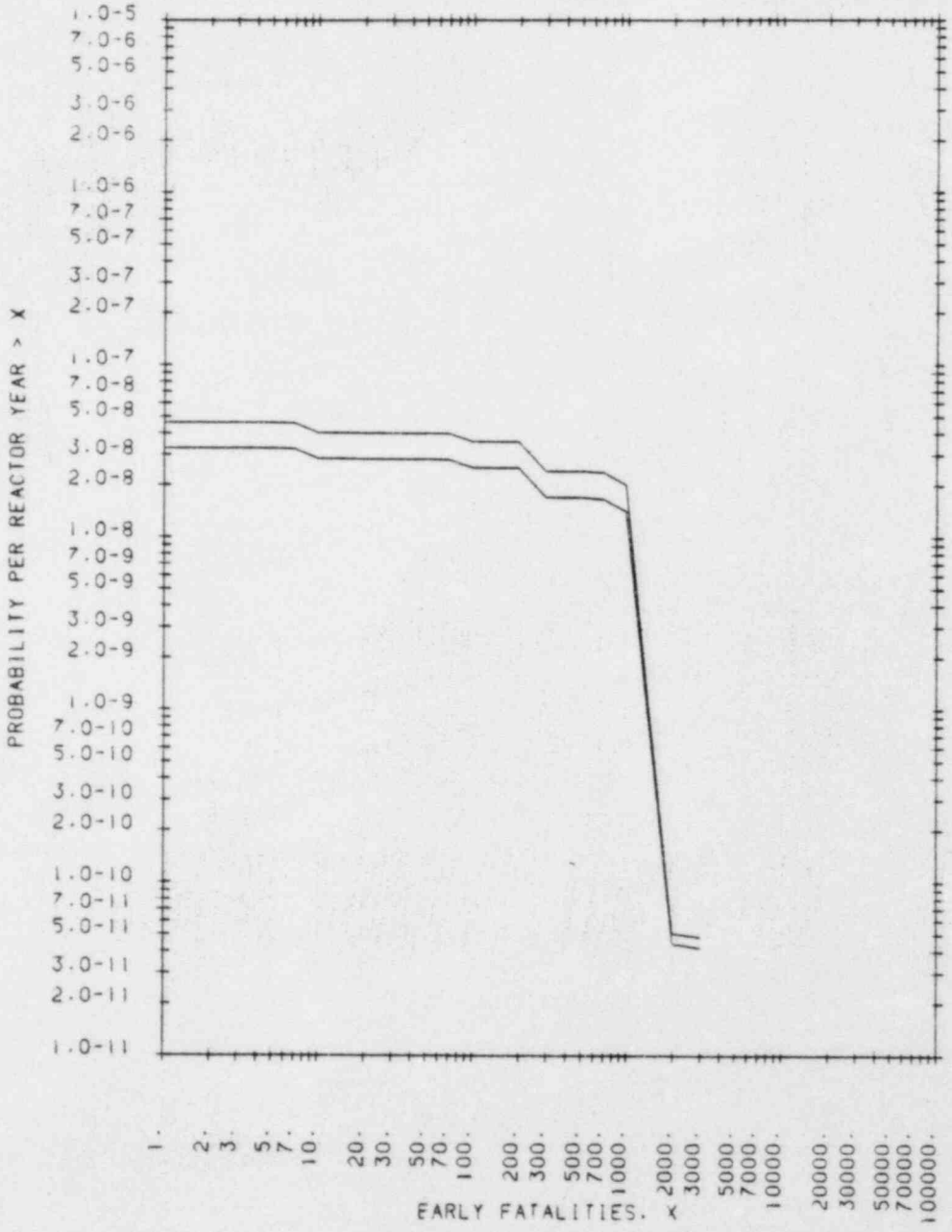


FIGURE 6.6-2

POINT ESTIMATE RISK CURVES FOR LATENT CANCERS
SUPPORT SYSTEMS FOR ONE UNIT ARE MODELED
INTERNAL RISK ONLY

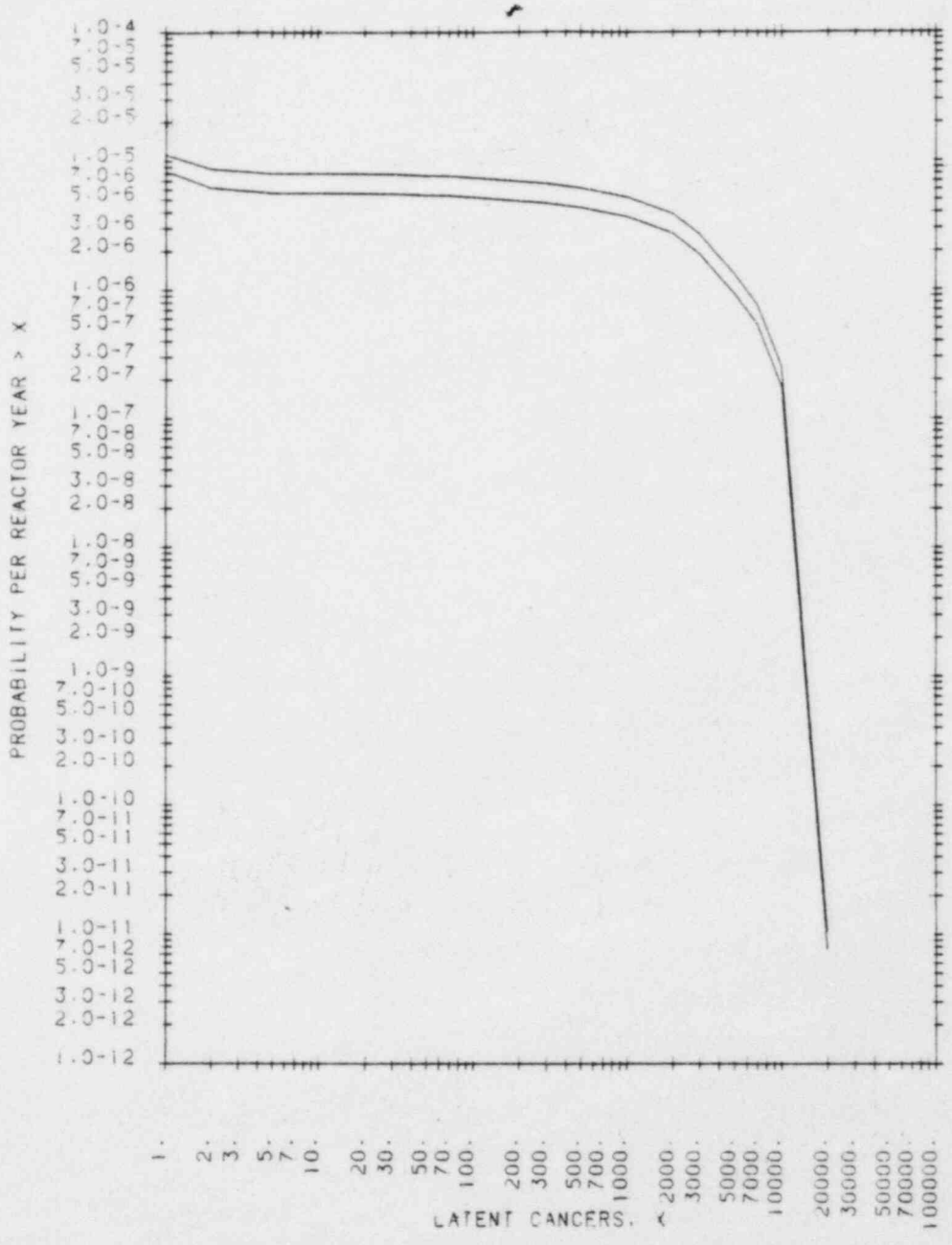


FIGURE 6.6-3

