NUREG/CR-4207
BNL-NUREG-51872

Fault Tree Application to the Study of Systems Interactions at Indian Point 3

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Prepared for
U.S. Nuclear Regulatory
Commission

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Manuscript Completed: March 1985
Date Published: January 1986

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NRC FIN A3725

ABSTRACT

This report describes an application of fault tree methods to search for systems interactions at Indian Point 3. This project was carried out in support of the resolution of Unresolved Safety Issue A-17 on Systems Interaction. Here, the methods are introduced, the findings are presented, and comments on the methods are offered.

Findings are presented in the following manner. Systems interactions which may <u>qualitatively</u> violate regulatory requirements (regardless of their probability) are discussed; additionally, a <u>probabilistically ranked</u> list of system interactions is provided.

This study resulted in the discovery of a previously undetected active single failure causing loss of low pressure injection. After verifying this finding, the licensee took immediate corrective actions, including a design modification to the switching logic for one of the safety buses, as well as procedural changes.

NRC SUMMARY

The NRC staff has been evaluating methods that analyze for intersystems dependencies. The evaluations were both (a) toward resolving Unresolved Safety Issue A-17 (Systems Interaction in Nuclear Power Plants) and (b) toward improving the analysis for dependencies in Probabilistic Risk Assessments. Two methods, Fault Tree/Interactive Failure Modes & Effects Analysis and Digraph-Matrix Analysis, appeared effective although previously not applied on a large scale to nuclear systems. This report describes the demonstration of the Fault Tree/Interactive Failure Modes & Effects Analysis on a large fraction of the systems at one nuclear power plant. The demonstration of the Digraph-Matrix Analysis is described in NUREG/CR-4179.

The objective of the systems interaction analysis was to provide assurance that the independent functioning of selected safety-related systems was not jeopardized by components that cause faults to be dependent. The results reported here came from work beyond the routine criteria used by the NRC to license nuclear power plants. The report should be read as a technical evaluation by the laboratory performing the analysis rather than as a safety evaluation performed by the licensing staff of the NRC. The NRC resolution of USI A-17 will include both a safety evaluation and a regulatory analysis.

The demonstration plant was selected primarily based upon the cooperation extended by the utility toward a resolution of USI A-17. A copy of the draft report was provided to the utility and placed in the Public Document Room on July 3, 1985.

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PREFACE

This project was performed in support of the resolution of USI A-17 on Systems Interactions (SIs). The resolution of USI A-17 involves deciding whether SI studies ought to be required and, if so, what sort of study will best meet NRC needs in this area. This project represents a limited trial of a particular approach, carried out to illustrate strengths and weaknesses of the approach.

A major element of NRC's Task Action Plan for the resolution of USI A-17 was to compare the results of this project (which used fault trees) with results of a similar project carried out at LLNL (which used digraph-matrices). Accordingly, the two projects were closely matched in scope and level of effort, and essentially the same documentation was supplied, under NRC control, to the two labs.

It must be clearly understood that this project is not a full-scope SI study. Only certain accident sequences are considered; within these sequences, only certain interaction types are considered; and for these sequences and interaction types, only limited information was made available to the labs. For comparison purposes, these limitations were deemed acceptable by NRC, provided that the limitations were comparable between the labs.

Although this report is not a substitute for a full SI study, it has achieved a number of important successes, and has thereby contributed to the resolution of USI A-17. In particular, by applying prescribed methods, BNL found a significant, previously undetected single active failure which causes loss of LPI in medium or large LOCA sequences. Additionally, other situations were found which warrant further review to establish whether regulatory requirements are met. This report discusses those strengths of the present method which have contributed most directly to these results.

ACKNOWLEDGMENTS

We are grateful to the IP-3 personnel for their hospitality, cooperation, and helpfulness during our plant visit and in subsequent encounters.

We also gratefully acknowledge the commitment and support of our NRC technical monitor, E. Chelliah.

Perhaps, most importantly, we are indebted to Cheryl Conrad for the dedication and expertise that have been required to complete this report in a timely fashion.

1. INTRODUCTION

This report presents the results of an application of fault tree techniques to a search for system interactions (SIs) at Indian Point Unit 3, performed in support of the resolution of Unresolved Safety Issue A-17 on System Interactions. This first section describes the background of the project and the scope of this report and of the project as a whole.

1.1 Background

Unresolved Safety Issue A-17 (USI A-17)[1] is concerned with what, if anything, should be done about Systems Interactions. One possible resolution is to conclude that nothing needs to be done. Another possible resolution is to require plant-specific SI studies aimed at identifying SIs at particular plants. If studies revealed the existence of SIs, any which were judged significant could of course be addressed, and if no SIs were found, a suitable basis for the negative finding could be made available. If a decision is made to perform SI studies, it is appropriate to ask what sort of study best serves these intended purposes. The answer to this will depend on the efficiency of the different methods and the degree of confidence that can be placed in the results.

The project reported here addressed the above questions in support of the resolution of USI A-17. Several years ago, USNRC asked for recommendations regarding preferred methods for carrying out SI studies. BNL recommended[2] a phased application of Fault Trees/Interacting Failure Modes and Effects Analysis (FT/IFMEA), in which a logical model of the plant is developed iteratively, in successively more detailed stages. Thisproject is an application by BNL of part of its own recommended method. Other laboratories have also made recommendations. In particular, Lawrence Livermore National Laboratory (LLNL) recommended a method using a logic model based on so-called "digraphs" rather than fault trees.[3]

NRC therefore decided to compare these two methods (fault tree and digraph) to demonstrate their strengths and weaknesses. It was decided to apply both methods concurrently to selected identical portions of Indian Point Unit 3, and to try to ensure that the same input was used in both studies. This might mean that the results obtained from the two projects would reflect directly on relative strengths and weaknesses of the two methods. Additionally, although a major utility-sponsored PRA had already been performed on IP-2 and IP-3,[4] and although a separate utility-sponsored SI study had also been conducted on IP-3,[5] it was hoped that the results of the two applications would shed additional light on the extent to which SIs are a problem.

1.2 Scope of the Project

The topics addressed in this project were chosen by negotiations between BNL, LLNL, and NRC. It was important to NRC to maximize the overlap in the areas studied by the two laboratories so that the results could be scored more easily. Early agreement was reached not to address containment systems or the reactor subcriticality function, and to emphasize "early" core melt sequences. This led to development of a list of accident sequences and corresponding frontline systems which is given in Section 2.

Certain areas of inquiry (addressed below) which might have been pursued here were eliminated in order to concentrate on other areas and to avoid overlapping other NRC work. Several of these exclusions were spelled out in the Statement of Work. One such exclusion is that of human error. By now, it is well established that human error is generally an important consideration, but it is also being addressed in other NRC programs and was therefore out of scope here. Maintenance errors are not modeled here, nor are control room operator errors. The only counterproductive human acts which are reflected in this project are based on misinformation due to display malfunction. These acts are not "errors," and as treated here do not involve human factors considerations; humans are treated as extensions of the hardware, which behave by procedures according to the information displayed.

Another excluded area is the effect of certain control system malfunctions. Events of this type appear in some of the sequences modeled, but have n§t generally been emphasized.

So-called common cause failure effects have also been excluded. Thus, for example, no primary event on the fault tree corresponds to "failure of two diesels for unspecified reasons." Some studies incorporate such developments, using beta-factor arguments based on operational data, but this has not been done here.

The Statement of Work contemplated a fairly detailed analysis of spatial coupling, but because of the lack of documentation, a much reduced effort was carried out, as described in Section 2.

1.3 Scope of the Report

Section 2 briefly mentions the method originally recommended by BNL for full-scope SI studies, and then describes how the methodology was tailored for the unique scope of this project. Section 3 describes the findings, and details what constitutes a "finding" within the context of each sequence analyzed in the study. Then "discovered systems interactions" are quantified so that their safety significance can be assessed. Section 4 offers comments on the method which was followed in order to address NRC's need to understand strengths and weaknesses of the method employed here.

The Appendices provide information about the system models and compendia of results. The main body of this report contains "findings" which are failure combinations that satisfy a screening criterion for significance; the appendices contain a more exhaustive set of failure combinations, most of which are not judged to be probabilistically significant.

References for Section 1

1. Task Action Plan for Resolution of USI A-17, January 1984.
2. A. Buslik, I. Papazoglou, and R. A. Bari, Review and Evaluation of Systems Interactions Methods, NUREG/CR-1901, 1981.
3. H. P. Alesso, I. J. Sacks, and C. F. Smith, Initial Guidance on Digraph-Matrix Analysis for Systems Interaction Studies, NUREG/CR-2915, 1983.

4. Indian Point Probabilistic Safety Study, Power Authority of the State of New York, Consolidated Edison Company of New York, Inc., 1982.
5. Power Authority of the State of New York-Indian Point 3 Nuclear Power Plant Systems Interaction Study, Ebasco Services, Inc., 1981.

2. METHODS

2.1 Overview of the General Approach

The method on which this project was based has been discussed elsewhere, and will not be extensively reviewed here.[1] Its steps are summarized in Table 2.1.1. The method is intended to cover the full range of possible accidents; accordingly, the early phases of the process emphasize development of an overview. Owing to the special circumstances governing this project, important steps in Table 2.1.1 were bypassed; the actual steps performed are given in Table 2.1.2. While the proposed method (Table 2.1.1) contemplates a full-scope study of a previously unanalyzed plant, this project was performed as a limited scope application of fault tree methods for demonstration purposes, carried out on a plant which had already been extensively studied.

Noteworthy features of the method are (1) the emphasis on explicitly modeling the initiating event, in order to search for correlations between initiating events and failure of mitigating systems, (2) basing the searches for spatial and induced-human interactions on results of the functional model, (3) solving the model first at, say, the train level and scrutinizing the results of this development before proceeding to develop the model to a finer level of resolution, in order that SIs can be discovered early in the process and that the development of the model benefits from the iterative feedback process, and (4) linking the support systems to the frontline systems as well as the other support systems.

In the first phase, a functional model was developed which prescribed the scope of the searches for spatial and induced-human interactions. Important interactions are those which link events that appear jointly in minimal cutsets of the functional model; the results of the functional model therefore provide one way to set priorities in the search for spatial or induced-human coupling.

Systems were resolved first to the segment level (a segment being a group of components in series, lying between two nodes of the system). For each segment, functional failure was modeled as failure of supports to the segment or internal failures, i.e., failures not due to supports. For each segment, all events internal to the segment were collapsed into a single event. For example, a segment consisting of several valves in series would have a single event corresponding to plugging of any of the valves, spurious transferring closed because of local faults, failing to open because of local faults, etc.

It is essential that analysis of mitigating systems' failure be properly conditioned on the character of the initiating events. A number of things were done to accomplish this:

1. A fault tree for transient initiators was developed. Transient accident sequence cutsets were displayed including the particular transient-initiating event for at least those transients which functionally correlate with support system faults.
2. Certain conditions were explicitly displayed on the fault trees as events: presence of a safety injection (SI) signal, whether a LOCA was medium or small, etc.
3. NOT logic was used to distinguish failure modes appropriate to different conditions. For example, at IP-3, the component cooling pumps are running or not depending on the availability of offsite power and on the presence of an SI signal. "Failure" of these pumps must be judged against the prevailing conditions.

Thus, in general, accident sequence cutsets contained explicit indication of all relevant conditions. Consider the example of a transient sequence initiated by a service water failure leading to a turbine trip accompanied by failure of fast transfer and eventual failure of auxiliary feedwater pumps to start. The cutset will display the service water failure, the fast transfer failure, and the failures causing the pumps not to start; since different components of the actuation logic come into play for non-LOCA scenarios, the presence or absence of a safety injection signal may show up explicitly.

All essential support system fault trees were developed and linked, with certain exceptions which can be classed as environmental control systems. For each frontline system, then, the resulting model explicitly displayed all support faults as described above. At the indicated level of resolution (the segment level), it is still possible to survey cutsets out to, say, third order in a meaningful way. This is a logical necessity if cutset searching is to play any role in the search for spatial or induced-human interactions.

Before this project was undertaken, a substantial utility-sponsored PRA[2] (hereafter "the PRA" or "the IPPSS") had been performed, and a separate utility-sponsored SI study (hereafter "the PASNY study") had also been completed.[3] Concurrently with the BNL application of its fault-tree-based approach, Lawrence Livermore National Laboratory (LLNL) was applying its own method to a study of the same accident sequences, basing its development on digraph codes rather than fault tree codes. For purposes of a straightforward comparison, both labs were to have received essentially the same information and covered essentially the same ground. Accordingly, the PRA was to have been used by both labs as a source document (and the PASNY SI study was, for the most part, not made available to either lab).

Priorities which had been established for this project and the circumstances which governed the availability of information combined to dictate emphasis of some portions of the search and deemphasis of others. Systems and sequences to be analyzed were chosen through a process of mutual agreement between LLNL, NRC, and BNL in which documentation considerations were significant; this bypasses most of the early (thinking) steps given in Table 2.1.1. Ultimately, the sequences analyzed and the success criteria chosen were taken (where possible) from the PRA. A meaningful study of spatially coupled SIs cannot be based solely on diagrams available to BNL, and must entail a good deal of physical inspection and analysis; accordingly, the iterations of steps IIJ-IIN on Table 2.2.1, recommended in a search for spatial interactions, were deemphasized in favor of a reduced search for "candidate spatial SIs" (CSSIs). In this study, CSSIs are essentially locations which are potentially critical by virtue of their linking different events in a cutset; here, however, neither physical inspection nor physical analysis has been performed, and the CSSIs are therefore simply candidates.

The search for induced-human interactions corresponds to a very restricted subset of the possibilities for operator involvement in accident sequences. In this study, traditional "human factors" considerations were out of scope, as these are being considered in other NRC-sponsored work. Again, the method given in Table 2.1.1 is more general than that used in the current project.

In summary, then, this project is not a full-scope SI study. To focus more directly on NRC needs, and to stay within the constraints imposed on the project, BNL has developed a segment-level (see Section 2.2) functional model of certain accident sequences, and has made a limited application of this model to a search for candidate spatially coupled system interactions and display-malfunction-induced system interactions.

2.2 Approach to the Search for Functionally Coupled Systems Interactions

2.2.1 Scope

"Frontline" systems (FLS) to be analyzed are listed in Table 2.2.1. In this project, a "frontline" system is essentially a system which (a) is indirectly related to one of the safety functions being analyzed (protection of RCS boundary, control of coolant inventory, removal of decay heat), and (b) has been selected by consensus for study. On this basis, main feedwater (MFW) has been listed as a FLS, although it has been modeled here essentially as a transient initiator (reasons for this are given in Section 2 of Appendix A). Support systems considered were those which support any of these frontline systems. As it turned out, environmental control systems were not modeled (fire protection, HVAC, etc.).

Accident sequences considered are given in Table 2.2.2. These, too, were arrived at by consensus. Factors in the selection were:

(a) a decision to emphasize certain safety functions (e.g., removal of decay heat) and not others (e.g., reactor subcriticality),

(b) a decision not to analyze containment systems,

(c) a decision to emphasize "early" core melt sequences (and not recirculation phase failures), and

(d) a decision to avoid certain control systems failures which are being considered in other NRC-sponsored work.

Table 2.1.1 Approach to Study of Systems Interactions

I. Selection of Systems for Detailed Evaluation

- a. Study Plant Design and Operating History
- b. Develop a List of Accident Initiators
- c. Develop a Functional Event Tree
- d. Assign Frontline Systems to the Functions of the Event Trees
- e. Assign Support Systems to Frontline Systems
- f. Develop Dependence Tables or Diagrams for Front-Line Systems and Support Systems
- g. Develop Systemic Event Trees
- h. Develop Fault Trees for Accident Initiators
- i. Develop List of Secondary Effects of Accident Initiators

II. Identification of Systems Interactions
(These steps are to be iterated at successively finer levels of resolution)

- j. Perform Cascade Failure Analysis
- k. Develop the System Fault Trees
- l. Generate Minimal Cutsets
- m. Search for Interactions in the Minimal Cutsets
- n. Complete Search for System Interactions

III. Evaluation Criteria for System Interactions

- o. Evaluation (Ranking) of System Interactions

2.2.2 Methodology and Implementation

The method (Section 2.1) calls for evaluating the model at successively finer levels of resolution. The reason for this is as follows. For purposes of illustration, consider the example of the three HPI pumps, which share a common location. Analyzing the few functional cutsets emerging from an early, low-resolution evaluation, one is led directly to ask whether the three pumps have anything in common, and to realize that there is indeed spatial commonality; the observation does not have to await the development of the full, detailed model. Indeed, spatial interactions may be an area in which such high-level models are useful. In searching for functional interactions, however, such train-level models are not likely to be useful in real applications, apart from possible pedagogical considerations. In this project, then, an effort was made to construct a fairly accurate functional model at the segment level. A "segment" is a group of elements (e.g., pipe segments, valves, pumps) in series, which can logically be lumped together in the development of the functional fault tree. The segmentation schemes for each of the systems studied are shown on the figures in Appendix A. (See also the IREP Procedures Guide[4].) This level of resolution is fine enough that the tree can faithfully reflect the logic of the system, and coarse enough not to generate unmanageably large numbers of cutsets.

Frontline systems having been decided upon, it was necessary to develop a list of support systems. Frontline and support system dependences are listed in Table 2.2.3 .

At this point, with frontline and support systems in hand, and particular top events in mind, it was necessary to establish success criteria. Where these existed in the PRA, they were adopted. For systems which BNL found to contribute to the frequency of transient initiation, and for which success criteria had not been defined in the PRA, the FSAR or plant personnel were consulted to define the normal operating status of certain support systems.

The method calls for generating a top-down model of the transient initiator. In the interest of efficiency, this approach was modified in the present study. The purpose of studying the initiator is, after all, to search for correlation between initiating events and mitigating system faults; it is therefore inappropriate to consider the entire balance of plant in modeling the initiating event. Rather, as the development of support system fault trees progressed for analysis of mitigating system failure, the support faults were assessed for their transient-causing potential. The support faults which were found to contribute to transient initiation were combined into the Transient-Initiator Fault Tree. This is further discussed in Appendix A (Section 18) under Transient Initiator.

Table 2.1.2 Stages in Present FT/IFMEA Application

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1. Initiation of Work

   Begin process of agreement on project scope between BNL, NRC, and LLNL.

2. Receipt of Documents Describing Systems and PRA

   Receive from PASNY the documents to be used as input for both labs.

3. Selection of Systems Combinations for Detailed Evaluation

   Develop consensus between BNL, NRC, and LLNL as to which frontline systems to analyze and which accident sequences to consider.

4. Fault Trees Development - Cascade Failure Analysis for Functional Interactions

   This step corresponds to IIj-IIn (Table 2.1.1) for functional interactions.

5. Cascade Failure Analysis for Spatial Interaction

   This corresponds to Steps IIj - IIn for spatial interactions, where now the functional model implicitly prescribes the components and locations which (by virtue of being functionally important) are important areas to be searched for spatial interactions.

6. Revision of Fault Trees - Final Set of Minimal Cutsets for Spatial Interaction

   This task corresponds to steps IIk-IIm (Table 2.1.1).

7. Cascade Failure Analysis - Induced Human Interactions

   This task was a search within the functional model for coupling between failures which derived directly from display malfunctions.

8. Revision of Fault Trees - Final Set of Minimal Cutsets for Induced-Human Interactions.

   Owing partly to the reduced scope of this portion of the project, no induced-human couplings discussed here warranted modification of the model.

9. Evaluation of the Discovered Interactions

   The safety significance of each cutset is considered with regard to its quantitative probabilistic significance and to acceptance criteria of the Standard Review Plan/licensing basis for IP-3.

Table 2.2.1 Frontline Systems Studied

High Pressure Injection
Low Pressure Injection
Auxiliary Feedwater
Main Feedwater
Pressurizer Valves
RCP Seals

Table 2.2.2 System Top Events and Accident Sequences

Individual Top Events

U_1, U_2, $S_2(P)$, $S_2(Q)$, L, D

Sequences

T*L
$S_2(P)U$
$S_2(Q)U$
$S_2(P)L$
$S_2(Q)L$
S_1D
S_1U_1
S_1P

T	Transient Initiator
$U_{1,2}$	High Pressure Injection (Med LOCA, Small LOCA)
D	Low Pressure Injection
S_2	Generic Small LOCA
$S_2(Q)$	Small Pressurizer LOCA
$S_2(P)$	Small RCP Seal LOCA
S_1	Medium LOCA
L	Auxiliary Feedwater

Table 2.2.3 System/Support System Dependences

Support System System	Electrical Power	Service Water	Station Air	Component Cooling	CST	CVCS	Heat Tracing	Instrument Air	RWST	SIAS
LPI	*								*	*
HPI	*			*			*		*	*
AFW	*				*		*	*		*
RCP				*		*		*		*
Pressurizer	*			*				*		
MFW	*	*	*					*		*
Electric Power		*								*
Service Water	*							*		*
Station Air	*	*								
Component Cooling	*	*								*
CST							*			
CVCS	*			*				*	*	*
Heat Tracing	*									
Instrument Air	*	*	*							
RWST							*			
SIAS	*									

2.3 Approach to the Search for Candidate Spatially Coupled System Interactions

2.3.1 Scope

The scope of the present search for candidate spatially coupled system interactions (CSSI) represents a balance which reflects the information made available to BNL and the limited end use (i.e., comparison of methods) anticipated by NRC for the results. The purpose of this section is to describe this scope and how this part of the project was executed.

The emphasis of the BNL approach was to set priorities for physical analysis; that is, rather than analyzing all possible spatial interactions, one analyzes those which

- couple pairs of events appearing in minimal cutsets of the functional model,
- satisfy some screening criterion for susceptibility, e.g., a pair of objects may be considered susceptible to spatial coupling if the coupled objects share a common location (e.g., fire zone).

For present purposes, "potential significance" means the following. One is usually interested in interactions between event A and event B only if they appear jointly in at least one minimal cutset. Otherwise, they may contribute to each other's probabilities, but not usually in a way that dramatically changes any one cutset probability. If A and B are in the same minimal cutset, however, and if they are spatially correlated, the cutset probability may be much higher than if they were uncorrelated.

Given a potentially significant candidate, there are grounds for investing in physical analysis and/or visual inspection to determine the credibility of the candidate. This is appropriate in a full SI study and would have to be done before any conclusion could be drawn about the candidate's contribution to core melt probability. However, the scope and purpose of this project is to test the process of identifying candidates, not to perform the analysis necessary to elevate a candidate to the status of being a credible contributor to risk.

Therefore, BNL has identified multiple events which are candidate spatial systems interactions (CSSI). A CSSI will

- couple pairs of events appearing in one or more minimal cutsets
- satisfy a screening criterion based on common location of the coupled events

It is crucial that the distinction between a real SI and a CSSI be borne in mind; a CSSI will not necessarily survive physical analysis, and a presumption to the contrary can lead to severely distorted conclusions.

2.3.2 Methodology and Implementation

It was assumed in this study that the fire zones defined in the IP-3 Fire Hazards Analysis[5] represented an appropriate decomposition of the plant into common locations; that is, these zones were taken to define the level of spatial resolution at which the search would be undertaken.

This choice having been made, a full study would need to link every zone containing any component whose failure contributes to any of the purely functional top events, and further, to consider every component in each of those zones. This is true because components which do not appear on the functional fault tree may, nevertheless, cause an initiating event, and if they share location with a mitigating system, there is a potential for linking accident initiation with failure of mitigation. Some location information on major components of particular safety systems is tabulated in the IP-3 Fire Protection Analysis. This became a primary information source for modeling purposes. Walkthroughs would have been extremely valuable, but after an initial plant familiarization visit, they were not conducted.

It has been assumed that within each zone, an adverse environment causes the following:

- Components in the affected zone which energize to perform their functions (motor-operated valves, solenoid-operated valves, and electric motors) fail to do so.

- Valves which are energized in the safe position are assumed to spuriously change state to the unsafe position if their control circuits are in the affected zone.
- Electrical components (buses, transformers, circuit breakers, motor control centers, battery chargers, batteries, diesels, inverters, distribution panels) in the affected zone fail to perform their functions.
- Equipment (pumps, valves) which energizes to perform its function fails, if its power or control cables are routed through the affected zone.
- Electric heaters for the BIT fail because of fire in the zones containing them.
- Transmitters in the affected zone fail to transmit a signal.

Given this information, wherever any particular events on the functional fault tree are influenced by "fire in zone 17," say, an event F17 is defined in the fault tree as implying those events. This straightforwardly leads to new cutsets which are mixtures of F___ events and functional failures. For some purposes, this is adequate. More revealing transformation of the functional events are discussed in a Sandia report[6]; the simple prescription given above leads to a result which is more condensed but less scrutable. This approach has been taken here as a simplified first cut.

Some years ago, Sandia conducted a systems interaction study[6] which illustrated the logic of augmenting a functional model with "linking characteristics" correlating hardware failures, in order to produce a combined result. This was done using SETS. The present search for spatially coupled SIs also uses SETS, and has benefited from the Sandia work. However, there is one difference. The Sandia report recommends obtaining the minimal cutsets for the functional model ("Run the SETS computer programs to obtain minimal cutsets. Store these cutsets but do not review them [!]") and then transforming the cutsets by using the linking characteristics. This works if the cutsets obtained initially are a reasonably exhaustive set. In the present study, however, functional results were obtained out to second order. These second-order results would be relatively uninteresting to transform, because some omitted triple might be the lowest-order cutset at which some common location factor could come through. Because of this, because the model is not burdened with excessive detail, and because low-order cutsets are of primary interest in this application, it is easy, inexpensive, and sufficient to rerun the calculation using the augmented fault trees.

2.4 Approach to the Search for Induced Human System Interactions

2.4.1 Scope

Human actions play an important role in accidents. Maintenance errors or testing errors can render individual trains or even whole systems unavailable; misdiagnosis of plant conditions, or procedural errors in dealing with accidents, can be crucial.

None of these actions is the subject of this phase of the project, although the word "human" figures prominently in its title. Human factors are studied extensively in other NRC programs; this large area continues to develop. To avoid overlap with other programs, and in keeping with the overall project emphasis on mechanical coupling, this search was confined to linkages between hardware failures which are mediated by operators who are correctly following procedures but who are misled by display malfunctions or erroneous procedures. To see more concretely what is being sought, consider the hypothetical example of a bus fault which initiates a plant transient and also causes some instrument failures. If these instrument failures mislead the operator and cause him to do further harm according to procedures, then the coupling between the bus fault and the additional harm is the "induced-human system interaction."

The documentation used in completing this search included Indian Point 3:

- System Descriptions
- Piping and Instrumentation Diagrams
- Emergency Procedures
- Off-Normal Operating Procedures
- Alarm Response Procedures
- Operating Procedures

2.4.2 Methodology and Implementation

Figure 2.4.1 summarizes the method used to search for potential induced-human systems interactions. The functional fault trees defined the boundaries of the search and the documentation noted above provided the input data. The original plan envisioned for this analysis was to search cutsets to see whether an induced-human linkage could be found that would reduce the order of any cutset. For reasons to be discussed in Section 4, this approach was not followed. Instead, a decision was made to proceed by individual analysis of each of the 750 or so primary failure events (PE) in the functional model, to see whether any given event could cause, or be caused by, some operator action relating to any other PE. The term "primary failure events," as used here, means events at the limit of resolution of the present model, namely, basic or diamond events on the fault tree.

The first step in this search was to categorize the PEs with respect to their potential for induced human interactions. A listing was obtained for each frontline and support system of the PEs that made up the functional fault tree for that system. This grouping of PEs by system facilitated a categorization of the PEs. Five categories were defined:

Category 1: The PE has stimuli (e.g., a display malfunction) that could result in a rational operator action that causes the PE. Included in this category were PEs where an individual display malfunction could induce an operator to take action that would cause the PE.

Category 2: There are stimuli that could induce an operator action that causes the PE but the stimuli are highly unlikely to occur. Included in this category are PEs where multiple independent display malfunctions would be required to induce the operator to cause the PE.

Category 3: There are no reasonable stimuli that could induce the operator to cause the PE. Included in this category are passive failures such as pipe breaks or flow blockage in a pipe.

Category 4: This category is reserved for identifying PEs that are categorized under a different system. For example, an electrical fault on bus 6A may be one of the PEs for the service water system, but it would also be included in the electrical distribution system fault tree. The PE would be shown as a Category 4 PE for the service water system and a Category 1, 2, or 3 PE for the electrical distribution system. This category was used to avoid unnecessary redundancy in searching.

Category 5: The PE is the operator action. There are some PEs in the functional fault tree that are failures of the operator to take some action (e.g., "Operator fails to actuate nitrogen backup").

Step 2 of the search (as shown in Figure 2.4.1) was to identify, for the Category 1 PEs, the stimuli and human actions that could cause the PE.

Step 3 of the search was a determination of the expected operator response(s) to the PE (fault) occurring based upon a review of the appropriate plant procedures.*

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* Note: For Category 4 PEs, no operator response is shown. To find the human actions associated with Category 4 PEs, refer to the system associated with the PE (e.g., for EPI22-01 refer to the Electrical Power System).

Appendix D of this report provides the results of these first three steps for all the PEs of the functional fault trees.

Step 4 of the search was a further screening of the Category 1 PEs to identify "candidate induced human system interactions" (CIHSIs). The screening criteria used for this step were the following:

A. Do two or more Category 1 PEs have the same stimulus?

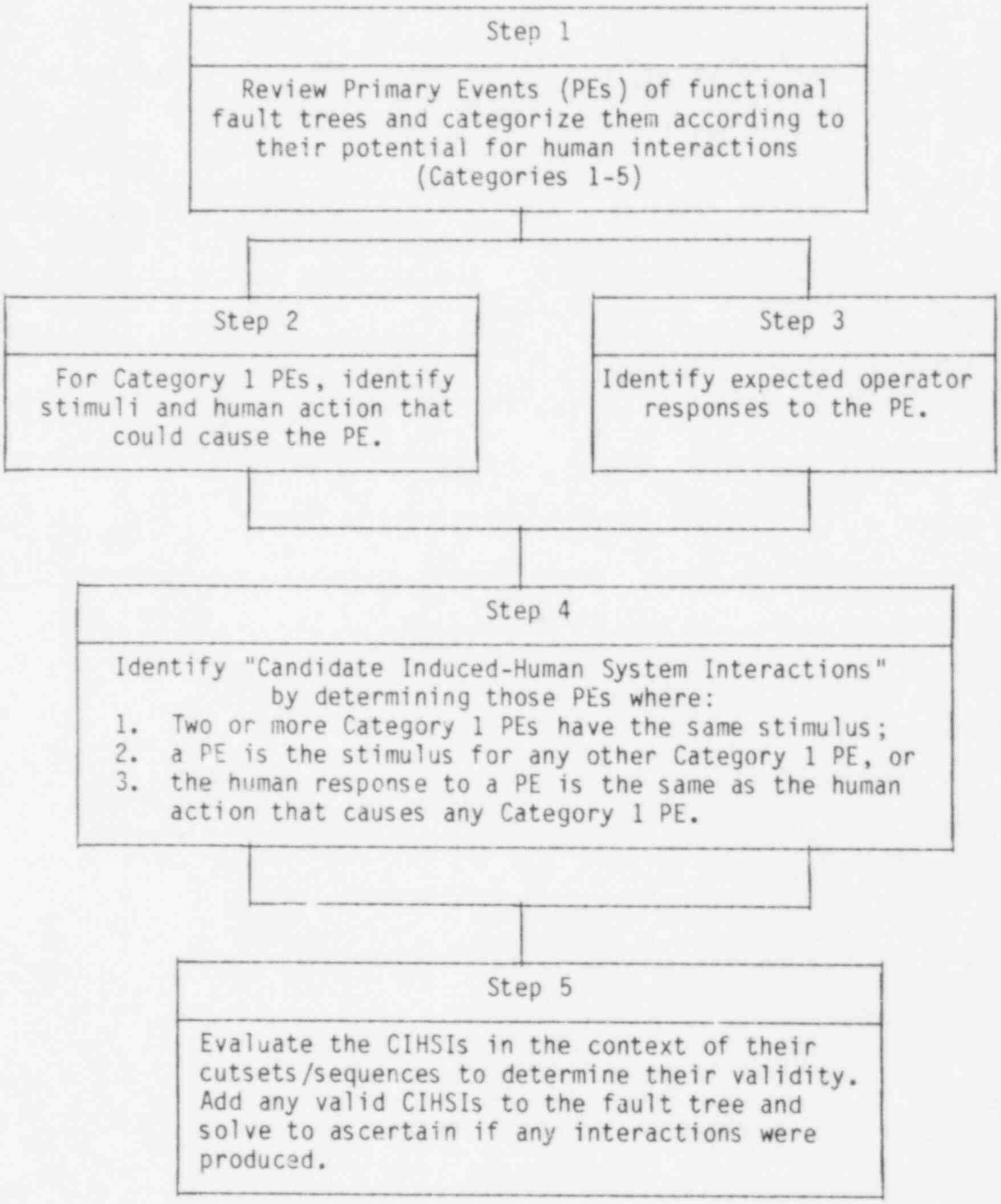
B. Is any PE the stimulus for any other Category 1 PE?

C. Is the human response to any PE the same as the human action that causes the Category 1 PE?

Table 2.4.1 shows the Category 1 PEs that met any of these three screening criteria and were thus identified as CIHSIs.

Step 5 of the search was to consider whether any of the CIHSIs credibly leads to a reduction in the order of any functional cutset.

This was accomplished by first reviewing the CIHSIs from Table 2.4.1 in the context of their respective cutsets, in order to identify whether the CIHSI would be valid under the given combinations of plant conditions (e.g., an operator might be induced to secure one train of a redundant system except when the other train is out of service). Any CIHSIs emerging as valid would have been added to the appropriate fault trees, and the effect on the cutsets would have been studied. This latter step was not performed, as none of the items in Table 2.4.1 was found to be valid in the context of its cutsets.



Step 1

Review Primary Events (PEs) of functional fault trees and categorize them according to their potential for human interactions (Categories 1-5)

Step 2

For Category 1 PEs, identify stimuli and human action that could cause the PE.

Step 3

Identify expected operator responses to the PE.

Step 4

Identify "Candidate Induced-Human System Interactions" by determining those PEs where:

1. Two or more Category 1 PEs have the same stimulus;
2. a PE is the stimulus for any other Category 1 PE, or
3. the human response to a PE is the same as the human action that causes any Category 1 PE.

Step 5

Evaluate the CIHSIs in the context of their cutsets/sequences to determine their validity. Add any valid CIHSIs to the fault tree and solve to ascertain if any interactions were produced.

Figure 2.4.1 Summary of induced human system interactions method.

Table 2.4.1 Candidate Induced Human System Interactions

PE DESIGNATOR	PE DESCRIPTOR	SCREENING CRITERIA MET			COMMENTS
		A	B	C	
AFO12-A-INT	Internal failure of Segment 12 FC	✓			A faulty high flow indication to SG 33 (FT 1202) may be diagnosed by the operator as a pipe break downstream of the flow element This would cause tne operator to close FCV-405C and FCV-406C. (Ref: PEP-FW-1 and ONOP-ES-1.)
AFO19-A-INT	Internal failure of Segment 19 FC	✓			
AFO13-A-INT	Internal failure of Segment 13 FC	✓			Same as above for SG 34 (FT 1203). This would cause the operator to close FCV-405D and FCV-406D.
AFO18-A-INT	Internal failure of Segment 18 FC	✓			
AFO14-A-INT	Internal failure of 14 FC	✓			Same as above for SG 32 (FT 1201). This would cause the operator to close FCV-405B and -406B.
AFO17-A-INT	Internal failure of Segment 17C	✓			
AFO15-A-INT	Internal failure of Segment 15C	✓			Same as above for SG 31 (FT 1200. This would cause the operator to close FCV-405A and -406A.
AFO16-A-INT	Internal failure of Segment 16A	✓			
AFO12-B-INT	Failure of FCV-406C		✓		A loss of power to instrument bus 34 (PE EPI24-01) will cause FT 1202 (SG 33 flow indication) to fail low. In response to this indication, the operator may open FCV-406C fully, causing pump runout.

Table 2.4.1 (Continued)

PE DESIGNATOR	PE DESCRIPTOR	SCREENING CRITERIA MET			COMMENTS
		A	B	C	
AFO13-B-INT	Failure of FCV-406D		✓		Same as above except loss of power to instrument bus 31 (PE EPI21-01) will cause FT 1203 (SG 34 flow indication) to fail low. Operator will open FCV-406D.
AFO14-B-INT	Failure of FCV-406B FO		✓		Same as AFO12-B-INT except loss of power to instrument bus 33 (PE EPI23-01) will cause FT 1201 (SG 32 flow indication) to fail low. Operator will open FCV-406B.
AFO15-B-INT	Failure of FCV-406A FO		✓		Same as AFO12-B-INT except loss of power to instrument bus 32 (PE EPI22-01) will cause FT 1200 (SG 31 flow indication) to fail low. Operator will open FCV-406A.
CD-7B-A	NOIF from FCV-1120		✓		A loss of power to FT 1113 (gland steam condenser flow transmitter) will result in a gland steam condenser low flow alarm. This alarm would induce the operator to throttle down FCV-1120 to restore gland steam condenser flow. This action may result in no or insufficient flow from FCV-1120. (NOTE: The power source to FT 1113 was not determined from the information available.)

References for Section 2

1. A. Buslik, I. Papazoglou, and R. A. Bari, Review and Evaluation of Systems Interactions Methods, NUREG/CR-1901, 1981.

2. Indian Point Probabilistic Safety Study, Power Authority of the State of New York, Consolidated Edison Company of New York, Inc., 1982.

3. Power Authority of the State of New York-Indian Point 3 Systems Interaction Study, Ebasco Services, Inc., 1981.

4. D. D. Carlson et al., Interim Reliability Evaluation Program Procedures Guide, NUREG/CR-1728, July 1982.

5. Review of the Indian Point Station Fire Protection Program, Consolidated Edison Company of New York and Power Authority of the State of New York, December 1976.

6. G. J. Boyd, W. R. Cramond, S. W. Hatch, J. W. Hickman, A. M. Kolaczkowski, and D. W. Stack, Final Report-Phase 1, Systems Interaction Methodology Applications Program, NUREG/CR-1321, 1980.

3. FINDINGS

In the course of this project, a logical model was constructed which gives system failure modes for certain top events. This list of failure combinations is intended to be exhaustive (for the types of failures considered) for one- and two-element cutsets. One now asks about their significance: which of them, if any, represents a "discovered systems interaction," and what is the probabilistic significance, if any? The next subsection (3.1) discusses the notion of systems interaction, and in Subsection 3.2, "discovered systems interactions" are quantified.

3.1 Definition of Systems Interactions

This section considers definitions of "Systems Interactions." The language appearing in the following definitions is taken from earlier BNL work[1] and from a recent Task Action Plan for USI A-17 (January 1984).[2] These definitions broadly governed the scope of the project as a whole. This section culminates in Table 3.1.1, which qualitatively indicates, for the systems and sequences analyzed, what sort of cutset would be considered to represent an SI at Indian Point 3.

A formal definition of system interaction (SI) can be given as follows:

An SI exists if two or more faults (in the same system or in distinct systems, these being associated with vital safety criteria) are dependent, and the dependence was not intended in the design.

An example may serve to illustrate why intent is invoked, and what other considerations might substitute for it. Consider the case of the RWST supplying water to three HPI pumps through a single line containing one or more supposedly open valves. Plugging of these valves will fail the HPI, but this is not an SI, because the designer was aware of it and, presumably, considered the plugging event to be a low probability one. "Intent," therefore, becomes involved because it is necessary to discriminate against trivial SIs.

More concretely, an SI is an undesirable result deriving from a single credible failure within one system, component, or structure, which propagates to other systems, components, or structures by inconspicuous or unanticipated

Table 3.1.1 Sequence-Specific Characterization of Systems Interaction

Event (Refer to Table 2.2.1)	Design-Intended Leading Cutsets	Examples of SI
L	a*a*a	a*a
T*L	a*a*a*a	a*a p*a p*a*a a*a*a
U_{small} LOCA	a*a*a p	a*a
U_{medium} LOCA	a*a p	a
D	a*a p	a
S_2(P)	p a*a*a a*a*O	a*a
S_2(Q)	a*a p	a
S_2(P)*U	p*a*a*a	a*a a*a*a

Key: a = active failure
p = passive failure
o = operator act
a*a = cutset consisting of two active failures
p*a = cutset consisting of one passive and one active failure

interdependences. "Undesirable results" of particular significance for this study are the following:

1. Degradation of redundant portions of a safety system, including consideration of all auxiliary support functions. Redundant portions are those considered to be independent in the design and analysis (FSAR, chapter 15) of the plant.
2. Degradation of a safety system by a non-safety system.
3. Initiation of an accident (e.g., LOCA) <u>AND</u>

   a) the degradation of at least one redundant portion of any one of the safety systems required to mitigate that event,

   <u>or</u>

   b) degradation of critical operator information sufficient to cause him to perform unanalyzed, unassumed, or incorrect action.
4. Initiation of a transient (including reactor trip) <u>AND</u>

   a) degradation of at least one redundant portion of any one of the safety systems required to mitigate the event,

   <u>or</u>

   b) degradation of critical operator information sufficient to cause him to perform unanalyzed, unassumed, or incorrect action.

From the language of the foregoing ("intended in the design," "unanticipated interdependences"), it is clear that the notion of design intent is involved. In some areas, assessment of design intent is less straightforward than might be supposed. Demonstrating that a system will succeed in spite of an assumed single active failure does <u>not</u> imply that the designer was content simply to make the system single-failure-proof. Thus, while Chapter 15 analyses are generally required to postulate certain failures, these cannot be assumed to define the intended level of redundancy, which is frequently higher than one might conclude from such a conservative approach.

In this study, success criteria for frontline systems have been taken to be those used in the IPPSS. For a specific scenario, then, a flow requirement is defined; considering the pumps which are available and their capacities, one arrives at a measure of how many independent active failures the system was intended to withstand. For example, consider the HPI system given a medium LOCA. The HPI system has three pumps; two are required to operate to mitigate a medium LOCA. Therefore, two pump failures imply HPI failure, but one pump failure does not (indeed, by the single failure criterion, cannot). The design intent which pertains to HPI for medium LOCA is therefore essentially the single-failure criterion. For small LOCA, however, one out of three pumps is enough. In this study, then, any two-element cutset for HPI corresponds to a systems interaction.

The case of RCP LOCAs calls for additional discussion. The event analyzed here is failure of systems providing cooling to the RCP seals. One question is, what is the intended level of redundancy of the supports? Briefly, the argument is as follows. The two direct support systems are the charging system which provides seal injection flow, and the component cooling system which provides cooling to the RCP thermal barriers and to the charging pumps. It can be assumed that both the thermal barrier cooling and the seal injection must be lost to cause a seal LOCA. However, because the charging pumps depend on CCW, they can arguably be eliminated from counting towards the "intended" redundancy. (City water can cool the charging pumps in lieu of CCW, but this requires a manual act outside the control room.) Here, then, the criterion for RCP is taken to be that applied to CCW. The CCW system has three pumps; two are sufficient for any scenario, and one is sufficient for critical loads under some conditions if the operator eliminates nonessential loads in order to direct the single pump's flow to where it is most needed. "RCP Seal Failure" is therefore either three active pump failures, or two active pump failures and one active operator failure. An adverse SI for the top event "seal LOCA" is therefore a double active failure which fails CCW or a single active failure which fails more than one pump's worth.

Linkage between initiating event and mitigating system is of special importance, as mentioned above in examples of SIs. Since HPI is required to mitigate an RCP seal LOCA, any linkage between the seal system and HPI is of potential interest. It was indicated above that the design intent for HPI, given small LOCA, corresponds to triple redundancy and that the design intent for RCP seals would be taken to correspond to triple redundancy; the design intent for the core damage sequence "RCP seal LOCA and HPI failure" might therefore be argued to correspond to sixfold redundancy. This is excessive, because the emergency ac power system is itself a three-train system supporting both HPI and CCW. Here, one comes up against an example of the "inconspicuous" and "unanticipated" provisions in the definition of SI. It is clear that two active failures (for the sequence RCP and HPI) would surely correspond to an SI, and a sequence consisting of three active failures would also qualify because the initiating event is included. Since this exhausts the scope of the present study, we need not carry the argument further.

3.2 Functionally Coupled Systems Interactions

This section presents cutsets which meet the following criteria:

1. They meet the criteria given in Section 3.1 for SIs.
2. They have two or fewer events.
3. They were not found by the IPPSS.
4. They contribute to the top event at a level greater than the cutoff chosen, which was a system unavailability of 10^{-8} or a sequence frequency of 10^{-8}/yr, depending on the particular top event being evaluated.

This quantification has been performed in order to provide some perspective on the cutsets. This project has not been carried out with any intention of requantifying the top events defined in the IPPSS; qualitative insights have been sought, and found, and the present exercise is simply a final culling process, assigning a rough measure of significance to the cutsets. A complete list of the cutsets for each system/sequence is provided in Appendix C.

Table 3.2.1 displays the events which appear in those cutsets which

Table 3.2.1 Primary Event Quantification

Event	Description	Failure Rate λ or Probability of Failure on Demand	Source	Mission Time T (hours)	Q (Unavailability)
AFBLKG-BFD67	Backleakage of BFD67 and other check valves in discharge.	2.6E-7/hr	IPPSS	245	6.2E-5
AFBLKG-BFD68	Backleakage of BFD68 and other check valves in discharge.	2.6E-7/hr	IPPSS		6.3E-5
AFBLKG-BFD69	Backleakage of BFD69 and other check valves in discharge.	2.6E-7/hr	IPPSS		6.3E-5
AFBLKG-BFD70	Backleakage of BFD70 and other check valves in discharge.	2.6E-7/hr	IPPSS		6.3E-5
AFSEG4-6-8-NOA	Failure of operator to align CW at AFW pump.	7.E-3/D	IPPSS		7.E-3
AF001-A-INT	CT64 fails closed.	9.2E-8/hr	IPPSS	258	2.4E-5
AF010-A-INT	Motor-driven AFW pump 31 failure.	1.51E-3/D	IPPSS		1.51E-3
AF011-A-H	Operator fails to bring AFW pump 32 up to speed.	7.E-3/D	IPPSS		7.E-3
AF011-A-INT	AFW pump 32 failure.	4.61E-3/D	IPPSS		4.61E-3
AF014-A-INT	Failure of flow path from AFW pump 31 to SG32.	7.3E-4/D	IPPSS		7.3E-4
AF015-A-INT	Failure of flow path from AFW pump 31 to SG31.	7.3E-4/D	IPPSS		7.3E-4
AF024-A-INT	AFWS injection line fails to supply water to SG32.	7.1E-5/D	IPPSS		7.1E-5
AF025-A-INT	AFWS injection line fails to supply water to SG 31.	7.1E-5/D	IPPSS		7.1E-5

Table 3.2.1 (Continued)

Event	Description	Failure Rate λ or Probability of Failure on Demand	Source	Mission Time T (hours)	Q (Unavailability)
CC015-A-INT	HPI pump 31 oil or seal Hx failure.	3×10^{-5}/hr	IPPSS + NUREG/CR-2815	720	1.1E-2
CC018-A-INT	Manual valve 787 fails closed.	9.3×10^{-8}/hr	IPPSS	720	3.3E-5
CS015-A-INT	Segment 5 internal failure.	9.2×10^{-8}/hr	IPPSS	258	2.4E-5
CW002-A-INT	Internal failure of CT-49 segment.	9.2×10^{-8}/hr	IPPSS	1.75×10^{5}	1.6E-2
EPA-LATE-LOOP	LOOP during mitigation (within 8 hrs of initiator).	3.1E-5/hr	IPPSS	8	2.5E-4
SPA-TR-IN-LOOP	Transient-induced LOOP.	3.41E-4/D	IPPSS (P.1.6-217)		3.41E-4
EPA08-INT-F	Local fault in DG31.	1.44E-2/D FTS 9.4E-4/hr FTR	IPPSS	8	2.2E-2
EPA16-S-F	Local fault of tie breaker 2AT3A.	1.33E-3/D	IPPSS		1.33E-3
EPD03-02-F	Local fault at dc power panel 33.	3.25E-8/hr (2.8E-4/yr)	IPPSS		2.8E-4
EPD02-02-F	Local fault at dc power panel 32.	3.25E-8/hr	IPPSS		2.6E-4

Table 3.2.1 (Continued)

Event	Description	Failure Rate λ or Probability of Failure on Demand	Source	Mission time T (hours)	Q (Unavailability)
EPD12-F	Failure of battery 32.	1.1E-3/D	NUREG		1.1E-3
EPD13-F	Failure of battery 33.	1.1E-3/D	NUREG		1.1E-3
EPD3132-U-F	Fault in dc power panels 31 & 32 associated with tie breaker.	6.0E-5/yr	NUREG		6E-5
EPI21-15-F	Local fault in inverter 31 or cable.	3.77E-6/hr		8	3E-5
HP002-A-INT	HPI pump 32 internal failure.	2.3E-3/D	IPPSS		2.3E-3
HP007A-C-INT	Leakage past NC MOV 1852A.	9.87E-8/hr	IPPSS	720	3.5E-5
HP007B-C-INT	Leakage past NC MOV 1852B.	9.87E-8/hr	IPPSS	720	3.5E-5
HP0079-A-INT	Internal failure segment 7E (plugging) (2 sections).	8.6E-9/hr Each Section	IPPSS	1.3×10^{-4}	1.1E-4
HP007F-A-INT	Valve 1846 opens, diverts flow to CVCS hold-up tanks.	2.0E-8/hr.	IPPSS	1.5	1.5E-8
HP011A-A-INT	No valve 1862 or MOV 842 or MOV 843 fails closed.	9.2E-8/hr Each Valve	IPPSS	360	9.9E-5
LP016-A	RHR min flow line plugged MOV 1873 or 743 PC.	9.15E-8/hr Each Valve		720	6.6E-5
SE-52-EG1-INT	Local fault of DG31 breaker actuation scheme.	1.33 E-3/D	IPPSS		1.33E-3

Table 3.2.1 (Continued)

Event	Description	Failure Rate λ or Probability of Failure on Demand	Source	Mission time T (hours)	Q (Unavailability)
SWN2-A-CONT	SW pump 35 fails to restart.	1.36E-3/D	IPPSS		1.36E-3
SWN2-A-INT-F	Failures in NSW pump 35 segment.	4.68E-5/hr	IPPSS	8	3.75E-4
SWN3-A-INT-F	Failures in NSW pump 34 segment.	4.68E-5/hr	IPPSS	8	3.75E-4

survive the culling process. For purposes of comparison between LLNL and BNL, it was agreed to use IPPSS failure data wherever these were available and applicable.

3.2.1 Qualitative Insights Regarding Discovered Functional SIs

Qualitative Insight

Understanding the cutsets is much easier if a few key points are made clear. These are presented here. Each sequence is then discussed separately.

The nomenclature applied to the events and logic gates within the BNL model is not that used in the IPPSS. The present methodology requires that the level of resolution be as coarse as possible while displaying all support linkages. The IPPSS resolution tended to be finer, and the IPPSS did not cover exactly the same ground as this study. It was, therefore, decided to create an independent nomenclature that would be self-consistent, would be directed toward the search for system linkages, and would provide the flexibility of coding more information into the event names as the need arose. Event names are restricted to 16 characters by the SETS code. Appendix B provides the listing of all primary events and their definitions.

Dc Control Power (Battery 32)

There is an important functional coupling between redundant trains of various systems taking power from 480-V buses 3A and 6A. The coupling is most telling in the medium LOCA sequence, wherein it leads to a single active failure mode for LPI; but it affects the cutsets of other sequences as well.

Refer to Figure 3.2.1. Most of the present discussion revolves around the availability of ac to 480-V bus 3A. One sees that 3A is supplied from 6.9-kV bus 3. Ordinarily, power to bus 3 is coming from the unit auxiliary transformer, but following a turbine trip, a fast transfer should be made so that power to bus 3 comes from bus 6. If power to 3A is unavailable from bus 3, then 3A can receive power from 2A if breaker 2AT3A closes. However, this happens automatically only if 2A also loses offsite power and after diesel generator 31 closes on 2A. If 3A loses offsite power and 2A does not, 3A remains deenergized until an operator closes 2AT3A. One way to lose offsite power to 3A is by a failure of bus 3 fast transfer following a turbine trip.

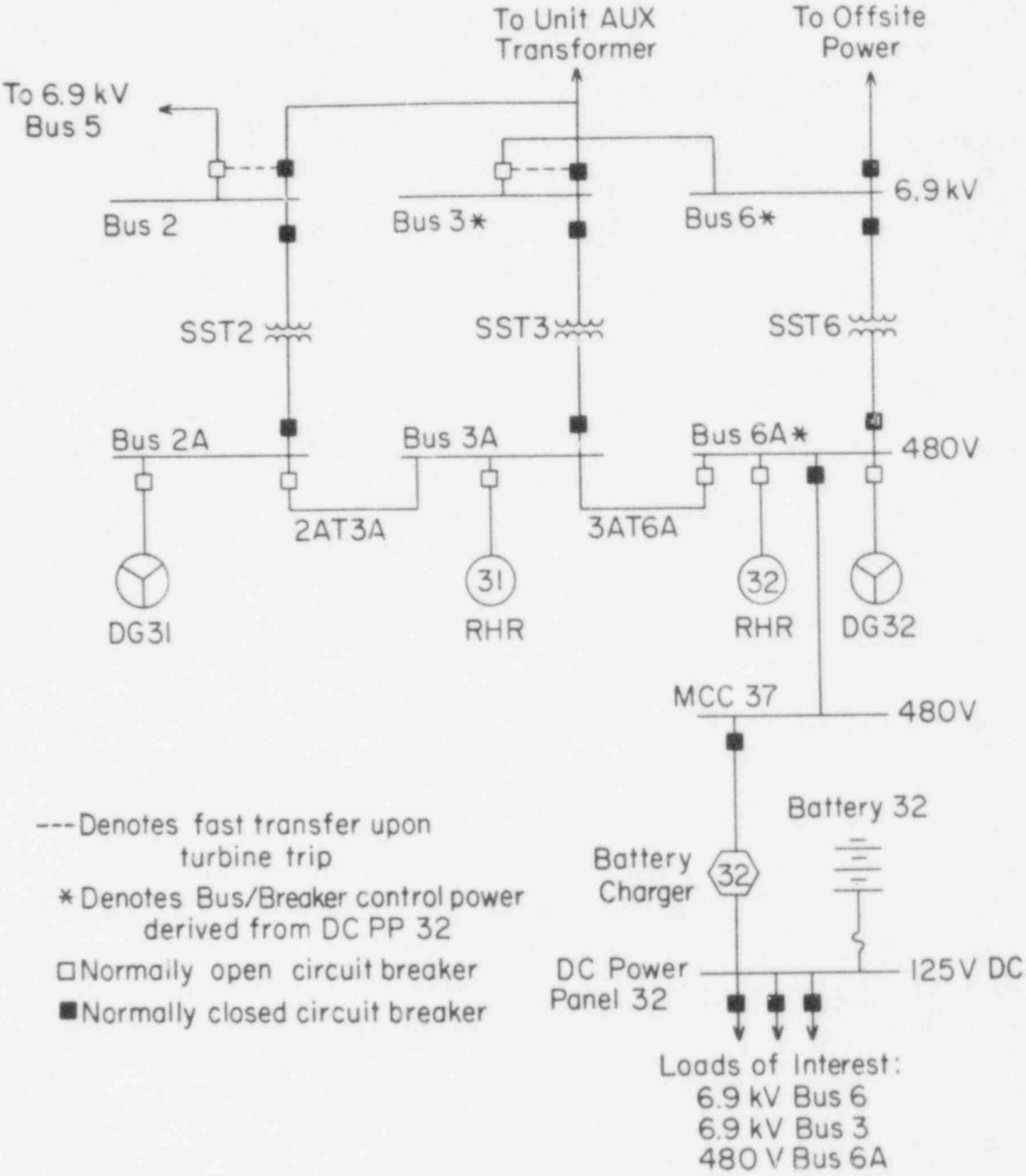


Figure 3.2.1 Selected portions of IP-3 electrical power system.