POINT ESTIMATE RISK CURVE FOR THYROID CANCERS
SUPPORT SYSTEMS FOR ONE UNIT ARE MODELED
INTERNAL RISK ONLY

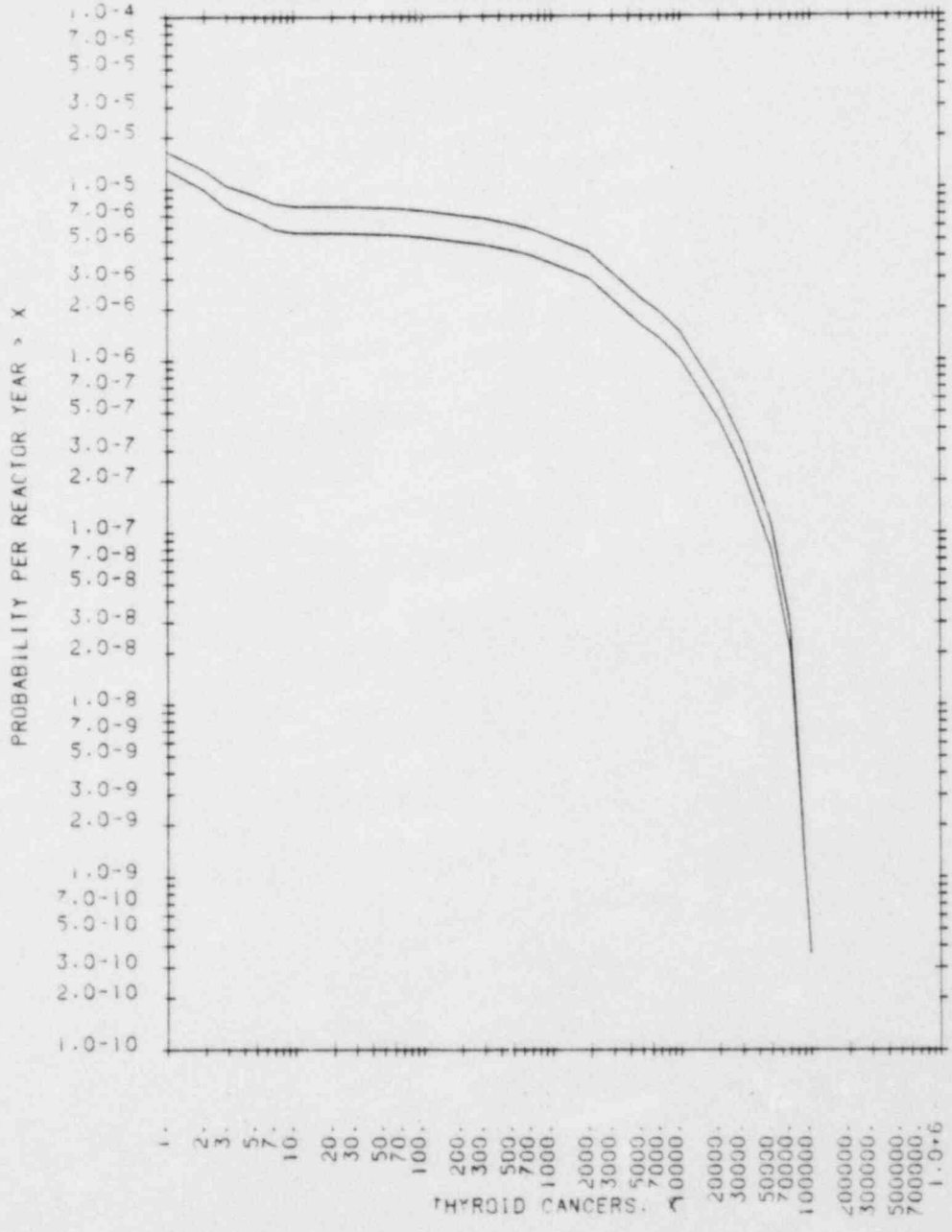
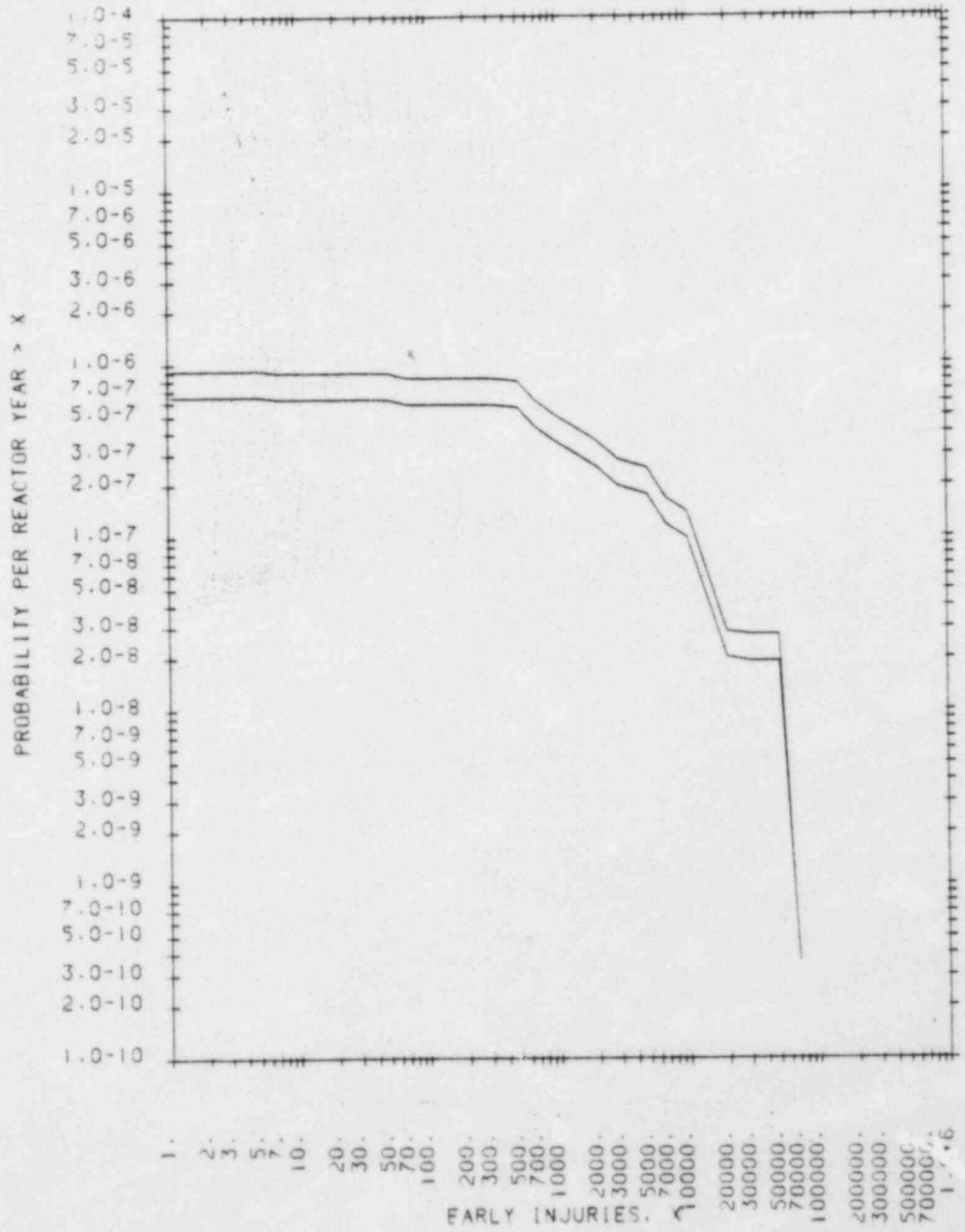


FIGURE 6.6-4

POINT ESTIMATE RISK CURVE FOR EARLY INJURIES
SUPPORT STATES FOR ONE UNIT ARE MODELED
INTERNAL RISK ONLY



7.1 REFERENCES

7.1 Zion Probabilistic Safety Study, Commonwealth Edison Company, 1981.

7.2 Indian Point Probabilistic Safety Study, 1982.

7.3 Millstone Unit 3 Probabilistic Safety Study, Westinghouse Electric Corporation, August 1983.

7.4 Byron Risk Study, Westinghouse Electric Corporation/Commonwealth Edison Company, February 1983.