Next, consider the causes of failure of bus 3 fast transfer. Clearly, breakers could be involved, but for present purposes, the important failure mode is unavailability of dc. The dc power controlling the fast transfer of bus 3 is derived from dc bus 32, which also serves 480-V bus 6A.

Finally, consider the sources of power to dc bus 32. One source, of course, is its battery. Another is bus 6A via MCC 37. However, whenever an SI signal is present, MCC 37 is shed from 6A, and dc bus 32 is powered only by its battery. Given an SI, then dc battery 32 is responsible for controlling loads on 480-V bus 6A, and for fast transfer of bus 3 supplying offsite power to 3A. The SI signal directly (immediately) causes the shedding of dc bus 32 via MCC 37 and indirectly initiates fast transfer (30-second time delay for turbine trip following reactor trip), so that fast transfer following an SI depends on the battery.

Now let us assemble this chain of events for a particular case, namely, large or medium LOCA. Assume that dc battery 32 is unavailable upon demand. An SI signal is generated, whereupon dc bus 32 is shed from 6A. Without dc control power, the LPI pump which ought to be picked up by 6A will not start. The fast transfer of bus 3 (delayed by design for 30 seconds) will not take place, leaving 3A without offsite power. Since 2A is unaffected, 3A will not automatically receive onsite power so the other LPI pump, which ought to be picked up by 3A, will not function.

Therefore, battery 32 is a single failure for large or medium LOCA. However, the effects are also significant in other sequences. The bottom line is that two supposedly independent 480-V buses are affected; LPI is special in that its two trains are powered by these buses, but it is clear that other systems are affected.

Service Water to Diesels

In this model, two out of three service water pumps are required for system success. This means that failure of two diesels in a LOOP sequence causes failure of the third diesel, because one diesel powering one service water pump is not considered a success state. (There is insufficient service water flow to the diesel.) Many of the cutsets in the appendices reflect this logic. Note that events other than TR-LOOP, EPA-TR-IN-LOOP, and EPA-LATE-LOOP cause loss of normal power to one or more 480-V buses, so that this coupling affects scenarios other than obvious cases of LOOP.

Service Water Cooling of CCW Heat Exchanges

The present model considers loss of conventional service water to imply a failure of component cooling. Ultimately, this is correct, but for short-time scenarios, it is likely to be a substantial conservatism. As an alternative to development of different logic for long and short terms, however, this conservatism was left in place, with the attitude that manifestly conservative cutsets would not be taken at face value. This comment applies to spurious SI scenarios or LOOP scenarios, which interrupt conventional service water and thereby deprive CCW of a heat sink until operator action is taken to restore it. Note that operators, in this study, are assumed to take proper action unless instrumentation faults mislead them.

3.2.2 Quantification of Discovered Functional Systems Interactions

Cutsets are presented and quantified for each top event considered which yielded cutsets meeting the criteria spelled out at the beginning of Section 3.2.

3.2.2.1 Auxiliary Feedwater System (Event L)

Cutsets are shown in Table 3.2.2. Note that wherever EPD12-F appears, the effect discussed above under "Dc Control Power (Battery 32)" is being manifested. (The cutsets shown here are for the case of a LOCA, i.e., an SI signal is present, for some purposes.) The events appearing in conjunction with EPD12-F cause failure of the turbine-driven pump. Other cutsets are failures of suction to the AFWS pumps.

3.2.2.2 Transient and Loss of Auxiliary Feedwater (Event T*L)

Cutsets are shown in Table 3.2.3. Again, many of the cutsets are related to the discussion of "Dc Control Power (Battery 32)." Here, however, the battery itself is not displayed explicitly. [In transient cases (except LOOP) there is no signal to shed MCC 37 and thereby deprive dc bus 32 of its normal

Table 3.2.2 Quantified Cutsets - S_2L Sequence

S_2 = 1.11E-2/yr

	Cutset	Cutset Quantification	Contribution to AFWS Unavailability (Event L)	Events/yr
(1)	AF011-A-H * EPD12-F	(7.0E-3)*(1.1E-3)	7.7E-6	8.55E-8
(2)	AF011-A-INT * EPD12-F	(4.6E-3)*(1.1E-3)	5.1E-6	5.7E-8
(3)	CS015-A-INT * CW002-A-INT	(2.36E-5)*(1.6E-2)	3.8E-7	4.22E-9
(4)	AF001-A-INT * CW002-A-INT	(2.36E-5)*(1.6E-2)	3.8E-7	4.22E-9
(5)	AFSEG4-6-8-NOA * CS015-A-INT	(7.0E-3)*(2.36E-5)	1.7E-7	1.9E-9
(6)	AF001-A-INT * AFSEG4-6-8-NOA	(2.4E-5)*(7.0E-3)	1.7E-7	1.9E-9
(7)	AFBLKG-BFD67 * EPD12-F	(6.3E-5)*(1.1E-3)	6.9E-8	7.66E-10
(8)	AFBLKG-BFD68 * EPD12-F	(6.3E-5)*(1.1E-3)	6.9E-8	7.66E-10
(9)	AFBLKG-BFD69 * EPD12-F	(6.3E-5)*(1.1E-3)	6.9E-8	7.66E-10
(10)	AFBLKG-BFD70 * EPD12-F	(6.3E-5)*(1.1E-3)	6.9E-8	7.66E-10
(11)	EPI21-15-F * EPD12-F	(3.0E-5)*(1.1E-3)	3.3E-8	3.66E-10

Table 3.2.3 Quantified Cutsets - T*L Sequence

	Initiating Event	Enabling Event	Sequence Frequency (Events/yr)
(1)	EPD02-02-F	AF011-A-H	(2.8E-4/yr)*(7.0E-3) = 2.0E-6
(2)	EPD02-02-F	AF011-A-INT	(2.8E-4/yr)*(4.6E-3) = 1.3E-6
(3)	EPD3132-U-F	EPA08-INT-F	(6.0E-5/yr)*(2.2E-2) = 1.3E-6
(4)	EPD3132-U-F	AF010-A-INT	(6.0E-5/yr)*(1.5E-3) = 9.0E-8
(5)	EPD3132-U-F	SWN2-A-CONT	(6.0E-5/yr)*(1.4E-3) = 8.4E-8
(6)	EPD3132-U-F	EPA16-S-F	(6.0E-5/yr)*(1.33E-3) = 8.0E-8
(7)	EPD3132-U-F	SE-52-EG1-INT	(6.0E-5/yr)*(1.3E-3) = 8.0E-8
(8)	EPD3132-U-F	EPD13-F	(6.0E-5/yr)*(1.1E-3) = 6.6E-8
(9)	EPD3132-U-F	AF014-A-INT	(6.0E-5/yr)*(7.3E-4) = 4.4E-8
(10)	EPD3132-U-F	AF015-A-INT	(6.0E-5/yr)*(7.3E-4) = 4.4E-8
(11)	EPD3132-U-F	SWN3-A-INT-F	(6.0E-5/yr)*(3.7E-4) = 2.2E-8
(12)	EPD3132-U-F	SWN2-A-INT-F	(6.0E-5/yr)*(3.7E-4) = 2.2E-8
(13)	EPD3132-U-F	EPA-TR-IN-LOOP	(6.0E-5/yr)*(3.41E-4) = 2.0E-8
(14)	EPD02-02-F	AFBLKG-BFD67	(2.8E-4/yr)*(6.3E-5) = 1.8E-8
(15)	EPD02-02-F	AFBLKG-BFD68	(2.8E-4/yr)*(6.3E-5) = 1.8E-8
(16)	EPD02-02-F	AFBLKG-BFD69	(2.8E-4/yr)*(6.3E-5) = 1.8E-8
(17)	EDP02-02-F	AFBLKG-BFD70	(2.8E-4/yr)*(6.3E-5) = 1.8E-8
(18)	EDP3132-U-F	EPA-LATE-LOOP	(6.0E-5/yr)*(2.5E-4) = 1.5E-8

source of power without an additional failure. Further, it has been assumed that the dc bus functions normally even with no battery connected. Therefore, battery failures do not show up in leading order cutsets for transient sequences.] Rather, a fault of the associated dc bus occurs, causing a transient (as modeled here) and then going on to have the additional effects previously discussed.

The other initiating event showing up on Table 3.2.3 is EPD3132-U-F, which represents a fault of both dc bus 31 and dc bus 32. A single tie breaker links these buses. It is not clear that any event which would be considered a single failure would lead to faulting of both buses (barring some external influence), and display of this event in a cutset is not intended to imply otherwise. Rather, the existence of a suggested frequency for the event "loss of two dc buses linked by a single breaker" indicated that it was appropriate to model the event in this way. The effect of the event includes some of the effects discussed under "Dc Control Power (Battery 32)" but with some important differences. Loss of dc bus 32 fails fast transfer of bus 3 as noted previously. Loss of dc bus 31 fails fast transfer of bus 2. This leads to a loss of offsite power to 480-V buses 2A and 3A, which signals the DG supplying 2A to start and pick up 2A and 3A. (Recall that the loss of dc bus 32 alone, which loses offsite power to 480-V bus 3A, does not call for automatic restoration of power to bus 3A.) The events seen here in conjunction with EPD3132-U-F are, accordingly, failure of the AFW pump on 480-V bus 3A, or failure to supply diesel power to 3A via 2A, including a variety of breaker faults, diesel faults, or service water faults, or failure of one of the two flow paths leading from this AFW pump. EPD3132-U-F fails the turbine-driven pump by failing instrument bus 31.

3.2.2.3 Failure of HPI Given Small LOCA (Event S_2*U)

Cutsets shown on Table 3.2.4 are failure of all miniflow protection, failure of CCW cooling to the HPI pumps, and failure of cooling to two HPI pumps in conjunction with failure of the third pump itself.

Table 3.2.4 Quantified Cutsets - S_2U Sequence
S_2 = 1.1E-2/yr

Cutset	Cutset Quantification	Contribution to HPI Un-Availability (Event U)	Events/yr
HP011A-A-INT	9.9E-5	9.9E-5	1.09E-6
CC015-A-INT*CC018-A-INT	(1.08E-2)*(3.3E-5)	3.6E-7	4.0E-9
CC018-A-INT*HP002-A-INT	(3.3E-5)*(2.3E-3)	7.6E-8	8.4E-10

Table 3.2.5 Quantified Cutsets - S_1U Sequence
S_1 = 1.17E-4/yr

	Cutset	Contribution to HPI Unavailability (Event U)	Events/Yr
(1)	HP007E-A-INT	1.1E-4	1.3E-8
(2)	HP007B-C-INT	3.5E-5	4.1E-9
(3)	HP007A-C-INT	3.5E-5	4.1E-9
(4)	CC018-A-INT	3.3E-5	3.9E-9
(5)	HP007F-A-INT	1.5E-8	1.8E-12

3.2.2.4 Failure of HPI Given Medium LOCA (Event S_1*U)

The cutsets shown here (Table 3.2.5) all have the property of failing all flow through one of the two injection lines (lines 16 and 56). One of these events (CC018-A-INT) accomplishes this by failing two pumps directly; the others fail the BIT injection line.

3.2.2.5 Failure of LPI in Conjunction With Medium LOCA

One of these cutsets (Table 3.2.6) has previously been discussed in Section 3.2 under "Dc Control Power (Battery 32)." The other is failure of minimum flow protection for the LPI pumps. This is expected to apply when, and only when, depressurization of the RCS is slow enough for the LPI pumps to need this protection. Such events may be only a subset of all "Medium LOCA" events.

3.2.2.6 Transient-Induced RCP Seal Failure [Event S_2(P)]

Treatment of this event in this study differs from the treatment of other events. The RCP seals are protected by two normally operating support systems. "Long-term" failure of both of these is assumed to lead to seal failure, where "long term" probably means on the order of half an hour or more. At IP-3, there are certain transient conditions under which these support systems are interrupted or degraded by design, and are to be restored by operator action. Human error would appear to be an important topic in this area, but was specifically excluded from this project.

Here, the event has been modeled initially with no credit for operator action. The resulting cutsets are, for the most part, overconservative in that they ignore the plant's design basis which clearly takes credit for operator action in this area. These cutsets are given in Appendix C. They were then examined for recovery potential, resulting in a much shorter list of cutsets not clearly within the operator's ability to recover.

Finally, these were measured by the criteria given at the beginning of Section 3.2, and only the two shown on Table 3.2.7 remain. These are loss of multiple dc buses and loss of offsite power, either transient induced or within 8 hours. It is reemphasized that there may be numerous events involving human error which would probabilistically dominate these, but which have not been explored.

3.2.2.7 Transient-Induced RCP Seal LOCA and Failure of Auxiliary Feedwater [Event $S_2(P)*L$]

It suffices to note that the two cutsets shown on Table 3.2.8 show up separately as cutsets of T*L (Table 3.2.3) and $S_2(P)$ (Table 3.2.7).

3.2.2.8 Transient-Induced RCP Seal LOCA and Failure of HPI [Event $S_2(P)*U$]

The two cutsets shown on Table 3.2.9 are, as previously noted, cutsets of event $S_2(P)$. They do not show up in Table 3.2.4 for S_2U because the independent simultaneous occurrence of EPD3132-U-F and a small LOCA is extremely unlikely. They show up here because EPD3132-U-F is modeled as (in part) causing the small LOCA.

3.3 Findings of Search for Candidate Spatial Couplings

The fire zones defined in the IP-3 Fire Hazards Analysis in Section 2 have been adopted here as defining discrete locations within the plant for purposes of a screening analysis. As per Section 2, certain assumptions have been made concerning which components will fail and how they will fail. Here, for each top event considered, tables are provided giving those zones which individually contain enough vulnerable components that the top event can potentially be caused from within the zone in question. For most cases, this will be conservative; the purpose of such an analysis is screening, as described in Section 2.

Appendix F provides a listing of the zones which were found to contain or affect major components addressed in this study. Of course, a given major component will reside only in one zone, but power and control cables may pass through a number of zones, and an attempt has been made here to collect as much of this information as was made available. In Appendix F, for the table entry corresponding to (say) component A in zone N, an X means that some power or control cable of A passes through N, while X* means that A itself is located in N.

Table 3.2.6 Quantified Cutsets - S_1D Sequence

S_1 = 1.17E-4/yr

Cutset	Contribution to HPI Unavailability (Event D)	Events/yr
EPD12-F	1.1E-3	1.3E-7
LPO16-A	6.7E-5	7.8E-9

Table 3.2.7 Quantified Cutsets - $S_2(P)$ Sequence

Cutset	Quantification	Events/yr
EPD3132-U-F * EPA-TR-IN-LOOP	(6.E-5/yr)*(3.4E-4)	2.0E-8
EPD3132-U-F * EPA-LATE-LOOP	(6.E-5/yr)*(2.5E-4)	1.5E-8

Table 3.2.8 Quantified Cutsets - $S_2(P)*L$ Sequence

Cutset	Quantification	Events/yr
EPD3132-U-F * EPA-TR-IN-LOOP	(6.E-5/yr)*(3.4E-4)	2.0E-8
EPD3132-U-F * EPA-LATE-LOOP	(6.E-5/yr)*(2.5E-4)	1.5E-8

Table 3.2.9 Quantified Cutsets - $S_2(P)*U$ Sequence

Cutset	Quantification	Events/yr
EPD3132-U-F * EPA-TR-IN-LOOP	(6.E-5/yr)*(3.4E-4)	2.0E-8
EPD3132-U-F * EPA-LATE-LOOP	(6.E-5/yr)*(2.5E-4)	1.5E-8

Table 3.3.1 provides a list of zones capable of "causing" each top event as described above. In Table 3.3.2, for each zone, an explanation is given of how this zone might cause the top event in question. Note that these explanations are generally not unique: there may be several ways in which a given top event could be caused from within a single zone.

For some purposes, it is useful to ask how the results change if a loss of offsite power is assumed. It turns out that given a LOOP, zone 22 must be added to Table 3.3.1 for top events D, U_1, and U_2, because the service water pumps are vulnerable in this zone and the diesels' failure on loss of service water will lead to these top events.

3.4 Induced-Humanly Coupled System Interactions

No induced-humanly coupled interactions were identified. This does not mean that none exists; as discussed in Sections 2 and 4, the search excluded certain important areas, and the search procedure actually employed is not believed to be optimal.

Certain linkages turned up by the search are identified in Appendix D, but are not considered significant. An operator misled by a *single* instrument *might*, under some conditions, introduce multiple faults, until further reflection and checking other instruments led to a more accurate understanding of plant conditions. These linkages have not been presented here even as candidate induced-human SIs because, in the context of the cutsets of interest, the operator is expected not to take those actions or is expected to recover quickly from those actions.

As discussed in Section 2.4.1, this result should *not* be taken to imply that human action does not contribute to system interactions; this result is considered to reflect the premises and scope of this part of the study.

3.5 Regulatory Perspective

Cutsets for each of the top events considered in this study were reviewed to see whether any of them corresponds to a breach of regulatory requirements. Two categories of requirements were considered:

Table 3.3.1 Zones from Within Which Top Events Can Potentially Originate

Top Event	1	3	4A	7A	9	9A	11	12A	13	14	15	17A	22	23	30A	37A	38A	39A	41A	54A	55A	58A	59A	60A	66A	70A	71A	87A	
D (LPI failure)		o	o	o		o	o	o	o	o	o	o																	
U_2 (HPI failure given small LOCA)					o		o			o	o	o																	
U_1 (HPI failure given medium LOCA)					o		o			o	o	o												o					
L (SFWS failure)							o			o	o			o															
Transient Initiator	o						o			o	o	o	o		o	o	o	o	o	o	o	o	o		o	o	o	o	
T*L							o			o	o																		
S_2(P) (Transient-Induced RCP Seal LOCA)							o			o	o	o																	
S_2(P)*U_2							o			o	o	o																	
S_2(P)*L							o			o	o																		

Table 3.3.2 Examples of How Each Top Event Can Be Caused from Within the Indicated Zones

Top Event	Zone	Example of Component Combination Residing in Zone, and Capable of Causing Top Event.
D (LPI failure)	F3	RHR pump 31 and cabling for RHR pump 32.
	F4A	Cabling for RHR pumps 31 and 32.
	F7A	Cabling for RHR pumps 31 and 32.
	F9A	Cabling for RHR pumps 31 and 32.
	F11A	Cabling for RHR pumps 31 and 32.
	F12A	Cabling for RHR pumps 31 and 32.
	F14	Cabling for RHR pumps 31 and 32.
	F15	Cabling for RHR pumps 31 and 32.
	F13	Battery 32.
	F17	MCC 36A & MCC36B (power for LPI valves).
U_2 (HPI given small LOCA)	F9	HPI pumps 31, 32, 33.
	F11 F14 F15 F17A	Cabling for HPI pumps 31, 32, 33.
U_7 (HPI given medium LOCA)	All zones applicable to U_2.	
	F60A	Cabling for HPI pumps 31 and 33.
L (AFWS Failure)	F11	Cabling for AFWS pumps 31, 32, 33.
	F14	Cabling for AFWS pumps 31, 32, 33.
	F15	Cabling for AFWS pumps 31, 32, 33.
	F23	Location of AFWS pumps 31, 32, 33.
T*L	F11	Cable spreading room: cabling for SW & CCW pumps and AFW pump.
	F14	Switchgear room: transient (e.g., Loss of CCW or SW) and cabling of AFW pumps.
	F15	Control room (transient and loss of pump control)
S_2(P)	F11	Cable spreading room: cables for CCW pumps and charging pumps.
	F14	Switchgear room: cables for CCW pumps and charging pumps.
	F15	Control room (control of CCW pumps and charging pumps).
	F17A	CCW heat exchangers and cabling for charging pumps.

Table 3.3.2 (continued)

Top Event	Zone	Example of Component Combination Residing in Zone, and Capable of Causing Top Event.
$S_2(P)*U_2$	F11	See table above for zones yielding $S_2(P)$ and zones yielding U_2
	F14	
	F15	
	F17A	
$S_2(P)*L$	F11	See table above for zones yielding $S_2(P)$ and zones yielding L.)
	F14	
	F15	

1. 10CFR50[3] and its requirements that systems successfully mitigate transients and accidents with or without loss of offsite power, given a single failure. "Single failure" was defined by 10CFR50, Appendix A, which basically states that all electrical failures and active mechanical failures should be considered "single."

2. The Standard Review Plan (SRP), NUREG-0800.[4] This generally contains acceptance criteria which go beyond 10CFR50 requirements. An example is Branch Technical Position ASB 10-1, which requires that the AFWS be able to meet its requirement given a high energy line break concurrent with a single active failure.

Detailed Discussion

In the following discussion, each of the major reference documents is identified and any specific considerations gleaned from them and used in this review are detailed.

10CFR50

The application of these requirements differed between the transient and LOCA sequences. In the LOCA sequences, all single active failure cutsets and all two-element cutsets that contained a transient-induced loss of offsite power (LOOP) were classified as single failures that did not meet the 10CFR50 requirement of being capable of mitigating accidents/transients with or without offsite power available. In the transient sequences, doubles that contained a transient initiator and a single active failure, as well as all triples that contained a transient initiator, an active failure, and a transient-induced LOOP, were classified as single-failure events. All cutsets with two transient initiators were considered probabilistically incredible. In short, LOOP is potentially part of any initiator (transient or LOCA), for purposes of evaluating system failure modes.

SRP 3.6.1

Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside Containment

In the transient sequences, only pipe breaks which initiated transients were considered. In the LOCA sequences, additional pipe breaks would constitute passive failures, and this consideration is not required by 10CFR50. Therefore, pipe breaks beyond the LOCA itself were not considered in this analysis.

SRP 6.3

Emergency Core Cooling System

Specific considerations applied to this review came from BTP RSB 6-1 which addresses piping from the RWST to the safety injection pumps. The BTP requires the piping configuration to be able to withstand a single active failure. This criterion is met at IP-3 by locking or deenergizing open all the valves between the HPI pumps and the RWST.

SRP 7.7

Control Systems

The following guidance was used in this review of transient sequence cutsets: "The review should confirm that the failure of any control system component or any auxiliary supporting system for control systems do not cause plant conditions more severe than those bounded by the analysis of anticipated operational occurrences in Chapter 15 of the SAR. (The evaluation of multiple independent failures is not intended.)" Although no control system interactions were found which led to an excursion beyond the safety analyses, an interaction was found within the Pressure Control System. This is fully described in Section A.6.1. In summary, depending upon the position of the PCS channel selector switch, a single pressure transmitter failing low can result in a high pressure transient and prevent both PORVs from responding.

SRP 8.0

Electrical Power Systems

Specific guidance for this review came from the following passage and was applied in the consideration of the many single bus tie breakers within the IP-3 design: "Regarding the interconnections through bus tie breakers, an acceptable design will provide for two tie breakers connected in series and physically separated from each other in accordance with the acceptance criteria for separation of safety-related systems . . . ." The above acceptance criterion was formulated after the licensing of IP-3, but was included in the modeling. A failure mode causing a single tie breaker to fault two buses would be extremely significant. However, no single-failure mechanisms were found that would accomplish this failure mode, and of the double failures (e.g., bus fault AND spurious breaker operation), none made the probabilistic cutoff.

SRP 9.2.1

Station Service Water System

The service water system must be capable of withstanding a single active failure with loss of offsite power and still meet its functional requirements.

SRP 9.2.2

Reactor Auxiliary Cooling Water

The component cooling water system must be capable of withstanding a single active failure with loss of offsite power and still meet its functional requirements.

SRP 9.3.4

Chemical and Volume Control System

The charging and letdown systems must be able to sustain the loss of any active component and meet the minimum system requirements for plant shutdown or accident mitigation with or without a loss of offsite power.

SRP 9.5.1

Fire Protection (Appendix R, 10CFR50)

This review used the fire zones estblished by the IP-3 Fire Hazards Analysis as applicable to define the spatial zones of the plant. These zones were considered in light of the criteria of Appendix R, 10CFR50, which require at least one train of shutdown equipment to be available following an assumed fire large enough to render inoperable all equipment within a given zone. Appendix R further states that the above criterion is not to be applied in LOCA (design basis accident) sequences. An alternative criterion states that it is permissible for both trains necessary for achieving a cold shutdown to be damaged if repair to one could be made within 72 hours. This criterion was not considered here, because the focus of the modeled sequences is on early core damage. Cutsets involving two independent fires were not analyzed further, nor were any cutsets that included a fire that was not the initiator of the transient.

SRP 10.4.9

Auxiliary Feedwater System

The guidance of BTP ASB 10-1 was used in reviewing this system. Part 5 of that position deals with high energy line breaks (HELB) within the system itself. These were treated here as follows. It should be noted that the model was not developed to explicitly consider piping ruptures. For the LOCA sequences, HELBs within the auxiliary feedwater system were not considered, as they are passive failures. For the transient sequences, major piping segments with failure mode 'A' (NOIF) were assumed equivalent to HELBs and the cutsets were reviewed accordingly. In this limited investigation of HELBs, one cutset was found that violated this regulatory criterion. This is discussed in the following section.

Results

Table 3.5.1 provides a listing of the functional cutsets, for each sequence, that penetrate regulatory acceptance criteria. Those cutsets penetrating SRP criteria are so labeled; all others are believed to be in potential violation of 10CFR50. The spatial analysis identified a number of candidate fire zones that could theoretically, of themselves, fail a given system or sequence. As these cutsets are only products of a screening analysis, they are cited but not quantified here. See Section 2.3 for further discussion.

Two cutsets of LPI were significant: EPD12 (battery 32) and EPD02-02 (dc bus 32). These two cutsets have the same effect, although their probability of occurrence is quite different. This particular failure mode is discussed in detail in Section 3.2. Upon verification of this finding, the utility immediately effected a design change.

The single cutset for AFWS (transient) reflects the acceptance criteria of SRP 10.4.9 BTP ASB10-1. The first element (AF011-A-INT) is considered to be equivalent to an HELB in the steam supply line to the turbine driver of AFW pump 32. This event should cause a transient, and the SRP requires that AFWS be capable of withstanding a single failure and still meet functional requirements. The second element (EPD02-02) represents a loss of dc bus 32. AF011-A-INT fails the turbine-driven pump 32 and causes a transient. EPD02-02 prevents the starting of pump 33 on bus 6A and fails fast transfer of bus 3 which leaves bus 3A deenergized and thus fails pump 31.

For the sequence T*L, six basic groups of events have been identified. Group 1 consists of EPD3132-U (failure of dc buses 31 and 32 via their single tie breaker) and TR-IN-LOOP (transient-induced loss of offsite power). Loss of the two dc buses initiates a transient and prevents the starting of diesels 32 and 33. This would still leave diesel 3 powering AFW pump 31 on bus 3A, but the model requires at least two nuclear SW pumps to support even one diesel; therefore, the third pump is assumed to be lost in a relatively short time.

T*L Group 2 consists of F22 (fire in the SW pump zone which fails SW pumps 31, 32, 33, 34, 35, and 36), EPD01-02 (loss of dc bus 31), and TR-IN-LOOP. F22 initiates the transient; per the model (given LOOP), lack of service water fails the diesels, which fails AFW pumps 31 and 33. EPD01-02 is the dc bus which feeds inverter 31 which in turn feeds instrument bus 31. The turbine controls for pump 32 require instrument bus 31.

T*L group <u>3</u> consists of a common initiator and four single failures. EPD02-02 (dc Bus 32) deprives AFW pump 33 of control power and fails fast transfer of bus 3, leaving AFW pump 31 without motive power. The four single failures all relate to failure of the turbine pump. EPI21-15 is failure of Inverter 31. EPI21-02 is failure of instrument bus 31. AF011-A-H is failure of the operator to regulate the turbine pump, and AF011-A-INT is failure of the turbine pump or its steam supply.

T*L group <u>4</u> provides two sets of elements in conjunction with TR-IN-LOOP. The first set of elements all have the effect of failing service water and initiating a transient. Because of SW failure, the diesels will ultimately fail and AFW pumps 31 and 33 will be lost. The second set all have the effect of failing the turbine pump. EPD11 is battery 31 and its failure contribution arises because the normal (ac) feed to dc bus 31 is shed upon bus 5A undervoltage (LOOP) and this deenergizes Instrument bus 31. The other elements have already been discussed above.

T*L group <u>5</u> consists of EPD02-02, EPD11, and TR-IN-LOOP. EPD02-02 initiates the transient and fails control power for bus 6A. In this case, AFW pump 33 and NSW pump 36 are not available. EPD11, as discussed above, is the only power source for dc bus 31 (given LOOP), and for this cutset it represents the loss of an NSW pump and of AFW pump 32 turbine control. This leaves AFW pump 31 being powered by diesel 31, which will shortly fail because only one service water pump will be available and the plant as modeled requires two.

T*L group <u>6</u> consists of EPD01-02, a set of single failures and TR-IN-LOOP. EPD01-02 initiates a transient, prevents the sequencing of an NSW pump, and fails AFW pump 32 turbine control. The single-failure elements all lead to failure of a second NSW pump and thus leave the remaining motor-driven AFW pump on a diesel which will shortly fail for lack of cooling. SE-52-EG2-INT is failure to connect diesel 32 to bus 6A (loss of AFW pump 33 and NSW pump 36). SE-52-EG1-INT is failure to connect diesel 31 to buses 2A and 3A (loss of AFW pump 31 and NSW 34). EPA16-S is failure of automatic bus tie breaker 2AT3A which leaves bus 3A deenergized (loss of NSW pump 35 and AFW pump 31). EPA12-INT is failure of diesel 32 and EPA08-INT is failure of diesel 31; their respective consequences are the same as outlined above for buses 6A and 2A/3A. EPD13 and EPD12 are failure of batteries 33 and 32, respectively; again their respective consequences are the same as outlined above for Buses 2A/3A and 6A as they prevent energization and loading of the bus.

References for Section 3

1. See Reference 2, Section 1.

2. See Reference 1, Section 1.

3. Code of Federal Regulations, Title 10, Part 50, Domestic Licensing of Production and Utilization Facilties, 1984.

4. NUREG 0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, July 1981.

Table 3.5.1 Cutsets Penetrating Regulatory Criteria

D (LPI Failure)

1. EPD12
2. EPD02-02
3. See Table 3.3.1 for description of single fire zones.

U_1 (HPI-Medium LOCA)

1. See Table 3.3.1 for description of single fire zones.

U_2 (HPI-Small LOCA)

1. See Table 3.3.1 for description of single fire zones.

L ($AFWS_{LOCA}$) failure given LOCA)

None

L ($AFWS_{(TR)}$ failure given transient)

1. AF011-A-INT(HELB) * EPD02-02 (SRP 10.4.9)
2. See Table 3.3.1 for description of single fire zones.

T * L (Transient and failure of auxiliary feedwater)

	Transient Initiator		Single Active Failure		
1.	EPD3132-U	*	--	*	TR-IN-LOOP
2.	F22	*	EPD02-02	*	TR-IN-LOOP
3.	EPD02-02	*	EPI21-15 EPI21-02 AF011-A-H AF011-A-INT		
4.	F22 SWA06 SWN4-A-INT SWN6-A-INT SWN7-9-INT	*	EPD11 EPI21-15 (Inverter) EPI21-02 (I Bus 31) AF011-A-H AF011-A-INT	*	TR-IN-LOOP
5.	EPD02-02	*	EPD11	*	TR-IN-LOOP

Table 3.5.1 (continued)

6. $\text{EPD01-02} * \left\{ \begin{array}{l} \text{SE-52-EG2-INT} \\ \text{SE-52-EG1-INT} \\ \text{EPA16-5} \\ \text{EPA12-INT} \\ \text{EPA08-INT} \\ \text{EPD13} \\ \text{EPD12} \end{array} \right\} * \text{TR-IN-LOOP}$

7. See Table 3.3.1 for description of single fire zones.

$S_2(P)$ (RCP Seals)

1. See Table 3.3.1 for description of single fire zones.

$S_2(P) * U$ (RCP Seal LOCA and failure of HPI)

1. See Table 3.3.1 for description of single fire zones.

$S_2(P) * L$ (RCP Seal LOCA and failure of AFWS)

1. See Table 3.3.1 for description of single fire zones.

4. COMMENTS AND CONCLUSIONS

4.1 General Comments

On the basis of experience gained in this project and in other projects, comments and insights are offered on the method described in Section 2. Two general categories of comments are offered below which bear on the success of this project. In following subsections, comments are offered separately on the functional, spatial, and induced-human phases of the project. Finally, some overall conclusions are provided.

4.1.1 Particular Strengths of the Present Approach

Scrutability and completeness of the modeling done here were materially enhanced by the following:

1. Explicit conditioning of mitigating system status/failure modes on the character of the initiating event (e.g., shedding of MCCs on an SI signal).
2. Explicit conditioning of system/component failure modes on plant conditions (e.g., the availability of onsite power to bus 3A being affected by the availability of offsite power to bus 2A).
3. Explicit linking of all support system fault trees with frontline system fault trees.
4. Working with primary sources of information (e.g., plant drawings as opposed to other studies), and understanding the operation of the system.

4.1.2 Where to Stop Modeling

The burden of this study is to identify the intersystem/intrasystem dependences, in order to ascertain whether the redundancy or independence of the given systems is compromised. Accordingly, for this study, it was decided to logically link all required support systems to frontline systems, in order to obtain accident sequence cutsets entirely in terms of basic events. (Certain systems related to environment, such as HVAC, require special consideration, because their failure does not immediately fail other systems.) For detailed fault trees corresponding to the end product of a PRA, this might be extremely challenging, depending on the computer code being used. Here, because the trees are not overburdened with detail and because the main interest is in low-order cutsets, it is perfectly feasible. Moreover, as it turns out, it is extremely desirable: for example, the finding of one single active failure (battery 32 in LPI) emerged as a direct result of this systematic process. Neglecting the failure modes of fast transfer following a LOCA would have hidden this failure mode.

The previous obscurity of this failure mode, together with the method of its eventual detection, shows that it is necessary to explicitly model and link all direct functional support systems, unless these are sufficiently self-contained to be regarded as featureless black boxes. This is a simple matter of completeness. Once the cutsets have been reviewed, and the qualitative implications of the basic model are fully grasped, quantification can proceed expeditiously.

4.2 Comments on Functional Phase

4.2.1 Use of the SETS Code

It was decided to use the computer code SETS[1] to analyze the fault trees developed in this project. SETS is a flexible and powerful tool for use in fault tree analysis. Other codes exist, of course, and several might have been perfectly reasonable choices. Some of these enjoy the reputation of being easier to use than SETS. However, the generality of SETS is such that any logically definable transformation that is likely to be of interest can be implemented within SETS (possibly at some human expense), while some other codes appear to gain their relative user friendliness by sacrificing some generality. This comment is not offered as an established insight; the point is simply that SETS appeared to be the least inherently constraining choice. Ultimately, it may be found that the incapacities of some easier-to-use code manifest themselves only in areas which are useless anyhow; but at the outset of this study, this was a judgment that the team was unwilling to make.

Other factors weighing in favor of SETs:

- SETS was already up and running at BNL (9/82 versions).

- SETS works in conjunction with a fault tree drawing code. The importance of automated fault tree drawing should be emphasized. Among the many benefits derived from use of this combination is that the tree drawn by the code is derived from the SETS input, and therefore corresponds to the tree SETS is actually analyzing, whether or not this is the tree that the user thought SETS was analyzing.

4.2.2 Level of Detail

It was decided initially to develop system fault trees to the "segment" (or supercomponent) level.[2] A segment is essentially a portion of the system consisting of one or more components in series. Defining segments is a standard way to go about constructing a fault tree. In a normal PRA, the fault tree would show, for each segment, all support system faults leading to failures of components within the segment, all pertinent failure modes of all components within the segment, and probably a number of different maintenance errors. In the functional phase of this study, support faults are included as above, but details of failures internal to a given segment are collapsed into a single event. The purpose of this, of course, is to prevent a pointless explosion of the number of cutsets produced by the model. If segment A has 50 internal failure events, and segment B has 20, then segment A * segment B has 1000. In later phases of the study, it is appropriate to transform the events "segment A" and "segment B" to display some of this structure, in order to see whether there are interactions (e.g., spatially coupled) between the two, but in the functional phase this is logically unnecessary and basically undesirable.

Earlier plans were to develop insights about the systems and sequences first at the system level, then at the train level, and only then at the segment level. This approach is probably desirable for one or two analysts developing their own understanding of the plant, but for a sizable team the coordination required (e.g., in assembling such high-level information and then pausing to admire the view before proceeding to the segment level) was more trouble than it was worth. Formally, skipping these steps runs the risk of not finding a functional SI as early in the study as is theoretically possible, but the likelihood of this is believed to be small and the consequences are not great.

4.2.3 Logic Loops

The occurrence of logic loops in complex fault trees is a well understood problem. For example, diesel generators generally depend on service water after their first few minutes of operation, while the service water pumps depend on the diesels immediately after a loss of offsite power. Blindly modeling the diesels' dependence on service water and service water's dependence on diesels creates a loop. In a sense, this can be viewed as an artifact of the neglect of time dependence in the construction of the loop. Some approaches to the problem are based on recognizing this time dependence. It is typical to speak of "breaking" logic loops, and to treat such problems as having short-term logic and long-term logic.[2]

In the present study, however, a somewhat different approach is taken. Consider the failure of power at a 480-V ac bus which supports an essential service water pump. Conceptually, one separates out those bus failure events which do not depend on service water, and feeds this subset into the tree for failure of service water. Thus, the tree for failure of service water will include local faults of the diesel, but not failure of service water to the diesel. Similarly, service water failures other than diesel failures are separated out, and fed into the tree for diesel failure.

In this approach, partial replicas of certain subtrees appear in more than one place. But while this increases the number of gates, it does not increase the number of primary events, and it allows the primary event definitions (internal diesel fault, etc.) to retain their general time-independent intuitively clear significance, while still providing an exhaustive set of cutsets for "failure of service water" and "failure of diesel generator output" within a single global fault tree.

Details of this approach must, of course, depend on the system to be modeled.

4.2.4 Obtaining Minimal Cutsets From the Fault Trees

4.2.4.1 Size of the Problem

The prescription outlined above (proceeding to the segment level, showing all support faults and a single "internal" fault for each segment) led to a substantial amount of fault tree development. Along the way, considerable energy was spent in preventing unnecessary development of detail within segments. Even so, as dependences are followed from one system down into another and then into yet another, the number of cutsets grows explosively.

A feature of SETS which proved particularly useful here is its ability to gather events into "independent subtrees," which are essentially portions of the fault tree which can (at least temporarily) be treated as diamond events. This feature is capable of compensating for certain possible lapses in analyst discipline which might otherwise have resulted in overdevelopment of some events (i.e., inclusion of detail that does not shed light on dependences).

4.2.4.2 Truncation

As support faults are developed and resolved into lower level support faults, the number of cutsets can easily become unmanageable, and it is difficult to avoid truncation while working at the segment level (let alone the component level).

There is more than one type of truncation. One type involves assigning probabilities to basic events and discarding cutsets whose probabilities are less than some cutoff. As truncation methods go, this has a good deal to recommend it. For present purposes, one is interested in discarding cutsets which are unlikely to bear fruit in a search for spatial or induced-human interactions, and while any truncation method is capable of throwing away a cutset that should be searched, probabilistic truncation is less arbitrary than truncation on number of basic events in the cutset carried out without regard to their probability. Probabilistic truncation keeps apparently likely cutsets even if they are high order, while rejecting presumptively unlikely ones; truncation on cutset order does not distinguish multiple pipe ruptures from multiple diesel failures. In spite of this, in the early phases of this project, truncation on cutset order is essentially written into the statement of work. Clearly, however, fundamental questions remain about the desirability of basing a cutset search on a body of cutsets derived using truncation on cutset order. This issue is intimately connected with that raised in the next subsection, which has to do with the effect of modeling assumptions.

Initially, the goal in this project was to obtain cutsets out to fourth order (which seemed to be a substantial but not prohibitive undertaking), and search them for interactions which would reduce them to first or second order. Early in the project, cutsets were actually obtained to fourth order for all top events except those involving RCP seal LOCA (which were carried out to third order). This operation confirmed the "substantial-but-not-prohibitive" assessment, for the case of fully linked frontline and nonenvironmental support systems. Because it was a substantial effort, the need to do it again when the fault trees were completed was examined carefully. Reasons for doing it again ranged from administrative (simply to deliver cutsets to some specified order) to technical (a serious intention of searching the cutsets). NRC called for second-order cutsets, which turns out to be a usefully revealing level of development. That is, for an ostensibly three-train system, a three-element cutset does not correspond to an SI, but a two-element cutset may do so. For reasons specific to this project, which are discussed elsewhere in this section, higher-order cutsets were not sought, and cutsets were therefore developed only out to second order, with certain special events not counting in the length of the cutset.

4.2.4.3 Modeling Assumptions

It is part of the essence of an SI study that unexpected and obscure connections are sought. With this in mind, one may be inclined to make one's models as "complete" as possible. This may suggest, for example, modeling failures of heat tracing used on a suction line. However, this may involve thousands of cutsets, which, plugged into another system fault tree at a low level, may give rise to an astronomical number of cutsets for that system. (If it is not clear why heat tracing would do this, consider that electric heat tracing calls power, which calls diesels, which calls service water, which calls dc . . . .) If heat tracing failure is arguably important, then well and good, but in some cases it will not be, and in order to proceed, one needs to fall back on either probabilistic truncation or a convincing physical argument.

Apart from the difficulties of dealing with astronomical numbers of cutsets, there is the more fundamental problem that a hard-won list of cutsets can easily be dominated (in terms of numbers of cutsets) by cutsets which are inherently implausible. Thus, cutset searching schemes which weigh all cutsets alike will tend to allocate effort to areas which happen to have large numbers of cutsets, without regard to their probability; and from the above discussion, it should be clear that "conservative" modeling assumptions can be crippling under these circumstances.

4.2.5 Fault Trees Used in Multiple Contexts

An essential feature of this project is that a fault tree has been developed for the transient-initiating event itself. The point of doing this is to shed light on failures which link initiating events to unavailability of mitigating systems. Failures in the electric power system are obvious examples of such events.

A certain complexity can result from this approach, however, as different transients impose different demands on systems. For many reasons, the failure logic changes appreciably, depending on whether a safety injection signal is present, or whether offsite power is available. The present study differs from some of its predecessors in that an attempt has been made to handle this complexity in a few large fault trees, within which certain events are toggled by the analyst to handle different cases. This does not differ conceptually from simply running many different trees for different cases, which is closer to the usual practice; it means simply that the task of assuring accuracy and completeness is carried out on a single complex tree, rather than piecemeal on multiple trees which are individually simple. At this point, it seems that while the large-single-tree approach is taxing to review, it forces the analysts to confront completeness in a single list of cutsets, rather than allowing a multiplicity of more narrowly defined cases to obscure the absence of an important one.

A further side effect of this approach leads to seeming conservatism in some cases. For example, if a safety injection signal is present, certain loads are shed from emergency buses, among them conventional service water. This leaves component cooling without a heat sink. This, in turn, conservatively applying binary logic, leads to an RCP seal LOCA. In brief, a spurious

SI seems to lead to an RCP seal LOCA. In some contexts, it is presumably appropriate to model loss of service water as leading to failure of CCW; in others, it is not (at least, in the present case, not immediate failure of CCW). The approach adopted here thus highlights failure modes which closer inspection may rule out. In this sense, all cutsets given here are strictly provisional, and all primary events are to be regarded as having rather general meaning.

4.3 Comment on the Spatial Phase

4.3.1 Information Gathering

Previous descriptions of the method being surveyed here imply an emphasis on searching functional cutsets for spatial intracutset coupling. In the actual analysis, however, a different emphasis emerges. Cutset searching is one approach, but information about parts of the plant which are not already in the cutsets must be brought in. A zone may contain only one component which appears in a frontline system fault tree or any of its support system fault trees; but if, in addition, the zone contains components which can cause transients, this needs to be known. Therefore, even before the cutsets are confronted, a list of zones containing all modeled components should be generated, and it is logically necessary to know all the components in these zones.

In this project, the Fire Hazards Analysis and certain plant arrangement drawings were primary information sources. This means that only major components and selected power cables could readily be located. The information presented here must therefore be considered an example of how to proceed. It is doubtful that our inventory of any zone's contents is complete, and these results are therefore partial. Onsite inspection is necessary before faith can be justified in results of this type.

4.3.2 Screening Analysis

Given a set of zones, components located therein, and susceptibilities, a simplified model can readily be generated which corresponds logically to further development of the events in the fault tree. It is feasible to provide cutsets in which only an explicitly delineated part of a zone is destroyed (by a fire, say), and other failures occur for other reasons. This should be the goal of the analysis; it becomes especially imortant when the individual zones are large. However, distinctions of this type begin to require physical analysis, which was not performed in this study.

4.4 Comment on Search for Induced Human Interactions

Discussion of this part of the project is probably best carried out in light of a specific example. Suppose that there is a cutset for accident sequence T*L (transient and failure of auxiliary feedwater) which contains an instrument bus fault and failure of certain AFW flowpaths to the steam generators, along with other events as well. As developed under the present method, this cutset would reflect functional dependences and perhaps spatial coupling, and the idea now is to see whether one event in the cutset can cause any of the others by causing the operator to do something. If so, then the causative event logically implies the others, and the true minimal cutset is correspondingly shorter. Suppose, further, that the instrument bus fault causes certain instruments to fail in a misleading way, causing the operator by some written procedure to close the AFW flowpaths in the cutset which prevents flow. Then one element of the cutset will have induced the operator to cause others. This is an "induced-human SI." Actually, whether this would be classed as an SI under the ground rules given here would depend on how many events the cutset ended up with (see Section 3). If this interaction shortened a 7th-order cutset to a 5th-order cutset, it would not count as an SI. If it shortens a 4th-order cutset to a 2nd-order cutset, it counts as an SI. The essential qualitative point is the shortening of cutsets. This part of the project was intended to search for such couplings.

The Original Plan

Ideally, one would construct a data base that contained an explicit index of all acts mentioned in written procedures, reflecting the cues that stimulate each act. The data base would be used in the following way. Given the cutset in the example outlined above, one could call for a listing of all procedural acts which have the effect of throttling the indicated flowpath , and a listing of all actions taken after the instrument bus fault. This information, placed in the context of the specific cutset under scrutiny, should lead to identification of the coupling.

The data base was to have been constituted from information contained in IP-3 procedures and information contained in the INPO Reactor Operator Task Analysis Data Base. This INPO data base was developed to identify the training needs of reactor operators by first determining the tasks performed by these personnel and then analyzing the cue conditions, standards of performance, and skills/knowledge associated with these tasks. This data base is resident on the INPO computer and is accessed by member utilities through a telephone network. It is organized in such a way that data can be sorted in support of a variety of user needs.

The Actual Implementation

The actual implementation differed from the above in two essential respects. First, BNL was not given access to the INPO data base. (While NRC has authorization to use the data base for purposes related to training, the present application was not considered to fall within the scope of that authorization.) This meant that generating a list of causes for flowpath throttling was done essentially by individuals with operator experience and knowledge of IP-3, who reviewed IP-3 procedures and related information. Second, each primary event in the cutsets was considered individually, not in the context of any particular scenarios in which it appeared, and this tended to deprive the search of what should have been a useful focus. For example, returning again to the example given above, considering the event "AFW flowpath blockage" in isolation is less convergent than considering "AFW flowpath blockage" AND "instrument bus fault."

The lack of access to the INPO data base influenced the decision to search primary events rather than cutsets. This decision was also influenced by the following considerations. First, the list of primary events is substantially complete (never really complete) at a fairly early stage of the project, certainly before the trees have been debugged and the cutsets obtained at a useful level of correctness. Second, it had been hoped to obtain cutsets out to fourth order or so, and to establish priorities for the search for interactions between pairs (triple, etc.) of events by computing an importance measure defined on pairs (triples, etc.) of events (i.e., how many times the pair/triple appeared in the cutsets), in order to focus the search on the most important (prevalent) pairs (triples, etc). However, after examination of the preliminary round of fourth-order cutsets, it was felt that no reasonable importance measure could be defined without invoking probabilities. The number of cutsets containing a particular pair tends to be an artifact of otherwise relatively unimportant modeling assumptions. At the time, a commitment had been made to proceed without explicit regard to probabilities until the findings were quantified; a moderation of this commitment appears to offer considerable advantages.

The problems mentioned up to now reflect on the basic approach. One significant problem arose directly in connection with the content of the functional model. The example given at the beginning of this comment clearly illustrates that instrumentation-related failures are expected to dominate the field of induced-human coupling. Ideally, then, one wants to relate basic events in functional cutsets to instrumentation failures. Unfortunately, this is less straightforward than it might be. In practice, instrumentation failures are reflected in functional cutsets only if they happen to contribute to an actuation failure or perhaps an automatic control failure, so some hard work (and a good deal more information than was made available) is necessary in order to explicitly relate a power failure to pertinent instrumentation. Note that the PRA did not conduct much analysis at the low-voltage level, and was not any help in this area. In fact, there are instrument buses indicated on recent wiring diagrams which are not reflected in the System Descriptions. We believe that these are recent modifications.

Summary

- The functional model does not automatically contain instrumentation failure modes of the type that could straightforwardly be interpreted in the review for induced-human SIs. A systematic approach to relating functional failure modes to instrument malfunctions is essential.
- This portion of the analysis has information needs which apparently go beyond those of traditional PRA; instruments which do not directly fail systems tend not to show up in PRA fault trees. Instruments which mislead operators, not control circuits, are the objects of study here.

- This portion of the study should consider entire cutsets rather than individual events.
- Because a high percentage of precursors to potentially severe accidents involve human error,[3] broadening the scope of future analyses to treat the operators as humans rather than machines is recommended. Maintenance errors should also be included.
- The ability to search a data base in the manner indicated should prove to be a considerable strength, if the data base actually spans the set of procedure-based operator acts and relates cues to responses.

4.5 Conclusions

The approach used here has proved successful in finding significant interactions which were previously missed. Important aspects of this approach deserve consideration as guidance [illegible] developed by NRC for performance of future studies of this type. Summarized below are a few important highlights of this project, which were fully developed in Sections 3 and 4.

Major Findings

Unavailability on demand of battery 32 leads directly to failure of low pressure injection in large and medium LOCA sequences, and contributes to failure of other systems in other accident sequences as well (e.g., loss of both motor-driven auxiliary feedwater trains). This particular finding motivated the licensee to implement an immediate modification of the plant.

Table 3.5.1 lists cutsets which, taken at face value, appear to violate the plant's licensing basis. At this writing, the status of these other findings, with regard to the process of NRC/licensee review, is unknown.

Lessons Learned

The process of achieving qualitative insight into the systems' failure modes is greatly assisted by the following:

- Development of accident sequence cutsets by linking fully developed support system fault trees to frontline system fault trees.

- Explicit conditioning of events on the character of the initiator; explicit display of the initiating event in sequence cutsets, explicit display of the presence or absence of a safety injection signal, availability or otherwise of offsite power, etc.

- Searching large numbers of cutsets for interactions would probably benefit from a priority setting scheme employing screening probabilities for certain basic events.

- Once identified, an SI is usually easy enough to understand; the major task of an SI study is to manage a large amount of information in such a way as to identify the system interactions as efficiently as possible. Two comments are offered here regarding the use of computers in this area. It is particularly interesting in this case that the battery 32 failure mode of LPI was actually found by computer; that is, the computer output came as a surprise to the analysts who had prepared the fault trees which were linked to produce the finding. The first comment, accordingly, is that an apparently crucial gain in efficiency was achieved by having a machine systematically consider combinations of failures which had previously gone unscrutinized by humans working without the benfit of linked fault tree models. The second comment is that the use of a computer was not in itself particularly expensive in this project. Of course, analysis of large Boolean expressions in the course of full-PRA quantitative accident sequence analysis can seem expensive, but computer costs will generally correspond to a modest fraction of the effort expended in getting the information together. Additionally, if high-order terms are not pursued for whatever reason, the cost of obtaining only low-order terms is relatively nominal. The proper perspective seems to be that computer costs are a) part of the information management problem, b) not necessarily a substantial fraction of the project cost, and c) a bargain, in our experience.

References for Section 4

1. R. B. Worrell and D. W. Stack, A SETS Manual for the Fault Tree Analyst, NUREG/CR-0465, 1978.

2 D. D. Carlson et al., Interim Reliability Evaluation Program Procedures Guide, NUREG/CR-2728, July 1982.

3. J. W. Minarick et al., Precursors to Potential Severe Core Damage Accidents: 1969-1970; A Status Report, NUREG/CR-2497, ORNL, June 1982.

APPENDIX A

SYSTEM MODELS

A.0 INTRODUCTION

The following descriptions are of fault trees developed in this project. Most correspond to frontline or support systems; the two exceptions are the "Sequencer" tree, which contains most of the logic treating control of pump breakers, and the Transient Initiator tree, which is essentially an "OR" gate top event with inputs from various other trees.

System descriptions are accompanied by figures showing how the systems were broken down into segments. In most cases, primary fault tree events are named with these segment identifiers.

Plots of the following fault trees can be found in a jacket at the end of this report. Each fault tree is plotted on a separate microfiche, and therefore, need not be placed in any specific order within the jacket. Each fault tree microfiche carries the name FITZPATRICK in the heading.

Auxiliary Feedwater
Main Feedwater
HPI Medium LOCA
HPI Small LOCA
LPI (Low Pressure Injection)
RCP Seal LOCA
Pressurizer
CCW (Component Cooling Water)
CST (Condensate Storage Tank)
Loss of Charging
Loss of Letdown
Electrical Power
Heat Tracing
Instrument Air
RWST (Refueling Water Storage Tank)
Station Air
Sequencer Part 1
Sequencer Part 2
SIAS (Safety Injection Actuation System)
Service Water
Transient

A.1. AUXILIARY FEEDWATER

A.1.1 Introduction

The auxiliary feedwater (AFW) system serves to remove decay heat by supplying water to the steam generators in the course of mitigating transients or small LOCAs. Additionally, it serves along with the main feedwater system in startup or shutdown operations, or during hot standby.

The AFW system includes two electric-motor-driven AFW pumps and one steam-turbine-driven AFW pump. Ordinarily, these take suction from the condensate storage tank (CST), but the city water storage tank is also available as a backup source. Each of the motor-driven pumps normally supplies two of the four steam generators, while the steam-turbine pump supplies all four.

Air to all AFWS AOVs (city water suction PCVs, AFW pump discharger FCVs, and atmospheric S/G relief dump valves) is backed up by an independent nitrogen supply system. The PCV 1139 AOV (AFWS turbine-driven AFW pump turbine-steam inlet governor valve) is not backed by the nitrogen system, but has its own control air supply.

A.1.2 Top Events

For this SI study, only one top event is of interest for this system: failure to remove decay heat through the steam generators. Scenarios in this study for which AFW is required are small LOCAs and transients.

A.1.3 Success Criteria

For all transients and for small LOCA, AFW mission success requires at least one auxiliary feedwater pump feeding to two steam generators. This corresponds to at least 200 gpm to each of at least two steam generators. AFW flow must be initiated within 30 minutes of the trip.

At least one means must be available for removing steam from the SGs. Either the atmospheric steam generator dump valves or the steam generator safety relief valves must open for each of the corresponding steam generators which is intact and receiving feedwater. The configuration assumes that the four steam lines are isolated from each other.

A.1.4 Assumptions

1. Blowdown from a steam generator failing to be isolated constitutes sufficient outflow to result in a failure of that steam generator due to loss of steam generator inventory in the secondary side.

2. All steam generator safety relief valves must fail, in order to constitute a failure to remove steam from a steam generator. That is, one relief valve per steam generator suffices for decay heat removal.

3. A failure mode was considered for SG AFW injection header check valves (BFD 69, 70, 67, and 68) in which they allow reverse flow leakage. This results in heated main feedwater entering the AFW discharge lines. High temperature water can result in a water hammer condition or steam binding of the AFW pumps. Failure of a single AFW injection header check valve, allowing reverse flow leakage, will affect two AFW pumps (one motor driven and one turbine driven), and the corresponding pump discharge lines.

4. For the steam generator atmospheric steam relief valves (ASRV), the control loop power supply diagram was not available; here, it will be assumed that the SG ASRV requires this power for operation and that loss of this power will constitute a failure of the SG ASRV.

5. The SG atmospheric steam relief valve modeling does not take credit for the N_2 backup mode of operation because it is only a local/manually controlled means of operation.

6. The loss of air and backup N_2 or the loss of dc power to the solenoids controlling the AFW FCVs to the AFW pump discharge segment AOVs (FCV 405 A-D and FCV 406 A-D) is taken as a failure of the ability to control auxiliary feedwater to the steam generators, as it will

result in these failing wide open. Although this does not lead to insufficiency of AFW, controlling the supply of feedwater is difficult.

7. Individual AFW pump flow diversion by check valve backleakage of hot water through an idle AFW pump was not included.

8. The failure mode of the SG safety/relief valve and SG atmospheric dump valves (failure to reclose) has not been modeled. This condition is akin to a main steam line break. There would be excessive heat transfer from primary to the secondary until a SG dryout condition was reached.

9. AFW pump 32 turbine can be supplied with sufficient steam from either SG 32 or SG 33.

10. Freezing of water lines is not reflected in the present results. Information on heat tracing was gathered and modeled, but the computational burden associated with the additional complexity seemed out of proportion to the expected product. In other words, heat rracing failures leading to freezing of large-diameter lines was considered, but generating cutsets for this was considered not worthwhile.

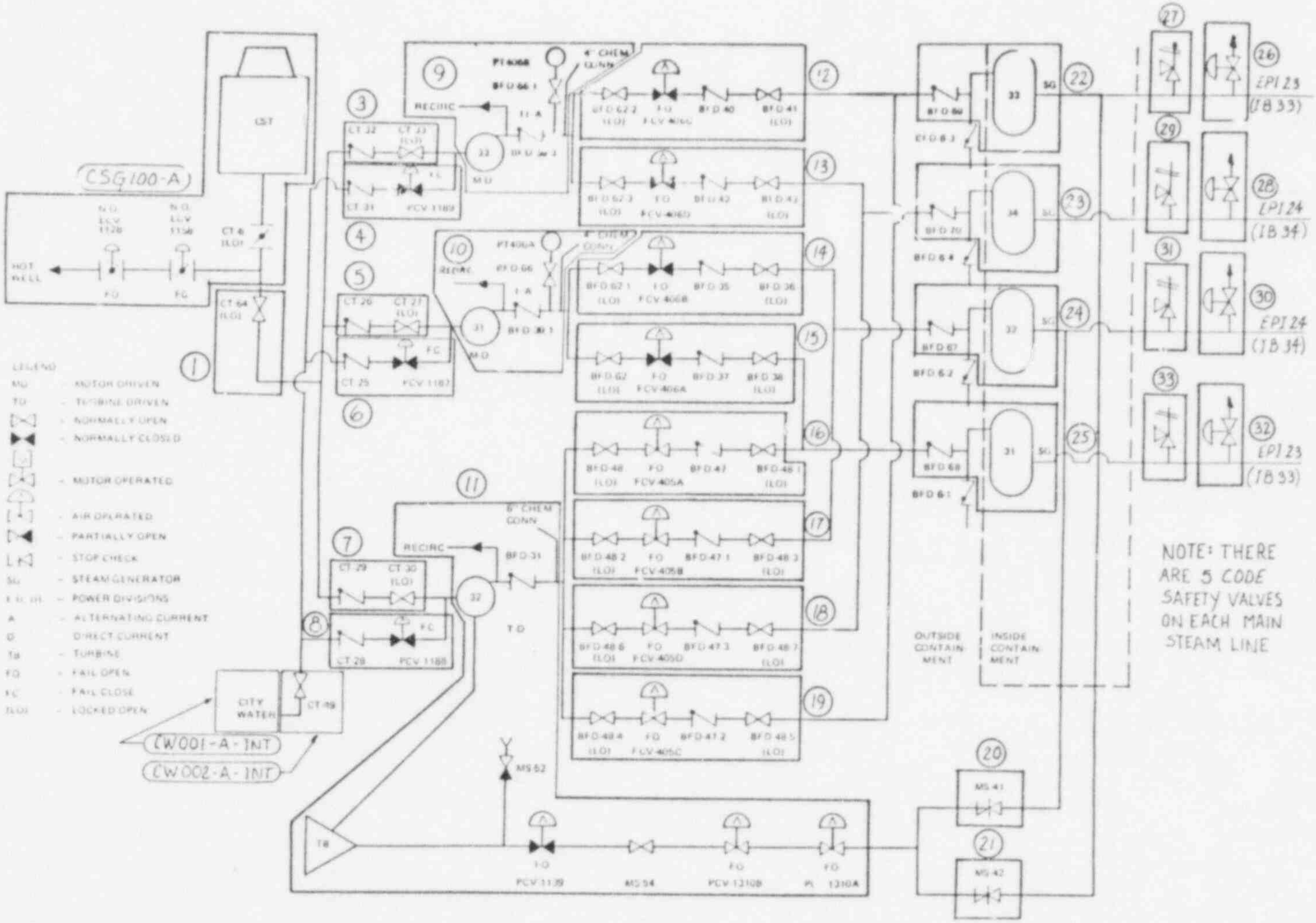


Figure A.1.1 Indian Point 3 auxiliary feedwater system segment diagram.

Table A.1 Electric Power Dependences for AFWS

		Bus		Event Name
SG31	ADV PCV1134	Inst	Bus 33	EPI23-01
SG32	ADV PCV1135	Inst	Bus 34	EPI24-01
SG33	ADV PCV1136	Inst	Bus 34	EPI24-01
SG34	ADV PCV1137	Inst	Bus 33	EPI23-01
AOV CW to AFW Pump 31		Inst	Bus 33	EPI23-01
AOV CW to AFW Pump 32		Inst	Bus 31	EPI21-01
AOV CW to AFW Pump 33		Inst	Bus 32	EPI22-01
Pump 31				
480-Volt Motive Power			Bus 3A	EPA14-T
Dc Control Power		Dc	Bus 33	EPD03-01
Runout Protection Ext (FCV 406A & FCV 406B)		Inst	Bus 33	EPI23-01
Pump 33				
480-Volt Motive Power			Bus 6A	EPA11-T
Dc Control Power		Dc	Bus 32	EPD02-01
Runout Protection Ext (FCV 406C & FCV 406D)		Inst	Bus 32	EPI22-01
Pump 32				
Control Power HC1118		Inst	Bus 31	EPI21-01
EHT				HTG320-T*

*Heat tracing related failure of Pump 32 suction line requires low ambient temp, no flow in line 1080, and loss of power to EHT FP-DP 32 from MCC 35 (EPA28-T)

A.2. MAIN FEEDWATER

A.2.1 Introduction

This section briefly discusses the main feedwater system (MFW). It is not usual for this system to be discussed in any detail in studies of this type, and its role in the present study needs some clarification.

Among the reasons the MFW might appropriately be studied are the following:

1. Some PRAs take credit for use of the MFW system to remove decay heat.
2. Since loss of MFW initiates a plant transient, any significant linkage (interaction) between MFW and AFW might connect a challenge to the AFW system with some degradation of its performance.

Accordingly, at an early stage of the study, it was intended to study the MFW system with the goal of exploring both of items 1 and 2 above.

However, information available to us indicates that it is difficult, at best, to use the MFW system immediately after a trip. In fact, procedures call for a manual trip of MFW after a reactor, turbine or generator trip, and in any case, certain automatic actions following a reactor trip will lead to a MFW trip. Moreover, while the MFW system at IP-3 is being upgraded to permit practical operation at low flow, this modification was not in place when the present anlaysis was performed. Analyzing abnormal scenarios (such as MFW operation after a total AFW failure) for the sake of realism is well beyond the scope of the present study, which is intended to shed light on existing and prospective regulatory practice, rather than on beyond-design-basis recoveries. Consideration of MFW in this study was therefore limited to its possible correlation with AFW failures. Correspondingly, development of the MFW fault tree was undertaken for the purpose of highlighting support system faults which would affect AFW operation as well.

A fault tree was developed for the MFW system and included as part of the transient initiator fault tree.

A.2.2 Top Event

The top event was taken to be loss of (or insufficient flow of) main feedwater to at least one out of four steam generators, with the plant initially at full power.

A.2.3 Mission Success

Success criteria do not apply to this system as it was modeled only as a transient initiator.

A.2.4 Assumptions

1. The plant is initially at full power.
2. Failure of more than one circulating water pump leads to a trip.

BOILER FEEDWATER SYSTEM

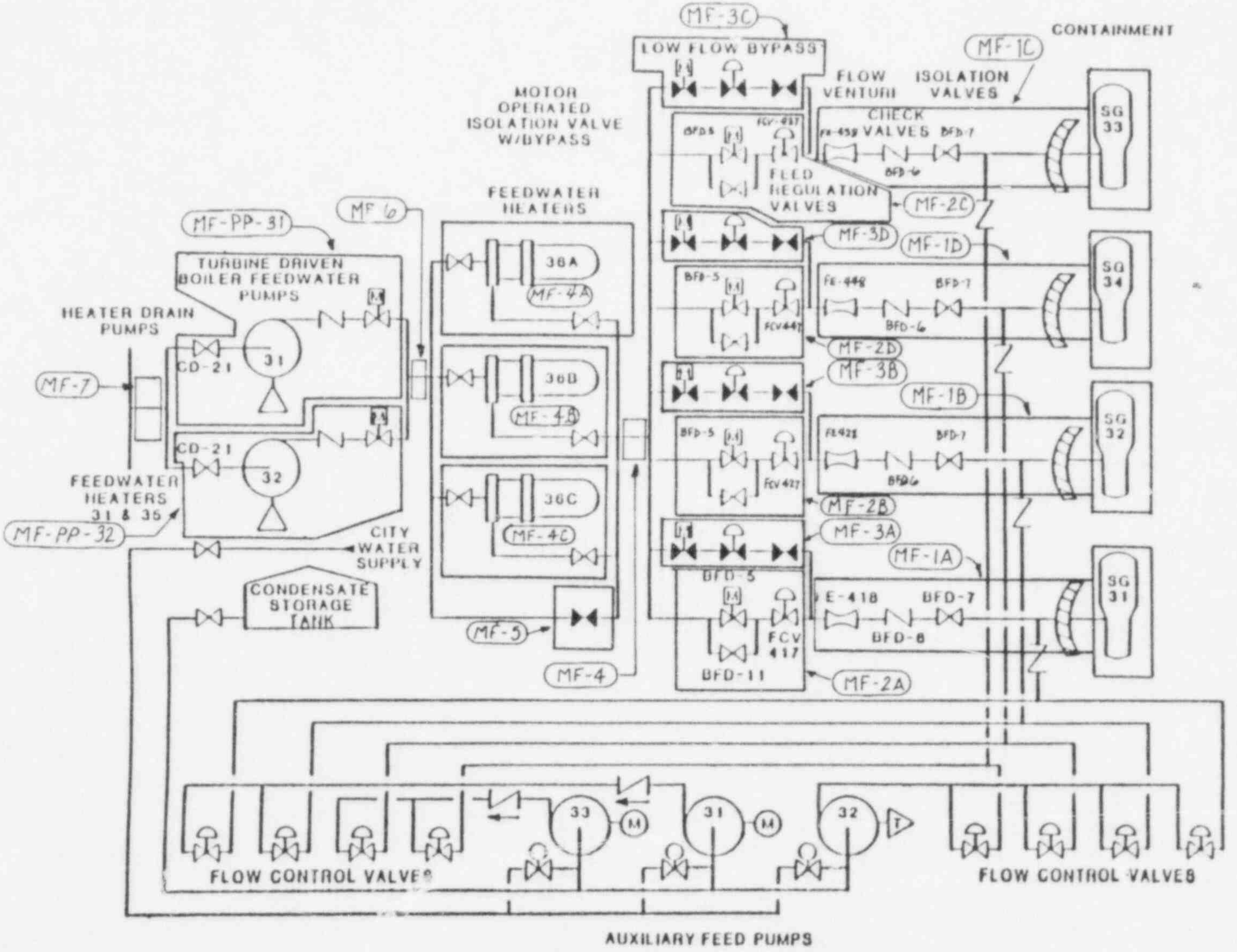


Figure A.2.1 Main feedwater simplified P&ID.
(sheet 1 of 3)

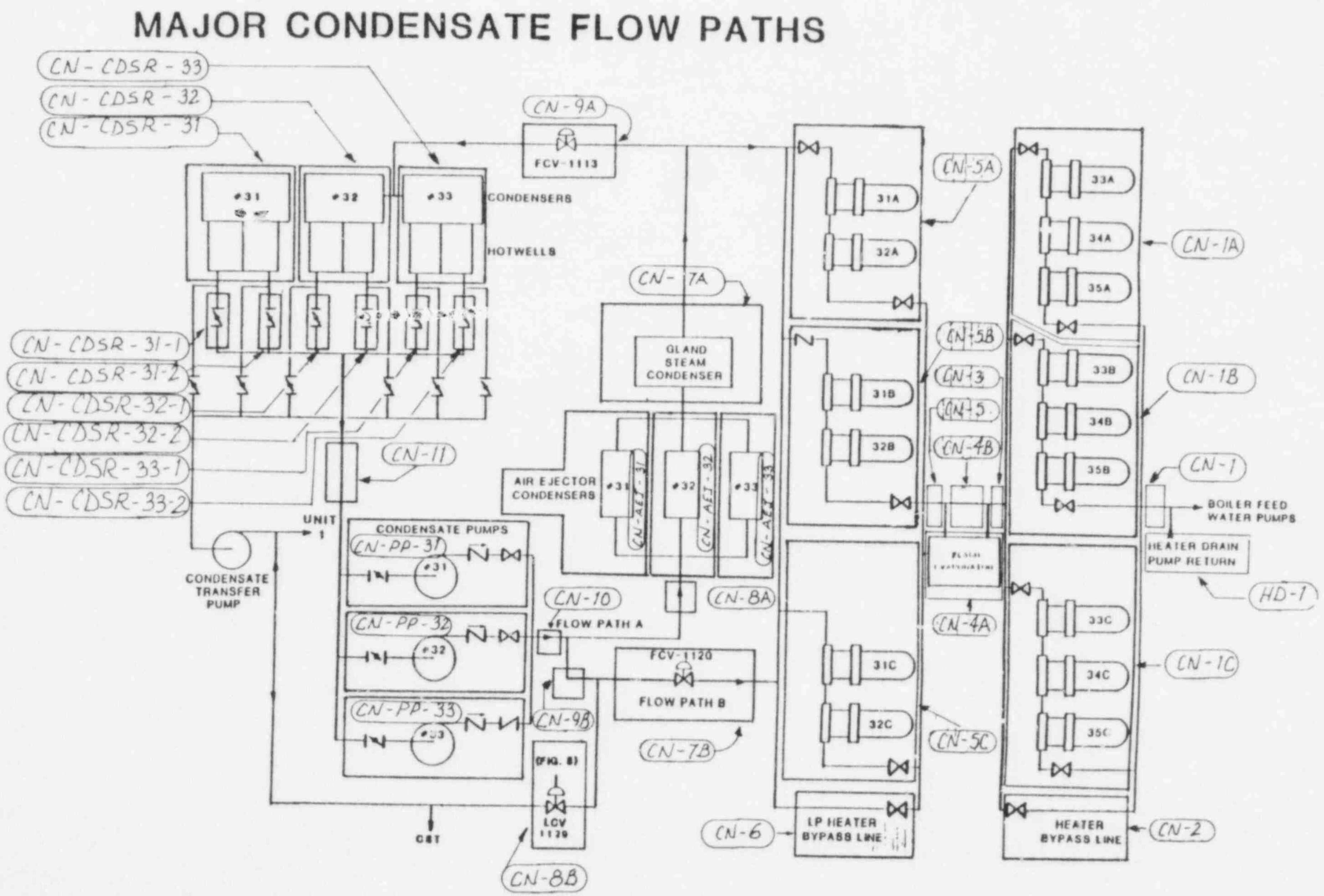


Figure A.2.1 Main feedwater simplified P&ID.
(sheet 2 of 3)

HEATER DRAIN TANK SYSTEM AND CONTROLS

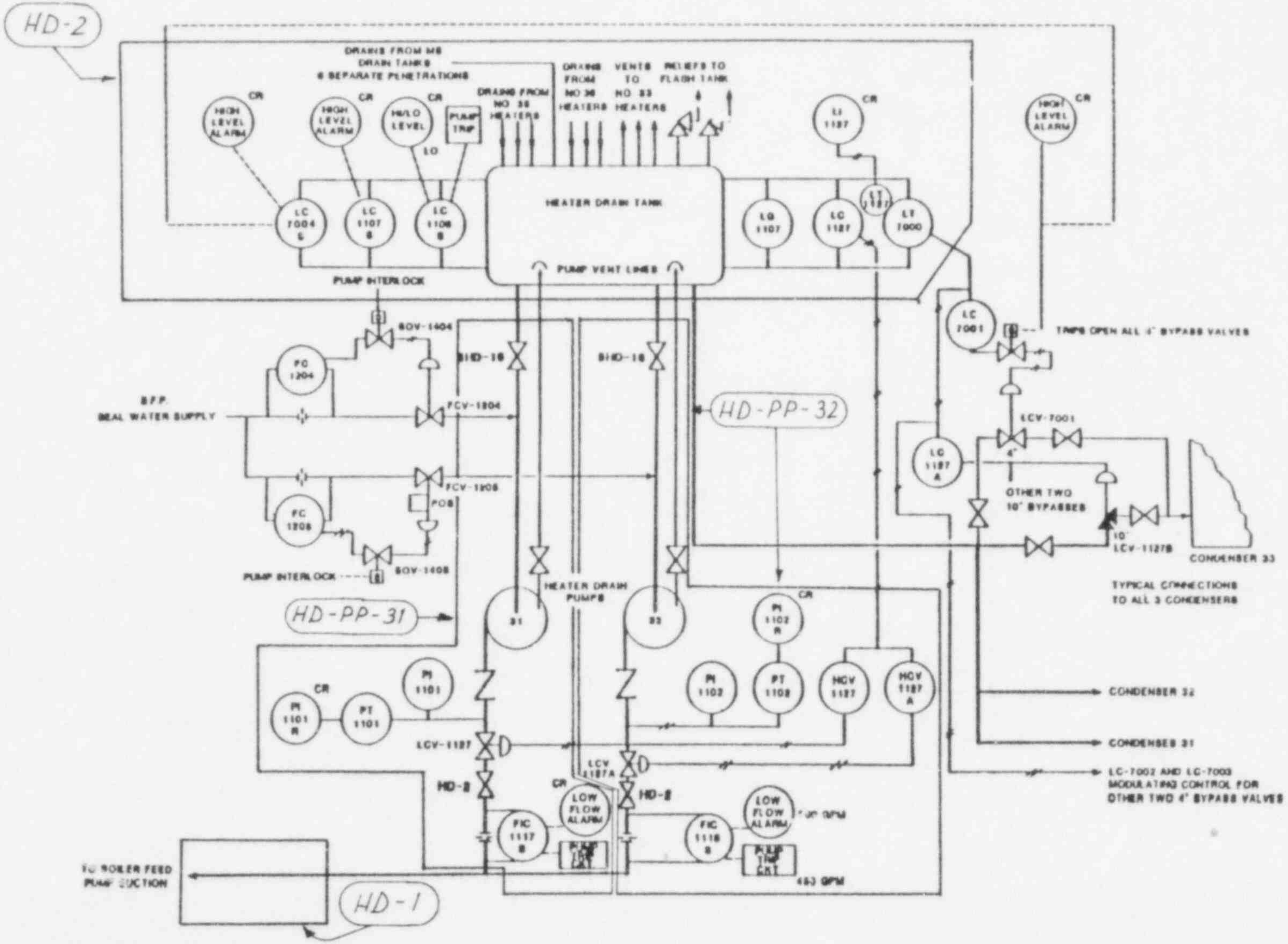


Figure A.2.1 Main feedwater simplified P&ID.
(sheet 3 of 3)

A.3. HIGH PRESSURE INJECTION

A.3.1 Introduction

The high pressure injection (HPI) system provides water to the RCS in the event of a loss-of-coolant accident (LOCA) or other depressurization events. In this study, two scenarios calling for HPI are considered; small LOCA and medium LOCA. Only the injection phase is considered.

The HPI system includes three centrifugal electric-motor-driven pumps. These take suction from the RWST and inject into the cold legs of the RCS. One of the two paths from the pumps to the cold legs passes through the boron injection tank. The boron itself does not play a mitigating role in the scenarios considered, but the flow path is, of course, necessary. This path must be kept heated or the highly concentrated boric acid will crystallize, blocking the flowpath.

A.3.2 Top Events

The top events considered are failure to supply sufficient HPI flow for each LOCA scenario considered.

A.3.3 Success Criteria

These criteria are based on the IPPSS analysis.

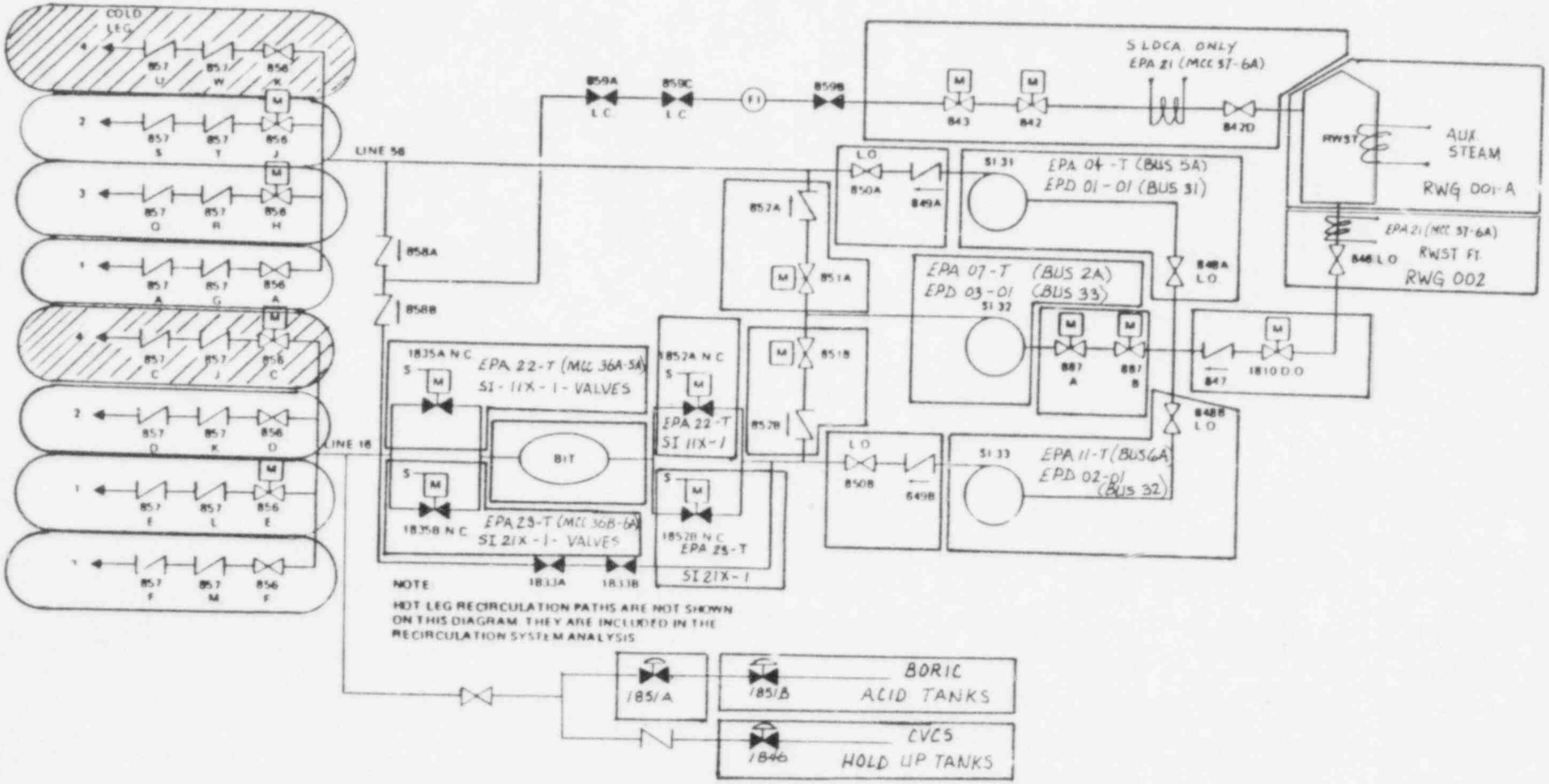
Small LOCA - at least one out of three high pressure safety injection pumps capable of feeding at least one out of eight RCS cold leg injection paths.

Medium LOCA - at least two out of three high pressure safety injection pumps capable of feeding at least two out of four RCS cold leg injection paths in each safety injection system discharge header.

A.3.4 Assumptions

1. It was conservatively assumed that the break incapacitates one cold leg.

2. For the small LOCA case, a flow diversion back to the RWST was considered (through segments HP009 and HP011 or through segments HP010 and HP011). In the small LOCA case, wherein single operation of a safety injection pump constitutes success, it was assumed that enough flow through this path (full flow test line) would occur to result in insufficient flow to the RCS. In the medium LOCA case, with greater flow being delivered to both headers from at least two high pressure safety injection pumps, this small flow diversion through the 3/4-inch full flow test line was not considered to result in insufficient high pressure safety injection flow.
3. Failure modes considered in the development of the HPI system functional fault trees were insufficient flow (failure mode A), reverse flow (failure mode C), and electrical power supply loss (failure mode T). Failure modes B (excess flow) and D (rupture) were not modeled into the HPI functional fault tree.



NOTE

HOT LEG RECIRCULATION PATHS ARE NOT SHOWN ON THIS DIAGRAM. THEY ARE INCLUDED IN THE RECIRCULATION SYSTEM ANALYSIS

Figure A.3.1 Indian Point 3 high pressure injection system simplified P&ID.

A.4. LOW PRESSURE INJECTION

A.4.1 Introduction

The low pressure injection (LPI) system is designed to inject water into the core following a large or medium LOCA. The LPI system also performs other functions, but is analyzed here for the injection phase of large or medium LOCA scenarios.

The system includes two pumps, each capable of delivering 3000 gpm when primary pressure is 150 psig. During the injection phase, the pumps take suction from the RWST, and inject through four cold leg injection paths. Operation of this system during the injection phase is, of course, required to be completely automatic.

A.4.2 Pertinent Top Event

There is only one pertinent top event: failure to inject, following a large or medium LOCA.

A.4.3 Mission Success Requirement

At least one of the two LPI pumps must inject through two cold leg paths (it being assumed that the break incapacitates one of the four existing cold leg injection paths). This is based on the IPPSS analysis.

A.4.4 Assumptions

The following failure modes were considered:

1. Insufficient Flow (failure mode A)
   This failure mode includes plugging of pipe segments and valves, valves failing closed, and pump failures.
2. Flow Diversion (failure mode E)

   The following flow diversion paths were considered:

   - Flow diversion to the containment sump, given failure of MOV-885A and MOV-885B in the open position (event LP015-E1 and LP015-E2).

- Flow diversion to the containment sprays (flow path used in the containment spray recirculation mode), given failure of MOV-889-A or MOV-889-B in the open position (LP014A-E and LP014B-E in the fault tree). It was assumed that:
  - a) With one LPI pump operating, and MOV-889A or MOV-889B failed open, sufficient flow is diverted to the containment spray to cause failure of LPI.
  - b) With both pumps and both heat exchangers providing normal flow, opening MOV-889A and/or MOV-889B will not divert sufficient flow to cause failure of LPI.
  - c) With both pumps and one heat exchanger providing normal flow, opening MOV-889A or MOV-889B will divert sufficient flow to containment spray that LPI will fail. This assumption is based on the design flow rate (3000 gpm) of the heat exchanger.
- Flow diversion back to the suction (upstream of MOV-882), given failure of MOV-863 and BV-1863 in the open position (events LP003-E1 and LP-003-B2 in the fault tree).

Note: The inclusion of these flow diversion paths as failure modes of the LPI is considered very conservative and may, in fact, be wrong.

The following flow diversion paths were not considered:

- Flow diversion to the suction of the HPI pumps, given failure of MOV-888A or MOV-888B in the open position. This flow diversion was not considered because part of this diverted water would be injected into the cold legs through the HPI pumps. However, if CV-847 is also failed (reverse leakage), a portion of this diverted flow would go back to the RWST and to the LPI pumps' suction.

- Flow diversion to the recirculation sump, given a failure of MOV-1802A or MOV-1802B in the open position AND (reverse flow through CV-886-A and recirculation pump 31 OR reverse flow through CV-886B and recirculation pump 32).

3. Loss of Minimum Flow Protection

   It was assumed that if the minimum flow line is blocked the LPI pumps will fail. For a range of break sizes, the LPI pumps will not inject for some time until RCS pressure is below shutoff head; it is assumed here that there is a significant probability that this delay (between actuation and actual injection) is sufficient to fail the pumps.

4. Failures of the following support systems were included:

   - 480-V ac power to the pumps.
   - Dc control power to the pumps.
   - SI actuation signal.

The following failure modes were not considered:

1. Reverse flow (failure mode C)
   The only path for reverse flow would require failure of LPI pump 31 (32) and failure (reverse flow through) CV-738A (CV-738B), it is not clear that even this combination would degrade the flow sufficiently to fail LPI.

2. Rupture (failure mode D)

3. Human Actions
   Operator actions were not considered in the fault tree. Maintenance errors, including misalignment, were not included.

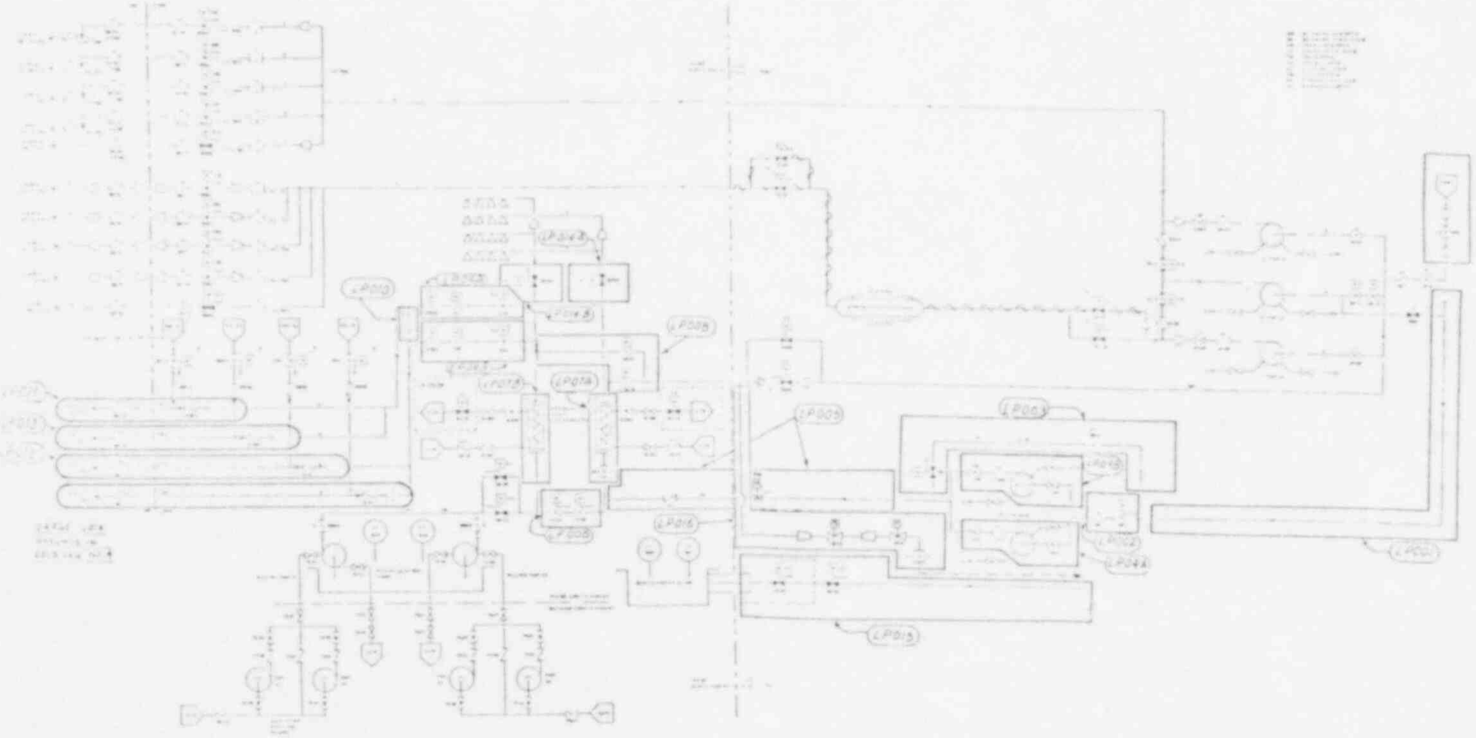


Figure A.4.1 Indian Point 3 low pressure injection system simplified piping and instrumentation diagram.

A.5. RCP SEALS

A.5.1 Introduction

The reactor coolant pump (RCP) seals are potential LOCA sites. Possible reasons for RCP seal failure are diverse. Among these reasons is loss of cooling to the seals. Cooling is provided by systems which can interact with HPI, which in turn would be involved in mitigating an RCP seal LOCA; therefore, there is potential for correlating a LOCA event with a failure of HPI. This is the main reason for including RCP seals in a study of this type.

Ordinarily, the seals are cooled by seal injection flow, which is a portion of the flow provided by the normally operating charging pump. Filtered seal injection flow passes through the seals and into the RCS; thus, the seals normally see clean and relatively cool water. Should seal injection flow be lost, flow through the seals reverses direction, and the seals see relatively dirty primary coolant. If the primary coolant passes through the seals at normal RCS temperature, there is a potential for seal failure, which increases with the passage of time. Normally, primary coolant flowing up the pump shaft to the seals will be cooled by the thermal barrier, a heat exchanger whose tube side is provided with component cooling flow. This is intended to compensate for loss of seal injection flow. If, however, both seal injection flow and component cooling flow are lost, the RCP seals are without cooling, and a LOCA is presumed to occur after some time under these conditions. Presumably, a few minutes without cooling can be tolerated, but times on the order of an hour cannot.

Some consideration of the time scale was applied to the results of the functional model. Here, the usual binary logic has been applied to hardware failure modes which would lead eventually to an RCP seal LOCA. Having done this, one obtains cutsets which are extremely conservative in light of the premises on which the design was based (i.e., procedurally mandated intervention by the operator). In particular, neither the component cooling pumps nor the charging pumps are considered essential loads during the injection phase of a LOCA; presence of a blackout (LOOP) signal and/or an SI signal immediately eliminates seal injection flow, and presence of both signals further eliminates component cooling. Moreover, presence of an SI signal or blackout signal interrupts SW flow to the CCW heat exchangers. In a sense, therefore, not much is required to temporarily interrupt cooling to the seals. However, the operators are expected to restore these functions under most conditions. This is fundamentally different from, say, operator recovery of HPI during a LOCA, which ought to be unneccessary by design; in the case of the RCP seal supports, operator action is necessary by design. Human factors are out of the scope of this study, and we have not assumed the burden of questioning the design from a human factors standpoint; here, the operators are part of the hardware. Therefore, the RCP two-element cutsets have been surveyed, and where there was a basis for concluding that the operator was expected to relieve the problem, the two-element cutsets were considered to have become three-element, and passed thereby out of consideration. These nominally two-element cutsets appear in the final listings, but do not survive the culling process which yields the quantified "systems interactions." In other words, given this study's premise that the operator will follow procedures to the letter, no first- or second-order cutsets were obtained that were outside the scope of the procedures.

A.5.2 Pertinent Top Events

The pertinent top event is RCP Seal LOCA. This is assumed to occur if seal injection flow and component cooling are lost; cutsets are then screened to take operator recovery into account.

A.5.3 Mission Success Requirement

Successful RCP seal cooling is assumed to require either CCW to the thermal barrier or seal injection flow. Seal injection requires a single charging pump. The requirement assumed for CCW is characteristic of the CCW system itself, that is, success requires either two CCW pumps operating or a single CCW pump carrying a reduced load. As mentioned above, the procedure of taking the hardware alone into account, and ignoring time scales, gives rise to a model which is conservative by the standard set by the design; CCW is "failed" by a SI signal because conventional SW is shed.

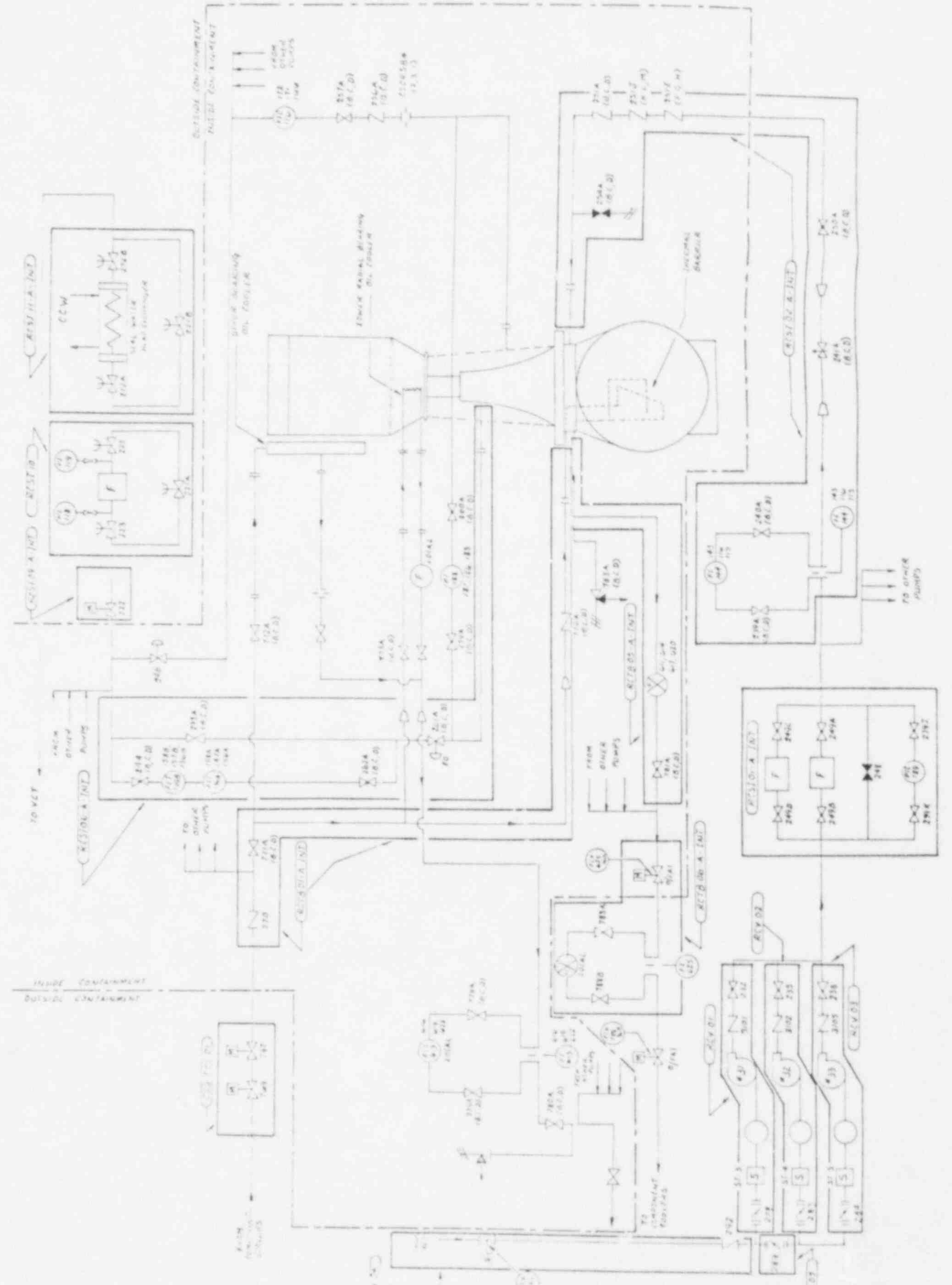


Figure A.5.1 RCP sealing cooling simplified P&ID.

A.5.4 Assumptions

It has been assumed in this model that the charging pumps require cooling. The possibility of intermittently operating the charging pumps without cooling for long enough to cool the seals has not been considered.

A.6 PRESSURIZER

A.6.1 Introduction

The pressurizer was divided into seven major segments for the initial FMEA and fault tree. A schematic of the model with a listing of the segments and gate nomenclature scheme is shown on Figure A.6.1. The seven segments are 1) the pressurizer vessel, 2) three code safety relief valves, 3) two PORV & block valve combinations (each PORV modeled independently within the segment because of differing control aspects), 4) spray, 5) heaters, 6) pressure control system, and 7) level control system.

The three SRVs, being independent of other segments and systems, were modeled as one valve with one failure mode, i.e., inadvertent opening with failure to reseat. (For quantification purposes, the failure/demand probability was multiplied by 3.) The two PORVs and associated block valves were modeled separately, as PCV-455C is controlled by the pressure control system and PCV-456 is controlled by a bistable with a fixed setpoint. Both PORVs have the same two failure modes, i.e., opening inadvertently and failing to open when signaled.

The pressurizer spray relies upon the driving head of either RCP 33 or 34, and is controlled by the pressure control system. The failure modes modeled were rupture of the spray piping, too much flow, and no or insufficient flow. Auxiliary spray capability was not included in the modeling.

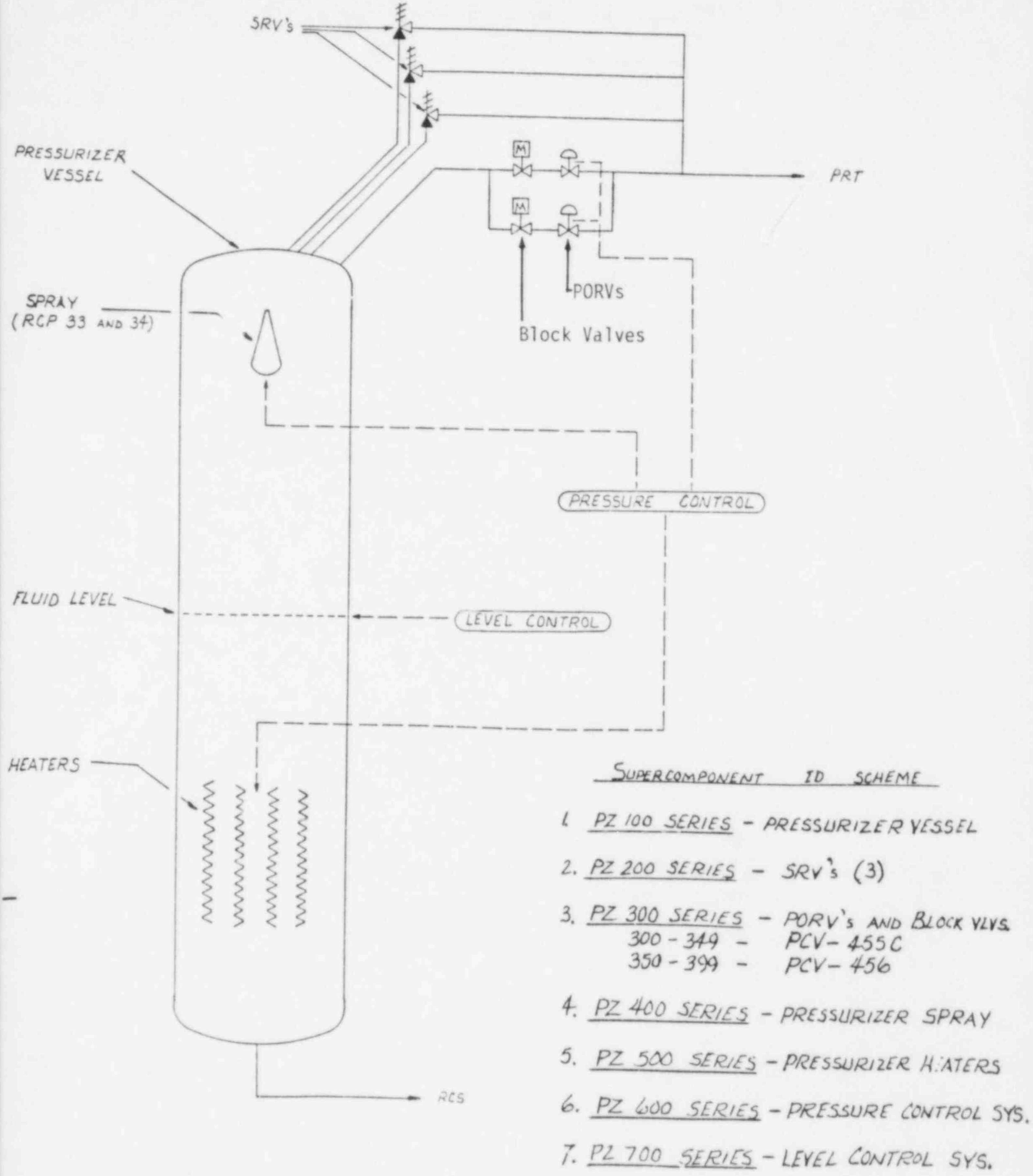
The pressurizer heaters are controlled in a mandatory fashion by the pressure control system. The level control system has the capability of overriding the pressure control system and turning on all heaters upon pressurizer high level or turning off all heaters upon pressurizer low level. The failure modes modeled were failure to supply heat to maintain primary pressure, and supplying too much heat, thus raising primary pressure.

The pressure control system is a single-channel system which compares a reference pressure value to the actual pressure within the pressurizer. The control system controls both pressurizer spray valves, all four banks of pressurizer heaters, and one of the two PORVs. The failure modes modeled were creating either a low pressure condition or a high pressure condition in the automatic (normal) mode of operation.

A significant SI was found within the pressure control system. The single channel of pressure control has a 3-position ganged selector switch by which one of two pressure transmitters (PT-455 or PT-457) may be selected for providing the actual pressure input signal to the pressure control system master controller in various combinations with one of the remaining two pressure transmitters (PT-456 or PT-474) which supplies a signal directly to the second PORV (PCV-456). The modeled position of this selector switch was chosen for PT-457 inputting to the pressure control system and PT-456 controlling the second PORV. This combination of the three was felt to be the most conservative one for the study, as it is the only one that allows a single transmitter/sensor failure to initiate a high pressure transient and simultaneously prevent both PORVs from responding. This occurs because independently of the selector switch, PT-457 also provides an interlocking function to PCV-456. According to the IP-3 System Description, to prevent a single failure from opening a PORV, each PORV requires two pressure transmitters to detect high pressure in order to open in the auto mode. Therefore, should PT457 fail low, the pressure control system would raise primary pressure in an attempt to match the output of PT-457 with the reference pressure, and without human intervention, the high pressure reactor trip setpoint would be reached.

The level control system is modeled in a manner similar to that of the pressure control system. It is a single-channel system which compares a reference level value (which is a function of reactor power level) to the actual level within the pressurizer. The control system controls the charging pump speed controller, isolates letdown, turns off the pressurizer heaters on low level, and turns on all heaters on high level. The failure modes modeled were creating either a low level condition or a high level condition in the automatic (normal) mode of operation.

The single channel of level control has a 3-position ganged selector switch by which any two of the three level transmitters may be selected for various control purposes. No obvious difference between switch positions was apparent. Therefore, the control switch was modeled as shown in Figure 13 of the System Description. This figure shows Channel III (LT-461) supplying



SUPERCOMPONENT ID SCHEME

1. PZ 100 SERIES - PRESSURIZER VESSEL
2. PZ 200 SERIES - SRV's (3)
3. PZ 300 SERIES - PORV's AND BLOCK VLVS.
    300 - 349 - PCV- 455C
    350 - 399 - PCV- 456
4. PZ 400 SERIES - PRESSURIZER SPRAY
5. PZ 500 SERIES - PRESSURIZER HEATERS
6. PZ 600 SERIES - PRESSURE CONTROL SYS.
7. PZ 700 SERIES - LEVEL CONTROL SYS.

Figure A.6.1 Pressurizer simplified P&ID.

input to the master level controller and Channel II (LT-460) being used for isolating letdown and deenergizing the heaters on low level.

A.6.2 Pertinent Top Events

The two top events modeled in the pressurizer fault tree are LOCA and reactor trip associated with pressurizer malfunctions/failures. Included under reactor trip are the three RPS logics associated with the pressurizer, i.e., 1) two out of three high level, 2) two out of three high pressure, and 3) two out of four low pressure.

A.6.3 Success Criteria

"Success" in the pressurizer model means that pressure and level are kept within bounds by the control systems and that the integrity of the RC boundary represented by the pressurizer is not breached.

A.6.4 Assumptions

1. The failure modes assumed are listed and discussed above.
2. Assumed control switch positions and basis for selection are discussed above.
3. Control systems are powered from the same instrument bus as that of the selected input sensor/transmitter. This was assumed to be due to lack of specific details within the documentation provided for the study.
4. Loss of control system power for the pressure control system renders it inoperable, and all control actions are terminated. (IP-3 System Description)
5. Loss of control power to the level control system simulates a low level condition and the charging system responds to create a high level condition. (IP-3 System Description)

A.7 COMPONENT COOLING WATER SYSTEM

A.7.1 Introduction

The component cooling water (CCW) system is a closed loop cooling system which is designed to remove residual and sensible heat from various primary plant components during power and shutdown operations, and under accident and transient conditions. The CCW consists of three pumps, two heat exchangers, which are cooled by service water, two surge tanks, and two supply and return headers (see Figure A.7.1). During normal plant operation, two of the three pumps are required to supply the necessary flow for plant cooling loads. Pump 32 has been modeled as the standby pump. The three CCW pumps are always lined up to the common pump discharge header and pump return header. The pump discharge header cross-tie valves and the pump suction header cross-tie valves are normally open during power operation. Both CCW heat exchangers are fed from the common pump discharge header. Low discharge pressure on either heat exchanger supply header (which indicates insufficient capacity) starts the third CCW pump.

Three groups of loads are modeled in the study as requiring component cooling water: the charging pumps, the high pressure injection pumps, and the reactor coolant pump thermal barrier. All other safety loads served by the CCW system do not require external cooling prior to the recirculation phase of an accident, and were therefore not modeled.

The two support systems required by the CCW system are service water and electrical power. Electrical power is made available to the three CCW pumps except under the condition of a concurrent occurrence of bus undervoltage (or LOOP) and an SIAS actuation signal. Under this latter condition, the running CCW pumps will be tripped and none will be automatically restarted.

Modeling of this system was, for some purposes, conservative. Failure of conventional SW "fails" CCW, for example, by depriving it of cooling for the short term; this is an oversimplification. In some scenarios, operator action is essentially built into the system, as when the operator is obliged to reduce CCW loads in order to ensure the sufficiency of a single CCW pump.

It is evident that the design contemplates operator intervention, and it is implicit that the time available for operator action is adequate.

A.7.2 Pertinent Top Events

For the charging pumps, the top events are no-or-insufficient flow to the three charging pump oil coolers. Beyond the individual manual isolation valves, the fault tree is common for all three pumps. Additionally, for the charging pumps, city water provides a backup source of cooling water.

For the high pressure injection pumps, the top events are no-or-insufficient flow in the CCW loops. The HPI pumps have booster pumps supplying CCW to themselves, and do not require that CCW pumps operate during the injection phase. Pump 31 is aligned to CCW loop 1 and pumps 32 and 33 are aligned to CCW loop 2.

For the reactor coolant pump thermal barrier, the top gate is no-or-insufficient pumped flow in loop 2. This same gate is predominant in the CCW portion (i.e., excluding city water) of the three charging pumps discussed above.

A.7.3 Success Criteria

The success criterion for SI pump cooling is to have water in the two CCW loops such that the shaft-driven booster pumps have a suction source.

The success criteria for the charging pumps and RCP thermal barrier are either two out of three CCW pumps running with normal flow, or one CCW pump and operator action to reduce other CCW loads.

A.7.4 Assumptions

1. CCW pump 32 is assumed to be in the standby mode and pumps 31 and 33 are assumed to be running.
2. The HPI pumps are assumed to require both the oil and seal heat exchangers for operation.
3. The charging pump oil coolers are assumed to be required to support the operation of the charging pumps.

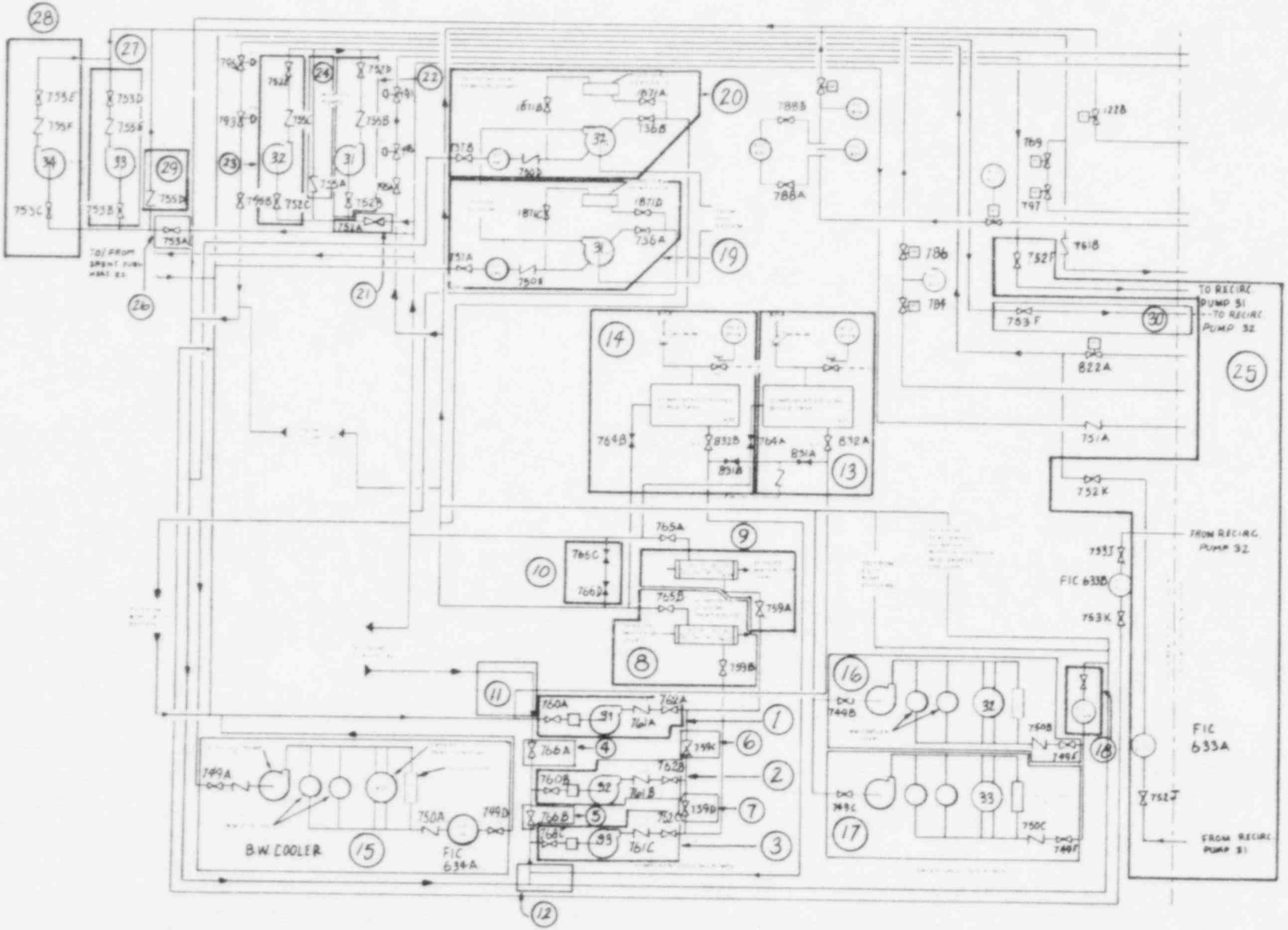
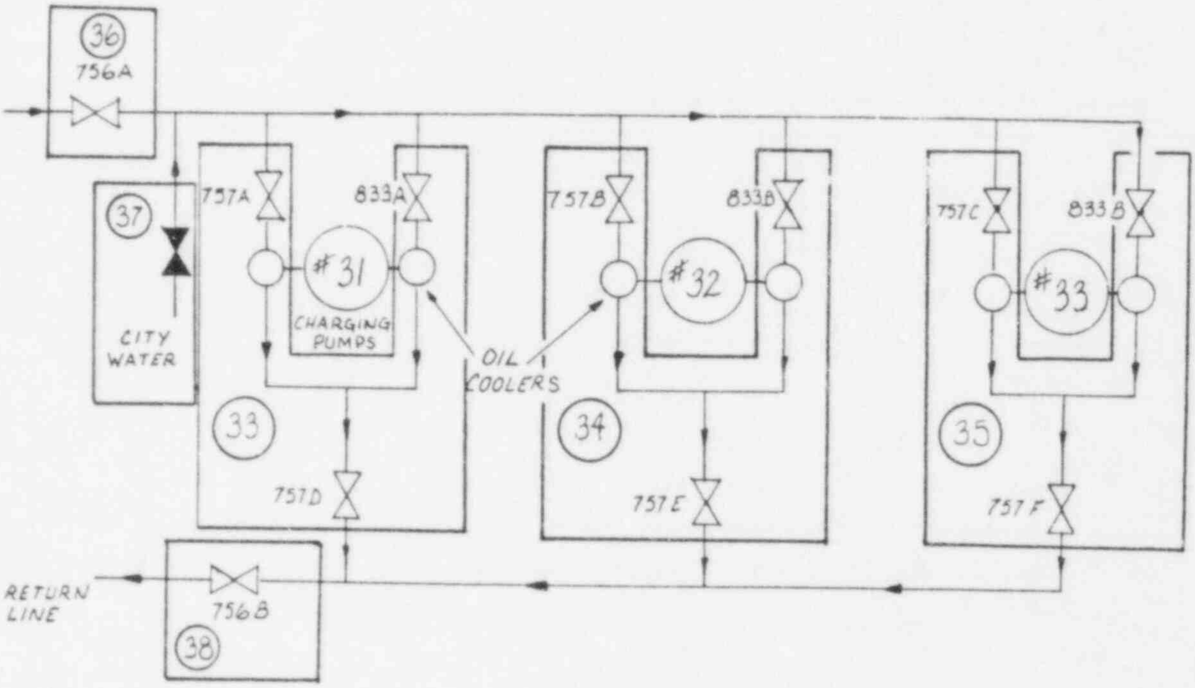


Figure A.7.1 Indian Point 3 simplified schematic of component cooling system (sheet 1 of 2).



CCWS INTERFACES WITH CHARGING PUMPS 31, 32, AND 33

Figure A.7.1 Indian Point 3 simplified schematic of component cooling system (sheet 2 of 2).

A.8 CONDENSATE STORAGE TANK

A.8.1 Introduction

The condensate storage tank segmentation scheme is shown in Figure A.8.1. It is the primary water source for the AFW system. The model includes possible flow diversion to the condenser and failure modes that lead to freezing of the outdoor lines.

A.8.2 Pertinent Top Events

The top event is failure to supply the auxiliary feedwater system with its primary water source.

A.8.3 Success Criteria

Success is delivering required flow to AFW suction.

A.8.4 Assumptions

NA

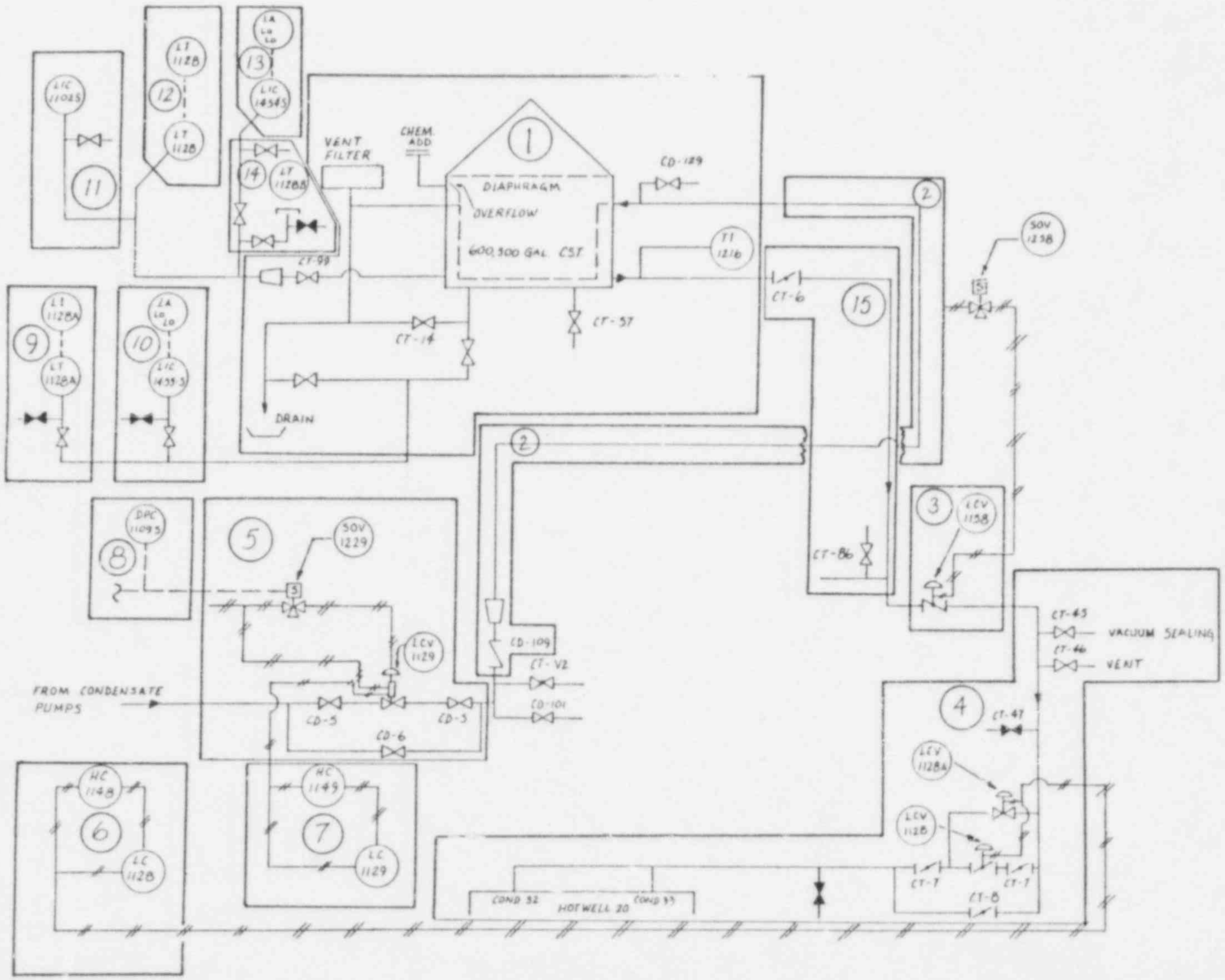


Figure A.8.1 Condensate storage tank (CST).

A.9. CHEMICAL AND VOLUME CONTROL SYSTEM

A.9.1 Introduction

The CVCS was broken down into two fault trees for convenience purposes, one for charging and one for letdown functions.

The charging function also includes seal injection flow for the RCP seals. There are three charging pumps and two charging lines. The charging pumps normally take suction from the volume control tank. The pump coolers are cooled by CCW with a city water backup. The remaining support systems for the charging fault tree are electrical power and instrument air for control valves.

Under normal operating conditions, one charging pump is sufficient to support all charging and seal water flow requirements. The charging pumps are positive displacement type and have a speed control system to regulate charging flow. On loss of control circuit output (i.e., internal failure or loss of power supply), if the pump has motive power (480 vac) available it will revert to its minimum speed, which is here assumed to be adequate for seal injection but not for charging.

The letdown function is divided into two parts, Normal Letdown and Excess Letdown. Normal letdown is under automatic control, whereas excess letdown is manually initiated. Letdown is isolated on low pressurizer level or SIAS. The support system for letdown includes instrument air, pressurizer level control, electrical power, CCW, and safety injection actuation system.

A.9.2 Pertinent Top Events

Three top events for the CVCS system are loss of charging, loss of letdown, and loss of RCP seal injection.

A.9.3 Success Criteria

Each of these top events corresponds to a complete loss of the indicated function.

A.9.4 Assumptions

It has been assumed that minimum pump speed on one charging pump (due, for example, to loss of control circuit output) is sufficient to meet RCP seal injection flow requirements but not to meet charging flow requirements.

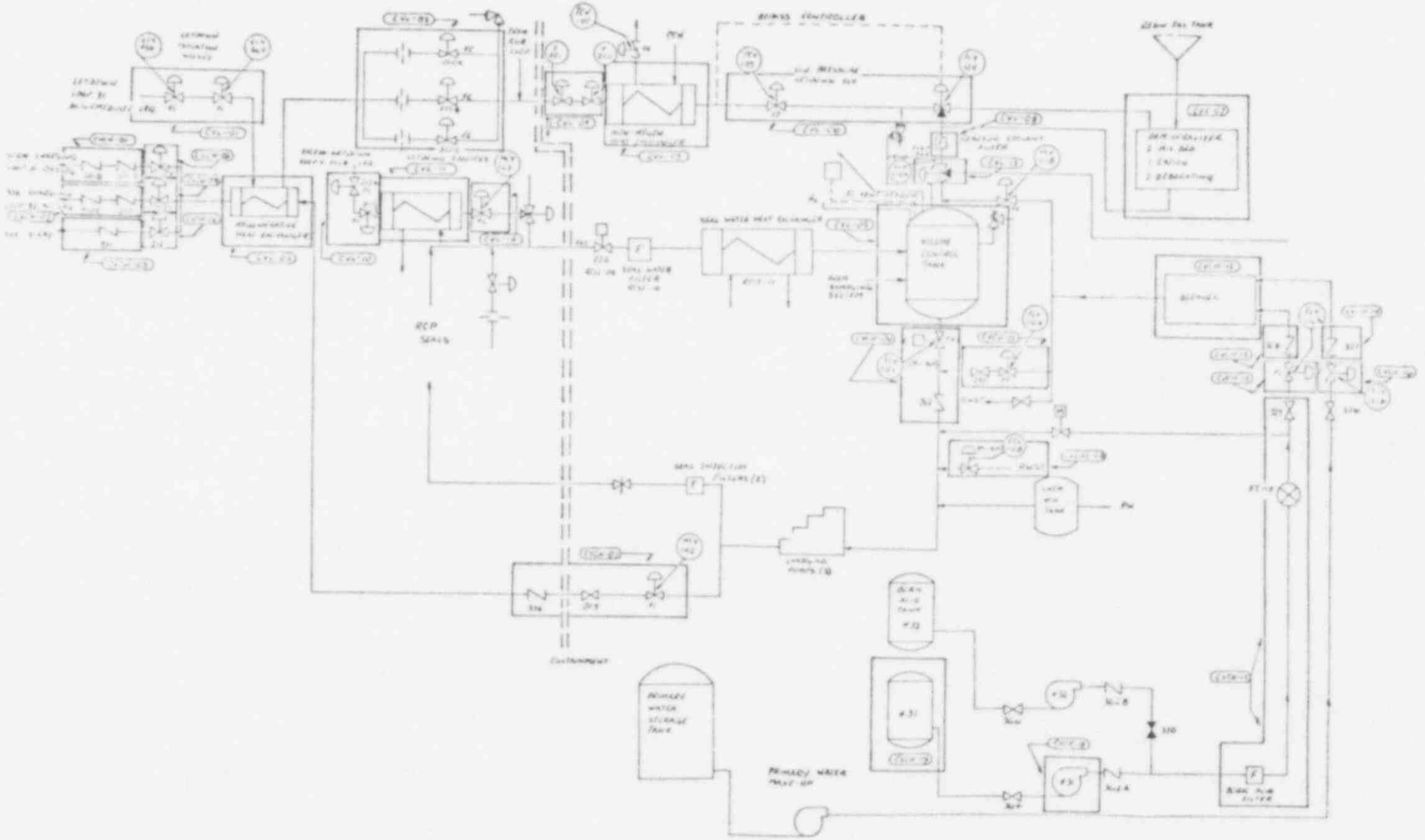


Figure A.9.1 Chemical and volume control system simplified P&ID.

A.10 ELECTRICAL POWER

A.10.1 Introduction

The electrical power fault tree is a model of most of the electrical power system of IP-3 (see Figure A.10.1). The exclusions from the model include the main turbine generator, 345-kV switchyard, and the 13.8-kV system with its gas turbines. The model considers that transient events will trip the main turbine generator and thereby isolate the plant from the 345-kV system. The gas turbines are not modeled.

There are five sources of ac power within the model: the 138-kV switchyard, the unit auxiliary transformer, and the three diesel generators. The unit auxiliary transformer is the normal source for the 6.9-kV buses 1, 2, 3, and 4. Given a turbine trip, buses 1 and 2 and buses 3 and 4 fast transfer to buses 5 and 6, respectively, as these last buses are always energized from the 138-kV system. Three of the four 480-V safety buses (5A, 2A, and 6A) have an emergency diesel generator to supply power upon the loss of offsite power to its respective bus. The fourth safety bus (3A) receives onsite emergency power from the diesel on bus 2A via a normally open automatic bus tie breaker. However, if bus 3A becomes deenergized and bus 2A does not, the interlocks within the tie breaker will prevent the automatic reenergization of bus 3A via bus 2A. (Note: This feature of the plant was changed on July 10, 1984, because of one of the findings of the present study.)

All 480-V MCCs are shed from their 480-V buses upon the occurrence of a bus undervoltage condition. The safety-related MCCs (36A, 36B, and 36C) are automatically reconnected following bus reenergization by their respective diesel generators. Upon the occurrence of an SIAS, only MCCs 34 and 39, along with the three safety-related MCCs noted above, remain energized; the others are shed and no provision exists for their automatic reenergization. The various combinations of when a given MCC would be shed (i.e., become deenergized by design) were addressed in the model in the following fashion. Each 480-V safety bus was conceptually divided into three distinct sections; one for safety loads (i.e., those which survive SIAS and receive diesel backup power), one for loads that are shed only on bus undervoltage (i.e., only receive offsite power), and one for loads that do not survive either an SIAS or a bus undervoltage condition (i.e., SIAS and bus undervoltages are modeled as "failure" modes of those loads).

For the dc power panels, a division similar to that for the ac buses was performed. Each dc bus was divided into two parts. The first part was modeled exactly as it occurs in the plant; the second part was modeled without any ac power input. This latter portion of each power panel was created to break the logic loop associated with dc power and the diesel generators.

The diesel generators were modeled as having four distinct failure categories. The first three categories are dc control power, diesel generator circuit breaker and actuation scheme (Sequencer FT), and service water for cooling the jacket water and lube oil cooler heat exchangers. These represented all of the major support system interdependences. All other failures were combined into a fourth category labeled internal failures. The logic loop associated with the diesels and the service water system was broken within the service water fault tree.

Portions of the overall electrical power fault tree play a role in a transient initiation, and portions play a role in supporting the mitigating systems. This was accomplished by placing a number of flags (house events) within the fault tree so that only those portions appropriate for a given sequence would be included in the solution. An alternative approach would have been to develope separate trees for different scenarios.

A final word about failure modes is in order for full understanding of the fault tree model. All the normal failure modes associated with an electrical power system have been included (e.g., open circuits, breaker transferring to wrong positions, etc.). However, we have selectively applied a failure mode which we have referred to as an "unclearable fault." An unclearable fault is one in which an electrical fault occurs in such a place in the power system that more than one bus is deenergized in the clearing of the electrical fault. Specifically, it has been applied in six places within the fault tree. The first two places are normally closed circuit breakers ST5 and ST6, the feeder breakers to 6.9-kV buses 5 and 6 respectively. An electrical fault within either of these two breakers would result in deenergizing both bus 5 and bus 6. This is significant in that loss of these two buses means loss of two circulating water pumps, which gives a plant trip. It further means that offsite power is not available to mitigate the transient, as all offsite power given a turbine trip comes through buses 5 and 6 (as discussed above). The last four places where an unclearable fault has been modeled are the four normally open single tie breakers which connect redundant and otherwise independent safety buses together. Three of these (2AT5A, 2AT3A, and 3AT6A) connect the pairs of 480-V safety buses that are included in their names. The fourth breaker ties together dc power panels 31 and 32. The concern here is that any flashovers within these breakers (that have all poles on both sides of the breaker continually energized and most probably out of phase) would cause the loss of two safety buses.

If the "unclearable faults" affecting multiple safety buses were credible as single events, they would be extremely significant. For this reason, hasty elimination of this failure mode has been avoided. However, no evidence has been found which lends credence to this failure mode as a single event, and in the reporting of results, unclearable faults in the 480-V tie breakers have been logically mapped into double failures. The tie breaker linking dc buses has been left as a single; there is no evidence for a credible single event faulting both dc buses either, but this event has been left in the results to represent scenarios in which both dc buses are lost. Previous work has estimated a frequency for this which would effectively require that the event be modeled, given its consequences.

A.10.2 Pertinent Top Events

The electrical power system is a support system within the study and, not unexpectedly, supplies the entire electrical needs of the plant. Therefore, all the other fault trees use various gates from the electrical tree, including the 120-V vital ac buses, 125-V dc buses, 480-V buses and MCCs, and the 6.9-kV buses.

A.10.3 Success Criteria

NA

A.10.4 Assumptions

1. No operator actions are allowed to be taken with respect to the power system. A few operator actions were included for completeness in the model, but none were allowed in the solution of the sequences.
2. Everything within the power system is initially in its normal full power alignment/status.
3. The occurrence of any transients or LOCAs gives a reactor and turbine generator trip, and removes the unit auxiliary transformer as a potential source of power. (In this study, this essentially defines "transient.")
4. All LOCAs are accompanied by an SIAS.
5. The battery chargers were assumed to be capable of carrying the entire dc load profile in the absence of their accompanying batteries. In practice, this is not usually the case. However, given no documentation in this area, this was the assumption made.

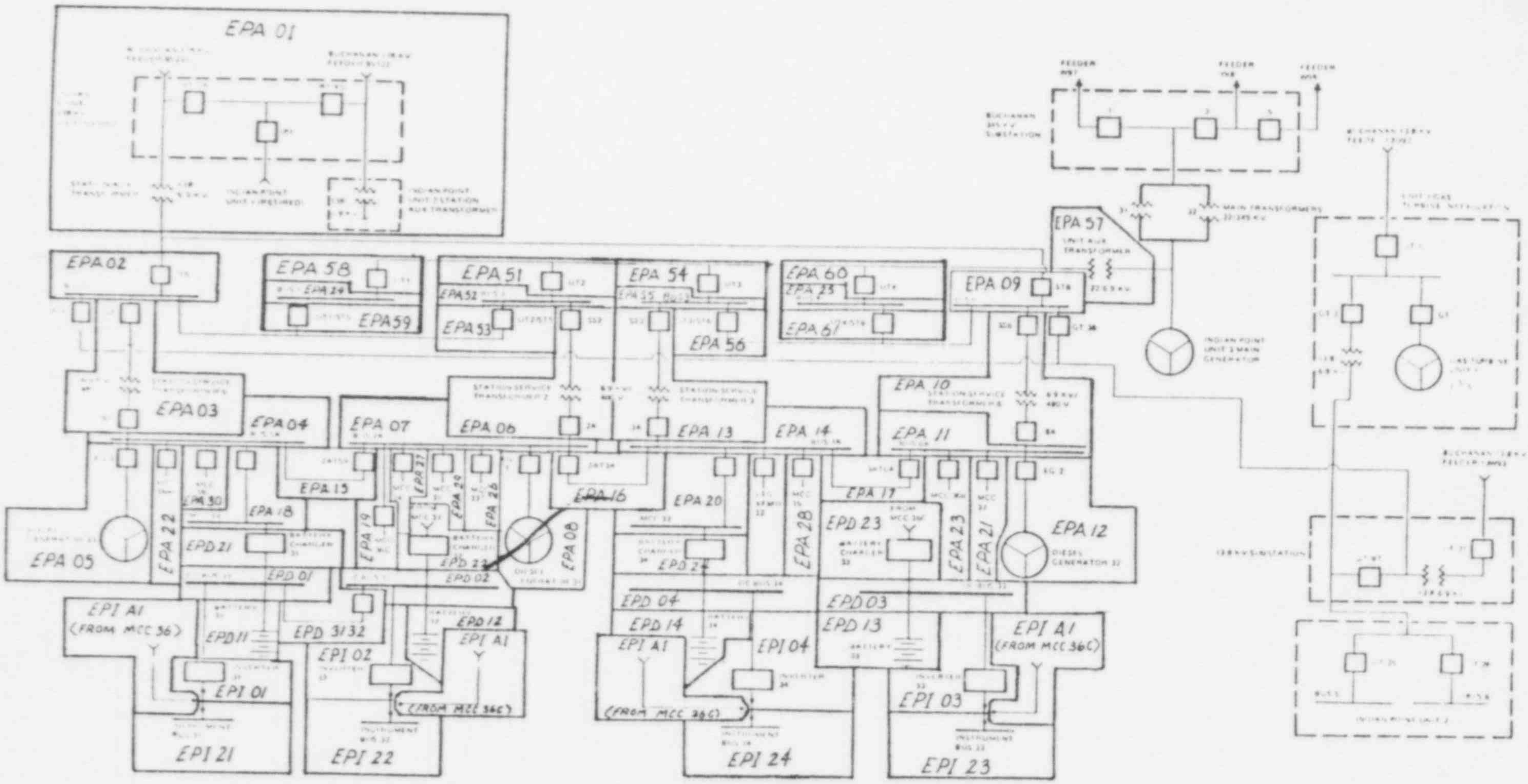


Figure A.10.1 Indian Point 3 electric power system diagram.

A.11 HEAT TRACING

A.11.1 Introduction

The fault tree models both freeze protection for some of the outdoor lines in the plant and those lines with concentrated boric acid solutions (BIT tank) in order to prevent boron precipitation. Discussion here is limited to the role of the heat tracing system in BIT protection as the potential significance of HT failure was judged greatest in the RCP seal failure sequence. (See assumptions below.)

All piping, valves, and pumps containing concentrated boric acid are provided with double circuit (redundant but not independent) electrical heat tracing. Either of the two redundant circuits may be used; they are selected at, and are supplied from, the local control cabinets. The local control cabinets are supplied from one of four distribution panels (33A, 33B, 33C, 33D). These distribution panels provide each circuit with overload protection and switchability by means of a molded case circuit breaker. The four distribution panels are supplied through individual 480/120-V transformers by panel 33. Panel 33 can be supplied from either MCC 36A or MCC 36B by means of a manual transfer switch.

A.11.2 Pertinent Top Events

Each of the segments in the other fault trees that contain components with concentrated boric acid, as well as those requiring freeze protection, will contain a gate from this tree yielding many overall top gates.

A.11.3 Success Criteria

NA

A.11.4 Assumptions

It has been assumed that loss of redundant heat tracing circuitry does not immediately fail the segment that it supports. Therefore, the only sequence in which loss of heat tracing coupled with a relatively slowly developing transient is satisified is in the RCP seal failure sequence.

It has further been assumed in the RCP seal failure sequence that failure of heat tracing (both redundant circuits) is failure of the heat-traced segment.

A.11.5 Review of Leading Cutsets

On the basis of the commonality of the heating circuits from their power sources to the control boxes, a number of single failures are found to result in loss of heat tracing for each of the heat-traced components. The significance of this is addressed in the analysis of the appropriate sequence(s).

A.12.0 INSTRUMENT AIR

A.12.1 Introduction

The instrument air (IA) system provides clean, dry air pressure to a number of components, including many air-operated valves (AOVs). The analysis given here is based on a system having two compressors; during the plant visit, BNL was told that a third is being added because maintenance of header pressure requires one compressor to run essentially all the time and the other compressor to run some of the time, so that there is no real redundancy in the existing two-compressor system.

It should be noted that in many applications instrument air is backed up by bottled nitrogen. Where this is the case, nitrogen backup has been credited explicitly in the fault tree for the system being supplied by IA/nitrogen. Additionally, many valves fail to the "safe" position on loss of air. For these reasons, IA does not loom large in the cutsets.

A.12.2 Pertinent Top Events

Top Gate IAG01: NOIF from IA system to Nuclear Services, DGS, and outside services.

Top Gate IACPG1: NOIF from IA system to conventional plant services.

A.12.3 Mission Success Criteria

Availability of both compressors has been assumed to be necessary in order to maintain adequate pressure. Loss of either compressor is assumed to lead to a transient.

A.13.0 REFUELING WATER STORAGE TANK

A.13.1 Introduction

The refueling water storage tank (RWST) provides the water supply for the HPI, LPI, and CVCS systems. The fault tree for the RWST model includes the tank itself, the common suction line for the three systems mentioned above, and the heating systems provide for these two elements to prevent boron precipitation. The tank itself is heated by auxiliary steam from the hotwell, and the bus suction line is heated by electrical heat tracing.

A.13.2 Pertinent Top Event

The top event of the fault tree is loss of the RWST source. The HPI, LPI, and charging system fault trees deal with the consequences of the loss.

A.13.3 Success Criteria

NA

A.13.4 Assumptions

It was assumed in the development of the fault tree that failure of auxiliary steam to the RWST or failure of the electrical heat tracing for its discharge line would not fail the RWST unless very cold weather was also present.

A.14.0 STATION AIR

A.14.1 Introduction

The station air system provides a backup source of air to the instrument air system and only this role has been modeled in the study. The system consists of two possible air supplies and a header/distribution system. The primary air source is the IP-3 compressor. This compressor receives cooling from two closed cooling loops and requires only one to sustain operation. The cooling loops are in turn cooled by the service water system. The backup air source is the IP-1 station air system. This system is included but not developed in the model. The only other support system required for station air is electrical power and this becomes unavailable because of bus undervoltage (or LOOP) or SIAS actuation.

A.14.2 Pertinent Top Events

The top event in the fault tree is failure to supply station air to the instrument air system.

A.14.3 Success Criteria

The success criteria modeled into the fault tree are that either the IP-3 or IP-1 compressor provides sufficient capacity, and that either of the two IP-3 compressor cooling loops provide sufficient cooling.

A.15.0 SEQUENCER

A.15.1 Introduction

The Sequencer tree was developed to model the actuation of the major active components (diesel generators and pumps) within the scope of the study. There is no "sequencer" per se in the IP-3 design that would, for example, sequence loads following a LOOP or SIAS. Each pump that was modeled has its own timer for actuating its breaker to close onto a bus. The scope of the modeling included all start signals (SIAS, undervoltage, and manual from the control room) and included all intervening relaying up to, but not including, the actuated device (e.g., the circuit breaker itself). The only support system required is dc control power and its failure prevents both automatic and manual (from the control room) start capability for all modeled components, except for auxiliary feedwater pump 32, whose turbine driver is actuated by the loss of its dc supply.

The reason for grouping the actuation circuitry for these components in a separate fault tree, rather than incorporating each into its appropriate front-line or support system fault tree, is related to the manner of its development. It was judged most efficient (in terms of time and manpower) to have one person develop all of the actuation logic (from a common set of drawings) and then to keep it together for ease of reference and review.

The basic structure of each actuation logic is quite similar, and a general description of a typical actuation circuit follows. Specific differences of importance for each of the actuation schemes will be addressed in the following section.

The logic model traces, by specific components modeled directly from the IP-3 electrical schematic diagrams, the actuation path from relay to relay between the initiation signal and the actuated device. For example, response to bus undervoltage (or LOOP) and SIAS is developed at the bus level by relaying logic within the switchgear. Specific relays energize, depending upon the event detected, and these relays in turn actuate the time delay relays associated with each individual load (e.g., SI pumps 3 seconds, RHR pumps 8 seconds, etc.). All pumps are sequenced whether or not a LOOP has occurred. Failure modes are therefore 1) failure of the initiating signal, 2) failure of the appropriate bus level relays, 3) failure of the individual load time delay relays, and 4) failure of dc control power.

It should also be noted that loads on buses 2A and 3A receive SIAS initiation signals from both SIAS trains, whereas buses 5A and 6A receive only train A and train B SIAS signals, respectively. The actuation scheme in the model also differentiates between the source of actuation initiation as does the actual relaying logic within the switchgear. Certain relays will actuate for a bus undervoltage (LOOP) condition and not for a safety injection signal and vice versa. This situation is addressed by NOT logic. The NOT logic in the model corresponds to interposing relay contacts within the switchgear. For example, the "non-SI blackout" relays would be "ANDED" with a "NOT-LOCA" event, so that during LOCA sequences ("LOCA" = 1 in the model) these relays would not be counted as their failure would not affect actuation of the pump.

A.15.2 Pertinent Top Events

The top events in the Sequencer fault tree are failure to actuate the following components: diesel generators (DG) 31, 32 and 33; safety injection pumps (HPI) 31, 32, and 33; auxiliary feedwater pumps (AFW) 31, 32, and 33; residual heat removal pumps (RHR) 31 and 32; nuclear service water pumps (SW) 34, 35, and 36; and component cooling water pumps (CCW) 31, 32, and 33. The three SW pumps are modeled twice each, once for applications other than cooling the diesel generators, and once to break the logic loops created by diesel dependency on the SW system for the diesels themselves.

The diesel generator actuation model differs in that the circuit breaker itself is included in the model and there is no intervening relaying, because bus undervoltage directly signals closure of the breaker as soon as the generator has attained a given output voltage.

The HPI pumps, RHR pumps, and SW pumps all generally conform to the typical actuation circuitry discussed previously.

The major difference to be noted in the CCW pump actuation scheme is that these pumps will not automatically sequence onto their buses, given that an SIAS signal and bus undervoltage signal both exist.

The actuation of the auxiliary feedwater pumps (31, 32, and 33) was explicitly modeled with respect to LOCA sequences and transient sequences. In addition, the two motor-driven pumps have a common actuation circuit based upon Lo-Lo steam generator level in any one steam generator (one out of four). The turbine-driven AFW pump (32) is actuated by deenergizing a dc-controlled, air-operated valve which admits steam to the turbine. AFW pump 32 is also actuated upon Lo-Lo steam generator water level in any two steam generators (two out of four).

A.15.3 Success Criteria

NA

A.15.4 Assumptions

No assumptions were made in the modeling of the actuation circuitry. The model was derived directly from the applicable electrical schematic diagrams of IP-3 supplied for the study.

A.16.0 SI ACTUATION

A.16.1 Introducton

The engineered safeguards actuation system is supposed to generate an SIAS signal under certain conditions. Failure to generate such a signal has been modeled here in the SI fault tree. In this study, the sequences which require an SI signal are small LOCA and medium LOCA; HPI pumps, LPI pumps, AFW pumps, diesels, and certain valves are affected by this signal.

A.16.2 Pertinent Top Events

There are two redundant trains of SI actuation, and the two important top events are failure of the SI signal at relays SI11X and SI21X.

A.16.3 Mission Success

The top events correspond to complete failure of their respective SIAS trains.

A.16.4 Assumptions

It was assumed (as per IP-3 procedure PEP-ES-1, p. 7) that for small LOCA, a containment high pressure condition might not exist; accordingly, credit for this signal was not taken.

Operator acts were not credited in this area.

A.17.0 SERVICE WATER

A.17.1 Introduction

The service water system (SWS) provides cooling to a number of components by supplying Hudson River water to their heat exchangers and returning the heated water to the river. One group of three SW pumps, designated "nuclear," is diesel backed and meets the cooling requirements of relatively critical components, including the diesel generators, the containment fan coolers, and certain other components. Another group of three SW pumps is designated "conventional"; it is not automatically diesel backed, and meets the cooling requirements of less critical systems, such as the component cooling water system. A third group, the backup SW pumps, can be made available under certain conditions, but this group is neglected in the IPPSS, and for simplicity, will be neglected here also.

The segmentation scheme is illustrated in Figure A.17.1

A.17.2 Pertinent Top Events

Top events of interest for the SWS are failure to supply service water to various components. Some of these events contribute to initiation of transients; some contribute to failure of mitigating systems; and some do both.

For purposes of breaking logic loops, special events were defined in the service water tree which can feed into the diesel-generator-failure events without leading to dependences either of service water on itself or of diesels on themselves. Names of these events contain the letters "DGS" to distinguish them from other events. For example, event SWNX14-A is "Insufficient Nuclear SW from Segment NX-14"; it includes all failure modes of the diesels supplying power to nuclear service water pumps, and would create a loop if fed into the diesel failure gates. SWNX14-DGS-A, on the other hand, is the same event except that the supporting diesels' dependence on service water does not contribute to this gate. Gates which manifestly supply only the diesels do not all carry the appellation DGS, but the headers which supply these gates do.

Service Water

Top Events	Descriptions
SW034-A	Failure to supply SW to DG 31.
SW035-A	Failure to supply SW to DG 32.
SW036-A	Failure to supply SW to DG 33.
SWC18-A	Failure to supply SW to CCW HX 31.
SW37-A	Failure to supply SW to CCW HX 32.
SW51-A	Failure to supply SW to Inst Air HX 31.
SW52-A	Failure to supply SW to Inst Air HX 32.
SWA15-A	Failure to supply SW to Circ. Water Pump 31 seals.
SWA14-A	Failure to supply SW to Circ. Water Pump 32 seals.
SWA13-A	Failure to supply SW to Circ. Water Pump 33 seals.
SWA12-A	Failure to supply SW to Circ. Water Pump 34 seals.
SWA11-A	Failure to supply SW to Circ. Water Pump 35 seals.
SWA10-A	Failure to supply SW to Circ. Water Pump 36 seals.
SWT16	Failure to supply SW to BFP & T Lube oil coolers.

A.17.3 Success Criteria

It has been assumed that SW flow requirements correspond to 2 out of 3 SW pumps on the nuclear header and 2 out of 3 SW pumps on the conventional header.

The requirement on the nuclear header is the same as that used in the IPPSS. However, the IPPSS defines a Special Case for the nuclear header, in which one NSW pump is able to supply SW to the DGS if diversion to the containment fan coolers is prevented. According to the IPPSS (§1.6.2.3.8.6), this is accomplished by the closing of TCU-1104 and TCU-1105. However, these valves fail open on loss of air or loss of power to the associated solenoid valve (p. 1.6-799 and p. 1.6-724), and the circumstances guaranteeing their closure under loss-of-offsite-power conditions have not been established. The 2/3 mission success requirement for the NSW header for all conditions has therefore been retained, though this may depart from the IPPSS. This has a noticeable qualitative effect on the results, and should probably be pursued. The approach taken here may be conservative.

The success criterion for the Conventional header corresponds to the requirements of the transient initiator tree (2/3 CSW pumps available). The IPPSS states that after an accident, 1/3 is sufficient. The effects of this "conservatism" are not very significant.

A.17.4 Assumptions

For purposes of this study, it was assumed that the SW system is aligned so that the usual nuclear header is supplying the usual nuclear loads, and similarly for the conventional header. Mode switch mispositioning has been included, however.

It has also been assumed that NSW pump 36 is ordinarily on standby on the nuclear header and that CSW pump 31 is the standby pump on the conventional header. Adding options to the trees to consider alternative assumptions is straightforward; the present case was chosen for the sake of initial simplicity, with the idea of later assessing whether there is enough asymmetry in the system to justify explicit consideration of the other alternatives.

References

1. IPPSS, Section 1.6.2.3.8 (Service Water) and Section 1.6.2.3.6 (Containment Form Coolers).

2. IP-3 System Description No. 24, Service Water Systems, August 1975.

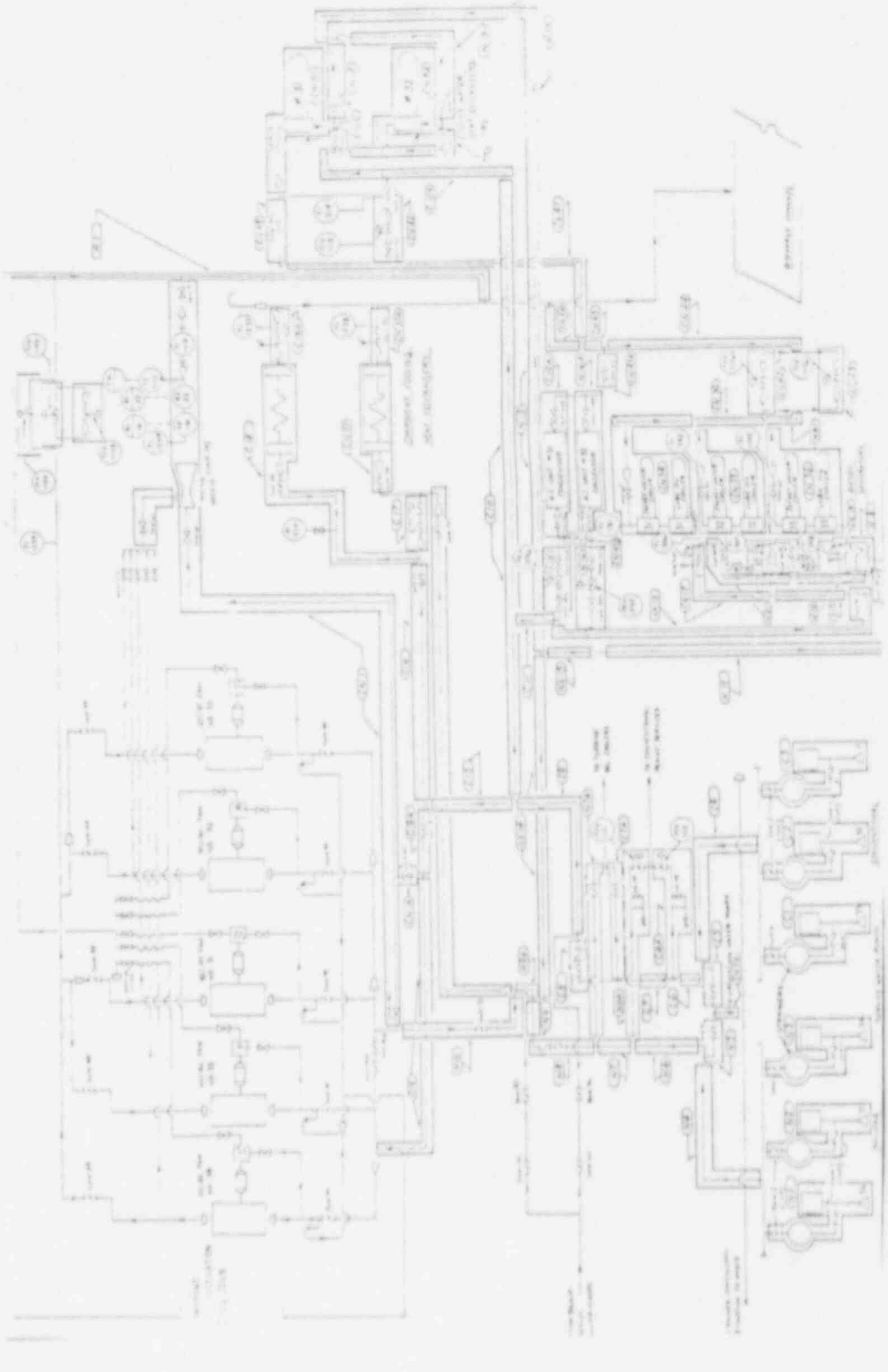


Figure A.17.1 Indian Point 3 service water system simplified P&ID.

A.18 TRANSIENT INITIATOR

A.18.1 Introduction

In this study, the purpose of developing a fault tree for the transient initiator is to search for interactions which link transient initiation to failure of a mitigating system. For example, a bus fault leads to a reactor trip, and simultaneously fails the offsite power path to one of the safety buses. The following was done in this study. The scope included the following transient sequences:

1. Transient and failure of AFW.
2. RCP seal LOCA sequences.
3. Transient-induced PZR LOCA sequences.

Events appearing in mitigating systems (including systems supporting the integrity of the RC pressure boundary), or their supports, were examined to see whether they would cause transients. A transient was taken to be an event which leads to a reactor trip or, in reasonably short order, to a shutdown.

The Transient tree, then, is a large OR gate whose inputs are mostly support system faults. In addition, a tree for loss of main feedwater to at least 1/4 SGs feeds into the Transient tree. Other transient initiators that are not somehow linked with the frontline systems, or their supports, have been excluded.

A.18.2 Top Events

The top event of the Transient tree is a Boolean OR of that subset of faults which a) have anything to do with the mitigating systems studied here and b) lead more or less directly to a shutdown (usually, but not necessarily, by a trip).

Developed events which are fed into this top event are listed on Table A.18.1.

A.18.3 Mission Success Criteria

NA

A.18.4 Assumptions

The defining characteristic of transient, as used here, is that the reactor shuts down and electric power is derivable only from the offsite source or from the diesels, not from the station generator.

Table A.18.1 Developed Inputs to Transient Initiator Top Event

Event Name	Consequence
MF-SG31323334	Insufficient MFIV to 1/4 SGs
CCGRETRN-A	Insufficient CCW to at least 1 RCP
CCG1000-A	Insufficient CCW to at least 1 RCP
CCGTBE01	Insufficient CCW to at least 1 RCP
RCPM01-INT	Insufficient CCW to at least 1 RCP
RCPM02-INT	Insufficient CCW to at least 1 RCP
RCPM03-INT	Insufficient CCW to at least 1 RCP
RCPM04-INT	Insufficient CCW to at least 1 RCP
SIPHASEB	Insufficient CCW to at least 1 RCP
EPA24-T	Loss of 6.9-kV Power to at least 1 RCP
EPA52-T	Loss of 6.9-kV Power to at least 1 RCP
EPA55-T	Loss of 6.9-kV Power to at least 1 RCP
EPA25-T	Loss of 6.9-kV Power to at least 1 RCP
CD-VAC	Loss of Condenser Vacuum
CR-01-A	Loss of 2/6 Circ. Water Pumps
PZRX TRIP	Reactor Trip on Pzr Fault
TR-LOOP	Loss of Offsite Power
IAG01	Loss of Instrument Air
TR-SPSI	Spurious SI or Phase B signal
CV-LOCH	Loss of Charging Flow
CV-LOLD	Loss of Letdown Flow

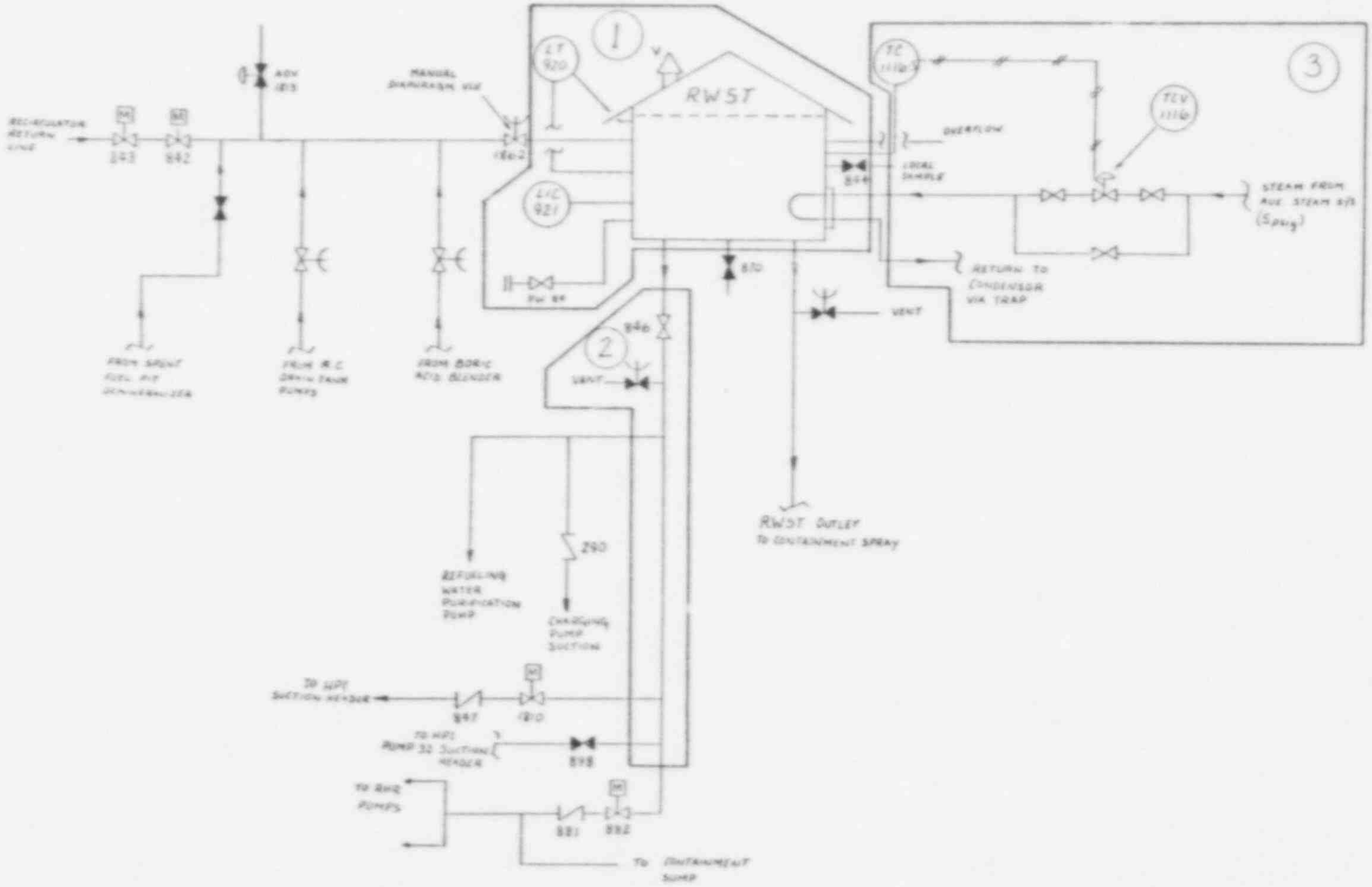


Figure A.13.1 Indian Point Unit 3 refueling water storage tank system simplified.

APPENDIX B

EVENT DEFINITIONS

1	AF001-A-INT	CT 64 FAILS CLOSED
2	AF003-A-INT	FAILURE OF CST DISCHARGE PATH TO MD AFW PUMP
3	AF004-A-INT	FAILURE OF CITY WATER DISCHARGE SEGMENT VALVES TO PUMP 33
4	AF005-A-INT	FAILURE OF CST DISCHARGE PATH TO MD AFW PUMP
5	AF006-A-INT	FAILURE OF CITY WATER DISCHARGE SEGMENT VALVES TO PUMP 31
6	AF007-A-INT	FAILURE OF CST DISCHARGE PATH TO TD AFW PUMP
7	AF008-A-INT	FAILURE OF CITY WATER DISCHARGE VALVES TO TD AFW PUMP
8	AF009-A-INT	MOTOR DRIVEN AFW PUMP FAILURE
9	AF009-B-INT	PT406B SIGNAL UNABLE TO CONTROL PU 33 DISCHARGE PRESSURE
10	AF010-A-INT	MOTOR DRIVEN AFW PUMP FAILURE
11	AF010-B-INT	PT406A SIGNAL UNABLE TO CONTROL PU 31 DISCHARGE PRESSURE
12	AF011-A-H	OPERATOR FAILS TO BRING AFW PU 32 UP TO SPEED
13	AF011-A-INT	SEGMENT 11 INTERNAL FAILURE
14	AF011-A-NOA	FAILURE TO MANIPULATE (LOCALLY) TRIP VALVE GIVEN LOSS OF AIR
15	AF011-B-INT	INADVERTANT OPENING OF RELIEF VALVE MS52
16	AF012-A-INT	LOCAL FAULT SEGMENT 12
17	AF012-B-INT	LOCAL FAULT FCV-406C FAILS OPEN
18	AF012-C-INT	BACKLEAKAGE OF FCV406C
19	AF013-A-INT	LOCAL FAULT SEGMENT 13
20	AF013-B-INT	LOCAL FAULT FCV-406D FAILS OPEN
21	AF013-C-INT	BACKLEAKAGE OF FCV406D
22	AF014-A-INT	LOCAL FAULT SEGMENT 14
23	AF014-B-INT	LOCAL FAULT FCV-406B FAILS OPEN
24	AF014-C-INT	BACKLEAKAGE OF FCV406B
25	AF015-A-INT	LOCAL FAULT SEGMENT 15
26	AF015-B-INT	LOCAL FAULT FCV-406A FAILS OPEN
27	AF015-C-INT	BACKLEAKAGE OF FCV406A
28	AF016-A-INT	LOCAL FAULT SEGMENT 16
29	AF017-A-INT	LOCAL FAULT SEGMENT 17
30	AF018-A-INT	LOCAL FAULT SEGMENT 18
31	AF019-A-INT	LOCAL FAULT SEGMENT 19
32	AF020-A-INT	NOIF OF STEAM FROM SEGMENT 20
33	AF021-A-INT	NOIF OF STEAM FROM SEGMENT 21
34	AF022-A-INT	AFWS INJECTION LINE FAILS TO SUPPLY WATER TO SG33
35	AF022-D-BLDN	BLOWDOWN FROM SG 33 NOT ISOLATED
36	AF023-A-INT	AFWS INJECTION LINE FAILS TO SUPPLY WATER TO SG34
37	AF023-D-BLDN	BLOWDOWN FROM SG 34 NOT ISOLATED
38	AF024-A-INT	AFWS INJECTION LINE FAILS TO SUPPLY WATER TO SG32
39	AF024-D-BLDN	BLOWDOWN FROM SG 32 NOT ISOLATED
40	AF025-A-INT	AFWS INJECTION LINE FAILS TO SUPPLY WATER TO SG31
41	AF025-D-BLDN	BLOWDOWN FROM SG 31 NOT ISOLATED
42	AF026-A-INT	ATM STM RLF VALVE PCV1136 INTERNAL FAILURE
43	AF027-A-INT	ALL SVS ASSOCIATED WITH SG33 FAIL TO OPEN
44	AF028-A-INT	ATM STM RLF VALVE PCV1137 INTERNAL FAILURE
45	AF029-A-INT	ALL SVS ASSOCIATED WITH SG34 FAIL TO OPEN
46	AF030-A-INT	ATM STM RLF VALVE PCV1135 INTERNAL FAILURE
47	AF031-A-INT	ALL SVS ASSOCIATED WITH SG32 FAIL TO OPEN
48	AF032-A-INT	ATM STM RLF VALVE PCV1134 INTERNAL FAILURE
49	AF033-A-INT	ALL SVS ASSOCIATED WITH SG31 FAIL TO OPEN
50	AFBLKG-BFD67	BACKLEAKAGE OF BFD67 AND OTHER CHECK VALVES IN PU DISC LINES

51	AFBLKG-BFD68	BACKLEAKAGE OF BFD68 AND OTHER CHECK VALVES IN PU DISC LINES
52	AFBLKG-BFD69	BACKLEAKAGE OF BFD69 AND OTHER CHECK VALVES IN PU DISC LINES
53	AFBLKG-BFD70	BACKLEAKAGE OF BFD70 AND OTHER CHECK VALVES IN PU DISC LINES
54	AFN2	LOSS OF N2 TO AFWS AOVS
55	AFN2-HU-01	OPERATOR FAILS TO ACTUATE N2 BACKUP - LOCAL
56	AFSE64-6-8-NOA	FAILURE OF OP TO ALIGN CW AT AFW PUMP SUCTIONS
57	AUXSTM----	FAILURE OF STM SUPPLY FROM AUX STM SYSTEM
58	CC-H	OPERATOR FAILS TO ADJUST CCW LOADS
59	CC001-A-BLK	CCW PUMP 31 TRAIN BLOCKAGE
60	CC001-A-INT	CCW PUMP 31 INTERNAL FAILURE
61	CC001-A-RSTRT	CCW PUMP 31 FAILS TO RESTART- INT. FAILURE
62	CC002-A-BLK	CCW PUMP 32 TRAIN BLOCKAGE
63	CC002-A-INT	CCW PUMP 32 INTERNAL FAILURE- INCLUDES FAILURE TO START
64	CC003-A-BLK	CCW PUMP 33 TRAIN BLOCKAGE
65	CC003-A-INT	CCW PUMP 33 INTERNAL FAILURE
66	CC003-A-RSTRT	CCW PUMP 33 FAILS TO RESTART- INT. FAILURE
67	CC004-A-INT	MANUAL VALVE 766A FAILS CLOSED
68	CC005-A-INT	MANUAL VALVE 766B FAILS CLOSED
69	CC006-A-INT	MANUAL VALVE 759C FAILS CLOSED
70	CC007-A-INT	MANUAL VALVE 759D FAILS CLOSED
71	CC008-A-INT	FAILURE OF CCW HX 32 LEG
72	CC009-A-INT	FAILURE OF CCW HX 31 LEG
73	CC010-A-INT	VALVE 766C OR 766D FAILS CLOSED
74	CC011-A-INT	LOOP 1 RETURN HEADER FAILS
75	CC012-A-INT	LOOP 2 RETURN HEADER FAILS
76	CC015-A-INT	HPI PUMP 31 OIL OR SEAL HX FAILURE
77	CC016-A-INT	HPI PUMP 32 OIL OR SEAL HX FAILURE
78	CC017-A-INT	HPI PUMP 33 OIL OR SEAL HX FAILURE
79	CC018-A-INT	MANUAL CCW VALVE 787 FAILS CLOSED
80	CC033-A-INT	MANUAL VALVES TO CHG PUMP 31 OIL COOLERS FAIL
81	CC034-A-INT	MANUAL VALVES TO CHG PUMP 32 OIL COOLERS FAIL
82	CC035-A-INT	MANUAL VALVES TO CHG PUMP 33 OIL COOLERS FAIL
83	CC036-A-INT	MANUAL VALVE 756A FAILS CLOSED
84	CC037-A-H	OPERATOR FAILS TO ALIGN CITY WATER
85	CC037-A-INT	INTERNAL FAILURE OF SEGMENT 37
86	CC038-A-INT	MANUAL VALVE 756B FAILS CLOSED
87	CCG1000-A	NOIF CCW FROM LOOP 32
88	CCG601-A	NOI CCW FLOW TO HPI PUMP 31
89	CCG602-A	NOI CCW FLOW TO HPI PUMP 32
90	CCG603-A	NOI CCW FLOW TO HPI PUMP 33
91	CCG800-A	NOIF CCW AND CITY WATER TO CHG PUMP 31 COOLERS
92	CCG804-A	NOIF CCW AND CITY WATER TO CHG PUMP 32 COOLERS
93	CCG805-A	NOIF CCW AND CITY WATER TO CHG PUMP 33 COOLERS
94	CCGRETRN-A	MOV 784 OR 786 NOFC- CCW RETURN LINE FROM RCP MOTORS
95	CCGS1	CCW SUPPLY TO RCPUS MOV769,797 FAIL CLOSED DUE TO INT OR FIRE
96	CCGTBE01	VALVE769 OR 797 FAIL CLOSED
97	CD-1-A	NOIF FROM COMMON DISCHARGE OF HEATERS 33 TO 35
98	CD-10-A	NOIF FROM CONDENSATE PUMPS DISCHARGE HEADER
99	CD-11-A	NOIF FROM CONDENSATE PUMPS SUCTION HEADER
100	CD-1A-A	NOIF FROM HEATERS 33A, 34A, & 35A

101	CD-1B-A	NOIF FROM HEATERS 33B, 34B, & 35B
102	CD-1C-A	NOIF FROM HEATERS 33C, 34C, & 35C
103	CD-2-A	NOIF FROM HEATER BYPASS LINE
104	CD-5-A	NOIFF FROM FLASH EVAP AND FROM ITS BYPASS
105	CD-5A-A	NOIF FROM LP HEATERS 31A & 32A
106	CD-5B-A	NOIF FROM LP HEATERS 31B & 32B
107	CD-5C-A	NOIF FROM LP HEATERS 31C & 32C
108	CD-6-A	NOIF FROM LP HEATERS BYPASS LINE
109	CD-7A-A	NOIF FROM GLAND STEAM CONDENSER
110	CD-7B-A	NOIFF FROM FCV-1120 - SUPPORT SYST NOT FOUND
111	CD-8A-A	NOIF FROM CONDENSATE PUMPS DISCHARGE TO FLOW PATH A
112	CD-9B-A	NOIF FROM CONDENSATE PUMPS DISCHARGE TO FLOW PATH B
113	CD-AEJCD313233-A	NOIF FROM AIR EJECTOR CONDENSERS 31,32, OR 33
114	CD-CDSR31-1-A	NOIF FROM WATERBOX 31-1
115	CD-CDSR31-2-A	NOIF FROM WATERBOX 31-2
116	CD-CDSR31-LF	CONDENSER 31 LOCAL FAILURE
117	CD-CDSR32-1-A	NOIF FROM WATERBOX 32-1
118	CD-CDSR32-2-A	NOIF FROM WATERBOX 32-2
119	CD-CDSR32-LF	CONDENSER 32 LOCAL FAILURE
120	CD-CDSR33-1-A	NOIF FROM WATERBOX 33-1
121	CD-CDSR33-2-A	NOIF FROM WATERBOX 33-2
122	CD-CDSR33-LF	CONDENSER 33 LOCAL FAILURE
123	CD-PP31-C-INT	REV FLOW THRU COND PUMP 31 DISCH-CV FAILURE (RF) AND OTHERS
124	CD-PP31-LF-F	CONDENSATE PUMP 31 LOCAL FAILURE
125	CD-PP32-C-INT	REV FLOW THRU COND PUMP 32 DISCH-CV FAILURE (RF) AND OTHERS
126	CD-PP32-LF-F	CONDENSATE PUMP 32 LOCAL FAILURE
127	CD-PP33-C-INT	REV FLOW THRU COND PUMP 33 DISCH-CV FAILURE (RF) AND OTHERS
128	CD-PP33-LF-F	CONDENSATE PUMP 33 LOCAL FAILURE
129	CD-VAC	LOSS OF CONDENSER VACUUM.
130	CL----LF	NOIFF TURBINE HALL CLOSED COOLING WATER SYSTEM LOCAL FAILURES
131	CR-01-A	LOSS OF 2 OUT OF 6 CIRCULATING PUMPS - ASSUMPTION
132	CR031-LF-F	LOCAL FAILURE IN CIRC PUMP 31 OR LINE TO CONDENSER
133	CR032-LF-F	LOCAL FAILURE IN CIRC PUMP 32 OR LINE TO CONDENSER
134	CR033-LF-F	LOCAL FAILURE OF CIRC PUMP 33 OR LINE TO CONDENSER
135	CR034-LF-F	LOCAL FAILURE OF CIRC PUMP 34 OR LINE TO CONDENSER
136	CR035-LF-F	LOCAL FAILURE OF CIRC PUMP 35 OR LINE TO CONDENSER
137	CR036-LF-F	LOCAL FAILURE OF CIRC PUMP 36 OR LINE TO CONDENSER
138	CS001-A-INT	INTERNAL FAILURE OF CST
139	CS003-A-INT	INTERNAL FAILURE OF LCV1158
140	CS004-A-H	OPERATOR FAILS TO CLOSE FLOWPATH ON ALARM
141	CS004-A-INT	INTERNAL FAILURE OF SEGMENT 4
142	CS011-A-INT	LIC1102-S FAILURE
143	CS011A-A-INT	CST ALARM FAILURE
144	CS015-A-INT	SEGMENT 15 INTERNAL FAILURE
145	CS020-LL	LOW CONDENSER HOTWELL LEVEL CONDITION
146	CSG100-A	FAILURE OF CST SUPPLY TO AFWS
147	CV-LOCH	LOSS OF CHARGING FLOW
148	CV-LOLD	LOSS OF LETDOWN FLOW.
149	CVCH-HU-01	OP. FAIL TO ALIGN THE SUCTION TO RWST.
150	CVCH-HU-02	OP. FAILS TO START A SECOND PUMP.

151	CVCH01-A	CHECK VALVES 210B &210D FAIL CLOSED.
152	CVCH02-A	AIR OPERATED VALVE 204B FAIL CLOSED.
153	CVCH03-A	CHECK VALVES 210A 210C FAIL CLOSED.
154	CVCH04-A	AIR OPERATED VALVE 204A FAILS TO OPEN ON DEMAND.
155	CVCH07-A-INT	VALVES 374 OR 142 FAIL CLOSED.
156	CVCH08-A	NOIF SEAL FLOW FROM CHARGING PUMPS
157	CVCH09-A-INT	LCV112C OR CHECK VALVE 292 FAIL CLOSED.
158	CVCH11-A-INT	VALVE FCV 110B FAILS TO OPEN OR VALVE 297(NO) FAILS CLOSED.
159	CVCH12-A-INT	BLENDER FAILS.
160	CVCH13-A-INT	CV328 FAILS TO OPEN OR XV329 (NOFC)
161	CVCH14-A-INT	CV327 FAILS TO OPEN OR XV326 (NOFC)
162	CVCH15-A-INT	FCV 110A FAILS CLOSED.
163	CVCH16-A-INT	FCV 111A FAILS TO OPEN.
164	CVCH17-A-INT	FILTER OR FLOW METER PLUGGED.
165	CVCH18-A-INT	BORIC ACID TRANSFER PUMP 31 FAILS TO START.
166	CVCH19-A-INT	BORIC ACID TANK 31 FAILS TO SUPPLY.
167	CVCH20-A-INT	FAILURE OF ELECTRIC HEATER IN BAT. 31.
168	CVCHE01	LEVEL TRANMITTER LT-112 FAILS.
169	CVCHE01-1	LEVEL CONTROL LC112A/X FAILS HIGH
170	CVCHE02	LEVEL CONTROLLER LC-112B OR CONTROL CIRCUIT FAIL.
171	CVCHE03	LEVEL CONTROLLER LC-112C OR CONTROL CIRCUIT FAIL.
172	CVCHE04	VALVE LCV112B FAILS TO OPEN.
173	CVL01-A-INT	LETDOWN ISOLATION VALVES FAIL.
174	CVL02-A-INT	REGEN. HX. FAILS.
175	CVL03-A-INT	SUPERCOMPONENT FAILS ITSELF.
176	CVL04-A-INT	CONT. ISOLATION VALVES FAIL.
177	CVL05-A-INT	NON-REGEN. HX. FAILS.
178	CVL06-A-INT	VALVES PCV135 OR TCV149 FAIL.
179	CVL08-A-INT	REACTOR COOLANT FILTER PLUGGED.
180	CVL09-A-INT	VCT RUPTURE.
181	CVL10-A-INT	ISOLATION VALVES 213A OR213B FAIL TO OPEN.
182	CVL11-A-INT	EXCESS LETDOWN HX. FAILS.
183	CVL12-A-INT	VALVE HCV123FAILS CLOSED.
184	CVL13-A-INT	LCV112A INTERNAL FAILURE CAUSING FLOW DIVERSION TO HOLDUP TANK
185	CVLD-HU-01	NO OP. ACTION FOR EX. LETDOWN IN SERVICE.
186	CVLE01	CONTROL CIRCUIT FOR VALVE PCV135 FAILS.
187	CW001-A-INT	FAILURE OF CITY WATER SUPPLY TO CT-49
188	CW002-A-INT	INTERNAL FAILURE OF CT-49 SEGMENT
189	DC--	LOSS OF DC POWER AT LEVEL INST & CONTR.- SUPPLY NOT FOUND
190	EE-1080	NO FLOW IN LINE 1080
191	EE-ATL	AMBIENT TEMP LOW
192	EE-CS015	NO FLOW IN SEGMENT 15
193	EE-MLOCA-RCSCL4	MEDIUM LOCA POSTULATED IN RCS COLD LEG NO. 4
194	EE-SGLP	LOW PRESS IN SGS
195	EE-SLOCA-RCSCL4	SMALL LOCA POSTULATED IN RCS COLD LEG NO. 4
196	EPA-LATE-LOOP	LOSS OF GRID DURING MITIGATION PHASE
197	EPA-TR-IN-LOOP	TRANSIENT INDUCED LOSS OF OFFSITE POWER
198	EPA02-S-F	LOCAL FAULT AT EPA02 (6.9 KV BUS 5)
199	EPA02-U-F	UNCLEARABLE FAULT AT BUS 5
200	EPA03-S-F	LOCAL FAULT AT EPA03 (SS XFMR 5)

201	EPA04-S	LOCAL FAULT AT EPA04 (BUS 5A)
202	EPA04-S-F	LOCAL FAULT AT EPA04 (BUS 5A)
203	EPA04-T	LOSS OF 480 VOLT BUE 5A
204	EPA04-T-LSI	LOP AT 480V BUS 5A, OR LOOP, OR SI
205	EPA05-INT	LOCAL FAULT IN DG 33
206	EPA05-INT-F	LOCAL FAULT IN DG NO. 33
207	EPA06-INT-F	LOCAL FAULT IN FAST TRANSFER BREAKER SCHEME
208	EPA06-S-F	LOCAL FAULT AT EPA06 (SS XFMR 2)
209	EPA07-S	LOCAL FAULT AT 2A
210	EPA07-S-F	LOCAL FAULT AT EPA07 (BUS 2A)
211	EPA07-T	LOSS OF 480V BUS 2A
212	EPA07-T-LSI	LOP AT BUS 2A, OR LOOP, OR SI
213	EPA08-INT	LOCAL FAULT IN DG 31
214	EPA08-INT-F	LOCAL FAULT IN DG NO. 31
215	EPA09-S-F	LOCAL FAULT AT EPA09 (6.9 KV BUS 6)
216	EPA09-U-F	UNCLEARABLE FAULT AT BUS 6
217	EPA10-S-F	LOCAL FAULT AT EPA10 (SS XFMR 6)
218	EPA11-S	LOCAL FAULT AT EPA11 (BUS 6A)
219	EPA11-S-F	LOCAL FAULT AT EPA11 (BUS 6A)
220	EPA11-T	LOSS OF 480V BUS 6A
221	EPA11-T-LSI	LOP AT 480V BUS 6A, OR LOOP, OR SI
222	EPA11-T-LSI-V	LOP AT BUS 6A(HPI VALVES)
223	EPA12-INT	LOCAL FAULT IN DG 32
224	EPA12-INT-F	LOCAL FAULT IN DG NO. 32
225	EPA13-INT-F	LOCAL FAULT IN FAST TRANSFER BREAKER SCHEME
226	EPA13-S-F	LOCAL FAULT AT EPA13 (SS XFMR 3)
227	EPA14-S	LOCAL FAULT AT EPA14 (BUS 3A)
228	EPA14-S-F	LOCAL FAULT AT EPA14 (BUS 3A)
229	EPA14-T	POWER SUPPLY FAILURE OF 480V BUS 3A
230	EPA14-T-LSI	LOP AT 480V BUS 3A, OR LOOP OR SI
231	EPA15-U	LOCAL FAULT AT EPA15 (TIE BKR 2AT5A)
232	EPA15-U-F	UNCLEARABLE FAULT AT EPA15 (TIE BKR 2AT5A)
233	EPA15-U-F1	FIRST FAILURE IN TIE BKR 2AT5A
234	EPA15-U-F2	SECOND FAILURE IN TIE BKR 2AT5A
235	EPA16-H	OPERATOR DOES NOT CLOSE 2AT3A
236	EPA16-S	LOCAL FAULT OF 2AT3A TIE BREAKER
237	EPA16-S-F	LOCAL FAULT OF TIE BKR 2AT3A
238	EPA16-U	LOCAL FAULT AT EPA16 (TIE BREAKER 2AT3A)
239	EPA16-U-F	UNCLEARABLE FAULT AT EPA16 (TIE BKR 2AT3A)
240	EPA16-U-F1	FIRST FAILURE IN TIE BKR 2AT3A
241	EPA16-U-F2	SECOND FAILURE IN TIE BKR 2AT3A
242	EPA17-U	LOCAL FAULT AT EPA17 (TIE BKR 3AT6A)
243	EPA17-U-F	UNCLEARABLE FAULT AT EPA17 (TIE BKR 3AT6A)
244	EPA17-U-F1	FIRST FAILURE IN TIE BKR 3AT6A
245	EPA17-U-F2	SECOND FAILURE IN TIE BKR 3AT6A
246	EPA18-S-F	LOCAL FAULT AT MCC 39.
247	EPA18-T	MCC 39 LOSS OF POWER
248	EPA19-S-F	LOCAL FAULT AT MCC 36C.
249	EPA20-S-F	LOCAL FAULT AT MCC 32.
250	EPA20-T	LOSS OF POWER FROM 480V AC MCC 32

251	EPA21-S-F	LOCAL FAULT AT MCC 37.
252	EPA21-T	MCC 37 LOSS OF POWER
253	EPA21-T-V	LOP AT EPA21(MCC 37)(HPI VALVES)
254	EPA22-S-F	LOCAL FAULT AT EPA22 (MCC 36A)
255	EPA22-T	LOSS OF POWER TO MCC 36A
256	EPA23-S-F	LOCAL FAULT AT MCC36B (SEG EPA23)
257	EPA23-T	LOSS OF POWER TO MCC 36B
258	EPA24-S-F	LOCAL FAULT AT 6.9KV BUS 1
259	EPA24-T	LOSS OF POWER FROM 6900V AC BUS NO. 1
260	EPA25-S-F	LOCAL FAULT AT 6.9KV BUS 4
261	EPA25-T	LOSS OF POWER FROM 6900V AC BUS NO. 4
262	EPA26-S-F	LOCAL FAULT AT MCC 33
263	EPA26-T	LOSS OF POWER FROM 480V AC MCC 33
264	EPA27-S-F	LOCAL FAULT AT MCC 34
265	EPA27-T	NO POWER AT MCC 34 - FROM EPS FT
266	EPA28-S-F	LOCAL FAULT AT MCC 35
267	EPA28-T	LOSS OF POWER FROM 480V AC MCC 35
268	EPA29-S-F	LOCAL FAULT AT MCC 31
269	EPA29-T	MCC 31 LOSS OF POWER
270	EPA30-S-F	LOCAL FAULT AT MCC 38
271	EPA51-S-F	BKR UT2 FAILS OPEN - DE-ENERGIZES BUS 2
272	EPA52-S-F	LOCAL FAULT AT BUS 2
273	EPA52-T	LOSS OF POWER FROM 6900V AC BUS NO. 2
274	EPA54-S-F	BKR UT3 FAILS OPEN - DE-ENERGIZES BUS 3
275	EPA55-S-F	LOCAL FAULT AT BUS 3
276	EPA55-T	LOSS OF POWER FROM 6900V AC BUS NO. 3
277	EPA57-S-F	FAILURE OF UNIT AUX XFMER
278	EPA58-S-F	BKR UT1 FAILS OPEN - DE-ENERGIZES BUS 1
279	EPA60-S-F	BKR UT4 FAILS OPEN - DE-ENERGIZES BUS 4
280	EPAG11	LOP AT EPA03 (SS XFMR 5)
281	EPAG12	LOP AT EPA06 (6.9KV BUS 2 + SS XFMR 2)
282	EPAG13	LOP AT EPA13 (6.9KV BUS 3 + SS XFMR 3)
283	EPAG14	LOP AT EPA10 (SS XFMR 6)
284	EPAG15	LOSS OF POWER FROM 6900V AC BUS NO. 5
285	EPAG16	LOSS OF POWER FROM 6900V AC BUS NO. 6
286	EPD01-01	LOSS OF DC POWER REQD TO OPEN AOV 261A OR C
287	EPD01-02-F	LF AT DC POWER PANEL 31.
288	EPD01-06-F	LF AT BATTERY CHARGER 31, CB, CABLES.
289	EPD01-31	LOSS OF 125V DC DISTRIBUTION PANEL 31
290	EPD01-P1-F	LF, FB16 OPENS.
291	EPD01-P3-F	LF, FB13 OPENS.
292	EPD02-01	LOSS OF DC POWER REQD TO OPEN AOV 261B OR D
293	EPD02-01-V	LOP AT DC PP 32(HPI VALVES)
294	EPD02-02-F	LF AT DC POWER PANEL 32.
295	EPD02-03-V	LOP TO DC PP 32(HPI VALVES)
296	EPD02-04-V	LOP FROM EPD22(HPI VALVES)
297	EPD02-06-F	LF AT BATTERY CHARGER 32, CB, CABLES.
298	EPD02-32	LOSS OF 125V DC DISTRIBUTION PANEL 32
299	EPD02-32-V	LOP TO DC DP 32(HPI VALVES)
300	EPD02-P2-F	LF, FB12 OPENS.

301	EPD02-P4-F	LF,FB13 OPENS.
302	EPD03-01	LOP AT EPD 03 (DC POWER PANEL 33)
303	EPD03-02-F	LF AT DC POWER PANEL 33.
304	EPD03-06-F	LF AT BATTERY CHARGER 33,CB,CABLES.
305	EPD04-02-F	LF AT DC POWER PANEL 34.
306	EPD04-06-F	LF AT BATTERY CHARGER 34,CB,CABLES.
307	EPD11-A	BATTERY 31 FAILURE
308	EPD11-F	LOP AT EPD 11 (FAILURE OF BATTERY 31).
309	EPD12-A	LOP AT DC PP 32 - BATTERY 32 SOURCE ONLY
310	EPD12-F	LOP AT EPD 12 (FAILURE OF BATTERY 32).
311	EPD13-A	BATTERY 33 FAILURE
312	EPD13-F	LOP AT EPD 13 (FAILURE OF BATTERY 33).
313	EPD14-F	LOP AT EPD 14 (FAILURE OF BATTERY 34).
314	EPD2--	CONTROL POWER LOST TO SPRAY CONTROL VALVES - NO SPRAY
315	EPD3132-U-F	UNCLEARABLE FAULT IN TIE BKR BETWEEN DC PPNL 31 AND 32
316	EPGENTRAN	FUTURE SPACE FOR GENERAL TRANSIENT TREE
317	EPI-A1X	LF AT XER OR CB 36C , AC BUS 1.
318	EPI-A2X	LF AT XER , CB 36B ,AC BUS 2.
319	EPI21-01	LOSS OF INST BUS 31
320	EPI21-02-F	LF AT I BUS 31.
321	EPI21-06	LF IN MANUAL SWITCH 31,TRANSFER FAILURE TO AC SOURCE 1.
322	EPI21-15-F	LF IN INVERTER 31 OR CABLE TO IT.
323	EPI21-SW-F	MANUAL SWITCH 31 OPENS.
324	EPI22-01	LOSS OF INST BUS 32
325	EPI22-02-F	LF AT I BUS 32.
326	EPI22-06	LF IN MANUAL SWITCH 32,TRANSFER FAILURE TO AC SOURCE 1.
327	EPI22-15-F	LF IN INVERTER 32 OR CABLE TO IT.
328	EPI22-SW-F	MANUAL SWITCH 32 OPENS.
329	EPI23-01	LOSS OF INST BUS 33
330	EPI23-02-F	LF AT I BUS 33.
331	EPI23-06	LF IN MANUAL SWITCH 33,TRANSFER FAILURE TO AC SOURCE 1.
332	EPI23-15-F	LF IN INVERTER 33 OR CABLE TO IT.
333	EPI23-SW-F	MANUAL SWITCH 33 OPENS.
334	EPI24-01	LOSS OF INST BUS 34
335	EPI24-02-F	LF AT I BUS 34.
336	EPI24-06	LF IN MANUAL SWITCH 34,TRANSFER FAILURE TO AC SOURCE 1.
337	EPI24-08	LF IN MAN. CB 34, TRANSFER FAILURE TO AC SOURCE 2.
338	EPI24-15-F	LF IN INVERTER 34 OR CABLE TO IT.
339	EPI24-CB-F	LOP AT MAN.CB 34 (OPENS).
340	EPI24-SW-F	MANUAL SWITCH 34 OPENS.
341	EPL01-02	LF AT DISTR PANEL FOR FAN HOUSE & TUNNEL.
342	EPL01-06	LF AT BUS 33.
343	EPL01-10	LF OF L XER OR CB 33.
344	EPL01-11	BREAKER (FB3)TO EPD 02 OPENS.
345	EPL01-12	CRTIE CB 3233 OR L BUS 32 IS NOT AVAILABLE .
346	EPL01-SW	SWITCH 37 OPENS.
347	EPL01-SWF	LF IN SWITCH 37,TRANSFER FAILURE TO (E) SOURCE.
348	EPL02-02	LF AT DISTR PANEL FOR NUCLEAR PLANT.
349	EPL02-05	BREAKER (FB2) TO EPD 02 OPENS.
350	EPL02-SW	SWITCH 34 0PENS.

351	EPL02-SWF	LF IN SWITCH 34, TRANSFER FAILURE TO (E) SOURCE.
352	EPL03-02	LF AT DISTR PANEL FOR CONVENTIONAL PLANT.
353	EPL03-06	LF OF XER, CB, (120VAC) BUS 31.
354	EPL03-08	LF AT BUS 31 .
355	EPL03-12	AUTO SWITCH FAILS.
356	EPL03-15	BREAKER (FB2) TO EPD 01 OPENS.
357	EPL03-SW	SWITCH 31 OPENS.
358	EPL03-SWF	LF IN SWITCH 31, TRANSFER FAILURE TO (E) SOURCE.
359	EPL04-02	LF AT DISTR PANEL FOR CONTROL ROOM.
360	EPL04-06	LF AT BUS 32.
361	EPL04-10	LF OF L XER OR CB 32.
362	EPL04-12	CRTIE CB 3233 OR BUS 33 IS NOT AVAILABLE.
363	EPL04-15	BREAKER (FB11) TO EPD 01 OPENS.
364	EPL04-SW	SWITCH 33 OPENS.
365	EPL04-SWF	LF IN SWITCH 33, TRANSFER FAILURE TO (E) SOURCE.
366	EPL06-06	LF OF XER, CB, (120 VAC) BUS, DISTR PANEL 34.
367	EPL06-08	LF AT BUS 33.
368	EPL06-12	SWITCH 34 IS UNAVAILABLE.
369	EPL06-14	SWITCH 34 OPENS.
370	EPMITIGATE	TOGGLE SWITCH FOR MITIGATION CASE
371	EPTRANSIENT	TOGGLE SWITCH FOR TRANSIENT CASE
372	F1	FIRE IN ZONE 1
373	F10	FIRE IN ZONE 10
374	F101A	FIRE IN ZONE 101A
375	F102A	FIRE IN ZONE 102A
376	F10A	FIRE IN ZONE 10A
377	F11	FIRE IN ZONE 11
378	F12	FIRE IN ZONE 12
379	F12A	FIRE IN ZONE 12A
380	F13	FIRE IN ZONE 13
381	F14	FIRE IN ZONE 14
382	F15	FIRE IN ZONE 15
383	F17A	FIRE IN ZONE 17A
384	F19	FIRE IN ZONE 19
385	F19A	FIRE IN ZONE 19A
386	F22	FIRE IN ZONE 22
387	F23	FIRE IN ZONE 23
388	F27A	FIRE IN ZONE 27A
389	F2A	FIRE IN ZONE 2A
390	F3	FIRE IN ZONE 3
391	F30A	FIRE IN ZONE 30A
392	F31A	FIRE IN ZONE 31A
393	F37A	FIRE IN ZONE 37A
394	F38A	FIRE IN ZONE 38A
395	F39A	FIRE IN ZONE 39A
396	F3A	FIRE IN ZONE 3A
397	F4	FIRE IN ZONE 4
398	F40A	FIRE IN ZONE 40A
399	F41A	FIRE IN ZONE 41A
400	F42A	FIRE IN ZONE 42A

401	F4A	FIRE IN ZONE 4A
402	F5	FIRE IN ZONE 5
403	F52A	FIRE IN ZONE 52A
404	F54A	FIRE IN ZONE 54A
405	F55	FIRE IN ZONE 55
406	F57A	FIRE IN ZONE 57A
407	F58A	FIRE IN ZONE 58A
408	F59A	FIRE IN ZONE 59A
409	F6	FIRE IN ZONE 6
410	F60A	FIRE IN ZONE 60A
411	F66A	FIRE IN ZONE 66A
412	F68A	FIRE IN ZONE 68A
413	F69A	FIRE IN ZONE 69A
414	F7	FIRE IN ZONE 7
415	F70A	FIRE IN ZONE 70A.
416	F71A	FIRE IN ZONE 71A
417	F73A	FIRE IN ZONE 73A
418	F74A	FIRE IN ZONE 74A
419	F75A	FIRE IN ZONE 75A
420	F78A	FIRE IN ZONE 78A
421	F7A	FIRE IN ZONE 7A
422	F8	FIRE IN ZONE 8
423	F86A	FIRE IN ZONE 86A
424	F87A	FIRE IN ZONE 87A
425	F9	FIRE IN ZONE 9
426	F9A	FIRE IN ZONE 9A
427	FMCC311LOC	FIRE IN ZONE MCC311LO
428	FULZ-1	FIRE IN UNLABELLED ZONE 1,PAB ELEV 32.5-41
429	FZNEAR11	FIRE IN ZONE ZNEAR11
430	FZNEAR55A	FIRE IN ZONE ZNEAR55A
431	HP001-A-INT	INTERNAL FAILURE OF SEGMENT 1
432	HP002-A-INT	PUMP 31 INTERNAL FAILURE
433	HP003-A-INT	PUMP 32 INTERNAL FAILURE
434	HP004-A-INT	PUMP 33 INTERNAL FAILURE
435	HP005-A-INT	NOIF OF PUMP 32 DISCHARGE HEADER
436	HP005-C-INT	SEGMENT NO. 5 CKV 852A REVERSE FLOW
437	HP006-A-INT	FAILURE OF PUMP 32 DISCHARGE HEADER
436	HP066-C-INT	SEGMENT NO. 6 CKV 852B REVERSE FLOW
439	HP007-HTR31-INT	INTERNAL FAULTS OF BIT HEATER 31
440	HP007-HTR32-INT	INTERNAL FAULTS OF BIT HEATER 32
441	HP007A-A-INT	INTERNAL FAILURE OF SEGMENT 7A
442	HP007A-C-INT	LEAKAGE PAST NC MOV1852A
443	HP007B-A-INT	INTERNAL FAILURE OF SEGMENT 7B
444	HP007B-C-INT	LEAKAGE PAST NC MOV1852B
445	HP007C-A-INT	INTERNAL FAILURE OF SEGMENT 7C
446	HP007D-A-INT	INTERNAL FAILURE OF SEGMENT 7D
447	HP007E-A-INT	INTERNAL FAILURE OF SEGMENT 7E
448	HP007F-A-INT	FLOW DIVERSION TO CVCS HOLD UP TANKS-VALVE 1846 OPENS
449	HP007G-A-INT	VALVE 1851B INTERNAL FAILURE
450	HP007H-A-INT	VALVE 1851A INTERNAL FAILURE

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451 HP011A-A-INT      MOV 842,MOV843,OR VALVE 1862 NOFC
452 HP012-A-INT       COLD LEG NO. 4 INJECTION PATH FAILURE
453 HP013-A-INT       COLD LEG NO. 2 INJECTION PATH FAILURE
454 HP014-A-INT       COLD LEG NO. 3 INJECTION PATH FAILURE
455 HP015-A-INT       COLD LEG NO. 1 INJECTION PATH FAILURE
456 HP016-A-INT       COLD LEG NO.4 INJECTION PATH FAILURE
457 HP017-A-INT       COLD LEG NO. 2 INJECTION PATH FAILURE
458 HP018-A-INT       COLD LEG NO. 3 INJECTION PATH FAILURE
459 HP019-A-INT       COLD LEG NO. 1 INJECTION PATH FAILURE
460 HP02A-A-INT       VALVE 849A,850A,OR 848A FAILS CLOSED
461 HP02A-C-INT       SEGMENT 2A CKV 849A REVERSE FLOW
462 HP03A-A-INT       MOV 887A,887B FAILS CLOSED
463 HP04A-A-INT       VALVE 849B,850B,OR 848B FAILS CLOSED
464 HP04A-C-INT       SEGMENT 4A CKV 849B REVERSE FLOW
465 HP33A061-T-INT    FAILURE OF LOCAL CNTRLS EHT PNL 33A CKT 6
466 HP33A062-T-INT    EHT PNL33A CKT 6 PRIMARY TRACING FAILS
467 HP33A063-T-INT    INTERNAL FAILURE OF EHT PNL33A CKT 6 REDUNDANT TRACING
468 HP33A063-T-OPER   OPERATOR FAILS TO ALIGN REDUNDANT TRACING
469 HP33A064-T-INT    EHT PNL33A CKT 6 ALARM FAILURE
470 HP33A111-T-INT    FAILURE OF LOCAL CNTRLS EHT PNL 33A CKT 11
471 HP33A112-T-INT    EHT PNL 33A CKT 11 PRIMARY TRACING FAILS
472 HP33A113-T-INT    INTERNAL FAILURE OF EHT PNL 33A CKT 11 REDUNDANT TRACING
473 HP33A113-T-OPER   OPERATOR FAILS TO ALIGN REDUNDANT TRACING
474 HP33A114-T-INT    EHT PNL 33A CKT 11 ALARM FAILURE
475 HP33A121-T-INT    FAILURE OF LOCAL CNTRLS EHT PNL 33A CKT 12
476 HP33A122-T-INT    EHT PNL 33A CKT 12 PRIMARY TRACING FAILS
477 HP33A123-T-INT    INTERNAL FAILURE OF EHT PNL 33A CKT 12 REDUNDANT TRACING
478 HP33A123-T-OPER   OPERATOR FAILS TO ALIGN REDUNDANT TRACING
479 HP33A124-T-INT    EHT PNL 33A CKT 12 ALARM FAILURE
480 HP33A191-T-INT    FAILURE OF LOCAL CNTRLS EHT PNL33A CKT 19
481 HP33A192-T-INT    EHT PNL33A CKT 19 PRIMARY TRACING FAILS
482 HP33A193-T-INT    INTERNAL FAILURE OF EHT PNL 33A CKT 19 REDUNDANT TRACING
483 HP33A193-T-OPER   OPERATOR FAILS TO ALIGN REDUNDANT TRACING
484 HP33A194-T-INT    EHT PNL 33A CKT 19 ALARM FAILURE
485 HP33A221-T-INT    FAILURE OF LOCAL CNTRLS EHT PNL 33A CKT 22
486 HP33A222-T-INT    EHT PNL33A CKT 22 PRIMARY TRACING FAILS
487 HP33A223-T-INT    INTERNAL FAILURE OF EHT PNL33A CKT 22 REDUNDANT TRACING
488 HP33A223-T-OPER   OPERATOR FAILS TO ALIGN REDUNDANT TRACING
489 HP33A224-T-INT    EHT PNL 33A CKT 22 ALARM FAILURE
490 HP33A231-T-INT    FAILURE OF LOCAL CNTRLS EHT PNL 33A CKT 23
491 HP33A232-T-INT    EHT PNL 33A CKT 23 PRIMARY TRACING FAILS
492 HP33A233-T-INT    INTERNAL FAILURE OF EHT PNL 33A CKT 23 REDUNDANT TRACING
493 HP33A233-T-OPER   OPERATOR FAILS TO ALIGN REDUNDANT TRACING
494 HP33A234-T-INT    EHT PNL 33A CKT 23 ALARM FAILURE
495 HT-POWER-MATTERS CONDX ARE SUCH THAT PWR FAILURES TO HT CAN CAUSE SYSTEM FAILUR
496 HT001-T-INT       SEGMENT 1 INTERNAL FAILURE
497 HT002-T-INT       SEGMENT 2 INTERNAL FAILURE
498 HT003-T-INT       SEGMENT 3 INTERNAL FAILURE
499 HT003-T-O         OPERATOR FAILS TO MAKE THE TRANSFER
500 HT005-LBFTO       SEGMENT 5 BRKR FTO
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501	HT006-LBFTO	SEGMENT 6 BRKR FTO
502	HT007-LBFTO	SEGMENT 7 BRKR FTO
503	HT008-LEF	TRANSFORMER TO PNL 33A ELEC FAULT
504	HT008-T-INT	SEGMENTS 5,8,OR 11 INTERNAL FAILURE
505	HT009-LEF	TRANSFORMER TO PNL 33B ELEC FAULT
506	HT009-T-INT	SEGMENT 6,9,OR 12 INTERNAL FAILURE
507	HT010-LEF	TRANSFORMER TO PNL 33C ELEC FAULT
508	HT010-T-INT	SEGMENT 7,10,OR 13 INTERNAL FAILURE
509	HT021-T-INT	SEGMENT 21 INTERNAL FAILURE
510	HT022-T-INT	SEGMENT 22 INTERNAL FAILURE
511	HT023-T-INT	SEGMENT 23 INTERNAL FAILURE
512	HT024-T-INT	SEGMENT 24 INTERNAL FAILURE
513	HT025-LEF	TRANSFORMER ELEC FAULT
514	HT025-T-INT	SEGMENT 25 INTERNAL FAILURE
515	HT026-LEF	TRANSFORMER ELEC FAULT
516	HT026-T-INT	SEGMENT 26 INTERNAL FAILURE
517	HT027-LEF	TRANSFORMER ELEC FAULT
518	HT027-T-INT	SEGMENT 27 INTERNAL FAILURE
519	HT028-LEF	TRANSFORMER ELEC FAULT
520	HT028-T-INT	SEGMENT 28 INTERNAL FAILURE
521	HT029-T-INT	SEGMENT 29 INTERNAL FAILURE
522	HT030-T-INT	SEGMENT 30 INTERNAL FAILURE
523	HT031-T-INT	SEGMENT 31 INTERNAL FAILURE
524	HT032-T-INT	SEGMENT 32 INTERNAL FAILURE
525	HT033-LBFTO	ASSOCIATED FP DP 31 LOAD BKR FTO
526	HT033-LEF	LOCAL FP DP 31 LOAD FAULT
527	HT0351-LBFTO	FP DP 34 LINE 155 CKT BRKRS FTO
528	HT0351-LEF	ELEC. FAILURE OF LINE 155 HT CKTS
529	HT0352-LBFTO	FP DP 34 LINE 161 CKT BRKRS FTO
530	HT0352-LEF	ELEC FAILURE OF LINE 161 HT CKTS
531	HT0353-LBFTO	FP DP 34 RWST INST STRIP HTRS CKT BRKRS FTO
532	HT0353-LEF	ELEC FAILURE OF RWST INST STRIP HTRS
533	HT0354-LBFTO	FP DP 34 NON RWST HT CKT BRKRS FTO
534	HT0354-LEF	ELEC FAILURE OF NON RWST HT CKTS
535	HT036-LBFTO	ASSOC BRKR FP DP 35 FTO
536	HT036-LEF	LOCAL FP DP 35 LOAD FAULT
537	HT33A-LBFTO	ASSOC LOAD BRKR FTO
538	HT33A-LEF	LOCAL LOAD ELEC FAULT ON PNL 33A
539	HT33B-LBFTO	ASSOC LOAD BRKR FTO
540	HT33B-LEF	LOCAL LOAD ELEC FAULT ON PNL 33B
541	HT33C-LBFTO	ASSOC LOCAL LOAD BRKR FTO
542	HT33C-LEF	LOCAL LOAD ELEC FAULT ON PNL 33C
543	HT341-LBFTO	FP DP 32 CKT 9 OR 11 FAULTED ASSOC BRKR FTO
544	HT341-LEF	ELEC FAULT OF EHT DP 32 CKTS 9 OR 11
545	HT341-T-INT	INTERNAL FAILURE OF HT FP DP 32 CKTS 9 OR 11
546	HT342-LBFTO	FP DP 32 CKT 7 LOAD BRKR FTO
547	HT342-LEF	FP DP 32 CKT 7 ELEC FAULT
548	HT343-LBFTO	FP DP 32 LOAD BKR ASSOC WITH FAULTED CKT FTO
549	HT343-LEF	ELEC FAULT OF ANY 1 OF EHT DP 32 CKTS 1 THRU 6
550	HT343-T-INT	INTERNAL FAILURE OF ANY 1 OF EHT DP 32 CKTS 1 THRU 6

551	HT351-T-INT	INTERNAL FAILURE OF LINE 155 HEAT TRACING
552	HT352-T-INT	INTERNAL FAILURE OF LINE 161 HEAT TRACING
553	HTG320-T	EHT FAILURE OF FP DP 32
554	HTG330-T	NO PWR TO EHT PNL 33A
555	HTG340-T	EHT FAILURE OF FP DP 34
556	HTSPSO-T	NO POWER TO SUPV PNL SO IN CR
557	IA005-A	COMMON PIPE FROM COMPRESSORS TO RECEIVER
558	IA006-A	RECEIVER ADN RV
559	IA007-A	PIPE AND VALVE DOWNSTREAM OF RECEIVER
560	IA008-A	PIPE PLUGGED - NOIF FROM COMPRESSORS AND BACKUP SERV AIR
561	IA009-A	PIPE PLUGGED - NOIF THRU DRYER 32 AND BYPASS
562	IA012-A	COMMON PIPE FROM ALT PATH(DRYER 31) AND BYPASS
563	IA013-A	PIPE,VALVES AND CONTROLLER IN BYPASS
564	IA014-A	PIPE IN BYPASS
565	IA015-A	COMMON PIPE FROM REF DRYERS TO DESIC DRYERS & TO CONV PLANT SE
566	IA016-A	PIPE TO DESICANT DRYERS
567	IA018-A	PIPES, VALVES, REGENERATIVE DRYERS - NORMAL FLOW PATH
568	IA01A-A-F	COMPRESSOR, PIPE,VALVE UPSTREAM OF AFTERCOOLER 31
569	IA01B-A-F	COMPRESSOR, VALVE,PIPE UPSTREAM OF AFTERCOOLER 32
570	IA025-A	PIPE,VALVES, CONTROLLER, NONREG.DRYER-BACKUP PATH(4HR SUPPLY)
571	IA026-A	PIPE FROM DESICANT DRYER TO AFTER FILTERS
572	IA027-A	FILTERS,PIPES,VALVES -
573	IA02A-A	AFTERCOOLER 31
574	IA02B-A	AFTERCOOLER 32
575	IA030-A	PIPE FROM AFTERFILTERS TO DISTRIBUTION
576	IA03A-A	PIPE AND VALVES DOWNSTREAM AFTERCOOLER 31 -
577	IA03B-A	PIPE AND VALVES DOWNSTREAM AFTERCOOLER 32
578	IA04A-A	PIPE DOWNSTREAM OF SEG IA03A
579	IA04B-A	PIPE DOWNSTREAM OF SEG IA03B
580	IA10A-A	PIPE,FILTER,DRYER AND VALVES IN ALT PATH (DRYER 31)
581	IA10B-A	PIPE,FILTER,DRYER AND VALVES IN OPERATING DRYER 32
582	IA11A-A	PIPE IN ALT PATH DOWNSTREAM OF DRYER 31
583	IA11B-A	PIPE DOWNSTREAM OF OPERATING DRYER 32
584	IAC02-A	PIPE DOWNSTREAM OF BOTH CW PUMPS
585	IAC04-A	CW HX 32, INLET AND OUTLET VALVES AND PIPES
586	IAC05-A	CW HX 31, INLET AND OUTLET VALVES AND PIPE SEGS
587	IAC06-A	PIPE FROM CW HXS TO AFTERCOOLERS
588	IAC10-A	COMMON DISCHARGE PIPE FROM MOTORS 31 AND 32 TO PUMP SUCTION
589	IAC1A-A-F	CW PUMP 31,VALVES AND PIPE - OPERATING PUMP
590	IAC1B-A-F	CW PUMP 32,VALVES AND PIPE - STANDBY PUMP
591	IAC7A-A	VALVES AND PIPE TO AFTERCOOLER 31
592	IAC7B-A	VALVES AND PIPE TO AFTERCOOLER 32
593	IAC9A-A	VALVES AND PIPES- FROM AFTERCOOLER 31 TO/THRU MOTOR 31
594	IAC9B-A	VALVES AND PIPES- FROM AFTERCOOLER 32 TO/THRU MOTOR 32
595	IAG01	NOIF FROM INST. AIRSYS. TO NUCL. SERVICE FROM IA FT.
596	IAIRBYPASS	FLOW REG BYPASS VALVE COMMANDED OPEN (INST AIR HX SW OUTLET)
597	IAS01-A	VALVES,PIPE,FROM SERV AIR TO INST AIR AND WELD CHANNEL BACKUP
598	IAS02-A	PIPE FROM SERVICE AIR TO FILTERS
599	IAS07-A	PIPE,VALVES AND CONTROLLER DOWNSTREAM OF FILTERS
600	IAS08-A	VALVE AND PIPE FROM SERVICE AIR TO INST. AIR

601	IAS29-A	VALVES,FILTER AN PIPE
602	LC460C-A	BISTABLE FAILS
603	LOCA	LOCA EVENT
604	LP001-A	PIPE FROM XV846 TO MOV882
605	LP002-A	MOV882 (DOFC), CV881 (FTO), PIPE
606	LP003-E	FLOW DIVERTED, MOV883 (LCFO) OR BV1863 (NCFO)
607	LP003-E1	MOV 883(LCFO)
608	LP003-E2	BV1863
609	LP005-A	MOV744 (DOFC),CV741 (FTO),OR PIPE PLUGGED
610	LP006-A	MOV745A OR MOV745B FAILURE (NOFC)
611	LP008-A	NOIFF THRU HXS CROSS TIE - MOV1869A OR MOV1869B (NOFC)
612	LP010-A	CROSS TIE BLOCKED
613	LP011-A	COLD LEG 1 PATH FAILURE
614	LP012-A	COLD LEG 2 PATH FAILURE
615	LP013-A	COLD LEG 3 PATH FAILURE
616	LP015-E	MOV885A AND MOV885B (NCFO)-FLOW DIVERTED TO CONTAINMENT SUMP
617	LP015-E1	MOV 885A(NCFO)
618	LP015-E2	MOV 885B(NCFO)
619	LP016-A	RHR PUMPS MIN FLOW LINE PLUGGED-MOV 1873 OR 743 FC-ASSUMPTION
620	LP04A-A	RHR PUMP 31, XV739A (NOFC), XV735A (LOFC), CV738A (FTO), PIPE
621	LP04B-A	RHR PUMP 32, XV739B (LOFC), XV735B (LOFC), CV738B (FTO), PIPE
622	LP07A-A	HEX 31 FAILURES OR XV742 (LOFC)
623	LP07B-A	HEX 32 FAILURES
624	LP09A-A	FAILURES OF VALVES AND PIPE FROM HEX 31 TO CROSS TIE (MOV 899B
625	LP09B-A	FAILURES OF VALVES AND PIPE FROM HEX 32 TO XTIE (MOV 899A)
626	LP14A-E	MOV-889B (NCFO)
627	LP14B-E	MOV-889A (NCFO)
628	LT459-HF	LOCAL FAULT LT459 FAILS HI
629	LT460-A	PZR LEVEL SENSOR FAILS LOW - LT460
630	LT460-HF	LOCAL FAULT LT460 FAILS HI
631	LT460-LF-F	LOCAL FAULT LT460 FAILS LOW
632	LT461-A	PZR LEVEL SENSOR FAILS LOW - LT461
633	LT461-HF	LOCAL FAULT LT461 FAILS HI
634	LT461-LF-F	LOCAL FAULT LT461 FAILS LOW
635	MF-1A-A	NOIF FROM MFIV BFD-7 CV BFD-6 OR FE-418 TO SG 31
636	MF-1B-A	NOIF FROM MFIV BFD-7 CV BFD-6 OR FE-428 TO SG 32
637	MF-1C-A	NOIF FROM MFIV BFD-7 CV BFD-6 OR FE-438 TO SG 33
638	MF-1D-A	NOIF FROM MFIV BFD-7 CV BFD-6 OR FE-448 TO SG 34
639	MF-2A-LF-F	NOIFF MF REG FCV-417 OR MOIV BFD-5 TO SG 31 LOCAL FAILURES
640	MF-2B-LF-F	NOIFF MF REG FCV-427 OR MOIV BFD-5 TO SG 32 LOCAL FAILURES
641	MF-2C-LF-F	NOIFF MF REG FCV-437 OR MOIV BFD-5 TO SG 33 LOCAL FAILURES
642	MF-2D-LF-F	NOIFF MF REG FCV-447 OR MOIV BFD-5 TO SG 34 LOCAL FAILURES
643	MF-4-A	NOIF FROM MFW HP HEATERS COMMON DISCHARGE HEADER
644	MF-4A-A	NOIF FROM HP HEATER 36A
645	MF-4B-A	NOIF FROM HP HEATER 36B
646	MF-4C-A	NOIF FROM HP HEATER 36C
647	MF-5-A	OPER FAILS TO OPEN BYPASS VALVE OR VALVE FAILS
648	MF-6-A	NOIF FROM COMMON BFP DISCHARGE HEADER
649	MF-61-C-INT	BFP 31 DISCH REV FLOW -CV FAILS (RF) AND MOV FAILS TO CLOSE
650	MF-61-LF-F	BOILER FEED PUMP 31 LOCAL FAILURE

651	MF-62-C-INT	BFP 32 DISCH REV FLOW -CV FAILS (RF) AND MOV FAILS TO CLOSE
652	MF-62-LF-F	BOILER FEED PUMP 32 LOCAL FAILURE
653	MF-7-A	NOIF TO BFPS 31 & 32 FROM COMMON SUCTION HEADER
654	MF-SG31323334	NO MAIN FEEDWATER TO 1 OUT OF 4 STEAM GENERATORS
655	MS----LF	NOIFF MAIN STEAM AND MSR SUPPLY TO BFPTS LOCAL FAILURES
656	MS-AEJ----LF	LOSS OF MAIN STEAM AIR EJECTORS - LOCAL FAILURE
657	NOTLOCA	NOT A LOCA EVENT
658	NOTLOOP-6A	NO LOOP TO BUS 6A
659	NOTTR-SPSI	NO SAFETY INJECTION SIGNAL PRESENT
660	PC455E-NT	NO TRIP SIGNAL FROM PLP BISTABLE (PC 455E).
661	PC456E-NT	NO TRIP SIGNAL FROM PLP BISTABLE (PC 456E).
662	PC457E-NT	NO TRIP SIGNAL FROM PLP BISTABLE (PC 457E).
663	PC948D-NT	NO TRIP S. FROM CHP BISTABLE, PC 948D.
664	PC948E-NT	NO TRIP S. FROM CHP BISTABLE, PC 948E.
665	PC948F-NT	NO TRIP S. FROM CHP BISTABLE, PC 948F.
666	PM---	NO PRIMARY MAKE UP WATER GOES TO VALVE FCV111A.
667	POWER	NO POWER TO 4-WAY VALVE - SUPPLY NOT FOUND
668	PT455-HF	LOCAL FAULT PT455 FAILS HI
669	PT455-LF-F	LOCAL FAULT PT455 FAILS LOW
670	PT456-HF	LOCAL FAULT PT456 FAILS HI (PCV456 SIGNALLED TO OPEN)
671	PT456-LF-F	LOCAL FAULT PT456 FAILS LOW (PCV456 FAILS CLOSED)
672	PT457-HF	LOCAL FAULT PT457 FAILS HI (PCS AND PRMSV TO PCV456)
673	PT457-LF-F	LOCAL FAULT PT457 FAILS LOW (PCS AND INTLK PCV456)
674	PT474-HF	LOCAL FAULT PT474 FAILS HI (PRMSV TO PCV455C)
675	PT474-LF-F	LOCAL FAULT PT474 FAILS LOW (INTLK TO PCV455C)
676	PT948A-NT	NO TRIP S. FROM SENSOR+TRANSMITTER, PT 948A .
677	PT948B-NT	NO TRIP S. FROM SENSOR+TRANSMITTER, PT 948B .
678	PT948C-NT	NO TRIP S. FROM SENSOR+TRANSMITTER, PT 948C .
679	PZ200-OPN	PZR SRV FAILS OPEN
680	PZ301-A-F	LOCAL FAULT - PORV PCV-455C FAILS CLOSED
681	PZ301-B	LOCAL FAULT OPENS PORV
682	PZ335-INT-F	LOCAL FAULT OF BLOCK VALVE
683	PZ336-INT-F	LOCAL FAULT OF BLOCK VALVE
684	PZ351-A-F	LOOCAL FAULT - PORV PCV 456 FAILS CLOSED
685	PZ351-B	LOCAL FAULT OPENS PORV PCV 456
686	PZ356-B	LOCAL FAULT IN PRESSURE SENSOR CHANNEL
687	PZ400-D	RUPTURE OF PZR SPRAY LINE
688	PZ401-A	LOCAL FAULT - SPRAY PIPING CLOGS UP
689	PZ401-B	LOCAL FAULT - ONE OR MORE PZR SPRAY VALVES FAIL OPEN
690	PZ501-A-F	LOCAL FAULT WITHIN PZR HEATERS - NO HEAT OUTPUT
691	PZ501-B	LOCAL FAULT PZR HEATER POWER/CONTROL COMPONENTS - RAISES PRESS
692	PZ601-A	LOCAL FAULT WITHIN PZR PRESS CONTROL SYS - LOWERS PRESSURE
693	PZ601-B	LOCAL FAULT IN PZR PRESSURE CONTROL SYSTEM - RAISES PRESSURE
694	PZ701-A	LOCAL FAULT WITHIN PZR LEVEL CONTROL SYSTEM - LOWERS LEVEL
695	PZ701-B	LOCAL FAULT IN PZR LEVEL CONTROL SYSTEM CAUSES HIGH LEVEL
696	PZBLKV-NOA	OPERATOR DOES NOT CLOSE BLOCK VALVE
697	PZLREF-A	REACTOR CONTROL SYSTEM INPUTS LOW (LREF) LEVEL SIGNAL
698	PZLREF-B	REACTOR CONTROL SYSTEM INPUTS HIGH (LREF) LEVEL SIGNAL
699	PZN23-A	MOTIVE NITROGEN SUPPLY LOST - PORV PCV-455C FAILS CLOSED
700	PZN26-A	MOTIVE NITROGEN SUPPLY LOST - PCV 456 FAILS CLOSED

701	PZRXTRIP	REACTOR TRIP ON PZR FAULT
702	RCE01	UNDEFINED REASONS
703	RCE03	OTHER REASONS
704	RCE04	OTHER REASONS
705	RCPM01-INT	MANUAL VALVES 771A,772A,773A FAIL CLOSED FOR RCP 31 MOTOR COOL
706	RCPM02-INT	MANUAL VALVES 771B,772B,773B FAIL CLOSED FOR RCP 32 MOTOR COOL
707	RCPM03-INT	MANUAL VALVES 771C,772C,773C FC FOR RCP 33 MOTOR COOLING
708	RCPM04-INT	MAUAL VALVES 771D,772D,773D FC FOR RCP 34 MOTOR COOLING
709	RCSI01-A-INT	INJECTION FILTER TRAIN FAIL.
710	RCSI02-A-INT	PIPE,VALVE,FLOW METER FAIL.
711	RCSI06-A-INT	SEAL NO.1 PLUGGED OR VALVE PIPE FAIL.
712	RCSI09-A-INT	MOTOR VALVE 222 FAIL CLOSED
713	RCSI10	SEAL RETURN FILTER PLUGGED.
714	RCSI11-A-INT	SEAL WATER HX.FAILS.
715	RCSIE02	NO OPERATOR ACTION.
716	RCSIE03	INTERNAL FAILURE OF VALVE OR CONTROL CIRCUIT.
717	RCTB01-A-INT	VALVE OR PIPE FAIL
718	RCTB05-A-INT	PIPE OR VALVE 781A FAIL.
719	RCTB06-A-INT	FLOW METER OR FCV625 FAIL.
720	RCTBE01	THERMAL BARRIER OF ANY PUMP RUPTURES
721	RCV01-A-INT	PIPE, VALVE,CHARGING PUMP, MOTOR OF TRAIN 31 FAILS
722	RCV02-A-INT	PIPE,VALVE, CHARGING PUMP, OR MOTOR OF TRAIN 32 FAILS
723	RCV03-A-INT	PIPE, VALVE, CHARGING PUMP, OR MOTOR OF TRAIN 33 FAILS
724	RCV05-A-INT	VALVE 289 FAILS CLOSED
725	RW001-A-INT	INTERNAL FAILURE OF SEGMENT 1
726	RW002-A-INT	INTERNAL FAILURE OF SEGMENT 2
727	RW003-A-INT	INTERNAL FAILURE OF SEGMENT 3
728	RWG001-A	RWST FAILURE
729	RWG002-A	NOIF THROUGH RWST LINE 155
730	SA01-A-INT-F	COMPRESSOR LOCAL FAILS.
731	SA02-A-INT	SUPERCOMPONENT SA02 FAILS
732	SA03-A-INT	IP-1 STATION AIR BACK-UP FOR IP-3 STATION AIR FAILS.
733	SA04-A-INT	SUPERCOMPONENT SA04FAILS.
734	SA07-A	NOIF SUPPLY FROM SERVICE AIR SYST - FROM SERV AIR FT
735	SA07-A-INT	SUPERCOMPONENT SA07 FAILS.
736	SACCS1-A-INT-F	PUMP TRAIN 31 LOCAL FAILS.
737	SACCS2-A-INT-F	PUMP TRAIN 32 LOCAL FAILS.
738	SACCS3-A-INT	HEADER PLUGGED.
739	SACCS4-A-INT	HX. TRAIN 31 LOCAL FAILS.
740	SACCS5-A-INT	HX. TRAIN 32 LOCAL FAILS.
741	SACCS6-A-INT	NOIFF WATER SUPPLY TO CLOSED COOLING SYSTEM PUMPS
742	SACCS7-A-INT	NOIFF SUPPLY FROM CCS HXS HEADER
743	SACCSG01	FAILURE OF CLOSED COOLING SYSTEM- FROM SA FT
744	SE-1X-BFPT1-FD	RELAY 1X-BFPT1 FAILS TO ENERGIZE
745	SE-1X-BFPT2-FD	RELAY 1X-BFPT2 FAILS TO DEENERGIZE
746	SE-2-1-11D-S	LOCAL FAULT OF RELAY 2-1-11D
747	SE-2-1-6D-S	LOCAL FAULT OF RELAY 2-1-6D
748	SE-2-CC1-2-S	LOCAL FAULT OF RELAY 2-CC1-2
749	SE-2-CC2-2-S	LOCAL FAULT OF RELAY 2-CC2-2
750	SE-2-CC3-2-S	LOCAL FAULT OF RELAY 2-CC3-2

751	SE-2-RHR1-S	LOCAL FAULT OF RELAY 2-RHR1
752	SE-2-RHR2-S	LOCAL FAULT OF RELAY 2-RHR2
753	SE-2-SW4-S	LOCAL FAULT OF RELAY 2-SW4
754	SE-2-SW5-S	LOCAL FAULT OF RELAY 2-SW5
755	SE-2-SW6-S	LOCAL FAULT OF RELAY 2-SW6
756	SE-20-1-ABFP2-S	LOCAL FAULT OF RELAY 20-1-ABFP2
757	SE-27-2A-X3-UV	BUS 2A UV SCHEME THINKS LOW VOLTAGE CONDITION EXISTS
758	SE-27-3AX3	BUS 3A UNDERVOLTAGE SCHEME THINKS LOW VOLTAGE CONDITION EXISTS
759	SE-27-5A-X2-UV	BUS 5A UV SCHEME THINKS LOW VOLTAGE CONDITION EXISTS
760	SE-27-6A-X3-UV	BUS 6A UV SCHEME THINKS LOW VOLTAGE CONDITION EXISTS
761	SE-2SI1-S	LOCAL FAULT OF RELAY 2-SI1
762	SE-2SI2-S	LOCAL FAULT OF RELAY 2-SI2
763	SE-2SI3-S	LOCAL FAULT OF RELAY 2-SI3
764	SE-3-1-2A-S	LOCAL FAULT OF RELAY 3-1-2A
765	SE-3-1-3A-S	LOCAL FAULT OF RELAY 3-1-3A
766	SE-3-1-5A-S	LOCAL FAULT OF RELAY 3-1-5A
767	SE-3-1-6A-S	LOCAL FAULT OF RELAY 3-1-6A
768	SE-3-2-2A-S	LOCAL FAULT OF RELAY 3-2-2A
769	SE-3-2-3A-S	LOCAL FAULT OF RELAY 3-2-3A
770	SE-3-2-5A-S	LOCAL FAULT OF RELAY 3-2-5A
771	SE-3-2-6A-S	LOCAL FAULT OF RELAY 3-2-6A
772	SE-52-EG1-INT	LOCAL FAULT OF BREAKER/ACTUATION SCHEME
773	SE-52-EG1-OPN	BKR 52-EG1 (DG 31) OPEN
774	SE-52-EG2-INT	LOCAL FAULT OF BREAKER/ACTUATION SCHEME
775	SE-52-EG2-OPN	BKR 52-EG2 (DG 32) OPEN
776	SE-52-EG3-INT	LOCAL FAULT OF BREAKER/ACTUATION SCHEME
777	SE-52-EG3-OPN	BKR 52-EG3 (DG 33) OPEN
778	SE-63X1-BFP1-S-F	LOCAL FAULT OF RELAY 63X1-BFP1
779	SE-63X1-BFP2-S-F	LOCAL FAULT OF RELAY 63X1-BFP2
780	SE-AFP31-A	AFW PUMP 31 NOT ACTUATED
781	SE-AFP32-A	AFW PUMP 32 NOT ACTUATED
782	SE-AFP33-A	AFW PUMP 33 NOT ACTUATED
783	SE-AFW-NOA	NO OPERATOR ACTION TO ACTUATE AFW PUMPS
784	SE-BFP-L-S	LOCAL FAULT OF RELAY BFP-L
785	SE-BFP-S	LOCAL FAULT OF RELAY BFP
786	SE-CCS2P-A	FAILURE OF LOW HEADER PRESSURE AUTO ACTUATION
787	SE-CCS2P-S	LOCAL FAULT OF LOW HEADER PRESSURE ACTUATION SCHEME
788	SE-CCS31-A	CCW PUMP 31 NOT ACTUATED
789	SE-CCS32-A	CCW PUMP 32 NOT ACTUATED
790	SE-CCS32-NOA	MANUAL ACTUATION OF CCS32 FAILS (ALSO BLOCKED BY SI SIGNAL)
791	SE-CCS33-A	CCW PUMP 33 NOT ACTUATED
792	SE-CCW-NOA	NO OPERATOR ACTION TO ACTUATE CCW PUMPS
793	SE-EDG31-A	FAILURE OF DG BKR 52/EG1 TO ACTUATE
794	SE-EDG32-A	FAILURE OF DG BKR 52/EG2 TO ACTUATE
795	SE-EDG33-A	FAILURE OF DG BKR 52/EG3 TO ACTUATE
796	SE-HP031-A	PUMP 31 NO AUTO INITIATION SIGNAL
797	SE-HP032-A	PUMP 32 NO AUTO INITIATION SIGNAL
798	SE-HP033-A	PUMP 33 NO AUTO INITIATION SIGNAL
799	SE-HPI-NOA	NO OPERATOR ACTION TO ACTUATE HPI PUMPS
800	SE-RHR-NOA	NO OPERATOR ACTION TO ACTUATE RHR PUMPS

801	SE-RHR31-A	FAILURE OF SI SIGNAL TO START RHR PUMP 31
802	SE-RHR32-A	FAILURE OF SI SIGNAL TO START RHR PUMP 32
803	SE-SG1234X-FC	NORMAL START SIGNALS NOT RECEIVED (LO LO 2004 SG S)
804	SE-SGLOLO-A	STEAM GENERATOR LO LO LEVEL LOGIC (1004) FAILS
805	SE-SWN-NOA	NO OPERATOR ACTION TO ACTUATE SWN PUMPS
806	SE-SWN-SWITCH	SWITCH SELECTOR IN WRONG POSITION
807	SE-SWN34-A	SW PUMP 34 NOT ACTUATED FOLLOWING LOOP
808	SE-SWN34-DGS-A	SW PUMP 34 NOT ACTUATED FOLLOWING LOOP - FOR DGS ONLY
809	SE-SWN35-A	SW PUMP 35 NOT ACTUATED FOLLOWING LOOP
810	SE-SWN35-DGS-A	SW PUMP 35 NOT ACTUATED FOLLOWING LOOP- FOR DGS ONLY
811	SE-SWN36-A	SW PUMP 36 NOT ACTUATED
812	SE-SWN36-DGS-A	SW PUMP 36 NOT ACTUATED - FOR DGS ONLY
813	SE-SWN36-NOA	MANUAL ACTUATION OF SW PUMP 36 FAILS
814	SEDG-SWN36-NOA	MANUAL INITIATION OF SWN 36 FAILS
815	SI01-2FC	BISTABLE (PC 948F) RELAY FAILS TO CLOSE.
816	SI01-3FC	BISTABLE (PC 948E) RELAY FAILS TO CLOSE.
817	SI01-4FC	BISTABLE (PC 948D) RELAY FAILS TO CLOSE.
818	SI01-5FC	BISTABLE (PC 455E) RELAY FAILS TO CLOSE.
819	SI01-6FC	BISTABLE (PC 456E) RELAY FAILS TO CLOSE.
820	SI01-7FC	BISTABLE (PC 457E) RELAY FAILS TO CLOSE.
821	SI01-DFO	MAN.DEFEAT SWITCH FAILS OPEN.
822	SI01-FC	AUTOMATIC MASTER R, SI-1,FAILS TO CLOSE.
823	SI01-FF	DC POWER FUSES FAIL.
824	SI01-NOA	NO OPERATOR ACTION.
825	SI01-PB	SHORT ACROSS RESET P.B.2.(RESET R.ENERGIZES.).
826	SI02-2FC	BISTABLE (PC 948F) RELAY FAILS TO CLOSE.
827	SI02-3FC	BISTABLE (PC 948E) RELAY FAILS TO CLOSE.
828	SI02-4FC	BISTABLE (PC 948D) RELAY FAILS TO CLOSE.
829	SI02-5FC	BISTABLE (PC 455E) RELAY FAILS TO CLOSE.
830	SI02-6FC	BISTABLE (PC 456E) RELAY FAILS TO CLOSE.
831	SI02-7FC	BISTABLE (PC 457E) RELAY FAILS TO CLOSE.
832	SI02-DFO	MAN.DEFEAT SWITCH FAILS OPEN.
833	SI02-FC	AUTOMATIC MASTER R, SI-2,FAILS TO CLOSE.
834	SI02-FF	DC POWER FUSES FAIL.
835	SI02-NOA	NO OPERATOR ACTION.
836	SI02-PB	SHORT ACROSS RESET P.B.2.(RESET R.ENERGIZES.).
837	SI10X-FC	RELAY FAILS TO CLOSE.
838	SI11X-1	RELAY SI11X DOES NOT PROPAGATE SIAS SIGNAL
839	SI11X-1-VALVES	LOSS OF SIS FROM RELAY SI-11X
840	SI11X-FC	RELAY FAILS TO CLOSE.
841	SI11XDG-1	LOSS OF SIS FROM RELAY SI-11X -- FOR DGS ONLY
842	SI12X-FC	RELAY FAILS TO CLOSE.
843	SI13X-FC	RELAY FAILS TO CLOSE.
844	SI14X-FC	RELAY FAILS TO CLOSE.
845	SI15X-FC	RELAY FAILS TO CLOSE.
846	SI20X-FC	RELAY FAILS TO CLOSE.
847	SI21X-1	RELAY SI21X DOES NOT PROPAGATE SIAS SIGNAL
848	SI21X-1-VALVES	LOSS OF SIS FROM RELAY SI-21X
849	SI21X-FC	RELAY FAILS TO CLOSE.
850	SI21XDG-1	LOSS OF SIS FROM RELAY SI-21X -- FOR DGS ONLY

851	SI22X-FC	RELAY FAILS TO CLOSE.
852	SI23X-FC	RELAY FAILS TO CLOSE.
853	SI24X-FC	RELAY FAILS TO CLOSE.
854	SI25X-FC	RELAY FAILS TO CLOSE.
855	SIB1-FO	BLOCKING R. SIB1 FAILS OPEN.
856	SIB2-FO	BLOCKING R. SIB2 FAILS OPEN.
857	SIBK1-LF	SWITCH 1-SIB IN BLOCKING POSITION (SHORTS).
858	SIBK2-LF	SWITCH 2-SIB IN BLOCKING POSITION (SHORTS).
859	SID1-FC	RELAY FAILS TO CLOSE.
860	SID2-FC	RELAY FAILS TO CLOSE.
861	SIM1-FC	MANUAL MASTER R, SIM1,FAILS TO CLOSE.
862	SIM2-FC	MANUAL MASTER R, SIM2,FAILS TO CLOSE.
863	SIPHASEA-INT	CONT. ISOL. PHASE A INTERNAL FAILURE - RELAY FAILURE
864	SIPHASEB	SIGNAL OF CONTAINMENT ISOLATION PHASE B
865	SITR1-SE	TEST R. TR1-1 SPUR. ENERGIZED.
866	SITR2-SE	TEST R. TR1-2 SPUR. ENERGIZED.
867	SJ----LF	NOIFF BFP SEAL INJECTION WATER SYSTEM DUE TO LOCAL FAILURES
868	SL-CT12-LF	NOIFF SEAL WATER HEADER TO CONDENSATE PUMPS LOCAL FAILURE
869	SL-CT1331-LF	NOIFF SEAL WATER HEADER TO CONDENSATE PUMP 31 LOCAL FAILURE
870	SL-CT1332-LF	NOIFF SEAL WATER HEADER TO CONDENSATE PUMP 32 LOCAL FAILURE
871	SL-CT1333-LF	NOIFF SEAL WATER HEADER TO CONDENSATE PUMP 33 LOCAL FAILURE
872	SW034-A	NOIF SERVICE WATER TO DG JACKET/LUBE OIL HX S
873	SW034-A-INT	BLOCKAGE IN DG31 JACKET/LUBE OIL HX SEGMENT
874	SW035-A	NOIF SERVICE WATER TO DG JACKET/LUBE OIL HX S
875	SW035-A-INT	BLOCKAGE AT DG32 HX'S
876	SW036-A	NOIF SERVICE WATER TO DG JACKET/LUBE OIL HX S
877	SW036-A-INT	BLOCKAGE AT DG33 SW HX'S
878	SW039-A-INT	BLOCKAGE AT SW RETURN FOR DG'S 31 & 32
879	SW042-A-CONTROL	FAILURE TO DEPRIVE FCV1176 OF AIR; CONTROL FAILURE
880	SW042-A-INT	FAILURE OF FCV1176 TO OPEN ON LOSS OF AIR
881	SW043-A-CONTROL	FAILURE TO DEPRIVED FCV1176A OF AIR; CONTROL FAILURE
882	SW043-A-INT	FAILURE OF FCV1176A TO OPEN ON LOSS OF AIR
883	SW044-A	BLOCKAGE IN SW RETURN FROM DG'S
884	SW045-A	BLOCKAGE IN SW RETURN FROM DG'S
885	SW046-A	BLOCKAGE IN SW RETURN FROM DG'S
886	SW37-A	NOIF SERVICE WATER AT OUTLET OF HX 31
887	SW37-A-INT	LOCAL FAULT AT INLET OF CCW HX 31
888	SW37A-A-INT	LOCAL FAULT OUTLET OF CCW HX 31
889	SW46-A	NOIF SW RETURN SEG 46
890	SW47-A	BLOCKAGE IN SW RETURN
891	SW48-A-INT	INT FAULT BLOCKING FLOW REG BYPASS (INST AIR HX SW OUTLET)
892	SW49-A-INT	BLOCKAGE IN FLOW REG SEGMENT (INST AIR HX SW OUTLET)
893	SW51-A	NOIF SW TO COOLING WATER HX 31 - FROM SW FT
894	SW51-A-INT	BLOCKAGE AT OUTLET OF INST AIR HX 31
895	SW52-A	NOIF SW TO COOLING WATER HX 32 - FROM SW FT
896	SW52-A-INT	LOCAL BLOCKAGE AT OUTLET OF IAIR HX 32
897	SW60A-A-INT	SW BLOCKAGE IN CCS HX 31
898	SW60B-A-INT	SW BLOCKAGE IN CCS HX 32 SEGMENT
899	SWA01-A-INT	FAILURE IN SEG SUPPLYING SW HEADER FOR CIRC WATER PMPS AND SCR
900	SWA02-A-INT	FAILURE IN HEADER SUPPLYING CIRC WATER PUMPS AND SCREEN WASH

901	SWA06	INTAKE SCREEN PROBLEM INCLUDING FREEZING
902	SWA10-A	FAILURE OF SEG DELIVERING SW FROM HEADER TO CIRC PMP 36
903	SWA10-A-INT	BLOCKAGE IN SEG OR PCV 1186 FAILS CLOSED
904	SWA11-A	FAILURE OF SEG DELIVERING SW FROM HEADER TO CIRC PMP 35
905	SWA11-A-INT	BLOCKAGE IN SEG OR PCV 1185 FAILS CLOSED
906	SWA12-A	FAILURE OF SEG DELIVERING SW FROM HEADER TO CIRC PMP 34
907	SWA12-A-INT	BLOCKAGE IN SEG OR PCV 1184 FAILS CLOSED
908	SWA13-A	FAILURE OF SEG DELIVERING SW FROM HEADER TO CIRC PMP 33
909	SWA13-A-INT	BLOCKAGE IN SEG OR PCV 1183 FAILS CLOSED
910	SWA14-A	FAILURE OF SEG DELIVERING SW FROM HEADER TO CIRC PMP 32
911	SWA14-A-INT	BLOCKAGE IN SEG OR PCV 1182 FAILS CLOSED
912	SWA15-A	FAILURE OF SEG DELIVERING SW FROM HEADER TO CIRC PMP 31
913	SWA15-A-INT	BLOCKAGE IN SEG OR PCV 1181 FAILS CLOSED
914	SWC05-A-INT	BLOCKAGE OR VALVE CLOSURE IN SEG C5
915	SWC1-A-INT-F	FAILURES IN PUMP SEGMENT ITSELF (SWP33)
916	SWC10-A-INT	LOCAL FAULT CON SW SEG C10
917	SWC10A-A-INT	LOCAL BLOCKAGE SEGMENT C10A
918	SWC10C-A-INT	LOCAL FAULT CON SW SEG C10C
919	SWC11-A-INT	LOCAL FAULT CON SW SEG C11
920	SWC13-A-INT	LOCAL FAULT CON SW SEG 13
921	SWC15-A-INT	LOCAL BLOCKAGE SEG C15
922	SWC16-A-INT	LOCAL BLOCKAGE SEG C16
923	SWC17-A-INT	LOCAL FAULT SEG C17 (BET. CCW HX'S)
924	SWC18-A	NOIF SERVICE WATER AT OUTLET OF HX 32
925	SWC18-A-INT	LOCAL FAULT SEG C18
926	SWC18A-A-INT	LOCAL FAULT OUTLET OF CCW HX 32
927	SWC2-A-INT-F	FAILURES IN PUMP SEGMENT ITSELF (SWP32)
928	SWC3-A-CONT	PUMP FAILS TO START - STAND-BY PUMP
929	SWC3-A-INT-F	FAILURES IN PUMP SEGMENT ITSELF (SWP31)
930	SWC4-A-INT	LOCAL FAULT CON SW SUPPLY HEADR
931	SWC6-A-INT	LOCAL FAULT CON SW SEG C6
932	SWC6A-A-INT	BLOCKAGE OR FCV1112 ALIGNED CLOSED
933	SWC7-A-INT	LOCAL FAULT CON SW SEG C7
934	SWC8-A-INT	LOCAL FAULT CON SW SEG C8
935	SWC9-A-INT	LOCAL FAULT CON SW SEG C9
936	SWN1-A-INT-F	FAILURES IN PUMP SEGMENT ITSELF (SWP36)
937	SWN13-A-INT	LOCAL FAULT IN NUC SW PIPING SEGMENT N13
938	SWN14-A-INT	LOCAL FAULT IN NUC SW PIPING TO HX 31
939	SWN15-A-INT	LOCAL BLOCKAGE OF SEG N15
940	SWN17-A-INT	LOCAL FAULT NUC SW SEG N17
941	SWN18-A-INT	BLOCKAGE OF NSW TO DG33
942	SWN19-A-INT	BLOCKAGE AT SEGMENT SUPPLYING SW TO DG'S 31 & 32
943	SWN2-A-CONT	PUMP FAILS TO RESTART EVEN THOUGH MODE OK
944	SWN2-A-INT-F	FAILURES IN PUMP SEGMENT ITSELF (SWP35)
945	SWN20-A-INT	INTERNAL BLOCKAGE BETWEEN SUPPLY AND DG32 HX'S
946	SWN21-A-INT	BLOCKAGE AT SEGMENT SUPPLYING SW TO DG 31
947	SWN3-A-CONT	PUMP FAILS TO RESTART EVEN THOUGH MODE OK
948	SWN3-A-INT-F	FAILURES IN PUMP SEGMENT ITSELF (SWP34)
949	SWN4-A-INT	LOCAL FAULT NSW SUPPLY HEADER
950	SWN6-A-INT	LOCAL FAULT NUC SW SEG N6

951	SWN7-A-INT	LOCAL FAULT NUC SW SEG N7
952	SWN8-A-INT	LOCAL FAULT NUC SW SEG N8
953	SWN9-A-INT	LOCAL FAULT NUC SW SEG N9
954	SWNORMALIGN	NOIF CON SW TO INLET OF IAIR HX 32
955	SWNX14-A-INT	LOCAL FAULT NUC SW SEG NX14
956	SWNX15-A-INT	LOCAL FAULT NUC SW SEG NX15
957	SWT01-A-INT	BLOCKAGE OR PERHAPS INAPPROPRIATE PRESSURE RELIEF
958	SWT02-A-INT	BLOCKAGE IN PCV1179 OR LOCAL VALVES
959	SWT12-A-INT	BLOCKAGE IN SEG 12
960	SWT13-A-INT	FAILURE IN SEG SWT13 SUPPLYING BFP&T LUBE OIL COOLERS
961	SWT14-A	NOIFF SW TO BFP AND TURB LUBE OIL COOLER - BFP 31
962	SWT14-A-INT	BLOCKAGE IN HX COOLER A OR VALVES
963	SWT15-A	NOIFF SW TO BFP AND TURB LUBE OIL COOLER - BFP 32
964	SWT15-A-INT	BLOCKAGE IN HX COOLER B OR VALVES
965	SWT16-A-INT	BLOCKAGE IN RETURN SEGMENT
966	SWT27-A-INT	BLOCKAGE IN SEG T27
967	SWT52-A-INT	BLOCKAGE IN SEG 52
968	SWT56-A-INT	BLOCKAGE IN SEG 56
969	SWT58-A-INT	BLOCKAGE IN SEG T58 (SUPPLY TO CLOSED COOLING SYSTEM HX'S)
970	SWT60A-A	NOIF SERVICE WATER FOR HX. 31.
971	SWT60B-A	NOIF SERVICE WATER FOR HX. 32.
972	SWT61-A-INT	BLOCKAGE BEFORE FLOW REG SEGMENT
973	SWT62-A-CONTROL	CONTROL SIG TO CCS SW FLOW REG VALVE FAILS TO LOW FLOW
974	SWT62-A-INT	BLOCKAGE IN CCS SW FLOW REG VALVE
975	SWT63-A	FLOW REG BYPASS CLOSED OR BLOCKED
976	SWT64-A	BLOCKED SW RETURN
977	TGS----	FAILURE OF TURBINE GLAND SEALING STEAM CONDENSER
978	TR-LOOP	LOSS OF OFFSITE POWER TRANSIENT
979	TR-SP	SPURIOUS SAFETY INJECTION SIGNAL
980	TRET10-OTHER	MISCELLANEOUS CORE POWER EXCURSION
981	TRET10A	BORON DILUTION ACCIDENTS.
982	TRET10G	COLD WATER ADDITION
983	TRET10H	EXCESSIVE LOAD INCREASE
984	TRET10I	POSITIVE REACTIVITY INSERTION
985	TRET11A	CLOSURE OF ALL MSIV'S
986	TRET11B	INCREASE IN FEEDWATER FLOW IN ONE STEAM GENERATOR
987	TRET11C	INCREASE IN FEEDWATER FLOW IN ALL SG'S
988	TRET11F	THROTTLE VALVE CLOSURE/EHC CONTROL PROBLEMS
989	TRET11G	GENERATOR FAULTS OR GEN TRIP
990	TRET11H	MISC TURB-GEN ACCIDENTS
991	TRET11I	TURBINE TRIPS
992	TRET12A	CONTROL ROD PROBLEMS
993	TRET12D	SPURIOUS AUTO TRIP
994	TRET12E	OPERATOR ERROR CAUSING TRIP
995	TRET12F	MANUAL TRIP RESULTING FROM FALSE SIGNAL
996	TRET12G	SPURIOUS TRIP-CAUSE UNKNOWN.
997	TRET12H	PRIMARY SYSTEM PRESSURE, TEMP, POWER IMBALANCE
998	TRET7A	FEEDWATER BREAK
999	TRET7D	FW FLOW INSTABILITY- OPERATOR
1000	TRET7E	FW FLOW INSTABILITY- MECHANICAL

1001	TRET7H	OTHER SECONDARY LEAKAGE.
1002	TRET8A	TRIP OF ONE MSIV.
1003	TRET8B	TRIP OF TWO OR THREE MSIV'S.
1004	TRET8C	PARTIAL CLOSURE OF ONE OR MORE MSIV'S.
1005	TRET8D	LOSSES OF STEAM FLOW OTHER THAN MSIV TRIP
1006	TRET9B-F	LOSSES OF COOLANT FLOW OTHER THAN CCW- FROM TRANSIENT FT

APPENDIX C

ANNOTATED MINIMAL CUTSET TABLES

Annotated lists of the leading minimal cutset for each of the following sequences/systems can be found in a jacket at the end of this report. Each sequence/system minimal cutset table is printed on a separate microfiche and therefore need not be placed in any specific order. Each minimal cutset table can be distinguished from the other microfiche as these all carry the name CHU in the heading.

Transient Initiator (T)

Auxiliary Feedwater System Failure Given Transient (L_T)

Auxiliary Feedwater System Failure Given LOCA (L_L)

Transient and Auxiliary Feedwater System Failure ($T * L_T$)

High Pressure Injection Failure Given Small LOCA (U_2)

High Pressure Injection Failure Given Medium LOCA (U_1)

Transient-Induced RCP Seal LOCA ($S_2(P)$)

Transient-Induced RCP Seal LOCA and Failure of Auxiliary Feedwater ($S_2(P) * L_L$)

Transient-Induced RCP Seal LOCA and Failure of High Pressure Injection ($S_2(P) * U_2$)

Pressurizer LOCA ($S_2(Q)$)

Pressurizer LOCA and Failure of Auxiliary Feedwater ($S_2(Q) * L_L$)

Pressurizer LOCA and High Pressure Injection Failure ($S_2(Q) * U_2$)

Low Pressure Injection Failure Given Medium or Large LOCA (D)

APPENDIX D

PRIMARY EVENTS/OPERATOR ACTIONS

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Low Pressure Injection (LPI)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPA 11-T		4				
EPA 14-T		4				
EPD 02-01		4				
EPD 03-01		4				
LP001-A	Pipe from XV846 to MOV 882	1	LT 920 fails low	Shut 882 Shift to sump recirc if water is available in sump (PEP ES-1A)	Assure water in containment sump - shift to sump recirc (PEP-ES-1A)	RWST water supply to LPI/RHR pumps. PT 947 is redundant indication of RWST head if 1810 is open
LP002-A	MOV 882 (DOFC) CV 881 (FTO), Pipe	1	Same as above	Same as above	Same as above	Loss of RWST supply
LP003-E	Flow diverted, MOV 883 (LCFO) or BV 1863 (NOFO)	2			None possible from control rm. Manually override 883 and/or 1863 closed - shift to recirc (PEP-ES-1A)	Assumes both valves open. Pumps will partially recirculate back to their own suction. No reason to open these valves during SI mode.
LP005-A	MOV 744 (DOFC), CV 741 (FTO), or pipe plugged	3			Loss of LPI flow. Restore correct valve line up. If not possible, shift to use of recirc pumps if water is in recirc sump (PEP-ES-1A)	No LPI flowpath. No reason for operator to shut these valves during SI.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LPI (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
LP006-A	MOV 745A or MOV 745B failure (NOFC)	2			Restore proper valve line up. One RHR HX is sufficient. Otherwise no action required. (PEP ES-1A)	Loss of flow to #32 RHR HX. Only reason to shut 745 A/B is due to HX problem (leak) which would be confirmed prior to isolation.
LP008-A	NOIFF thru HXS cross tie - MOV 1869A or MOV 1869B (NOFC)	2			If only one fails - no effect. If both fail and RWST is dry, shut 882 & 846. Open 883 & 1863 and pump containment sump to SI suction - this gives no cooling (Lose RHR HX) If cooling is necessary, open PORV. Depressurize system to go on to LPI via RHR HX. (PEP ES-1A)	Only important in recirc phase with HP LPI or recirc pumps supplying sump water to SI pumps. Both valves would have to fail to cause any problem. Valves would not be shut unless HP recirc was to be terminated.
LP010-A	Cross tie blocked	3			If it is necessary to both spray containment and pump to loops with either 638 or 640 failed open, the cross tie is necessary if flow is to be supplied to all 4 loops - only possible action is to pump sump to RWST and use normal spray pumps. (PEP ES-1A)	Passive - only important if HCV 638 or 640 fail open during recirc containment spray. Cross tie open is more serious problem.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LPI (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
LP011-A	Cold leg 1 path failure	3			No action possible due to presence of cross tie if failure is a leak. No action necessary if failure is plugging again due to presence of cross tie.	All components are passive.
LP012-A	Cold leg 2 path failure	3			Same as above	Same as above
LP013-A	Cold leg 3 path failure	3			Same as above	Same as above
LP015-E	MOV 885A and MOV 885B (NCFO).	1	LT 920 fails low during SI. RWST appears empty.	Shift to recirc mode (if sump level is above 47'2" elev) which opens 885 A&B and dumps RWST to sump. (PEP ES-1A)	Shut 882 or 846. Then close 885 A & B and return to normal line up (PEP ES-1A)	During normal line up. This dumps RWST into containment sump.
	Flow diverted to containment sump	2			Shut MOVs (number unknown) from hot leg 2 to RHR pump suction. Shut off RHR pumps. (PEP ES-1A)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LPI (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
LP-016A	RHR pumps min flow line plugged - MOV 1873 or 743 FC-Assumption	3			Shut down RHR pumps. Repair problem. Restart pumps as needed. If RCS press drops below shut off head before min flow line is cleared, immediately restart pumps. (PEP ES-1A)	During SI with RCS pressure above RHR pump shut off head, if min flow line is blocked, pumps will rapidly overheat and be damaged.
LP04A-A	RHR pump 31, XV739A (NOFC), XV735A (LOFC), CV738A (FTO), pipe	3			Shut down affected pump (PEP ES-1A)	Passive or locked open manual valves. Shut only to remove pumps from service for maint. or leak.
LP-04B-A	Same, pump 32 XV739B (LOFR) XV 735B (LOFC) CV 738B (FTO)				Same as above	Same as above
LP07A-A	HEX 31 failures or XV742 (LOFC)	2			Place HX 32 in service. One HX is sufficient for ECCS loads. (PEP ES-3)	High radiation on RE-017 would suggest possible tube leak. Operator would remove HX from service after verifying.
LP07B-A	HEX 32 failures				Same as above	Same as above

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LPI (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
LP09A-A	Failure of valves and pipe from HEX 31 to cross tie (MOV 899B)	2	FT 945 fails low during RHR contain spray.		Valve fails shut or leak resulting in valve closure. No action required - all 4 loops are supplied by cross tie and normal path. Restore system to normal. (PEP ES-1A)	Same on both sides. These are category 2's because if the operator shuts any of the three valves on affected side - no increase in spray flow will suggest problem is not due to low back-pressure.
LP09B-A	Same as above, HEX 32, MOV 899A	2	FT 945A fails low during RHR containment spray		HCV 638 (640) fails open. If containment spray is required shut 747 or 899B (746 or 899A). This provides back-pressure required for spray and supplies all 4 loops via cross tie and normal path. (PEP ES-1A)	
LP14A-E	MOV-889B (NCFO)	2			Valve fails open - assure HCV 638 (640) is fully open to minimize undesired spray. Valve fails shut - redundant spray system no action needed. Spray from RWST and CS pumps if RWST has water. (PEP ES-1A)	Incorrect indication of containment conditions could cause opreator to initiate or terminate spray. However, redundant information makes this unlikely.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LPI (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
LP14B-E	MOV-889A (NCFO)	2			Same as above	Same as above
RWG001-A	RWST failure	4				
RWG002-A	XV846 (LOFC), or pipe-common to HPI and LPI.	4				
SE-RHR31-A		4				
SE-RHR32-A		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI Small LOCA

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CCG601-A		4				Note: HP...items are addressed under HPI medium LOCA (those listed as Review Category 4)
CCG602-A		4				
CCG603A		4				
EE-ATL	Ambient low temp.	3			NA	
EPA04-T		4				
EPA07-T		4				
EPA11-T		4				
EPA22-T		4				
EPA23-T		4				
EPD01-01		4				
EPD02-01		4				
EPD03-01		4				
HP001-A-INT		4				
HP002-A-INT		4				
HP003-A-INT		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI Small LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP005-A-INT		4				
HP005-C-INT		4				
HP006-A-INT		4				
HP006-C-INT		4				
HP007A-A-INT		4				
HP007A-C-INT		4				
HP007B-A-INT		4				
HP007B-C-INT		4				
HP007C-A-INT		4				
HP007D-A-INT		4				
HP007E-A-INT		4				
HP007F-A-INT		4				
HP007G-A-INT		4				
HP007H-A-INT		4				
HP007-HTR31-INT		4				
HP007-HTR32-INT		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI Small LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP011A-A-INT	MOV 842, MOV 843, or valve 1862 NOFC	2			If during SI, RCS pressure is >1600 psi there will be no flow through pumps which will damage them very quickly. Operator must shut down pumps until recirc path is reopened or until RCS pressure decreases to below the shut off head of the pumps. (PEP ES-1A)	Mini flow recirc line back to RWST - 1862 is manual diaphragm valve. These valves prevent flow of sump water to RWST during recirc mode. Procedural and redundant instr. guidance prevent RO from shutting these in any mode other than sump recirc.
HP013-A-INT		4				
HP014-A-INT		4				
HP015-A-INT		4				
HP016-EESL4	Small LOCA in RCS cold leg No. 4	3			Initiate loss of primary coolant procedure. Assure SI system running and injecting if RCS <1000 psi. If >1600 psi use charging system (PEP ES-1A)	Assumes that LOCA is small enough such that RCS pressure does not drop to accumulator discharge pressure.
HP017-A-INT		4				
HP018-A-INT		4				
HP019-A-INT		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI Smal' LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP02A-A-INT		4				
HP02A-C-INT		4				
HP03A-A-INT		4				
HP04A-A-INT		4				
HP04A-C-INT		4				
HP33A061-T-INT		4				
HP33A062-T-INT		4				
HP33A063-T-INT		4				
HP33A063-T-OPER		4				
HP33A064-T-INT		4				
HP33A111-T-INT		4				
HP33A112-T-INT						
HP33A113-T-INT		4				
HP33A113-T-OPER		4				
HP33A114-T-INT		4				
HP33A121-T-INT						
HP33A122-T-INT		4				
HP33A123-T-INT		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI Small LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP33A123-T-OPER						
HP33A124-T-INT		4				
HP33A191-T-INT		4				
HP33A192-T-INT		4				
HP33A193-T-INT		4				
HP33A193-T-OPER		4				
HP33A194-T-INT		4				
HP33A221-T-INT		4				
HP33A222-T-INT		4				
HP33A223-T-INT		4				
HP33A223-T-OPER		4				
HP33A224-T-INT		4				
HP33A231-T-INT		4				
HP33A232-T-INT		4				
HP33A233-T-INT		4				
HP33A233-T-OPER		4				
HP33A234-T-INT		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI Small LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HTG330-T	No power to EHT panel 33A	3			Restore power (PEP EL-1)	CCR alarm indicates failure
HTG340-T	EHT failure of FP DP 34	3			Institute maintenance repair (PEP EL-1)	CCR alarm indicates failure.
HT0352-LEF	Elec. failure of line 161 HT ckts	3			Institute maintenance repair (PEP EL-1)	CCR alarm indicates failure
HT352-T-INT	Internal failure of line 161 heat tracing	3			Institute maintenance repair (PEP EL-1)	CCR alarm indicates failure
RWG001-A		4				
RWG002-A		4				
SE-HP031-A		4				
SE-HP032-A		4				
SE-HP033-A		4				
SI 11X-1		4				
SI 21X-1		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CCG601-A		4				
CCG602-A		4				
CCG603-A		4				
EPA-04-T		4				
EPA07-T		4				
EPA11-T		4				
EPA22-T		4				
EPA23-T		4				
EPD01-01		4				
EPD02-01		4				
EPD03-01		4				
HP001-A-INT	Internal failure of segment 1	1	LT 920 fails low during SI	Operator shuts 1810 and shifts to sump recirc mode if sump level is above 47'2" elevation (PEP ES-1A)	Shift to sump recirc if water is available in sumps. If not depressurize RCS via PORV and inject with SI accumulators and LP safety injection using RCS and SIA volume discharged into containment sump (PEP ES-1A)	Either blockage or leakage of seg 1 eliminates water supply to SI pumps. PT 947 provides SI pump suct pressure and could inform operator that RWST level was normal

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP002-A-INT	Pump 31 internal failure	2			Shutdown affected pump and initiate maintenance actions. Two remaining pumps are capable of supplying full required HPI flow (PEP ES1-A)	Fluctuations in header flow or pressure would not identify any single pump. Operator might secure one pump at a time to identify problem pump but would discover the real problem during this process and restart pump.
HP003-A-INT	Pump 32 internal failure	2			Same as above	Same as above
HP004-A-INT	Pump 33 internal failure	2			Same as above	Same as above
HP005-A-INT	NOIF of pump 32 discharge header	3			Isolate pump 32 via 85/A & B and supply flow requirements with pump 31 if flow is to be via BIT or 33 if flow is direct to cold legs	Passive components

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP005-C-INT	Segment No. 5 CKV 852A Reverse flow	2			Shut 851B if pump 32 idle or shift to pump 32 and shutdown 33. Hard to diagnose this problem	Assumes pump 32 is idle and 851B is open. Failure of a single injection path flow element could cause operator to open recirc back to RWST. Redundant data makes this unlikely.
HP006-A-INT	Failure of pump 32 discharge header	3			Isolate pump 32 with 851A and B and 887A or B	Passsive components
HP006-C-INT	Segment No. 5 CKV 852B Reverse Flow	2			Shut 851A. This would be a difficult failure to diagnose since it would appear as a decrease in flow which could be the result of several conditions.	Assumes pump 32 is idle and 851A is open. Failure of a single flow element in injection line could cause operator to open recirc back to RWST. Redundant data makes this unlikely.
HP007A-A-INT	Internal failure of segment 7A	3			Parallel valve 1852B makes no action necessary	Assumes 1852A is plugged - There is no reason to shut 1852A so RO is not likely to be induced to shut it.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
HP007A-C-INT	Leakage past NC MOV 1852A	3			No action required since injection flow would go to cold leg via BIT path	Only occurs if SI in progress and BIT is being bypassed.
HP007B-A-INT	Internal failure of segment 7B	3			Parallel valve 1852A makes no action necessary	
HP007B-C-INT	Leakage past NC MOV 1852B	3			same as HP007A-C-INT	
HP007C-A-INT	Internal failure of segment 7C	3			Parallel valves make no action necessary	Only reason to shut valves would be BIT recirc or leakage from bit during SI
HP007D-A-INT	Internal failure of segment 7D	3			Same as above	Same as above
HP007E-A-INT	Internal failure of segment 7E	2			If plugged or leaking bypass BIT via line #56 (this is an automatic action of PEP ES-1A)	This is a category 2 rather than a 1 since shutting off BIT heaters puts you into a Tech Spec LCO
HP007F-A-INT	Flow diversion to CVCS hold up tanks - valve 1846 opens	3			Manually shut 1846 if radiation levels permit	1846 is a manually operated locked closed valve

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	 ACTION	OPERATOR RESPONSE TO PE	REMARKS
HP007G-A-INT	Valve 1851B internal failure	3			Redundant valves. No effect unless both fail together. Both fail closed on loss of IA No action necessary	Open only to recirc BIT
HP007H-A-INT	Valve 1851A internal failure	3			Same as above	Same as above
HP007-HTP31-INT	Internal faults of BIT heater 31	2			Restore heater (ONOP EL-1). If temp drops below 145° tech specs require shutdown of Rx to hot shutdown within 48 hrs. If >145° but one heater is out hot shutdown within 7 days	With no BIT heat, boric acid will solidify plugging bit. This is a Category 2 rather than a 1 since shutting off bit heaters is a tech spec LCO.
HP007-HTR32-INT	Internal faults of BIT heater 32	2			Same as above	Same as above
HP013-A-INT	Cold leg #2 injection path failure	1	High flow or low pressure indication in one injection line during SI FT 981 = CL2 980 = CL3 926 = CL1 PT 922 = Line press (press. not likely to cause problem)	Operator concludes that LOCA is in the injection line itself downstream of FT. He isolates the line to prevent loss of water from SI out the supposed break. (PEP ES-1A)	Most likely failure is line break down stream of isolation valve and downstream of FT resulting in LOCA. A high flow/low pressure indication indicates such a leak. RO shuts isolation valve for affected loop and path (PEP ES-1A)	This path bypasses BIT
HP014-A-INT	Cold leg #3 injection path failure	1				
HP015-A-INT	Cold leg #1 injection path failure	1				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP017-A-INT	Cold leg #2 injection path failure	1	Same as above FT 925 = CL2 926A = CL3 924A = CL1 PT 922 line pressure	Operator concludes that LOCA is in the injection line itself downstream of FT. He isolates the line to prevent loss of water from SI out the supposed break. (PEP ES-1A)	Most likely failure is line break downstream of isolation valve and downstream of FT resulting in LOCA. A high flow/low pressure indication indicates such a leak. RO shuts isolation valve for affected loop and path (PEP ES-1A)	This path goes through BIT
HP018-A-INT	Cold leg #3 injection path failure	1				
HP019-A-INT	Cold leg #1 injection path failure	1				
HP02A-A-INT	Valve 849A, 850A, or 848A fails closed	3			No flow increase in response to SI pump 31 start. If 848A indication of pump cavitation. If 849A or 850A indication of high flow on FI 950 (recirc to RWST). Shut off pump SI 31. Restore proper line up - restart pump (PEP ES-1A)	Passive - valves are locked open manually operated
HP02A-C-INT	Segment 2A CKV 849A reverse flow	3			Operator may not diagnose the problem	Assumes SI 33 not running and discharge path is via BIT
HP03A-A-INT	MOV 887A, 887B fails closed	2			Shut off SI 32 Open 897 A and B Restart SI 32 (not addressed by ONOP or PEP)	Only affects SI 32 pump cavitates (low suction pressure). In recirc mode 887 prevents water loss due to break down stream of 848A or B

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP04A-A-INT	Valve 849B, 850B, or 848B fails closed	3			Same as HP02A-A-INT for pump SI 33	Manual valves
HP04A-C-INT	Segment 4A CKV 849B Reverse flow	3			Operator may not diagnose the problem	Passive components
HP33A061-T-INT	Failure of local controls EHT PNL 33A CKT 6	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A062-T-INT	EHT PNL 33A CKT 6 Primary tracing fails	3			Operator aligns redundant circuit and institutes maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A063-T-INT	Internal failure of EHT panel 33A CKT 6 redundant tracing	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A063-T-OPER	Operator fails to align redundant tracing	5			Align redundant tracing (ONOP EL-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP33A064-T-INT	EHT PNL 33A CKT 6 alarm failure	3			None - no indication will tell the operator the alarm has failed	
HP33A111-T-INT	Failure of local controls EHT PNL 33A CKT 11	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A112-T-INT	EHT PNL 33A CKT 11 primary tracing fails	3			Operator aligns redundant circuit and institutes maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A113-T-INT	Internal failure of EHT PNL 33A CKT 11 redundant tracing	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A113-T-OPER	Operator fails to align redundant tracing	5			Align redundant tracing (ONOP EL-1)	
HP33A114-T-INT	EHT PNL 33A CKT 11 alarm failure	3			None - no indication will tell the operator the alarm has failed	
HP33A121-T-INT	Failure of local controls EHT PNL 33A CKT 12	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP33A122-T-INT	EHT PNL 33A CKT 12 primary tracing fails	3			Operator aligns redundant circuit and institutes maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A123-T-INT	Internal failure of EHT PNL 33A CKT 12 redundant tracing	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A123-T-OPER	Operator fails to align redundant tracing	5			Align redundant tracing (ONOP EL-1)	
HP33A-124-T-INT	EHT PNL 33A CKT 12 alarm failure	3			None - no indication will inform the operator that the alarm has failed	
HP33A191-T-INT	Failure of local controls EHT PNL 33A CKT 19	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A192-T-INT	EHT PNL 33A CKT 19 primary tracing fails	3			Operator aligns redundant circuit and institutes maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A193-T-INT	Internal failure of EHT PNL 33A CKT 19 redundant tracing	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP33A193-T-OPER	Operator fails to align redundant tracing	5			Align redundant tracing (ONOP EL-1)	
HP33A194-T-INT	EHT PNL 33A CKT 19 alarm failure	3			None - no indication will inform the operator that the alarm has failed	
HP33A221-T-INT	Failure of local controls EHT PNL 33A CKT 22	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A222-T-INT	EHT PNL 33A CKT 22 primary tracing fails	3			Operator aligns redundant circuit and institutes maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A223-T-INT	Internal failure of EHT PNL 33A CKT 22 redundant tracing	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A223-T-OPER	Operator fails to align redundant tracing	5			Align redundant tracing (ONOP EL-1)	
HP33A224-T-INT	EHT PNL 33A CKT 22 alarm failure	3			None - no indication will inform the operator that the alarm has failed	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HP33A231-T-INT	Failure of local controls EHT PNL 33A CKT 23	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A232-T-INT	EHT PNL 33A CKT 23 primary tracing fails	3			Operator aligns redundant circuit and institutes maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A233-T-INT	Internal failure of EHT PNL 33A CKT 23 redundant tracing	3			Institute maintenance repair (ONOP EL-1)	CCR alarm indicates failure
HP33A233-T-OPER	Operator fails to align redundant tracing	5			Align redundant tracing (ONOP EL-1)	
HP33A234-T-INT	EHT PNL 33A CKT 23 alarm failure	3			None - no indication will inform the operator that the alarm has failed.	
HTG330-T	No PWR to EHT PNL 33A	3			Restore power (ONOP EL-1)	CCR alarm indicates failure
RWG001-A		4				
RWG002-A		4				
SEHP031-A		4				
SEHP032-A		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: HPI MED LOCA (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SEHP033-A		4				
SI11X-1		4				
SI21X-1		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CCG1000-A	No IFF in CCW Loop 2	4				
EPA04-T-LSI		4				
EPA07-T-LSI		4				
EPA11-T-LSI		4				
EPA14-T-LSI		4				
EPA22-T		4				
EPA23-T		4				
EPD01-01		4				
EPD01-31		4				
EPD02-01		4				
EPD02-32		4				
EPD2--		4				
IAG01		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
LT459-A	Probably RPS level channel fails low	3			Place L/460 in Defeat 1. Restore normal plant conditions of letdown and charging. Take affected channel out of service - Trip all RPS trips from affected channel (ONOP RPC-1)	LT 459 is Channel 1. Automatic action depends upon position of L/460A. If in Defeat 1 there is no auto action as a result of failure high or low. Defeat 2 or 3 LT 459 fails low 1) Low level alarm 2) Przr heaters off 3) Letdown isolation 4) Max Chg Pump Speed 5) 1 Trip signal needs 2/3 Defeat 2 or 3 LT 459 fails high 1) High level alarm 2) All przr heaters on 3) Charging Pumps to min speed 4) 1 Trip signal - needs 2/3

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
LT459-B	RPS Level channel fails High	3			Switch to Defeat 3. Restore normal plant conditions (ONOP RPC-1)	
LT461-A	RPS Level sensor fails low	3			Switch to Defeat 3. Restore normal plant conditions (ONOP RPC-1)	LT 461 is channel 3 in Defeat 1 LT 461 low gives 1) Low level alarm 2) Przr heaters off 3) Letdown isolation 4) Max Chg Pump Speed 5) 1 Trip signal - needs 2/3 LT 461 High gives 1) High level alarm 2) All przr heaters on 3) Charge Pumps to min speed 4) 1 Trip signal needs 2/3 In Defeat 2 LT 461 low 1) Low level alarm 2) All przr heaters off 3) Letdown isolation 4) 1 Trip signal

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
LT461-A (Cont'd)						LT 461 high 1) High level alarm 2) 1 Trip signal
LT461-B	RPS Level channel fails high	3			In all cases defeat the affected channel and restore plant conditions to normal. Take channel out of service. Trip all RPS trips for that channel. Reactor trip and safety injection functions are independent of switch position for all channels. (ONOP RPC-1)	
PT456-A	RPS Pressure channel fails low	3				PT-456 is Channel 12 In Defeat 1-4 or 3-4 Fails High 1) Open PCV 456 (poev) signal prevented by Ch III 2) High Press Alarm 3) One HP trip signal 4) OTΔT setpoint increases 5) Unblock safety injection

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
PT456-A (Cont'd)						Fails Low 1) Low press alarm 2) One LP trip signal 3) OTΔT setpoint decreases 4) LP safety injection 1/4 needs 2/4
PT456-B	RPS Pressure channel fails high	3			Same as above	Same as above
PT457-A	RPS Pressure channel fails low	3			Same as above	PT 457 is Channel 3 In Defeat 1-4 (no function in any other switch position) Fails High 1) PCV 455C arms 2) Spray valves open 3) High alarm 4) Back up Htrs off 5) Modulating Heaters off 6) Unblicks SI

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
PT457-A (Cont'd)						Fails Low 1) Low alarm 2) LP safety injection 1/4 - needs 2/4 3) Back up heaters on 4) Modulating Heaters Max
PT457-B	RPS Pressure channel fails high	3			Same as above	Same as above
PT474-A	RPS Pressure channel fails low	3			Same as above	PT 474 Fails High Arms PORVs Fails Low Low press alarm
PT474-B	RPS Pressure channel fails high	3			Same as above	Same as above
PZBLKV-NOA	Operator does not close block valve	5			Same as above	
PZLREF-A	Reactor control system inputs low (LRef) level signal	2			Take manual control of PRZR level - Restore level to program level (ONOP RPC-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
PZLREF-B	Reactor control system inputs high (LRef) level signal	2				
PZN23-A	Motive nitrogen supply lost - PORV PCV-455C fails closed	1	Indication of leakage due to acoustic monitor tail pipe temp or valve position	Operator shuts block valve (ONOP RCS-2)	Valve normally shut. No action required. Failure of one leaves one PORV operational.	
PZN26-A	Motive nitrogen supply lost - PCV-456 fails closed	1	Indication of leakage due to acoustic monitor tail pipe temp or valve position	Operator shuts block valve (ONOP RCS-2)	Valve normally shut. No action required. Failure of one leaves one PORV operational.	
PZOP1	Overpressurization protection system inadvertent open signal	2			Shut associated block valve (ONOP RCS-2)	This causes one or both PORVs to open
PZ200-OPN	PZR SRV fails open	3			Pressurizer steam space LOCA initiate SI, Rx Trip (PEP ES-1A)	
PZ301-A	Local fault - PORV PCV-455C fails closed	1	Evidence of PORV leakage	Operator shuts block valve (ONOP RCS-2)	No action possible. PCV-456 provides protection.	
PZ301-B	Local fault opens PORV	2			Steam space LOCA shut block valve (ONOP RCS-2 and PEP ES-1A)	Operator can open PORV but would have ample redundant instrumentation and procedural guidance.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
PZ335-INT	Local fault of block valve	1	Evidence of PORV leakage	Operator shuts block valve (ONOP RCS-2)	No action possible. Valve normally open	Only important if valve fail shut when PORV is needed or fails open when PORV also fails open
PZ336-INT	Local fault of block valve	1	Same as above	Same as above	Same as above	Same as above
PZ351-A	Local fault - PORV PCV-456 fails closed	1	same as 301-A	same as 301-A	same as 301-A	same as 301-A
PZ351-B	Local fault opens PORV PCV-456	2	same as 301-B	same as 301-B	same as 301-B	same as 301-B
PZ356-B	Local fault in pressure sensor channel	3			Single channel failure does not open PORV but can prevent it from opening. Other channel remains operative. No action required.	PORV requires 2 channels to be high to open
PZ400-D	Rupture of PZR spray line	3			LOCA from cold leg or steam space depending upon which side of the spray valve	
PZ401-A	Local fault - spray piping clogs up	2			Control press using heaters. Use aux spray if ΔT not too great. (ONOP RCS-2)	There are two parallel valves

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
PZ401-B	Local fault - one or more PZR spray valves fail open	2			Place controllers in manual and close. If not successful, then remove fuses (ONOP RCS-2)	Loss of RCS pressurizer control.
PZ501A	Local fault within PZR heaters - No heat output	2			Manually energize heaters (ONOP RCS-2)	Slow loss of pressure
PZ501-B	Local fault PZR heater power/control components - Raises pressure	2			Take manual control of heaters. (ONOP RCS-2)	Spray can more than keep up with heaters.
PZ601-A	Local fault within PZR press control sys - lowers pressure	2			Take manual control of heaters and spray. (ONOP RCS-2)	All trips are active
PZ601-B	Local fault within PZR press control sys - raises pressure	2			Same as above	Same as above
PZ701-A	Local fault within PZR level control system - lowers level	2			Take manual control of charging pump speed. Maintain program level. (ONOP RCS-3)	All trips active

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Pressurizer (PZR) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
PZ701-B	Local fault in PZR level control system causes high level	2			Take manual control of charging pump speed. Maintain program level. (ONOP RCS-3)	All trips active
RCPM03-INT	Manual valves 771C, 772C, 773C FC for RCP 33 motor cooling	4				Loss of CCW to RCP Motor Bearings
RCPM04-INT	Manual valves 771D, 772D, 773D for RCP 34 motor cooling	4				Same as above
TRET98-F	Losses of coolant flow other than CCW from transient, FT	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Charging (CV)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CCG800-A	NOIF CCW and city water to CHG pump 31 coolers	4				
CCG804-A	NOIF CCW and city water to CHG pump 32 coolers	4				
CCG805-A	NOIF CCW and city water to CHG pump 33 coolers	4				
CVCHE01	Level transmitter LT-112 fails.	3			Isolate charging and letdown. (ONOP CVCS-2)	
CVCHE02	Level controller LC-112B or control circuit fail	3			Isolate charging and letdown. (ONOP CVCS-2)	Operator cannot cause an action which would cause the same effect as Transmitters/Controllers failing.
CVCHE03	Level controller LC-112C or control circuit fail.	3			Isolate charging and letdown. (ONOP CVCS-2)	
CVCHE04	Valve LCV112B fails to open.	3			Initiate boration via makeup control or emergency boration valve. (ONOP CVCS-2)	This failure assumes makeup from RWST is necessary. There is no operator action the same as a valve not opening when called on to do so.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Charging (CV) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CVCH01-A	Check valves 210B and 210D fail closed.	2			Shift charging to alternate path. (ONOP CVCS-1)	Low failure of FT-128 could cause operator action but seal injection flow rates not changing makes this unlikely.
CVCH03-A	Check valves 210A and 210C fail closed.	2			Same as above.	
CVCH02-A	Air operated valve 204 B fail closed.	2			Shift charging to alternate path. (ONOP CVCS-1)	Low failure of FT-128 could cause operate action but position indication not changing makes this unlikely.
CVCH04-A	Air operated valve 204 A fails to open on demand.	3				There is no operator action the same as a valve not opening when called on to do so.
CVCH07-A-INT	Valves 374 or 142 fail closed.	2			Instruct field operator to open HCV-142 bypass (227) (no procedural Reference, but addressed in CVCS System Description)	Low failure of FT-128 could cause operator action but seal injection flow rates not changing makes this unlikely.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Charging (CV) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CVCH09-A-INT	LCV112 or check valve 292 fail closed.	3				There is no operator action similiar.
CVCH 11-A-INT	Valve FCV 110B fails to open or valve 297 (no) fails closed.	3				There is no operator action similar.
CVCH12-A-INT	Blender fails.	3			If boration is necessary use suction from RWST. (ONOP CVCS-2/3)	
CVCH13-A-INT	CV328 fails to open or XV329 (NOFC)	3			Open MOV-333 as needed for boration. (ONOP CVCS-2/3)	If cause is FT-110 failure, operator might suspect FCV-110A failure.
CVCH14-A-INT	CV 327 fails to open or XV 326 (NOFC)	3			Instruct field operator to operate manual valve 293 for dilution as necessary. (ONOP CVCS-2)	If cause is FT-111 failure operator might suspect FCV-111A failure.
CVCH15-A-INT	FCV 110A fails closed.	3			Open MOV-333 as needed for boration. (ONOP CVCS-2/3)	Probable cause is FT-110 failure or diaphram separation.
CVCH16-A-INT	FCV111A fails to open.	3			Instruct field operator to operate manual valve 293 for dilution as necessary. (ONOP CVCS-2)	Probable cause is FT-111 failure or diaphram separation.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Charging (CV) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CVCH17-A-INT	Filter or flow meter plugged.	3			Instruct field operators to operate manual valve 293 for dilution as necessary. (ONOP CVCS-2)	
CVCH18-A-INT	Boric acid transfer pump 31 fails to start.	3			Start or ensure #32 pump is running. (ONOP CVCS-2)	Both pumps normally running.
CVCH19-A-INT	Boric acid tank 31 fails to supply.	3			Borate using RWST as necessary. (ONOP CVCS-2)	
CVCH20-A-INT	Failure of electric heater in Bat. 31	3				
CVCH-HU-01	Operator fails to actuate the suction to RWST.	5			When the oversight is identified, actuate suction to RWST. (ONOP CVCS-2)	
CVCH-HU-02	Operator fails to start a second pump.	5			When the oversight is identified, start a second pump. (ONOP CVCS-2)	
CVL02-A-INT	Regen, HX fails.	4				
CVL09-A-INT	VCT rupture	4				
CV-LOLD	Loss of letdown flow	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Charging (CV) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
DC--	Loss of DC power at level inst. and controller (supply not found)	4				
EDA04-T-LSI		4				
EPA11-T-LSI		4				
EPA14-T-LSI		4				
EPA21-T		4				
EPA22-T		4				
EPD01-01		4				
EPD01-31		4				
EPD02-01		4				
EPD03-01		4				
IA601		4				
PM---	No primary make up water goes to valve FCV111A	3			Check P.W. pumps running and valving aligned. Supply P.W. to chg pumps via FCV 110A if possible. (ONOP CVCS-2)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Charging (CV) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
RCV01-A-INT	Pipe, valve, charging pump or motor of train 31 fails.	3			Start #32 or #33 pump. (ONOP CVCS-1)	
RCV02-A-INT	Same, train 32	3			Start #31 or #33 pump. (ONOP CVCS-1)	
RCV03-A-INT	Same, train 33	3			Start #31 or #32 pump. (ONOP CVCS-1)	
RCV05-A-INT	Valve 289 fails closed	3			Ensure #31 charging pump is running or secure charging and letdown. (ONOP CVCS-1)	
RNG001-A	No water available from RWST	4				
RNG002-A	NOIF through RWST line 155	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Letdown (CVL)

PE DESIGNATOR	DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CCG1000-A	NOIFF in CCW Loop 2	4				
CVLD-HU-01	No op. action for ex. letdown in service	5				
CVLE01	Control circuit for valve PCV 135 fails	3			Isolate charging and letdown (ONOP CVCS-1)	
CVL01-A-INT	Letdown isolation valves fail	1	FT-128 fails low	Close LCV-459 & LCV-460	Reduce charging pump speed to min. Place excess letdown in service. (ONOP-CVCS-1)	Operator may subsequently check RCP seal injection flow rates to confirm low flow and then reopen the valves that were closed.
CVL02-A-INT	Regen. HX rupture	3			Secure charging and letdown (ONOP CVCS-1)	
CVL03-A-INT	Supercomponent fails itself	3			If failure obstructs letdown flow secure or reduce charging - use excess letdown. If failure is a leak isolate letdown and proceed as above. (ONOP CVCS-1)	
CVL04-A-INT	Cont. isolation valves fail	3			Secure charging (ONOP CVCS-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: CVL (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CVL05-A-INT	Non-regen. HX fails	3			Isolate charging and letdown. (ONOP CVCS-1)	
CVL06-A-INT	Valves PCV 135 or TCV 149 fail	3			Isolate charging and letdown (ONOP CVCS-1)	
CVL08-A-INT	Reactor coolant filter plugged	3			Secure charging and letdown shift to excess letdown and seal injection. (ONOP CVCS-1)	
CVL09-A-INT	VCT fails	3			Letdown to waste system as necessary. Charge from blender. Isolate VCT. (ONOP CVCS-1/2)	
CVL10-A-INT	Isolation valves 213A or 213B fail to open	3			Secure excess letdown operations (ONOP CVCS-1/2)	
CVL11-A-INT	Excess letdown HX fails	3			Same as CVL10-A-INT	
CVL12-A-INT	Valve HCV 123 fails closed	3			Same as CVL10-A-INT	
CVL13-A-INT	LCV 112A misleading letdown flow to holdup tank.	3			Conduct flow balance. Assure blended makeup. Set properly (ONOP CVCS-2)	
EPD01-31		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: CVL (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPD02-32		4				
IAG01		4				
LC460C-A	Bistable fails	3			Place control switches in open position. (ONOP CVCS-1/2)	
LT460-A		4				
LT461-A		4				
RCSI09-A-INT		4				
RCSI 10		4				
RCSI 11-A-INT		4				
SIPHASEA-INT		4				
SIPHASEB		4				
TR-SPSI		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Component Cooling (CCW)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CC001-BLK	CCW pump 31 train blockage	2			Start idle CCW pump (ONOP CC-1)	Multiple alarms and indications needed for stimulus
CC001-A-INT	CCW pump 21 internal failure	3			Institute maintenance procedures (ONOP CC-1)	Entering into Tech Spec LCO could result in plant load reduction
CC001-A-RSTRT	CCW pump 31 fails to restart - internal failure	3			Institute maintenance procedures (ONOP CC-1)	Entering into Tech Spec LCO could result in plant load reduction
CC002-A-BLK	CCW pump 32 train blockage	2			Start idle CCW pump (ONOP CC-1)	Multiple alarms and indication needed for stimulus
CC002-A-INT	CCW pump 32 internal failure - includes failure to start	3			Institute maintenance procedures (ONOP CC-1)	Entering into Tech Spec. LCO could result in plant load reduction.
CC003-A-BLK	CCW pump 33 train blockage	2			Start idle CCW pump (ONOP CC-1)	Multiple alarms and indications needed for stimulus
CC003-A-INT	CCW pump 33 internal failure	3			Institute maintenance procedures (ONOP CC-1)	Entering into Tech Spec. LCO could result in plant load reduction

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Component Cooling (CCW) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CC003-A-RSTRT	CCW pump 33 fails to restart - internal failure	3			Institute maintenance procedures (ONOP CC-1)	Entering into Tech Spec. LCO could result in plant load reduction.
CC004-A-INT	Manual valve 766A fails closed	3			Operate pumps and headers split (ONOP CC-1)	
CC005-A-INT	Same as above, 766B	3			Same as above	
CC006-A-INT	Same as above, 759C	3			Same as above	
CC007-A-INT	Same as above, 759D	3			Same as above	
CC008-A-INT	Failure of CCW HX 32 leg	2			Isolate affected HX leg and institute maintenance procedures. (ONOP CC-1)	Stimulus would require increased component temperatures (multiple) and/or decreasing surge tank level.
CC009-A-INT	Failure of CCW HX 31 leg	2			Same as above	Same as above
CC010-A-INT	Valve 766C or 766D fails closed	3			Operate headers split (ONOP CC-1)	
CC010-EE						
CC011-A-INT	Loop 1 return header fails	3			Loss of one RHR HX. Line up alternate HX as required. Investigate other lost loads and line up alternates. (PEP ES-3)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Component Cooling (CCW) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CC012-A-INT	Same as above, Loop 2	3			Loss of one RHR HX. Line up alternate HX as required. Investigate other lost loads and line up alternates. (PEP ES-3)	
CC015-A-INT	HPI pump 31 oil or Seal HX failure	3			Shutdown the pump if continued operation is likely to damage the pump (PEP ES-3)	
CC016-A-INT	Same as above, pump 32	3			Same as above.	
CC017-A-INT	Same as above, pump 33	3			Same as above	
CC018-A-INT	Manual CCW valve 787 fails closed	3			Same as above	FIC-634B indicating low and alarming could induce the operator to disable HPI pumps 32 and 33.
CC033-A-INT	Manual valves to chg. pump 31 oil coolers fail closed	3			Same as above	FIC-634A indicating low and alarming could induce the operator to disable HPI pump 31
CC034-A-INT	Same as above, pump 32	3			Same as above	FIC-634B indication low and alarming could induce the operator to disable HPI pumps 32 and 33.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Component Cooling (CCW) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
CC035-A-INT	Same as above, pump 33	3			Same as above	Same as above
CC036-A-INT	Manual valve 756 A fails closed	3			Monitor temps on charging pumps and supply city water if necessary	Procedure not available, but addressed in System Description No. 29
CC037-A-H	Operator fails to align city water	5			Align city water	Same as above
CC037-A-INT	Internal failure of segment 37	3			Alternately shutdown charging pumps as temperature limits are approached, and repair failure (ONOP CC-1)	
CC038-A-INT	Manual valve 756B fails closed	3			Monitor temps on charging pumps and supply city water if necessary	Same as CC036-A-INT
CC-H	Operator fails to adjust CCW loads	5			Adjust CCW loads	
CW001-A-INT	Failure of city water supply to CT-49	4				
CW002-A-INT	Internal failure of CT-49 segment	4				
EPA611		4				
EPA612		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Component Cooling (CCW) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPA614		4				
EPA04-T		4				
EPA07-T		4				
EPA11-T		4				
EPD03-01		4				
NOTTR-SPSI	No Safety Injection Signal Present	5			Start HPI pumps manually if necessary (PEP ES-1)	
SE-CCS2P-A		4				
SE-CCS31-A		4				
SE-CCS32-NOA		4				
SE-CCS33-A		4				
SWC18-A		4				
SW37-A		4				
TR-SPSI		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SWA01-A-INT	Failure in segment supplying SW header for circ water pumps and screen	3			Trip the reactor and the circ water pumps (ONOP-RW-1)	Piping only - no active components
SWA02-A-INT	Failure in header supplying circ water pumps and screen wash	3			Same as above	Only an actual pipe break would induce the operator to secure flow, because the valves are operated locally.
SWA06	Intake screen problem including freezing	3			Check bypass gates from circ water bay open (no procedural ref but addressed in system description)	No logical operator actions that can cause intake screen problem
SWA10-A-INT	Blockage in segment or PCV 1186 fails closed	2			Open bypass valve (SWN-23) to supply seal water (ONOP RW-2)	There is both a low pressure alarm (PC 1195) and a PI (PI 1270) that would have to fail to induce operator to this action. They are independent sensors.
SWA11-A-INT	Blockage in segment or PCV 1185 fails closed	2			Open bypass valve (SWN-21) to supply seal water (ONOP RW-2)	Same as above except PC 1194 and PI 1269

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SWA12-A-INT	Blockage in segment or PCV 1184 fails closed	2			Open bypass valve (SWN-19) to supply seal water (ONOP RW-2)	Same as above except PC 1193 and PI 1268
SWA13-A-INT	Blockage in segment or PCV 1183 fails closed	2			Open bypass valve (SWN-17) to supply seal water (ONOP RW-2)	Same as above except PC 1192 and PI 1267
SWA14-A-INT	Blockage in segment or PCV 1182 fails closed	2			Open bypass valve (SWN-15) to supply seal water (ONOP RW-2)	Same as above except PC 1191 and PI 1266
SWA15-A-INT	Blockage in segment or PCV 1181 fails closed	2			Open bypass valve (SWN-13) to supply seal water (ONOP RW-2)	Same as above except PC 1190 and PI 1265
SWC05-A-INT	Blockage or valve closure in Segment C5	2			Open valve SWN-5 to supply water for circ water pump seals and screen wash from NSW header and close SWN-4 (ONOP RW-2)	There are multiple independent indications that would have to fail to induce the operator to shut SWN-4 (circ water pump seal pressure alarms and indicators, and screen wash pressure alarms and indicators)
SWC10A-A-INT	Local blockage Segment C10A	3			Open valve SWN-70 to supply SW from NSW header and shut SWN-27 (PEP ES-3 and ONOP RW-1)	Piping only - no active components. Will result in loss of cooling to IA heat exchangers

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
SWC10C-A-INT	Local fault Con SW Segment 10C	3			Check open SWN-27. If that is open then deduce that the segment is blocked. Shut SWN-27 and open SWN-70, to supply SW from NSW header. (PEP ES-3 and ONOP RW-1)	Will result in loss of cooling to IA heat exchanger 31. Only an actual pipe break would induce the operator to close SWN-27, because it is operated locally.
SWC10-A-INT	Local fault Con SW Segment 10	3			Secure CSW supply to IA heat exchangers, CR air cond. units, and DGs, and supply these SW loads from NSW header (PEP ES-3 and ONOP RW-1)	Piping only - no active components
SWC11-A-INT	Local fault Con SW Segment C11	3			Secure CSW supply to CR air cond. units and DGs and supply these loads from NSW header (PEP ES-3 and ONOP RW-1)	Piping only - no active components. Results in loss of CR, NC and DG cooling
SWC13-A-INT	Local fault Con SW Segment 13	3			Secure CSW supply to DGs and supply DGs from NSW header (PEP ES-3 and ONOP RW-1)	Results in loss of all DG cooling. No rational event could occur to induce an operator to close SWN-30 except an actual pipe break, because the valve is locally operated.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SWC15-A-INT	Local blockage Segment C15	3			Secure CSW supply to CCW heat exchangers and supply these loads from NSW header (ONOP RW-1)	Piping only - no active components. Results in loss of cooling to both CCW heat exchangers
SWC16-A-INT	Local blockage Segment C16	3			Secure CSW supply to CCW heat exchangers and supply them from NSW header (ONOP RW-1)	Results in loss of cooling to both CCW heat exchangers. The only event that would induce an operator to secure this flow path is an actual pipe break, since the valves are operated locally.
SWC17-A-INT	Local fault Seg C17 (Bet. CCW HXs)	3			Blockage has no affect. Shut SWN 35 and 31. Supply HX 31 via SWN 32 (ONOP RW-1)	
SWC18A-A-INT	Local fault outlet of CCW HX 32	3			If leak, continue to pump, control flooding if blocked HX 31 will carry CCW system.	
SWC18-A-INT	Local fault Seg C18	3			Isolate HX 32. Carry CCW loads on HX 31 (ONOP RW-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SWC1-A-INT	Failures in pump segment itself (SWP 33)	3			Isolate segment (if necessary) and start non-running pump (SWP 31 or 32) (ONOP RW-1)	There are no control room indications that would cause an operator to stop a running SW pump and aux. operator can check to ensure fault is real before stopping SW pump.
SWC2-A-INT	Failures in pump segment itself (SWP 32)	3			Isolate segment (if necessary) and start non-running pump (SWP 33 or 31) (ONOP RW-1)	Same as above
SWC3-A-INT	Failures in pump segment itself (SWP 31)	3			Isolate segment (if necessary) and start non-running pump (SWP 32 or 33) (ONOP RW-1)	Same as above
SWN1-A-INT	Failures in pump segment itself (SWP 36)	3			Isolate segment (if necessary) and start non-running pump (SWP 34 or 35) (ONOP RW-1)	Same as above
SWN2-A-INT	Failures in pump segment itself (SWP 35)	3			Isolate segment (if necessary) and start non-running pump (SWP 34 or 36) (ONOP RW-1)	Same as above

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SWN3-A-INT	Failures in pump segment itself (SWP 34)	3			Isolate segment (if necessary) and start non-running pump (SWP 35 or 36) (ONOP RW-1)	Same as above
SWC3-A-CONT	Pump fails to start - standby pump	5			When failure to start standby pump is identified (e.g., due to additional alarms on equipment cooled by service water), start a standby pump (ONOP-RW-1)	The standby SW pumps will not start automatically. They must be started by the operator either locally or remotely in the control room.
SWC4-A-INT	Local fault Con SW supply header	3			Shut SWN-98, stop CSW pumps 31, 32 and 33. Start additional NSW pumps and supply CSW loads with NSW (would require a lot of valving) (ONOP RW-1)	Piping only - no active components
SWC6A-A-INT	Blockage or FCV 1112 aligned closed	3			If segment is blocked - supply loads from NSW pumps by opening FCV-1111. If valve is aligned closed - attempt to open FCV-1112 (ONOP RW-1)	1. Valve is manual local operation only. 2. If supplying the non-essential header, will not jeopardize nuclear or essential SW.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	 ACTION	OPERATOR RESPONSE TO PE	REMARKS
SWC6-A-INT	Local fault Con SW Segment C6	3			Same as SWC4-A-INT	Piping only - no active components
SWC7-A-INT	Local fault Con SW Segment C7	3			Same as SWC4-A-INT	Piping only - no active components
SWC8-A-INT	Local fault Con SW Segment C8	3			Same as SWC4-A-INT	Only real faults (i.e., pipe break) would cause aux operator to close SWN-98 because the indications are local (in area of break if it occurred)
SWC9-A-INT	Local fault Con SW Segment C9	3			Shift CSW loads that are lost to NSW header and isolate CSW supply.	Piping only - no active components
SWNORMALIGN	NOIF Con SW to inlet of IAIR HX 32	4				
SWNX14-A-INT	Local fault NUC SW Seg NX14	3			Shutdown NSW and supply its loads with CSW	Piping only - no active components
SWNX15-A-INT	Local fault in NUC SW Seg NX15	3			Same (NX14, NX15 and NX13 all connected with no valve for individual isolation)	Piping only - no active components

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
SWN13-A-INT	Local fault in NUC SW Piping seg N13	3			Same as SWNX15-A-INT	Piping only - no active components
SWN14-A-INT	Local fault in NUC SW Piping to HX31	3			Shutdown IA equipment cooled by HX31 - transfer operations to other equipment (ONOP RW-1 and PEP ES-3)	
SWN15-A-INT	Local blockage of Seg N15	3			Shift DG and control room cooling to CSW	
SWN17-A-INT	Local fault NUC SW Seg N17	3			Shift DG cooling to CSW header (ONOP RW-1 and PEP ES-3)	No reason for operator to close SWN-29 (NSW to diesels) for faulty indication.
SWN18-A-INT	Blockage of NSW to DG 33	3			Shift DG cooling to CSW header (ONOP RW-1 and PEP ES-3)	The only time the operator would close cooling water to DG would be real fault (HX tube leak) or maintenance
SWN19-A-INT	Blockage at segment supplying SW to DGs 31 and 32	3			Secure NSW to DG(s) and line up CSW to supply DG(s) (ONOP RW-1 and PEP ES-3)	Piping only - no active components
SWN20-A-INT	Internal blockage between supply and DG 32 HXs	3			Same as above	Same as SWN18-A-INT

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
SWN21-A-INT	Blockage at segment supplying SW to DG 31	3			Same as above	Same as SWN/8-A-INT
SWN2-A-CONT	Pump fails to restart even though mode OK	3			Manually start the pump (ONOP RW-1)	The only way an operator could cause this PE is by leaving the pump controller in the "pull to lock" position which would be a random human error.
SWN3-A-CONT	Pump fails to restart even though mode OK	3			Manually start the pump (ONOP RW-1)	same as above
SWN4-A-INT	Local fault NSW supply header	3			Shut SWN-99, stop NSW pumps that are running. Supply NSW loads with CSW. Shutdown unneeded SW loads. (ONOP RW-1 and PEP ES-3)	Piping only - no active components
SWN6-A-INT	Local fault NUC SW Seg N6	3			Shut SWN-99, stop NSW pumps that are running. Supply NSW loads with CSW. Shutdown unneeded SW loads. (ONOP RW-1 and PEP ES-3)	Piping only - no active components
SWN7-A-INT	Local fault NUC SW Seg N7	3			Same as above	Piping only - no active components

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SWN8-A-INT	Local fault NUC SW Seg N8	3			Check SWN-99 open. If cannot reestablish NSW, same as above (ONOP RW-1 and PEP ES-3)	Only real faults (i.e., pipe break) would cause aux operator to close SWN-99 because indications are in the area of the piping.
SWN9-A-INT	Local fault NUC SW Seg N9	3			Shut SWN-99. Close FCV-1112 and open FCV-1111 to supply NSW loads with. Shift NSW loads to CSW at each individual load. (ONOP RW-1 and PEP ES-3)	Piping only - no active components
SWT01-A-INT	Blockage or perhaps inappropriate pressure relief	3			Conduct a normal plant shutdown (ONOP-RW-1)	Operator has no control over relief valve SWT-8
SWT02-A-INT	Blockage in PCV 1179 or local valves	2			Manually open SWT-2 (bypass around PCV-1179) to attempt to re-establish flow. If flow cannot be established, conduct a normal plant shutdown (ONOP-RW-1)	Both PI 1185 and the "Service Water to Lube Oil Coolers High Pressure" alarm would have to fail high to induce the operator to block this flowpath. They are two independent sensors.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SWT12-A-INT	Blockage in Seg 12	3			Conduct a normal plant shutdown (ONOP-RW-1)	Piping only - no active components
SWT13-A-INT	Failure in Seg SWT13 supplying BFP&T Lube Oil Coolers	3			Same as above	Piping only - no active components
SWT14-A-INT	Blockage in HX Cooler A or valves	3			Loss of one turbine lube oil cooler. Monitor turbine L.O. temps. Assure other HX line up normal. (ONOP RW-1)	
SWT15-A-INT	Blockage in HX Cooler B or valves	3			Same as above	
SWT16-A-INT	Blockage in return segment	3			Loss both turbine L.O. coolers. Shutdown turbine. (ONOP RW-1)	Piping only - no active components
SWT27-A-INT	Blockage in Seg T27	3			Shutdown all equipment supplied through FCV-1111 or FCV-1112 as it becomes necessary to avoid equipment damage (ONOP RW-1)	Piping only - no active components. Would result in no cooling available to conventional plant services
SWT52-A-INT	Blockage in Seg 52	3			Shutdown systems cooled by conventional closed cooling system, as required to avoid equipment damage (ONOP RW-1)	Piping only - no active components. No cooling availabe to closed cooling system heat exchangers.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SWT56-A-INT	Blockage in Seg 56	3			Same as SWT 52-A-INT	Piping only - no active components
SWT58-A-INT	Blockage in Seg T58 (supply to closed cooling system HXs)	3			Same as above	Piping only - no active components
SWT61-A-INT	Blockage before flow reg segment	3			Same as above	Piping only - no active components
SWT62-A-CONTROL	Control Sig to CCS SW flow reg valve fails to low flow	3			Open bypass valve SWT-21 (ONOP RW-1)	Locally operated system. False indications can be verified before action is taken
SWT62-A-INT	Blockage in CCS SW flow reg valve	3			Open bypass valve SWT-21 (ONOP RW-1)	Same as above
SWT63-A	Flow reg bypass closed or blocked	3			Open it or take manual control of TCV-1109 and open it. (ONOP RW-1)	
SWT64-A	Blocked SW return	3			Shutdown systems cooled by conventional closed cooling system, as required to prevent equipment damage. (ONOP RW-1)	Piping only - no active components

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SW034-A-INT	Blockage in DG 31 jacket/lube oil HX segment	3			Shutdown DG 31 if running, as required, to prevent equipment damage (ONOP RW-1)	1. Piping only - no active components 2. If DG started on SI signal, then most equipment protection trips (except overspeed, overcurrent and reverse power) are inoperable. If damage to the core was <u>not</u> expected to result, the operator may shut the DG down to save the machine for use when the SW fault is corrected.
SW035-A-INT	Blockage at DG 32 HXs	3			Shutdown DG 32, if running, as required, to prevent equipment damage (ONOP RW-1)	Same as above
SW036-A-INT	Blockage at DG 33 SW HXs	3			Shutdown DG 33 if running, as required, to prevent equipment damage (ONOP RW-1)	Piping only - no active components See remark 2 under SW034-A-INT

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SW039-A-INT	Blockage at SW return for DGs 31 and 32	3			Shutdown DGs 31 and 32 if running, as required, to prevent equipment damage (ONOP RW-1)	Piping only - no active components See remark 2 under SW034-A-INT
SW042-A-CONTROL	Failure to deprive FCV 1176 of air: control failure	3			Take manual control and open valve (ONOP RW-1)	There is no fault that could cause operator to close valve and deprive diesels of cooling
SW043-A-CONTROL	Failure to deprive FCV 1176A of air: control failure	3			Same as above	Same as above
SW042-A-INT	Failure of FCV 1176 to open on loss of air	3			Take manual control and open valve (ONOP RW-1)	There is no fault that could cause operator to close valve and deprive diesels of cooling
SW043-A-INT	Failure of FCV 1176A to open on loss of air	3			Same as above	Same as above
SW044-A	Blockage in SW return from DGs	3			Shutdown all three (31, 32 and 33) DGs, as required, to prevent equipment damage (ONOP RW-1)	Piping only - no active components See remark 2 under SW034-A-INT

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SW045-A	Blockage in SW return from DGs	3			Same as above	Piping only - no active components See remark 2 under SW034-A-INT
SW046-A	Blockage in SW return from DGs	3			Same as above	Piping only - no active components See remark 2 under SW034-A-INT
SW37A-A-INT	Local fault outlet of CCW HX 31	3			Loss of one CCW HX. HX 32 will carry all necessary loads. Assure proper line up of HX 32. (ONOP RW-1)	
SW37-A-INT	Local fault at inlet of CCW HX 31	3			Same as above	
SW46-A	NOIF SW return Seg 46	3				Piping only - no active components Same as SW046-A?
SW47-A	Blockage in SW return	3			Secure Inst. Air and supply inst. air system with service air cross connect (PEP IA-1)	Piping only - no active components
SW48-A-INT	Int Fault blocking flow reg bypass (inst air HX SW outlet)	3			Take manual control of TCV-1113 and manually open (ONOP RW-1)	No faulty indication will cause operator to close bypass (SWN-47) if in use

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SW49-A-INT	Blockage in flow reg segment (inst air SW outlet) TCV-1113	3			Open bypass VLV SWN-47 or take manual control of TCV-1113 (ONOP RW-1)	No indications that would cause operator to close TCV-1113
SW51-A-INT	Blockage at outlet of inst air HX 31	3			Investigate cause of trip of IA Compressor 31 (check valve lineup, etc.). If IA pressure reaches 60 psig, trip the plant. If necessary open the station air tie valve. (PEP IA-1)	Locally operated valves; no false indications would induce operator to close these valves.
SW52-A-INT	Local blockage at outlet of IAIR HX 32	3			Same as above except IA Compressor 32	Same as above
SW60A-A-INT	SW blockage in CCS HX 31	4				
SW60B-A-INT	SW blockage in CCS HX 32 Seg	4				
EPAG11	LOP at EPA03 (SS XFMR 5)	4				
EPAG13	LOP at EPA13 (6.9KV BUS 3 + SS XFMR 3)	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPAG14	LOP at EPA10 (SS XFMR 6)	4				
EPA04-S	Local fault at EPA04 (BUS 5A)	4				
EPA04-T-LSI	LOP at 480V AC BUS 5A, or loop, or SI	4				
EPA04-T	LOP at 480AC BUS 5A	4				
EPA05-INT	Local fault in DG 33	4				
EPA07-T-LSI	LOP at 480V AC BUS [illegible]A, or loop, or SI	4				
EPA08-INT	Local fault in [illegible]	4				
EPA11-S	Local fault at EPA11 (BUS 6A)	4				
EPA11-T-LSI	LOP at 480V AC BUS 6A, or loop, or SI	4				
EPA11-T	LOP at 480AC BUS 6A	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
EPA12-INT	Local fault in DG 32	4				
EPA14-S	Local fault at EPA14 (BUS 3A)	4				
EPA14-T	LOP at 480AC BUS 3A	4				
EPA15-S	Local fault at EPA15 (Tie BKR 2AT5A)	4				
EPA16-S	Local fault at EPA16 (Tie BREAKER 2AT3A)	4				
EPA17-S	Local fault at EPA17 (Tie BKR 3AT6A)	4				
EPD01-01	LOP at DO PP 31	4				
EPD02-01	LOP at DO PP 32	4				
EPD11-A	LOP at DO PP 31 - battery supply only	4				
EPD12-A	LOP at DO PP 32 - battery supply only	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPD13-A	LOP at DO PP 33 - battery supply only	4				
IAIRBYPASS	Flow reg bypass valve commanded open (inst air HX SW outlet)	4				
LOCA	LOCA event	4				
NOTLOOP-6A	NO LOOP to BUS 6A	4				
NOTTR-SPSI	No safety injection actuation	4				
SEDG-SWN36-NOA	Manual initiation of SWN 36 fails	4				
SE-EDG31-A	Failure of DG breaker 52/EG1 to actuate	4				
SE-EDG32-A	Failure of DG bkr 52/EG2 to actuate	4				
SE-EDG33-A	Failure of DG bkr 52/EG3 to actuate	4				
SE-SWN34-A	SW pump 34 not actuated following LOOP	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Service Water (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SE-SWN34-DGS-A	SW pump 34 not actuated following LOOP - for DGS only	4				
SE-SWN35-A	SW pump 35 not actuated following LOOP	4				
SE-SWN35-DGS-A	SW pump 35 not actuated following LOOP - for DGS only	4				
SE-SWN36-A	SW pump 36 not actuated	4				
SE-SWN36-DGS-A	SW pump 36 not actuated - for DGS only	4				
SE-SWN36-NOA	Manual actuation of SW pump 36 fails	4				
TR-SPSI	Safety injection signal present	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Sequencing (SE)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPAG12		4			GENERAL The proper immediate action to be taken by the operator is always the same: if a piece of equipment does not perform its automatic action, the operator always verifies that correct automatic actions have occured and manually performs those that have not. (Ref: immediate action steps of PEPs)	GENERAL Loss of the controlled component (eg. pump) due to operator action is addressed under each individual system. Here we consider operator action that results in the control system PE being induced. This is limited to de-energizing the power supply for this control system. In general this would be the result of operator error since the only reason to kill the power supply would be fire or bus fault. Both of these must be independently verified prior to removing power to the bus.
EPAG13		4				
EPAG14		4				
EPD01-01		4				
EPD01-31		4				
EPD02-01		4				
EPD02-32		4				
EPD03-01		4				
EPD11-A		4				
EPD12-A		4				
EPD13-A		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Sequencing (SE) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
LOCA	LOCA EVENT	4				
SE-AFW-NOA	No operator action to actuate AFW pumps	5				
SE-BFP-L-S	Local fault of relay BFP-L (Common Auto Start relay) AFW pumps	2			Operator manually starts pumps as required. (PEP FW-1)	Common Auto Start relay for all AFW pumps.
SE-BFP-S	Local fault of relay BFP (AFP 31 and 33 Auto Start relay) motor	2			Operator manually starts pumps as required. (PEP FW-1)	Auto Start for both motor driven AFW pumps.
SE-CCS2P-S	Local fault of low header pressure actuation scheme (component cooling water)	2			Operator manually starts STBY CCW pump upon low CCW header pressure alarm. (ONOP-CC-1)	CCW pump in auto will start when PC-600 decreases to low CCW header press set point.
SE-CCW-NOA	No operator action to actuate CCW pumps.	5				
SE-HPI-NOA	No operator action to actuate HPI pumps.	5				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Sequencing (SE) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SE-RHR-NOA	No operator action to actuate RHR pumps.	5				
SE-SGLOLO-A	Steam Generator Lo Lo level logic (1004) fails (1 out of 4 logic-starts MD AFW pumps).	2			Note motor drive AFW pumps have not started. Manually start AFW pumps 31 and 33. Verify pressure and flow. (PEP FW-1)	Motor driven AFW pumps should auto start on Lo-Lo level in any one steam generator.
SE-S61234X-FO	Normal start signals not received (Lo-Lo 2004S6S) (2 out of 4 logic-starts TD AFW pump.	2			Operator notes turbine driven AFW pump not started. Manually start #32 AFW pump verify pressure and flow and correct turbine parameters. Determine cause of start failure. (PEP FW-1)	Turbine drive AFW pump (#32) Auto Starts on Lo-Lo level in two out of four steam generators.
SE-SWN-NOA	No operator action to actuate SWN pumps.	5				
SE-SWN-SWITCH	Switch selector in wrong position (selector switch for group of SW pumps).	5				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Sequencing (SE) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SE-1X-BFPT1-FD	Relay 1X-BFPT1 fails to energize (AFP 31 auto start ckt.)	2			Operator notes that AFP 31 (33) has failed to Auto Start. Operator manually starts pump. (PEP FW-1)	
SE-1X-BFPT2-FD	Relay 1X-BFPT2 fails to deenergize (AFP 33 auto start ckt.)	2			Same as above except AFP 33.	
SE-2SI1-S	Local fault of relay 2-SI1 (SI pump 31)	2			Operator notes that SI pump 31 has not started in response to ECCS signal. Manually start the pump. Note normal flow, pressure, motor AMPS. (PEP ES-1)	
SE-2SI2-S	Local fault of relay 2-SI2 (SI pump 32 starting).	2			Same as 2 SI1-S for SI pump 32.	
SE-2SI3-3	Local fault of relay 2-SI3 (SI pump 33 starting).	2			Same as 2SI1-S for SI pump 33.	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Sequencing (SE) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SE-20-1-ABFP2-S	Local fault of relay 20-1-ABFP2 (deenergizes to close PCV and) start AFP32	2			If operator notices PCV 1113 open on pump start he will take manual, control and regulate steam pressure manually. If not noticed in time reset overspeed trip and restart pump. (PEP FW-1)	With PCV 1113 fully open steam pressure to AFW pump turbine would be excessive. Most likely result would be loss of turbine on overspeed.
SE-27-2A-X3-UV	Bus 2A UV scheme thinks low voltage condition exists (SI pump 32)	2			Operator may manually start all affected pumps as necessary. (PEP ES-1)	Prevents Auto Start of SI 32, SW 32, CRF 32, CCW 32.
*SE-27-3AX3	Bus 3A undervoltage scheme thinks low voltage condition exists (RHR pump 31)	2			Same as above.	Prevents Auto Start of CRF34, SW35, RHR31, AF31.
SE-27-5A-X2-UV	Same, Bus 5A (SI pump 31)	2			Same as above.	Prevents Auto Start of CCW31, SW34, SW31.
SE-27-6A-X3-UV	Same, Bus 6A (SI pump 33).	2			Same as above.	Prevents Auto Start of SW36, SW33, AF33, SI33, CRF35, RHR32, CS32, CCW33.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Sequencing (SE) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SE-2-CC1-2-S	Local fault of relay 2-CC1-2 (CCW pump 31).	2			Operator may manually start all affected pumps as necessary. (PEP ES-1)	Loss of these relays prevents Auto Start of their respective pumps.
SE-2-CC2-2-S	Same, 2-CC2-2	2			Same as above	Same as above
SE-2-CC3-2-S	Same, 2-CC3-2	2			Same as above	Same as above
SE-2-RHR1-S	Local fault of relay 2-RHR1 (RHR pump 31).	2			Same as above	Same as above
SE-2-RHR2-S	Same, 2-RHR2 (RHR pump 32).	2			Same as above	Same as above
SE-2-SW4-S	Local fault of relay 2-SW4 (SW pump 34)	2			Same as above	Same as above
SE-2-SW5-S	Same, 2-SW5	2			Same as above	Same as above
SE-2-SW6-S	Same, 2-SW6	2				
SE-2-1-11D-S	Local fault of relay 2-1-11D (AFP 33)	2			Same as above. (PEP FW-1)	Same as above

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Sequencing (SE) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SE-2-1-6D-S	Same, 2-1-6D (AFP 31)	2			Operator may manually start all affected pumps as necessary. (PEP FW-1)	Loss of these relays prevents Auto Start of their respective pumps
SE-3-1-2A-S	Same, 3-1-2A (fails to energize causes relay 2-SI2 to not energize resulting in SI pump 32 not activated)	2			Same as above. (PEP ES-1)	Prevents Auto Start of SW32, SI32, CRF32, CCW32.
SE-3-1-3A-S	Same, 3-1-3A	2			Same as above	CRF34, SW35, RHR31, AF31.
SE-3-1-5A-S	Same, 3-1-5A	2			Same as above	CS31, CRF31, SI31, CRF33, SW34, SW31, CCW31.
SE-3-1-6A-S	Same, 3-1-6A	2				SW36, SW33, AF33, SI33, CRF35, RHR32, CS32, CCW33.
SE-3-2-2A-S	Same, 3-2-2A	2				CCW32, SW32.
SE-3-2-3A-S	Same, 3-2-3A	2				SW35, AF31, BFP32, start.
SE-3-2-5A-S	Same, 3-2-5A	2				CCW31, SW34, SW31.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Sequencing (SE) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SE-3-2-6A-S	Same, 3-2-6A	2				SW36, SW33, AF33, CCW33, BFP32 start.
SE-52-EG1-INT	Local fault of breaker/actuation scheme (DG31)	2			Operator manually closes breaker and loads affected diesel generator. (PEP EL-1)	Prevents auto closure of DG output breakers.
SE-52-EG2-INT	Same (DG32)	2			Same as above	Same as above
SE-52-EG3-INT	Same (DG33)	2			Same as above	Same as above
SE-52-EG1-OPN	BKR 52-EG1 (DG31) Open (DG31)	2			This is not necessarily a fault	In event of a trip and SI signal the position of the DG output breakers will determine if the CCW pumps will start. If the DG BKRS are shut the CCW pumps will not start as part of the loading sequence.
SE-52-EG2-OPN	Same, BKR52-EG2 (DG32) open	2			Same as above	Same as above
SE-52-EG3-OPN	Same, BKR52-EG3 (DG33) open	2			Same as above	Same as above

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Sequencing (SE) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SE-63X1-BFP1-S	Local fault of relay 63X1-BFP1 (relay controlling contact in AFP 31 and 33 Auto Start ckt.)	2			Operator will manually initiate AFW upon loss of both BFPs or operator will secure AFW if one BFP is running. (PEP EL-1 and PEP FW-1)	Both 63X1 BFP 1 and 2 must actuate to start AFW on loss of feed pumps. Contacts of one stuck shut would prevent initiation of AFW on loss of both BFPs. Contacts of one stuck open would initiate AFW with one BFP still running.
SE-63X1-BFP2-S	Same, 63X1-BFP2	2			Same as above	Same as above
SI21X06-I		4				
SI21X-I		4				
TR-SPSI		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Main Feedwater (LMFW)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CD-AEJCD313233-A	NOIF from air ejector condensers 31, 32, or 33.	3			Throttle down on FCV-1120 to increase flow in path A	No valves or other active components
CD-CDSR31-LF	Condenser 31 local failure	3			Isolate condenser by shutting VLV CS-1 or both water boxes from that condenser and use other condenser sections.	
CD-CDSR32-LF	Same, except condenser 32	3			Same as above	
CD-CDSR-33-LF	Same, condenser 33	3			Same as above	
CD-CDSR-31-1-A	NOIF from waterbox 31-1	2			Other than investigation and repair of fault at next shutdown, no response action applies	
CD-CDSR-32-1-A	Same, water box 32-1	2			Same as above	
CD-CDSR-33-1-A	Same, Water Box 33-1	2			Same as above	
CD-CDSR-31-2-A	NOIF from Water Box 31-2	2			Same as above	
CD-CDSR-32-2-A	Same, water box 32-2	2			Same as above	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LMFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
CD-CDSR-33-2A	Same, water box 33-2	2				
CD-PP-31-C-INT	Reverse flow through cond, pump 31 DISCH-CV failure (RF) and others	3			Send aux, oper. to close Disch. Valves. CD-2 and its bypass CD-3 of affected pump (condensate pump isolation)	
CD-PP-32-C-INT	Same, pump 32	3			Same as above	
CD-PP-33-C-INT	Same, pump 33	3			Same as above	
CD-PP-31-LF	Condensate pump 31 local failure	1	Eratic condensate pump 31 ammeter indication	Operator trips condensate pump 31	Use other pumps and have maintenance investigate	There is no procedural reference for these actions. They are postulated based upon the instrumentation configuration and operating experience.
CD-PP-32-LF	Same, pump 32	1	Same, pump 32	Same, pump 32	Same as above	
CD-PP-33-LF	Same, pump 33	1	Same, pump 33	Same, pump 33	Same as above	
CD-1A-A	NOIF from heaters 33A, 34A, 35A	1	Faulty high level in heater 33A or 34A indicating leak (LT-1118, LT1115)	Isolate heater (shut CD-16, CD-17 and CD-18 on appropriate string) (SOP HDS-1)	Open heater bypass VLV (CD-19) and isolate string by closing (CD-16, CD-17 and CD-18) on appropriate string (SOP HDS-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LMFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CD-1B-A	Same, heaters 33B, 34B, 35B	1	Same, heater 33B, 34B, 35B (LT-1119, LT-1116)	Same as above	Same as CD-1A-A	
CD-1C-A	Same, heaters 33C, 34C, 35C	1	Same, heater 33C or 34C (LT-1120, LT-1117)	Same as above	Same as above	
CD-10-A	NOIF from cond pumps discharge header	3			Check MFPs tripped and start MD AFWPs	
CD-11A	NOIF from cond pumps suction header	3			Same as above	
CD-1-A	NOIF from common discharge of heaters 33 to 35	3			Open heater bypass VLV CD-19 (SOP HDS-1)	
CD-2-A	NOIF from heaters bypass line	3			Start MD AFWPs 31 and 33, open FCV-406A, 406B, 406C and 406D (PEP FW-1)	For TML transient one string of heaters will provide sufficient flow, so for an operator response to the bypass not opening you must assume all 3 failed so the bypass is the only remaining path.
CD-5A-A	NOIF from LP heaters 31A, 32A	2			Open heater bypass line (CD-11)	Not addressed by ONOP or PEP

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LMFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	 ACTION	OPERATOR RESPONSE TO PE	REMARKS
CD-5B-A	NOIF from LP heaters 31B, 32B	2			Same as CD-5A-A	
CD-5C-A	Same, LP heaters 31C, 32C	2			Open heater bypass line (CD-11)	Not addressed by ONOP or PEP
CD-5-A	NOIF from flash EVAP and from its bypass.	3			Total failure of condensate, use MD AFWPs. (PEP FW-1)	
CD-6-A	NOIF from LP heaters bypass line.	3			Start MD AFWPs 31 and 33, open FCV-406A, 406B, 406C and 406D. (PEP FW-1)	For the TML transient one string of heaters will provide sufficient flow, so for an operator response to the bypass not opening you must assume all 3 strings failed so the bypass is the only remaining path.
CD-7A-A	NOIF from gland steam condenser	3			Close down on FCV-1120 to force flow through path A (ONOP C-1)	
CD-7B-A	NOIF from FCV-1120	1	False gland steam condenser low flow alarm (FT-1113)	Close down on FCV-1120 to restore gland steam condenser flow (ONOP C-1)	Take manual control of FCV-1120 and open (ONOP C-1)	
CD-8A-A	NOIF from cond pump dischg to flow path A	3			Close down on FCV-1120 to force flow through path A (ONOP C-1)	No valves in line

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LMFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CD-9B-A	NOIF from cond. pumps discharge to flow path B	1	False gland steam condenser low flow alarm (FT-1113)	Close down on FCV-1120 to restore gland steam condenser flow. (ONOP C-1)	Open FCV-1120 in an attempt to increase flow through flow path B (ONOP C-1)	
CL----F	NOIFF turbine hall closed cooling water system local failures	3			Restore in appox. 1/2 hr. or trip BFP and cond. pumps. Start AFW SYS. (ONOP RW-1 and PEP FW-1)	No control room indication, local operation by auxiliary operator
CR-31-LF	Local failure in Circ pump 31 or line to condenser	2			Send maintenance to investigate and monitor condenser vacuum, reduce power if needed (ONOP C-1)	
CRO-32-LF	Same, Circ pump 32	2			Same as above	
CRO-33-LF	Same, Circ pump 33	2			Same as above	
CRO-34-LF	Same, Circ pump 34	2			Same as above	
CRO-35-LF	Same, Circ pump 35	2			Same as above	
CRO-36-LF	Same, Circ pump 36	2			Same as above	
EPAG-12		4				
EPAG-13		4				
EPAG-15		4				
EPAG-16		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LMFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPA-20-T		4				
EPA-24-T		4				
EPA-25-T		4				
EPA-26-T		4				
EPA-28-T		4				
EPD-01-01		4				
EPD-01-31		4				
EPD-02-01		4				
EPD-02-32		4				
IAG-01		4				
MF-1A-A	NOIF from MFIV BFD-7, CV BFD-6 or FE 418 to SG 31	2			Start MD AFWP 31 and open FCV-406A (PEP FW-1)	
MF-1B-A	Same, BFD-7, BFD-6, FE 428, SG 32	2			Start MD AFWP 31 and open FCV-406B (PEP FW-1)	All of these faults involve isolating MFW to SGs. For all transients of interest the reactor would trip and the operator is directed to trip MFW and use AFW

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LMFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
MF-1C-A	Same, BFD-7, BFD-6, FE 438, SG 33	2			Start MD AFWP 33 and open FCV-406C (PEP FW-1)	
MF-1D-A	Same, BFD-7, BFD-6, FE 448 to SG 34	2			Start MD AFWP 33 and open FCV-406D (PEP FW-1)	Operator might be induced to isolate flow to a SG (the PE) based on faulty high flow to SG (suggesting a leak). However, multiple FTs and FIs exist in feed line, so this induced operator action is not likely.
MF-2A-LF	NOIF MF reg FCV-417 or MOIV BFD-5 to SG 31 local failures	2			Start MD AFWP 31 and open FCV-406A (PEP FW-1)	These faults involve isolating MFW to SGs. For all transients of interest the reactor would trip and the operator is directed to trip MFW and use AFW
MF-2B-LF	Same, FCV 427, BFD-5 to SG 32	2			Start MD AFWP 31 and open FCV-406B (PEP FW-1)	Same as above

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LMFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
MF-2C-LF	Same, FCV 437, BFD-5 to SG 33	2			Start MD AFWP 33 and open FCV-406C (PEP FW-1)	Operator might be induced to isolate flow to a SG (the PE based on faulty high flow to SG (suggesting leak). However, multiple FTs and FIs exist feed line, so this induced operator action is not likely.
MF-2D-LF	Same, FCV 447, BFD-5 to SG 34	2			Start MD AFWP 33 and open FCV 406D (PEP FW-1)	Same as above
MF-4A-A	NOIF from HP heater 36A	2			Open bypass VLV BFD-8 and close BFD-3, BFD-4 and BFD-10 to isolate string A	Not addressed by ONOP or PEP
MF-4B-A	Same, HP heater 36C	2			Same, for string B	
MF-4C-A	Same, HP heater 36C	2			Same, for string C	
MF-4-A	NOIF from MFW HP heaters common discharge header	3			Start MD AFWPs 31 and 33, open FCVs-406A, 406B, 406C and 406D	No valves

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LMFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
MF-5-A	Operator fails to open bypass valve or valve fails	5/3			Operator opens bypass valve when oversight is recognized	For the TML transient one string of heaters will provide sufficient flow, so for an operator response to the bypass not opening you must assume all 3 strings failed so that bypass is only remaining path.
MF-61-C-INT	BFP 31 disch reverse flow-CV fails (FF) and MOV fails to close	3			Send Aux Oper to manually close MOV	Not addressed by ONOP or PEP
MF-62-C-INT	Same, BFP 32	3			Same as above	
MF-61-LF	Boiler feed pump 31 local failure	2			Restrict unit load per PEP FW-1	Multiple indications of cavitation needed to induce operator to shut down a BFP
MF-62-LF	Same, pump 32	2			Same as above	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LMFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
MF-6-A	NOIF from common BFP discharge header	3			Start MD AFWPs 31 and 33, open FCV-406A, 406B, 406C and 406D (PEP FW-1)	No valves
MF-7-A	NOIF to BFPs 31, 32 from common suction header	3			Same as above	
MS-AEJ----LF	Loss of main steam air ejectors-Local failure	2	$T_{ave}<540$ indication (multiple indication)	Oper secures SJAE as per trip procedure (PEP-RPC-1)	Carry out subsequent actions of ONOP C-1 (actions vary depending upon source of failure)	
MS-----LF	NOIF main steam and MSR supply to BFPTS local failures	3			Start MD AFWPs 31 and 33, open FCV-406A, 406B, 406C and 406D (PEP FW-1)	
SACCSG01		4				
SJ-----LF	NOIF BFP seal injection water system due to local failures	3			Trip BFP (not addressed in ONOP or PEP)	Would appear to be large steam leak at BFP
SL-CT-12-LF	NOIF seal water to cond pumps local failure	3			After some time trip cond. pump due to indications of cavitation (not addressed in ONOP or PEP)	Pump would pull air in seal and get air bound

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: LNFW (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
SL-CT1331-LF	NOIF seal water header to cond pump 31 local failure	3			Shutdown cond. pump 31 and repair (not addressed in ONOP or PEP)	
SL-CT1332-LF	Same, pump 32	3			Same pump 32	
SL-CT1333-LF	Same, pump 33	3			Same pump 33	
SWA10-A		4				
SWA11-A		4				
SWA12-A		4				
SWA13-A		4				
SWA14-A		4				
SWA15-A		4				
SWT14-A		4				
SWT15-A		4				
TGS	Failure of turbine gland sealing steam condenser	3			No actions identified	
TR-SPSI		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Auxiliary Feedwater (AFWS)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
AFN2-HU-01	Operator fails to actuate N2 backup	5			Actuate N2 backup (not addressed in ONOP or PEP)	
AFN2	Loss of N2 to AFWS AOV	3			Replace N2 bottles (not addressed in ONOP or PEP)	
AF001-A-INT	CT-64 fails closed	2			Open CT-64 or Open CT-49 and (PCV-1189 and PCV-1187 or PCV-1188) (PEP FW-1)	Multiple level indication available.
AF003-A-INT	Failure of CST dischg path to MD AFW pump	3			Open CT-49 and PCV-1189 (PEP FW-1)	
AF004-A-INT	Failure of city water discharge segment valves to open to pump 33	3			Lower SG pressure to <500 psig and use condensate pump* (PEP FW-1)	*If city water is in use, it is assumed that CST is not available.
AF006-A-INT	Failure of city water discharge segment valves to open to pump 31	3			Same as above.	
AF008-A-INT	Failure of city water discharge segment valves to open to TD pump	3			Same as above.	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: AFWS (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
AF005-A-INT	Failure of CST discharge path to MD AFW pump	3			Open CT-49 and PCV-1187 (PEP FW-1)	
AF007-A-INT	Failure of CST discharge path to TD AFW pump	3			Open CT-49 and PCV-1188 (PEP FW-1)	
AF009-A-INT	MD AFW pump 33 failure	2			Start TD AFW pump 32 (PEP FW-1)	Multiple indications of pump cavitation needed for stimulus, therefore category 2.
AF010-A-INT	MD AFW pump 31 failure	2			Same as above.	Same as above
AF009-B-INT	PT 406B signal unable to control PU 33 discharge pressure	3			Start TD AFW pump 32 (PEP FW-1)	
AF010-B-INT	PT 406A signal unable to control PU 31 discharge pressure	3			Same as above.	
AF011-A-H	Operator fails to bring AFW PU 32 up to speed	5			Bring AFW pump 32 up to speed (ONOP FW-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: AFWS (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
AF011-A-INT	TD AFW pump 32 failure	2			Start MD AFW pumps 31 and 32 or Lower SG pressure to <500 psig and use condensate pump (PEP FW-1)	Due to multiple indications for flow, speed, discharge pressure, operator is not likely to be induced to stop TD pump due to faulty indication.
AF012-A-INT	Failure of segment 12 FC	1	Faulty high flow indication to SG 33 (FT 1202)	Shut FCV 406C (PEP FW-1)	Start TD AFW pump 32 (PEP FW-1)	Stimulus can also cause AF019-A-INT
AF013-A-INT	Failure of segment 13 FC	1	Faulty high flow indication to SG 34 (FT 1203)	Shut FCV 406D (PEP FW-1)	Same as above.	Stimulus can also cause AF018-A-INT
AF014-A-INT	Failure of segment 14 FC	1	Faulty high flow indication to SG32 (FT 1201)	Shut FCV 406B (PEP FW-1)	Same as above.	Stimulus can also cause AF017-A-INT
AF015-A-INT	Failure of segment 15 FC	1	Faulty high flow indication to SG31 (FT 1200)	Shut FCV 406A (PEP FW-1)	Same as above.	Stimulus can also cause AF016-A-INT
AF012-B-INT	Failure of FCV 406C - FO	1	Faulty low flow indication to SG 33 (FT 1202)	Open FCV 406C (PEP FW-1)	Close BFD-41 and start TD AFW pump 32 (PEP FW-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: AFWS (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
AF013-B-INT	Failure of FCV 406D - FO	1	Faulty low flow indication to SG 34 (FT 1203)	Open FCV 406D (PEP FW-1)	Close BFD-43 and start TD AFW pump 32	
AF014-B-INT	Failure of FCV 406B - FO	1	Faulty low flow indication to SG 32 (FT 1201)	Open FCV 406B (PEP FW-1)	Close BFD-36 and start TD AFW pump 32	
AF015-B-INT	Failure of FCV 406A - FO	1	Faulty low flow indication to SG 31 (FT 1200)	Open FCV 406A (PEP FW-1)	Close BFD-38 and start TD AFW pump 32	
AF016-A-INT	Failure of segment 16 - FC	1	Faulty high flow indication to SG 31 (FT 1200)	Shut FCV 405A (PEP FW-1)	Start MD AFW pump 31 or lower SG pressure to <500 psig and use condensate pump (PEP FW-1)	See AF012-A-INT through AF015-A-INT
AF017-A-INT	Failure of segment 17 - FC	1	Faulty high flow indication to SG 32 (FT 1201)	Shut FCV 405B (PEP FW-1)	Same as above.	Same as above
AF018-A-INT	Failure of segment 18 - FC	1	Faulty high flow indication to SG 34 (FT 1203)	Shut FCV 405D (PEP FW-1)	Start MD AFW pump 33 or lower SG pressure to <500 psig and use condensate pump (PEP FW-1)	Same as above
AF019-A-INT	Failure of segment 19 - FC	1	Faulty high flow indication to SG 33 (FT 1202)	Shut FCV 405C (PEP FW-1)	Start MD AFW pump 33 or lower SG pressure to <500 psig and use condensate pump (PEP FW-1)	Same as above

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: AFWS (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
AF020-A-INT	NOIF steam from segment 20	2			Use steam from MS-42 or start MD AFW pumps 31 and 33 or lower SG pressure to <500 psig and use condensate pump (PEP FW-1)	PEP-ES-18, SG Tube Rupture Procedure, requires MS-41/42 to be shut with confirmed indications of tube leak - SG level increase and SG sample
AF021-A-INT	NOIF steam from segment 21				Use steam from MS-41 or start MD AFW pumps 31 and 33 or lower SG pressure to <500 psig and use condensate pump (PEP FW-1)	Not likely operator would shut MS-41/42 on faulty SG level indication only
AF022-A-INT	AFWS injection line fails to supply water to SG 33	3			Lower SG pressure to <500 psig and use condensate pump (PEP FW-1)	
AF023-A-INT	AFWS injection line fails to supply water to SG 34	3			Same as above.	
AF024-A-INT	AFWS injection line fails to supply water to SG 32	3			Same as above.	
AF025-A-INT	AFWS injection line fails to supply water to SG 31	3			Same as above.	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: AFWS (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
AF022-C-INT	AFW pumps 32, 33 fail due to main feed leakage from SG 33	3			Isolate SG 33 as per Steam Generator Tube Rupture Proc. PEP-ES-1B	Several valves are operated for the response
AF023-C-INT	AFW pumps 32, 33 fail due to main feed leakage from SG 34	3			Isolate SG 34 as per Steam Generator Tube Rupture Proc. PEP-ES-1B	Same as above
AF024-C-INT	AFW pumps 31, 32 fail due to main feed leakage from SG 32	3			Isolate SG 32 as per PEP-ES-1B	
AF025-C-INT	AFW pumps 31, 32 fail due to main feed leakage from SG 31	3			Isolate SG 31 as per PEP-ES-1B	
AF022-D-BLDN	Blowdown from SG 33 not isolated	3			Shut PCV-1216 or PCV-1216A or downstream manual isolation valve (not addressed in ONOP or PEP)	No feasible stimulus would induce the operator to leave the blowdown valve open and drain the SG
AF023-D-BLDN	Blowdown from SG 34 not isolated	3			Shut PCV-1217 or PCV-1217A or downstream manual isolation valve	
AF024-D-BLDN	Blowdown from SG 32 not isolated	3			Shut PCV-1215 or PCV-1215A or downstream manual isolation valve	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: AFWS (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
AF025-D-BLDN	Blowdown from SG 31 not isolated	3			Shut PCV-1214 or PCV-1214A or downstream manual isolation valve	No feasible stimulus would induce the operator to leave the blowdown valve open and drain the SG.
AF026-A-INT	ATM STM RLF valve PCV 1136 fails to open	3			Monitor pressure for operation of safety valves	
AF028-A-INT	ATM STM RLF valve PCV 1137	3			Same as above.	
AF030-A-INT	ATM STM RLF valve PCV 1135 fails to open	3			Same as above.	
AF032-A-INT	ATM STM RLF valve PCV 1134 fails to open	3			Same as above.	
AF027-A-INT	All safety valves associated with SG 33 fail to open	3			Attempt to reduce SG33 pressure through other paths (not addressed in ONOP or PEP)	
AF-029-A-INT	All safety valves associated with SG34 fail to open	3			Attempt to reduce SG34 pressure through other paths	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: AFWS (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
AF-031-A-INT	All safety valves associated with SG32 fail to open	3			Attempt to reduce SG32 pressure through other paths	
AF-033-A-INT	All safety valves associated with SG31 fail to open	3			Attempt to reduce SG31 pressure through other paths	
CSG100-A	Failure of CST supply to AFWS	4				
CW001-A-INT	Failure of city water supply to CT-49	3			Lower SG pressure to <500 psig and use condensate pump (PEP FW-1)	If city water is in use, it is assumed that CST is not available; hence, all AFW pumps become unavailable with these two faults
CW002-A-INT	Internal failure of CT49 segment	3			Same as above.	Same as above.
EE-ATL	Ambient Temp low .	3			N/A	
EE-1080	No flow in line 1080	2			Start a motor driven AFW pump to maintain flow in recirc line (not addressed in ONOP or PEP)	Due to multiple indications (flow, speed, discharge pressure), operator is not likely to be induced to stop TD pump due to faulty indication.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: AFWS (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPA11-T		4				
EPA14-T		4				
EPD02-01		4				
EPD03-01		4				
EPI21-01		4				
EPI22-01		4				
EPI23-01		4				
EP...T...FLT		4				
HTG320-T		4				
HT343-IFF		4				
HT343-T-INT		4				
IAG01		4				
SE-AFP31-A		4				
SE-AFP32-A		4				
SE-AFP33-A		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IAC02-A	Pipe downstream of both CW pumps	3			Loss of cooling to IA compressors and aftercoolers. Shut down IA compressors and supply IA from SA. (automatic action) (ONOP IA-1)	1. Piping only-no active components 2. Lose cooling to both IA compressors.
IAC04-A	CWHX 32, inlet and outlet valves and pipes	1	Level controller LC-1130 for the cooling water EXP tank fails to fill and overflow tank.	Isolate HX in service and put standby HX in service (ONOP RW-1)	Shift to Standby HX (ONOP-RW-1)	SW is at a higher press than CW, so if expansion tank overflows the operator may suspect failed HX tubes.
IAC05-A	CWHX 31, inlet and outlet valves and pipe segs.	1	Same as above	Same as above	Same as above	Same as above
IAC06-A	Pipe from CW Hxs to aftercoolers	3			Single line, if plugged or broken lose water to IA compressors and aftercoolers. Shutdown compressors and supply IA from SA (ONOP IA-1)	1. Piping only-no active components 2. Lose cooling to both IA compressors
IAC1A-A	CW pump 31, valves and pipe-operating pump	2			Check start of standby pump (not addressed in ONOP or PEP)	Because of multiple pressure indications (PI 1271 and PC 1173) the operator would not be induced to secure pump on failure of a single instrument.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
IAC1B-A	CW pump 32, valves and pipe-standby pump.	3			Pump not running-plug has no effect and will not be noticed. Leak will require isolation of pump. If pump not isolated system will drain requiring shutdown of IA compressors and IA will be supplied by SA. (ONOP IA-1)	
IAC10-A	Common discharge pipe from heater drain pump motors 31 and 32 to pump suction.	3			Leak will drain system requiring shutdown of IA comp and supply of IA loads from SA. Plug has no effect as IA cooling will recirculate through closed cooling Hxs.	Piping only-no active components
IAC7A-A	Valves and pipe to aftercooler 31.	3			Leak in either drains system and must be isolated. If isolated or plugged the affected compressor will be shutdown and the unaffected compressor shifted to "hand" mode. (ONOP IA-1)	No feasible stimulus to close valves

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IAC7B-A	Valves and pipe to aftercooler 32.	3				No feasible stimulus to close valves.
IAC9A-A	Valves and pipes from aftercooler 31 to/through motor 31.	1	TI 1180 fails to a temperature less than 100°F.	Operator opens CC-44A to allow additional cooling water to bypass motor 31 (Compressor is automatically tripped off on overtemperature at 150°F jacket temp) (not addressed in ONOP or PEP but in System Description)	Direct auxilary operator to determine the cause of the "Instrument Air Compressor Auto Trip" alarm. If Auxilary Operator determines that the auto trip was due to high cooling water temperature, he will check the valve lineup, throttle down on CC-44A and restart the compressor. (ONOP IA)	
IAC9B-A	Valves and pipes from aftercooler 32 to/through motor 32.	1	TI 1182 fails to a temperature less than 100°F	Same as above	Same as above	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IAS01-A	Valves, pipe, from serv air to inst air and weld channel backup	3			Direct NPO to determine cause of low station air pressure. HPO checks valve line up and system conditions. Realign or repair as necessary. Note: valve closure e.g. IA-30 will provide no indication of fault prior to loss of IA and no back up from SA (ONOP IA-1)	Serv Air is station air. All valves are local manual with ample local instrumentation
IAS02-A	Pipe from service air to filters	3			Isolate IA 21, 56 and 30. Repair pipe. (ONOP IA-1)	Piping only-no active components plug not evident unless IA is being supplied by SA.
IAS07-A	Pipe, valves and controller downstream of filters.	3			Isolate and repair as necessary. (ONOP IA-1)	Requires low instr air concurrent with control room instr. Failure to cause operator to shut PCV 1142. Otherwise no active component only controller and equipment upstream of IA 21 can be repaired without removing all IA from service.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IAS08-A	Valve and pipe from service air to inst. air.	3			Isolate and repair as necessary. (ONOP IA-1)	All valves are manual with adequate local indication. Local isolation should not be done without control room permission.
IAS29-A	Valves, filter and pipe.	1	DPI-1131 fails as is.	NPO will not recognize clogged filter if it occurs. If the on line filter is clogged SA cannot supply IA. With failed as is DP indication operator would be induced to take no action, eventually leading to plugged filters. (Not addressed in ONOP or PEP)	Operator notes ΔP or DP between IA (low) and SA (normal). Direct NPO to check local indication to determine component causing isolation. Investigate filter bank. Switching filters will remove problem. (ONOP IA-1)	The only valves present are to switch from one filter to another. Filters can be expected to plug after prolonged operation. Normally there is no flow so plugging is going to take a long time.
IA005-A	Common pipe from compressors to receiver.	3			Shut IA-6 - SA now supplies IA loads - repair as necessary. (ONOP IA-1)	Piping only-no active components.
IA006-A	Receiver ADN RV (and relief valve?)	3			Receiver failure-repair receiver. Shut IA-6 and supply IA from SA to repair all failures. (ONOP IA-1)	Relief valve-no operator action to open. Drain valves - not normally opened and left. Failure of RCVR.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IA007-A	Pipe and valve downstream of receiver.	2			NPO to investigate loss of receiver pressure. Check pressure at dryers verify PCV 1142 open to supply air from SA. (ONOP IA-1)	Several indicators other than PI 120 would show no loss of system pressure. This in conjunction with PCV 1142 remaining shut until IA 6 was shut indicates normal receiver pressure.
IA008-A	Pipe plugged - NOIF from compressors and backup serv air.	3			Investigate, locate and repair obstruction. Shut IA 6, 7, 8, 21, 70, 73 required to isolate obstruction RX trip. (ONOP IA-1)	Plug at this point results in loss of inst air. There is no back up available. Operator required by procedure to trip reactor if IA pressure drops to 60psig.
IA009-A	Pipe plugged - NOIF thru dryer 32 and bypass.	3			Place dryer 31 in service. (ONOP IA-1)	No inst. air will be available while repairs are being made.
IA01A-A	Compressor, pipe, valve upstream of aftercooler 31.	1	TI 1204 or TC 1104S fails high or low.	Shutdown compressor 31 due to temp out of specs. (Not addressed in PEP or ONOP, but in System Description)	Place compressor string 32 in service if not already running. (ONOP IA-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IA01B-A	Compressor, pipe, valve upstream of aftercooler 32.	1	TI 1205 or TC 11055 fails high or low.	Same as IA01A-A for compressor 32.	Place compressor string 31 in service if not already running. (ONOP IA-1)	
IA012-A	Common pipe from alt path (dryer 31) and bypass.	3			Remove inst air system from service - repair broken pipe. Reactor trip. (ONOP IA-1)	Piping only. No alternate source of IA available during repair. Pene and weld emerg are not affected.
IA013-A	Pipe, valves and controller in bypass.	2			No indication of plugging unless inservice refer dryer is also plugged. No action likely. On failure of 1144 the NPO notes PI 1207 reads normally which could imply blocking of either set of dryers. Redundant instrumentation should indicate that this is not the case.	No reason to isolate bypass unless PCV 1542 fails open. Failure of PI 1144 low would possibly induce NPO to open bypass valve by suggesting dryer might be blocked.
IA014-A	Pipe in bypass.	3			Air leak due to pipe break is isolated by shutting IA 70 and 71. (ONOP IA-1)	Pipes only. Leak only-plugged bypass would not be apparent unless in service dryer was also plugged.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IA015-A	Common pipe from ref dryers to desic dryers to conv. plant SE.	3			Remove inst air system from service, repair broken or plugged pipe Rx trip. (ONOP IA-1)	Emerg make up to Pene. and weld not affected. Piping only-no active components. No alternate source of IA available during repairs.
IA016-A	Pipe to desicant dryers	3			Remove IA system from service, repair broken or plugged pipe Rx trip. (ONOP IA-1)	Plug does not affect conventional plant IA. All loads affected by leak and by removal of IA from service for repair. Emerg make up to penetration and weld channel is unaffected.
IA018-A	Pipes, valves, regenerative dryers - normal flowpath.	2			Verify that non regen automatically placed in service. (Not addressed in ONOP or PEP)	Non regen only good for four hours.
IA02A-A	Aftercooler 31	3			Remove compressor 31 from service. Assure compressor 32 in "hand" mode. (ONOP IA-1)	No active components.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IA028-A	Aftercooler 32	3			Remove compressor 32 form service. Assure compressor 31 in hand mode. (ONOP IA-1)	No active components.
IA025-A	Pipe, valves, controller, nonregen, dryer backup path (4 hr. supply).	2			If leak shut IA-11 (double valve) and repair leak. (ONOP IA-1)	Non regen not normally in service.
IA026-A	Pipe from desicant dryer to after filters.	3			Isolate and repair line.	IA out of service no alternate available. No active components
IA027-A	Filters, pipes, valves.	1	DPI 1132 fails as is.	NPO will not recognize clogged filter and switch to alternate filter. Hence, taking no action would eventually lead to plugged filter. (Not addressed in ONOP or PEP)	Control room instrument shows decreasing IA pressure with no automatic actions occuring at desired setpoints. NPO investigates and finds PCV 1143 still shut indicating normal pressure at discharge of dryer. Investigate pressure drop. Filters are most likely cause. Swap filters. Increase CR IA pressure. (ONOP IA-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IA03A-A	Pipe and valves downstream after-cooler 31	3			Remove after cooler and compressor 31 from service. Assure compressor 32 in "hand" mode. Isolate and repair affected components. (ONOP IA-1)	Passive components IA 3 shut only to isolate air leak upstream.
IA03B-A	Pipe and valves downstream after-cooler 32.	3			Remove aftercooler and compressor 32 from service. Assure compressor 31 in "Hand" mode. Isolate and repair affected components. (ONOP IA-1)	Passive components IA 2 shut only to isolate air leak upstream.
IA03O-A	Pipe from after-filters to distribution.	3			Broken or plugged - no source of IA - Rx trip - repair. (ONOP IA-1)	Piping only - no active components.
IA04A-A	Pipe downstream of Seg IA03A.	3				Piping only - no active components.
IA04B-A	Pipe downstream of Seg IA03B.	3			Shift to alternate compressor. Investigate and repair as necessary. If leak IA 3, IA3, and IA 6 must be shut, the leak repaired. During leak repair IA loads supplied by SA. (ONOP IA-1)	Piping only - no active components.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Inst. Air (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
IA10A-A	Pipe, filter, dryer and valves in alt path (dryer 31).	3			Manually shift to standby filter downstream of dryer (ONOP IA-1)	
IA10B-A	Pipe, filter, dryer and valves in operating dryer 32.	2			Remove dryer from service establish flow through alternate dryer. (ONOP IA-1)	Redundant instrumentation makes it unlikely that a single instrument failure will cause inappropriate operator action.
IA11A-A	Pipe in alt path downstream of dryer 31.	3			If leak, must isolate both dryers and bypass. No source of IA available. If plugged, no action as dryer not in service.	Piping only - no active components.
IA11B-A	Pipe downstream of operating dryer 32.	3			If leak, must isolate both dryers and bypass - no source of IA will be available. Rx trip if plugged, bypass will open. Operator will shift to dryer 31. (ONOP IA-1)	Piping only - no active components.
Power	No power to 4-way valve - supply not found.	3			Verify non regen dryer supplying IA. Trace electrical fault and repair - reenergize the valve power supply. (ONOP IA-1)	Unlikely that a false indication would cause operator to trip the Buss supplying power to the valve.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Heat Tracing (HT)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EE-ATL	Ambient temp. low.	3			Note: Operator action throughout is to note the alarm and institute maintenance procedures to repair problem. Assure redundant system is operating where applicable.	There is never any reason for the operator to shut off heat tracing and no failure would induce him to do so.
HT021-T-INT	Segment 21 internal failure.	3				
HT022-T-INT	Segment 22 internal failure.	3				
HT025-T-INT	Segment 25 internal failure.	3				
HT026-T-INT	Segment 26 internal failure.	3				
HTG312-T	No power to segment 29.	3				
HTG322-T	No power to segment 30.	3				
HT029-T-INT	Segment 29 internal failure.	3				
HT030-T-INT	Segment 30 internal failure.	3				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Heat Tracing (HT) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HT025-LEF	Transformer elec. fault.	3				
HT026-LEF	Same as above	3				
HT033-LEF	Local FP DP31 load fault.	3				
HT033-LBFTO	Associated FP DP31 load BKR FTO.	3				
HT-Power-Matters	Conditions are suc that power failures to HT can cause system failure.	3				
EPA29-T	MCC31 loss of power.	4				
EPA-28-T	MCC 35 loss of power.	4				
HT341-LEF	FP DP32 CKTS 9 or 11 Elec. fault.	3				
HT341-LBFTO	FP DP32 CKTS 9 or 11 faulted associated breaker FTO.	3				
HT342-LEF	FP DP32 CKT 7 Elec. fault.	3				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Heat Tracing (HT) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HT342-LBFTO	FP DP32 CKT 7 load BKR FTO.	3				
HT343-LEF	FP DP32 any 1 CKTS 1 through 6 Elec. fault.	3				
HT343-LBFTO	FP DP32 load BKR assoc. with faulted CKT FTO.	3				
HT023-T-INT	Segment 23 internal failure.	3				
HT027-T-INT	Segment 27 internal failure.	3				
HT031-T-INT	Segment 31 internal failure.	3				
HT027-LEF	Transformer elec. fault.	3				
EPA21-T	MCC 37 loss of power.	4				
HT0351-LEF	Elec. failure of line 155 HT CKTS.	3				
HT0351-LBFTO	FP DP34 line 155 CKT BRKRS FTO.	3				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Heat Tracing (HT) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HT0352-LEF	Elec. failure of line 161 HT CKTS.	3				
HT0352-LBFTO	FP DP34 line 161 CKT BRKRS FTO.	3				
HT0353-LEF	Elec. failure of RWST inst strip HTRS.	3				
HT0353-LBFTO	FP DP34 RWST inst strip HTRS CKT BRKRS FTO.	3				
HT0354-LEF	Elec. failure of non-RWST HT CKTS.	3				
HT0354-LBFTO	FP DP34 non-RWST HT CKT BRKRS FTO.	3				
HT024-T-INT	Segment 24 internal failure.	3				
HT028-T-INT	Segment 28 internal failure.	3				
HT028-LEF	Transformer elec. fault.	3				
EPA 18-T	MCC 39 loss of power.	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Heat Tracing (HT) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HT032-T-INT	Segment 32 internal failure.	3				
HT036-LEF	Local FP DP35 load fault.	3				
HT036-LBFTO	Assoc, BRKR FP DP35 FTO.	3				
HT008-T-INT	Segments 5, 8, or 11 internal failure.	3				
HT33A-LEF	Local load elec. fault on PNL 33A.	3				
HT33A-LBFTO	Assoc. load BRKR FTO.	3				
HT003-T-INT	Segment 3 internal failure.	3				
HTSPS0-T	No power to SUPV PNL 90 in CR.	3				
HT003-T-O	Operator fails to make the transfer.	3				
HT002-T-INT	Segment 2 internal failure.	3				
EPA23-T	Loss of power to MCC 36B.	4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Heat Tracing (HT) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPA22-T	Loss of power to MCC 36A.	4				
HT001-T-INT	Segment 1 internal failure.	3				
HT008-LEF	Transformer to PNL 33A elec. fault.	3				
HT005-LBFTO	Segment 5 BRKR FTO.	3				
HT009-LEF	Transformer to PNL 33B elec. fault.	3				
HT006-LBFTO	Segment 6 BRKR FTO.	3				
HT010-LEF	Transformer to PNL 33C elec. fault.	3				
HT007-LBFTO	Segment 7 BRKR FTO.	3				
HT009-T-INT	Segment 6, 9, or 12 internal failure.	3				
HT33B-LEF	Local load elec. fault on PNL 33B.	3				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Heat Tracing (HT) (Cont'd)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
HT33B-LBFTO	Assoc. load BRKR FTO.	3				
HT010-T-INT	Segment 7, 10, or 13 internal failure.	3				
HT33C-LEF	Local load elec. fault on PNL 33C.	3				
HT33C-LBFTO	Assoc. local load BRKR FTO.	3				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
*EPA01-S	Local fault at EPA01 (switchyard)	2			Procedure PEP-EL-1 to verify start & loading of diesels. Then SOP-EL-S (as per PEP-EL-1) to restore 6.9kV with the gas turbine	
*EPA01-T	Loss of grid	2			Same	
*EPA02-S	Local fault at EPA02 (6.9kV Bus 5)	2			Check starting & loading of diesel 33. Lower power as necessary to maintain plant without circ. water pump 35 (PEP EL-1)	
*EPA03-S	Local fault at EPA03 (SS XFMR 5)	2			Open both 6.9 kV and 480v breakers. Supply Bus 5A from diesel 33 (PEP EL-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
*EPA02-U	Unclearable fault at Bus 5	2			Follow loss of outside power procedure PEP-EL-1	
*EPA04-S	Local fault at EPA04 (Bus 5A)	2			Replace essential loads with equipment from other 480V buses PEP-EL-1	If faulty indication of bus problem operator would look for faulty loads to remove from bus, not deenergize bus
*EPA05-INT	Local fault in DG no.33	2			Supply Bus 5A from Bus 5 if available, if not supply essential loads from redundant equipment on other 480V buses. Repair DG33 PEP-EL-1	If false indication of fault operator would try to cure fault, not trip DG.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
*EPA06-INT	Local fault in fast transfer breaker scheme	2			Preform manual dead bus transfer SOP-EL-5	The only way the operator can defeat the transfer is to put the breaker in pull-to-lock. No false indication could result in operator using pull-to-lock
*EPA06-S	Local fault at EPA06 (6.9kV Bus 2 and SS Xfmr 2)	2			Isolate Bus 2 & SS transformer 2. Supply Bus 2A from DG31 (auto start on no voltage) PEP-EL-1	If at power reactor would trip due to loss of RCP. (Low Flow) no false indication could induce operator to isolate the bus
*EPA07-S	Local fault at EPA07 (Bus 2A)	2			Same as EPA-04-S	
*EPA08-INT	Local fault in DG No.31	2			Supply Bus 2A from Bus 2 if available, or through 2A/3A tie breaker if allowed. Repair DG31	SOP-EL-5
*EPA09-S	Local fault at EPA09 (6.9kV Bus 6)	2			Check starting and loading of diesels. If at PWR, lower PWR to maintain vac. with circ. pump 36 ooc.	PEP-EL-1

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
*EPA09-U	Unclearable fault at Bus 6	2			Follow loss of power procedure PEP-EL-1	See note at EPA02-U
*EPA10-S	Local fault at EPA 10 (SS Xfmr 6)	2			Open breakers on both sides of the former and supply Bus 6A with diesel 32 (auto start on no voltage)	No faulty indicator that could simulate the fault. PEP-EL-1, SOP-EL-5
*EPA11-S	Local fault at EPA11 (Bus 6A)	2			Same as EPA04-S	Same as EPA04-S
*EPA12-INT	Local fault in DG No.32	2			Supply Bus 6A from Bus 6 if available, if not supply essential loads from redundant equipment on other 480V buses. Repair Diesel 32	If false indication of fault operator would try to cure fault, not trip diesel. PEP-EL-1
*EPA13-INT	Local fault in fast transfer breaker scheme	2			Perform manual dead bus transfer SOP-EL-5	The only way the operator can defeat the transfer is to put the breaker in pull-to-lock. No false indication could result in operator using pull-to-lock.
*EPA13-S	Local fault at EPA13 (6.9kV Bus 3 & SSXfmr3)	2			Isolate Bus 3 & SS transformer 3. Supply Bus 3A through 2AT3A bus tie. SOP-EL-5	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
*EPA15-U	Unclearable fault in tiebreaker 5A/2A	2			Isolate Buses 5A & 2A to repair fault. Supply essential 480V loads with Buses 3A & 6A, diesel 32 only would be available	PEP-EL-1
*EPA16-U	Unclearable fault in tiebreaker 2A/3A	2			Isolate Buses 2A & 3A to repair fault. Supply essential loads with Buses 5A & 6A. Diesel 32 & 33 would be available	PEP-EL-1
*EPA17-U	Unclearable fault in tiebreaker 3A/6A	2			Isolate Buses 3A & 6A to repair fault. Supply essential 480V loads with Buses 2A & 5A. Diesels 31 & 33 would be available	PEP-EL-1
*EPA18-S	Local Fault at MCCA39	2			Follow appropriate annunciator response procedures. Consult system description and determine the equipment lost as a result of losing this MCC.Verify operation of redundant equipment as available. Follow Tech. Spec. LCO's and procedures specific to the equipment loss (ARP's).	
*EPA19-S	Local Fault at MCC38C	2			Same	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPA20-S	Local fault at MCC32	2			All of these PE's result in loss of an MCC action is outlined in EPA18-S	
*EPA21-S	Local fault at MCC37	2			Same	Same as EPA18-S
EPA22-S	Local fault at EPA22 (MCC36A)	2			Same	
EPA23-S	Local fault at MCC36B (Seg.EPA23)	2			Same	
EPA24-INT	Local fault in fast transfer breaker scheme	2		See EPA06-INT		
EPA24-S	Local fault at 6.9kV Bus 1	2			This results in loss of several MCCs. Action for each is outline under EPA18-S	
EPA25-INT	Local fault in fast transfer breaker scheme	2			Results in loss of MCC. General actions are outlined under EPA18-S	
EPA25-S	Local fault at 6.9kV Bus 1	2			All of these result in the loss of one or more MCCs.	
*EPA26-S	Local fault at MCC33	2			General action is outline under EPA18-S	Same as EPA18-S
*EPA27-S	Local fault at MCC34	2			Same	Same

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPA28-S	Local fault at MCC34	2			Same	
EPA29-S	Local fault at MCC35	2			Same	
EPA29-S	Local fault at MCC31	2			Same	
EPA30-S	Local fault at MCC38	2			Same	
EPD01-P1	LF, FB16 opens	2			Loss of 125VDC distribution panel 31 resulting in loss of control of several important plant systems. Refer to individual emerg. proc. for actions to cope with each	These breakers are on 125VDC power panel 31
EPD01-P3	LF, FB13 opens	2			Loss of 125VDC distribution panel 33. See EPD01-P1 above	
*EPD01-02	LF at DC power panel 31	2			Primary concern would be loss of breaker control power and breaker position indications. Breakers would have to be operated locally. Go down the list of loads supplied and deal with symptoms. for loss of DC/AC inverter use ONOP-EL-13 (loss of instrument bus)	Operator would never deenergize a DC supply panel. All battery charger instrumentation is local.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPD01-06	LF at battery charger 31, CB cables	1	Charger output ampmeter fails to zero (local at charger, aux operator would get control room concurrence)	Remove charger from service. Battery carries load	Remove charger from service battery carries load. Repair Charger. If charger cannot be repaired shutdown as per Tech. Specs.	This and the battery form an and gate on the fault tree so assume the cable problem does not result in a loss of voltage on panel 31
*EPD02-06	LF at battery charger 32, CB cables	1	Same	Same	Same	Same for Panel 32
*EPD02-F2	LF, FB 12 opens	2			Check the load list for DC distribution panel 32 and respond to symptoms	Operator would deal with problems on the panel, not deenergize the panel
*EPD02-F4	LF, FB 13 opens	2			Same for dist. panel 34	Same
*EPD02-02	LF at DC power panel 32	2			Same as for power panel 31 above	Same as for power panel 31 above
*EPD03-02	LF at DC pwoer panel 33	2			Same	Same
*EPD03-06	LF at battery charger 33, CB cables	1	Charger ammeter fails to zero (local at charger)	Remove charger from service and use swing charger (get control room concurrence)	Same as EDP-01-06	See notes from battery chargers on previous page (EPD01-06)
EPD04-02	LF at DC power panel 34	2			Only load is inverter 34 which is standby supply for instr. bus 34. No action required other than repair of fault.	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPD04-06	LF at battery charger 34, CB, cables	2			Loss of charger-battery carries load temporarily. Repair charger-DC bus 34 not normally loaded	Only action required is repair of charger since battery is passive
*EPD11	LOP at EPD11 (failure of battery 31)	2			Repair battery as soon as possible follow Tech. Spec. LCO's	As per Tech. Spec. a single battery can be ooc for 24 hours if the charger is operable and carries its DC load
*EPD12	LOP at EPD12 (failure of battery 32)	2			Same	Same
*EPD13	LOP at EPD13 (failure of battery 33)	2			Same	Same
*EPD14	LOP at EPD14 (failure of battery 34)	2			Same	Same

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
*EPD3132-U	Unclearable fault in tie breaker between DC pannels 31 and 32	2			Take manual control of functions to cool core (atmospheric steam pump and Aux.FW) Not addressed in PEPs & ONOPs	Plant is prohibited from ever using this breaker. This PE would result in loss of both DC power panels 31 & 32
*EPI21-SW	Manual switch 31 opens	2			Upon loss of bus 31: (1)defeat runback if > 70% power (2)transfer rod control to manual (4)identify faulted bus (5)manually transfer to alt source if alt not already in use by other I bus (6)may have to block HI-HI const press (*7)take local control of turbine driven AFW as required (*8)block relay PC-402AX if RHR to be used (*9)reenergize BA tank headers (10)restore power & reset instruments (11)repair fault. ONOP EL-3 *These steps unique to bus 31 all others common to all I bus failures	No false indication would cause an operator to deenergize an instr. bus
*EPI21-02	LF at I Bus 31	2				
*EPI21-06	LF at manual switch 31, transfer failure to AC source 1	2				Same
*EPI21-15	LF in inverter 31 or cable to IT	2				Same
*EPI22-SW	Manual switch 32 opens	2			Next page	Same

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
*EPI22-02	LF at I Bus 32	2			Same as for I Bus 31 except (7) NA (8) block relay PC403AX if RHR is to be used (9) use local pyrometers to read RHR temps	No false indication could cause an operator to deenergize an instrument bus
*EPI22-06	LF in manual switch 32, transfer failure to AC source 1	2			Same	Same
*EPI22-15	LF in inverter 32 or cable to it				Same	Same
*EPI23-06	LF in manual SW33 transfer failure to AC source 1	2			Same as for Bus 31 except (7) take local manual control of motor driven AFW as required (8) NA (9) NA	Same
*EPI23-15	LF in inverter 33 or cable to it	2			Same	Same
*EPI23-SW	Manual switch 33 opens	2			Same	Same
*EPI23-02	LF in I Bus 33	2			Same	Same
*EPI24-SW	Manual switch 34 opens	2			Same as for I Bus 31 except (7)(8)(9) NA	There is no false indication that could result in operator isolating an instrument bus

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPI24-02	LF at I Bus 34	2			Same	Note: I Bus 34 is normally supplied by MCC 36B with manual transfer swtich 34 capable of switching supply to Inverter 34. In addition CB34 transfers from whichever of these sources is selected by SW34 to MCC36C which is the back up source used by all other I Buses
EPI-24-CB	LOP at man. CB34 (opens)	2			Same	
EPI-24-06	LF in manual switch 34, transfer failure to AC Source 1	2			Same	
EPI24-08	LF in man. CB 34, transfer failure to AC Source 2	2			Same	
EPI24-15	LF in inverter 34 or cable to it	2			Same	
*EPI-AIX	LF at XER or CB36C, AC Bus 1	2			36C is the back up source to all I Buses. Loss of this bus with no concurrent loss of normal I Bus power only requires repair of fault.	False indication of ground fault on 36C might prompt operator to isolate this bus but there is adequate redundant data on bus condition to prevent this error
EPI-A2X	LF at XER, CB 36B AC Bus 2	2			This is normal supply of I Bus 34 on loss of normal power shift supply to sola trans on Bus 36C. Inverter 34 can be manually switched to power the normal feeder to I bus 34. Reenergize and repair fault	False indication of ground fault might prompt the operator to shift to inverter 34 but there is ample redundant information to prevent this

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPL01-SWF	LF in switch 37, transfer failure to (E) Source	2			Upon loss of lighting get out flashlights and restore either normal or emergency light power source. (Not addressed in PEP or ONOP.)	Supplies E lights to fan house & tunnel very unlikely operator would deenergize DC power panel 32 buses upon false indication
EPL01-SW	Switch 37 opens	2			Repair switch	The only operator action that would simulate this would be to deenergize both DC panel 32 and ltg bus 33 which is highly unlikely
EPL01-02	LF at distribution panel for fan house and tunnel	2			Repair panel	Same-assuming fault is downstream of transfer switch
EPL01-06	LF at Bus 33	2			Lights transfer to E source after 10 sec. locate and repair bus 33 fault	Possible false indication of ground fault on bus 33 would cause operator to isolate bus however ample redundant indication makes this unlikely

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPL01-10	LF at L XER or CB 33	2			Loss of normal power to 208/120 vac lighting Bus 33. Bus can be cross tied to Bus 32 auto transfer to dc Bus 32 will provide E lighting-no action required. Find and repair fault.	Possible for operator to deenegize 480 Bus 5A or ltg Bus 33 but ample redundant infoamtion makes this unlikely
EPL01-11	Breaker (FB3) to EPD 02 ope[illegible] r 3 on DC Bus 3[illegible]	2			This results in loss of emergency supply to fan house & tunnel emergency lights normal supply from L Bus 33 still available no action required other than repair	Ample redundant information would prevent operator from isolating DC Bus 32 or opening FB3
EPL01-12	CRTIE CB-3233 or L Bus 32 is not available	2			Repair only	L Bus 33 has two sources of power. Bus 32 acts as the backup supply. If Bus 32 is not able to supply Bus 33, there will be no effect unless its normal source is lost.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPL02-SWF	LF in switch 34, transfer failure to (B) source	2			No emergency lighting available darkness in PAB. All operations conducted by flashlight & battery operated lamps. Implies loss of normal lighting prompted shift to E lights which were not available. Shift to standby source does not occur due to SW34 failure	Switch 34 supplies power to E lighting in PAB (nuc. plant) transfer failure implies that normal source has been lost. It is unlikely that an operator would deenergize dc Bus 34 based upon a single error
EPL02-SW	Switch 34 opens	2			With no failure in normal lighting no action would be required other than repairs	SW34 supplies all power to emergency lights in PAB. The operator would have to deenergize both L Bus 33 & DC Bus 32. There is no reason to do this
EPL02-02	LF at distr. panel for nuclear plant	2			Repair only-loss of emerg. lighting only significant if normal lighting is lost	Assumes loss of emergency lighting to PAB. Lighting normally supplied by non emergency system which is not affected
ELP02-05	Breaker (F82) to EPD-02 opens	2			This results in loss of emerg. supply to PAB emergency lights normal supply is from lighting Bus 33 & is still available no action required other than repair	Ample redundant info would prevent operator from isolating DC power source to E lighting

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPL03-SWF	LF in switch 31, transfer failure to (E) Source	2			Switch 31 supplies emerg lights in conventional plant otherwise same as EPL02-SWF	
EPL03-SW	Switch 31 opens	2			Same as EPL02-SW	Same as EPL02-SW for conventional plant lighting
EPL03-02	LF at distr. panel for conventional plant	2			Same as EPL02-02 for conv. plant	
EPL03-06	LF of xer, CB, (120VAC) Bus 31	2			Loss of lighting Bus 31 removes normal power for emergency lighting in conventional plant. No action other than repair	Ample redundant indications makes incorrect operator action unlikely
EPL03-08	LF at Bus 31	2			Same as EPL03-06	
EPL03-12	Auto switch fails	2			Loss of DC power to E lights no action other than repair	This is transfer switch 31-assume that it fails in its normal position
EPL03-15	Breaker (FB2) to EPD01 opens	2			Same as EPL03-12 above	DC power to transfer switch 31 is supplied via this CB

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPL04-SWF	LF in switch 33, transfer failure to (E) source	2			Loss of emergency source to control room emergency lights no action other than repair	Switch supplies DC power to control room emergency lights if necessary
EPL04-SW	Switch 33 opens	2			Loss of all power to control room emergency lights no action other than repair	
EPL04-02	LF at distribution panel for control room	2			Loss of control room emergency lighting repair only	
EPL04-06	LF at Bus 32				Loss normal source of emergency lighting power for control room repair only	
EPL04-10	LF of L xer or CB 32	2			Same	
EPL04-12	CRTIE CB3233 or Bus 33 is not available	2			Repair only	33 is back up source to 32. 32 and 33 not normally crosstied
EPL04-15	Breaker (FB11) to EPD01 opens	2			Loss of DC power to control room emergency lighting-repair only	Ample redundnt indication prevents incorrect opening of FB11

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Electric Power

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EPL06-06	LF at xer, CB (120VAC) Bus, Distr. Panel 34					
EPL06-08	LF at Bus 33	2			Loss normal source of emerg. lights in PAB (nuclear plant) repair only	Ample redundant indication prevents operator from needlessly deenergizing Bus 33
EPL06-12	Switch 34 is unavailable	2			Loss of emerg. source of emerg. lights in PAB repair only	Ample redundant indication prevents operator from needlessly deenergizing DC Bus 32 or opening HFB2
EPL06-14	Switch 34 opens	2			Loss of all emerg. lighting power to PAB repair only	Ample redundndt indications prevents operator from needlessly deenergizing all sources of power to emerg. light system for PAB
SE-EDG31-A		4				
SE-EDG32-A		4				
SE-EDG33-A		4				
SW034-A		4				
SW035-A		4				
SW036-A		4				
TR-LOOP		4				
TR-SPSI		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: RCP Seals

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CCGTBE01	Valve 769 or 797 fail closed	4				
CCG1000-A		4				
CVCH08-A		4				
IAG01		4				
RCE01	Undefined reasons	3				
RCE03	Other reasons	3				
RCE04	Other reasons	3				
RCSIE02	No operator action	5				
RCSIE03	Internal failure of valve or control circle	2			Initiate maintenance request	
RCSI01-A-INT	Injection filter train failure	2			Shift to parallel standby filter (ONOP RCS-5)	If PIC 189 indicates high filter Δp filters would be changed however if seal flow was not affected filter would not be clogged
RCSI02-A-INT	Pipe, valve, flow meter failure	2			If plugged-low seal flow slowly return seal flow to normal if low bearing > 225°F trip & trip RCP (ONOP CC-2) if leak isolute leak and proceed as above (ONOP CVCS-1)	Loss of seal flow is verified prior to taking action

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: RCP Seals

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
RCSI09-A-INT	Motor valve 222 fail closed	2			Loss of seal return flow loss of some seal flow loss of excess letdown to VCT seal flow & excess letdown now go to PRT via relief valve 218 no action necessary	
RCSI10	Seal return filter plugged	2			Open bypass valve 221A replace filter take action on low seal flow if necessary monitor lower bearing temp trip pump if > 225°F ONOP CC-2	Filter replacement not addressed in PEP or ONOP
RCSI11-A-INT	Seal water HX fails	2			Tube failure CCW leaks to VCT isolate & bypass HX monitor VCT temp line up return to PRT if necessary (not addressed in PEP or ONOP) plugging results in same-bypass HX	CCW pressure is higher than seal return pressure excess letdown is in same flow path
RCTBE01	Thermal barrier of any pump ruptures	3			Trip reactor trip RCP prolonged operation with RCS hot will destroy pump seals go to cold shutdown & repair ONOP CC-2	Reverse Δp and radiation in CCW would indicate that this had happened
RCTB01-A-INT	Valve or pipe fail	2			Upon loss of CCW to RCP restore flow within two minutes or trip RX & trip pump if motor bearing temp reach 200°F trip RX & trip pump ONOP CC-2	Loss of CCW to RCP considering the consequences it is unlikely that it would isolate CCW to RCP

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: RCP Seals

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
RCT805-A-INT	Pipe or valve 781A failure	2			Plug or FC loss of CCW flow to thermal carrier operation may continue if positive Δp indication of thermal carrier seal flow exists	
RCT806-A-INT	Flow meter or FCV625 failure	2			FCV625 shuts loss of all CCW flow to RCPs restore within two minutes or trip RX & trip pumps	
SIPHASEB	Signal of containment isolation phase B	2			Los of seal water and CCW to RCPs trip RX shutdown RCPs	Operator may initiate phase B but redundant data makes inadvertant phase B by operator unlikely
RCSI06-A-INT	Seal #1 plugged or valve, pipe failure	2			See RCSI02-A-INT. ONOP CC-2 #1 seal bypass may be used to provide radial bearing cooling flow	Indications of high seal return flow might lead operator to isolate seal - but this would be verified first.

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Station Air

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	 ACTION	OPERATOR RESPONSE TO PE	REMARKS
EPA04-T-LSI		4				
EPA20-T		4				
EPA26-T		4				
SACCS1-A-INT	Pump train 31 local fails	1	Local discharge pressure gage PI-1263 fails low	Aux operator turns off pump 31 NA in ONOP or PEP	Ensure that pump 32 starts SOP CC-2	If other train was out of service, operator would likely not take this action
SACCS2-A-INT	Same, train 32	1	Same, PI-1264	Same, pump 32	Same - pump 31	Same
SACCS3-A-INT	Header plugged	3			Shutdown SA system and open SA-3 to use IP-1 backup supply SOP SA-1	
SACCS4-A-INT	HX train 31 local fails	3			Put HX32 train inservice SOP CC-2	
SACCS5-A-INT	Same, train 32	3			Same, train 31	
SACCS6-A-INT	NOIFF water supply to closed cooling system pumps	3			Shutdown closed cooling system pumps and SA system and open SA-3 to use IP-1 backup supply	SOP SA-1
SACCS7-A-INT	NOIFF supply from CCS HXS header				Same	
SA01-A-INT	Compressor local fails	1	Local oil pressure gage fails low	Aux operator turns off compressor SOP SA-1	Open SA-3 to use IP-1 backup SOP SA-1	
SA02-A-INT	Super component SA02 fails	3			Repair SA system (fault downstream of backup supply)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Station Air

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
SA03-A-INT	IP-1 station air backup for IP-3 station air fails	3			Repair IP-1 backup station air system	
SA04-A-INT	Supercomponent SA04 fails	3			Repair SA system (fault downstream of backup)	
SA07-A-INT	Supercomponent SA07 fails	3			Same	
SWT60A-A		4				
SWT60B-A		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: RWST

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN STIMULUS	CTION CAUSING PE ACTION	OPERATOR RESPONSE TO PE	REMARKS
AUXSTM...	Failure of steam supply from aux steam system	3			No backup-call maintenance	
EE-ATL	Ambient temperature - Low	3			NA	
HTG340-T	EHT Failure of FP DP 34	4				
HT0351-LEF	Elec. failure of line 155 HT CKTS	4				
HT351-T-INT	Internal failure of line 155 heat tracing	4				
RW001-A-INT	Internal failure of segment 1	3			Put reactor in cold shutdown as per Tech. Spec.	
RW002-A-INT	Same, segment 2	2			Same	
RW003-A-INT	Same, segment 3	2			No backup-call maintenance	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Condensate Storage Tank

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CS001-A-INT	Internal failure of CST	3			Use city water to supply AFW	Not addressed in procedures - but in System Description.
CS003-A-INT	LCV-1158FO	2			Close LCV-1128 and LCV-1128A	CRO would likely have NPO check hotwell sightglass before taking action
CS004-A-H	Operator fails to close LCV-1158 on alarm	5/3			NA	
CS004-A-INT	Failure of flowpath to hotwell	3			Close LCV-1158	
CS011A-A-INT	CST alarm failure	3			NA	
CS011-A-INT	CST level switch LIC-1102S fail high	2			NA	The operator would probably not be aware LIC-1102S had failed. Operator would likely have NPO check sightglass on hotwell before taking action
CS015-A-INT	Failure of path from CST to AFW	3			Use city water to supply AFW	Not in procedures - but in System Description.
CS020-LL	Low hotwell level	3			Open LCV-1158	
EE-ATL	Low ambient temp	3			NA	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Condensate Storage Tank

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
EE-CS015	No flow in path from CST to AFW	2			Start TD AFWP 32 Not in procedures - but in System Description.	The lack of flow causes the flow path to freeze, so, the lack of flow would have resulted from a failure to operate MD pump 31 or 33
HTG320-T		4				
HT341-LEF		4				
HT341-T-INT		4				

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Transient (TR)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
CCGRETRN-A		4				
CCGTBE01		4				
CCG1000-A		4				
CD-VAC		4				
CR-01-A		4				
CV-LOCH		4				
CV-LOLD		4				
EPAG12		4				
EPAG13		4				
EPA24-T		4				
EPA25-T		4				
EPG01		4				
MF-SG31323334		4				
PZRXTRIP	Reactor trip on PZR fault	3			Reactor trip procedure (PEP-RPC-1)	There is too much instrumentation on PZR for operator not to know conditions also repsonse would be slow to operator induced transients, leaving time to correct

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Transient (TR)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
RCPM01-INT		4				
RCPM02-INT		4				
RCPM03-INT		4				
RCPM04-INT		4				
SIPHASEB		4				
TRET10A	Boron dilution accidents	2			Emergency borate in accordance with PEP-CVCS-3	Operator could respond to faulty boron sample, but power and temperature instruments would point out error
TRET10G	Cold water addition	2			Drive rods POP 2-1	Would be a minor reactivity addition, well within capability of control systems
TRET10H	Excessive load increase	2			Runback turbine load SOP TG-4	
TRET10I	Positive reactivity insertion	2			Insert rods or borate POP 2-1	Category 2 due to backup indication available
TRET10OTHER	Miscellaneous core power excursion	2			Insert rods or borate POP 2-1	
TRET11A	Closure of all MSIVs	3			Reactor trip procedure (PER-RPC-1)	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Transient (TR)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
TRET11B	Increase in feedwater flow in one steam generator	1	Level recorder fails as is slightly low	Operator increases feed to raise level PEP FW-1	Reactor trip procedure if > 10% power (PEP-RPC-1)	Requires "tunnel vision" on a single level indication
TRET11C	Increase in feedwater flow in all SGs	2			Same	
TRET11F	Throttle valve closure/EHC control problems (loss of stop oil pressure)	3			Same	Turbine trip Indian Point does not have an EHC system. Equivalent fault in "loss of stop oil pressure"
TRET11G	Generator fault or generator trip	2			Same	
TRET11H	Misc turbine gen accidents	3			Same	
TRET11I	Turbine trips	1	Turbine vibration monitor fails to > 15 MILLS	Operator trips turbine SOP TG-4	Same	
TRET12A	Control rod problems	2			Reactor trip procedure (PEP-RPC-1)	
TRET12D	Spurious auto trip	3			Same	
TRET12E	Operator error causing trip	5			Same	Stimulus can only be identified if know specific error

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Transient (TR)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE STIMULUS	ACTION	OPERATOR RESPONSE TO PE	REMARKS
TRET12F	Manual trip resulting from false signal	5/2			Same	Redundant trip indications needed before operator would trip turbine
TRET12G	Spurious trip cause unknown	3			Same	
TRET12H	Primary system pressure, temp, power imbalance	2			Same	
TRET7A	Feedwater break	3			Loss of feedwater procedure (PEP-FW-1)	
TRET7D	FW flow instability operator	5			Same	
TRET7E	Same mechanical	3			Same	
TRET7H	Other secondary leakage	3			Same	
TRET8A	Trip of one MSIV	2			Reactor trip procedure (PEP-RPC-1)	
TRET8B	Trip of 2 or 3 MSIVs	2			Same	
TRET8C	Partial closure of 1 or more MSIVs	2			Same	
TRET8D	Losses of steam flow other than MSIV trip	2			Same	

PRIMARY EVENT (PE) - INDUCED HUMAN INTERACTION TABLE

SYSTEM: Transient (TR)

PE DESIGNATOR	PE DESCRIPTOR	REVIEW CATEGORY	STIMULUS AND HUMAN ACTION CAUSING PE		OPERATOR RESPONSE TO PE	REMARKS
			STIMULUS	ACTION		
TRET9B-F	Losses of coolant flow other than CCW	2			Reactor trip procedure (PEP-RCP-1)	Procedure calls for tripping reactor before tripping pump
TR-LOOP	Loss of power to necessary plant systems	3			Same	emote possibility of operator securing power to necessary equipment
TR-SPSI	Spurious safety injeciton	2			Same	Parameters that initiate SI have redundant indications

APPENDIX E

COMPUTER COST ACCOUNTING

E.1 ALLOCATION OF PROJECT EFFORT

The following breakdown reflects the particular emphases of this project, and is not offered as a model. In particular, the emphasis on functional coupling reflects the particular methodological emphasis of this project. Percentages quoted correspond to fractions of the total budget.

Functionally coupled interactions	74%
Spatially coupled interactions	7%
Induced-human coupling	9%
Integration of results, ranking of discovered interactions, preparation of draft final	8%

The balance of effort has been allocated to issuance of a final report.

E.2 COMPUTER COSTS

This appendix is a comment on the computing costs incurred in this project. It has been suggested that fault tree codes are not particularly efficient in SI studies seeking only low-order cutsets, and that alternative algorithms might offer advantages in situations where only single-element and two-element cutsets are desired. The point to be made here is that obtaining low-order cutsets need not be particularly expensive using a fault tree code either.

Table E.1 compares costs of obtaining cutsets to second order with costs of obtaining cutsets to fourth order (third order in one case). The column labeled "CCUs" gives the cost of obtaining minimal cutsets for the indicated top event. One CCU (computer charge unit) corresponds to approximatly $1.60.

The column labeled "level" indicates whether cutsets were obtained in terms of primary events (in which case the label is "S" for "segment level") or in terms of "Independent Subtrees" (IST). In the latter case, the actual number of cutsets is much greater than indicated, because a typical "event" appearing in the cutsets may actually be a logical sum of several primary events.

One sees that running sequences out to two-element cutsets costs typically a few dozen CCUs or less. Running them out to fourth order costs substantially more. The second-order calculation is hardly prohibitive.

These costs are not a measure of the computer budget. In this project, computer costs have been dominated by permanent file storage.

Table E.1 Computer Cost (CCUs)

	4th order			2nd order		
System or Sequence	CCUs	Number of Cutsets	Level**	CCUs	Number of Cutsets	Level
Tr	68.7	647 1921	IST. S.	38.6	753	S.
AFWS (LOCA)	274.6	25391 5144	S. IST.	26.2	54	S.
AFWS (Tr.)	839.6	5577	IST.	41.1	292	S.
RCP	569.1*	8125*	S.	13.8	285	S.
PZLOCA	35.5	3027	S.	10.7	90	S.
LPI	58.6	1798	IST.	23.7	187	S.
HPI (S)	134.1	15513	S.	15.1	154	S.
HPI (M)	47.2	5784	S.	13.8	338	S.
Tr-L	73.3	8431	IST.	6	684	S.
RCP-L	--			1.9	84	S.
RCP-U	--			2.3	250	S.
PZ-L	6.3	2775	S.	1.9	5	S.
PZ-U	25	12604	S.	2.0	90	S.

*For this event, cutsets were obtained only to third order.

**IST denotes results obtained in terms of Independent Subtrees (ISTs); S denotes results obtained at the segment level. An IST corresponds to a Boolean expression whose elements are logically independent of the rest of the problem.

APPENDIX F

SPATIAL ZONES AFFECTING MAJOR COMPONENTS

Main Feedwater System

Fire Zone

Component ID and Event Name	17A	39A	41A	54A	55A	MCC 311 LO					
FCV 417 MF-2A-LF				X*							
FCV 427 MF-2B-LF				X*							
FCV 437 MF-2C-LF				X*							
FCV 447 MF-2D-LF				X*							
BFD 5A MF-2A-LF						X					
BFD 5B MF-2B-LF						X					
BFD 5C MF-2C-LF						X					
BFD 5D MF-2D-LF						X					
MF Pump 31 MF-61-LF		X*									
MOV BFD 2-31 MF-61-LF	X										
MF Pump 32 MF-62-LF		X*									
MOV BFD 2-32 MF-62-LF	X										
Circ. Pump 31 CR031-LF					X*						
Circ. Pump 32 CR032-LF					X*						
Circ. Pump 33 CR033-LF					X*						

*Denotes location of the component.

Main Feedwater System (Continued)

Fire Zone

Component ID and Event Name	17A	39A	41A	54A	55A	MCC 311 LO					
Circ. Pump 34 CR034-LF					X*						
Circ. Pump 35 CR035-LF					X*						
Circ. Pump 36 CR036-LF					X*						
Cond. Pump 31 CD-PP31-LF			X*								
Cond. Pump 32 CD-PP32-LF			X*								
Cond. Pump 33 CD-PP32-LF			X*								

High Pressure Injection

Fire Zone

Component ID and Event Name	9	10A	11	12A	14	15	17A	59A	60A	FULZ-1	
SI Pump 31 HP002-A-INT	X*		X		X	X			X		
SI Pump 32 HP003-A-INT	X*	X	X		X	X					
SI Pump 33 HP004-A-INT	X*		X	X	X	X			X		
MOV 1852A HP007A-A-INT	X*										
MOV 1852B HP007B-A-INT	X*										
MOV 1835A HP007C-A-INT								X*			
MOV 1835B HP007D-A-INT								X*			
BIT Heater 31 HP007-HTR31-INT										X*	
BIT Heater 32 HP007-HTR32-INT										X*	
MOV 843 HP011A-A-INT							X				
MOV 842 HP011A-A-INT							X				
MOV 856J HP013-A-INT							X				
MOV 856H HP014-A-INT							X				
MOV 856C HP016-A-INT							X				
MOV 856E HP018-A-INT							X				

High Pressure Injection (Continued)

Fire Zone

Component ID and Event Name	9	10A	11	12A	14	15	17A	59A	60A	FULZ-1	
MOV 887A HP03A-A-INT							X				
MOV 884B HP03A-A-INT							X				

Low Pressure Injection

Fire Zone

Component ID and Event Name	3	4	4A	7A	9A	11	12A	14	15	17A	60A	69A
RHR Pump 31 LP04A-A	X*		X	X	X	X	X	X	X			
RHR Pump 32 LP04B-A	X	X*	X	X	X	X	X	X	X		X	X
MOV 899B LP09A-A										X		
MOV 747 LP09A-A										X		
MOV [illegible] LP09A-A										X		
MOV 899A LP09B-A										X		
MOV 746 LP09B-A										X		
MOV 640 LP09B-A										X		
MOV 1869A LP008-A										X		
MOV 1869B LP008-A										X		
MOV 889A LP14B-E										X		
MOV 889B LP14A-E										X		
MOV 745A LP006-A										X		
MOV 745B LP006-A										X		
MOV 885A LP015-E										X		
MOV 885B LP015-E										X		

Auxiliary Feedwater System

Fire Zone

Component ID and Event Name	7A	11	14	15	23	52A	57A	60A	73A	74A	
AFW Pump 31 AF010-A-INT	X	X	X	X	X*					X	
AFW Pump 32 AF011-A-INT		X	X	X	X*	X	X				
AFW Pump 33 AF009-A-INT		X	X	X	X*			X	X		
PCV 1134 AF032-A-INT	X	X		X	X	X	X*	X	X		
PCV 1135 AF030-A-INT	X	X		X	X	X	X*	X	X		
PCV 1136 AF026-A-INT	X	X		X	X	X	X*	X	X		
PCV 1137 AF028-A-INT	X	X		X	X	X	X*	X	X		
FCV 406A AF015-B-INT					X*						
FCV 406B AF014-B-INT					X*						
FCV 406C AF012-B-INT					X*						
FCV 406D AF013-B-INT					X*						
PCV 1187 AF006-A-INT					X*						
PCV 1188 AF008-A-INT					X*						
PCV 1189 AF004-A-INT					X*						

Component Cooling Water System

Fire Zone

Component ID and Event Name	1	4A	7A	11	12A	14	15	58A	60A		
CCW Pump 31 CC001-A-INT	X*	X		X	X	X	X	X	X		
CCW Pump 32 CC002-A-INT	X*		X	X		X	X	X			
CCW Pump 33 CC003-A-INT	X*			X	X	X	X	X	X		

Service Water System

Fire Zone

Component ID and Event Name	11	14	15	22							
SW Pump 31 SWC3-A-INT	X	X	X	X*							
SW Pump 32 SWC2-A-INT	X	X	X	X*							
SW Pump 33 SWC1-A-INT	X	X	X	X*							
SW Pump 34 SWN3-A-INT	X	X	X	X*							
SW Pump 35 SWN2-A-INT	X	X	X	X*							
SW Pump 36 SWN1-A-INT	X	X	X	X*							

Instrument Air System

Fire Zone

Component ID and Event Name	14										
Compressor 31 IA01A-A	X*										
Compressor 32 IA01B-A	X*										
Cooling Water Pump 31 IAC1A-A	X*										
Cooling Water Pump 32 IAC1B-A	X*										

Station Air System

Fire Zone

Component ID and Event Name	19	38A									
St. Air Compressor SA01-A-INT	X*										
Closed Clg Water Pump 31 SACCS1-A-INT		X*									
Closed Clg Water Pump 32 SACCS2-A-INT		X*									

RCP Seals

Fire Zone

Component ID and Event Names	17A	59A	70A	71A							
AOV 261A RCSIE03				X*							
AOV 261B RCSIE03				X*							
AOV 261C RCSIE03			X*								
AOV 261D RCSIE03			X*								
MOV 769 CCGTBE01	X										
MOV 797 CCGTBE01	X										
RIC 625 RCTB06-A-INT		X*									
MOV 789 RCTB06-A-INT	X										
RCV 625 RCTB06-A-INT	X										
MOV 222 RCSI09-A-INT	X										

Chemical and Volume Control System

Fire Zone

Component ID and Event Name	1	2A	3A	4A	5	6	7	7A	8	11	12A
Charging Pump 31 RCV01-A-INT				X	X*					X	
Charging Pump 32 RCV02-A-INT	X					X*		X		X	X
Charging Pump 33 RCV03-A-INT	X	X	X				X*			X	
LCV 112B CVCHE04						X*					
LT 112 CVCHE01											
Valve 374 CVCH07-A-INT											
RCV 142 CVCH07-A-INT											
FCV 110B CVCH11-A-INT											
FCV 111A CVCH16-A-INT											
BA Transfer Pump 31 CVCH18-A-INT									X*		
BA Tk 31 Heater CVCH20-A-INT									X*		
LCV 112C CVCH09-A-INT											

Chemical and Volume Control System

Fire Zone

Component ID and Event Name	14	15	17A	19A	27A	30A	31A	58A	59A	60A	68A
Charging Pump 31 RCV01-A-INT	X	X	X					X		X	
Charging Pump 32 RCV02-A-INT	X	X	X	X				X			
Charging Pump 33 RCV03-A-INT	X	X	X							X	X
LCV 112B CVCHE04											
LT 112 CVCHE01						X					
Valve 374 CVCH07-A-INT									X*		
RCV 142 CVCH07-A-INT									X*		
FCV 110B CVCH11-A-INT							X*				
FCV 111A CVCH16-A-INT					X*						
BA Transfer Pump 31 CVCH18-A-INT											
BA Tk 31 Heater CVCH20-A-INT											
LCV 112C CVCH09-A-INT						X*					

Chemical and Volume Control System

Fire Zone

Component ID and Event Name	17A	59A	71A	87A							
AOV 213A CVL10-A-INT			X*								
AOV 213B CVL10-A-INT			X*								
MOV 222 RCSI09-A-INT	X										
AOV 201 CVL04-A-INT		X*									
AOV 202 CVL04-A-INT		X*									
AOV 200A CVL03-A-INT			X*								
AOV 200B CVL03-A-INT			X*								
AOV 200C CVL03-A-INT			X*								
LCV 459 CVL01-A-INT			X*								
LCV 460 CVL01-A-INT			X*								
LT 460 LT 460-A				X*							
LT 461 LT 461-A				X*							
HCV 123 CVL12-A-INT			X*								

Pressurizer

Component ID and Event Name	Fire Zone									
	7A	11	60A	70A	71A	73A	75A	78A	86A	87A
LT 460 LT 460-LF										X*	
LT 461 LT 461-LF										X*	
PT 455 PT 455-LF										X*	
PT 456 PT 456-LF										X*	
PT 457 PT 457-LF										X*	
PT 474 PT 474-LF										X*	
MOV 535 PZ 335-INT									X*		
MOV 536 PZ 336-INT									X*		
Przr. Htrs PZ 501-A				X*							
PCV 455C PZ 301-A	X	X	X	X	X	X	X	X	X*		
PCV 456 PZ 351-A	X	X	X	X	X	X	X	X	X*		

Sequencer

Fire Zone

Component ID and Event Name	14	15	39A								
SI Cabinets (SI Relays)		X*									
480V Busses (480V motor Control Relays)	X*										
Relay 63X1-BFP1 SE-63X1-BFP1-S			X*								
Relay 63XI-BFP2 SE-63X1-BFP2-S			X*								

Refueling Water Storage Tank

Fire Zone

Component ID and Event Name	17A										
MOV 885A LP015-E	X										
MOV 885B LP015-E	X										

Transient

Fire Zone

Component ID and Event Name	17A										
MOV 784 CCGRETRN-A	X										
MOV 786 CCGRETRN-A	X										

Electric Power System

Fire Zone

Component ID and Event Name	37A										
Brkr 52/ST5 EPA02	X*										
Brkr 52/UT1 EPA58	X*										
Brkr 52/UT2 EPA51	X*										
Brkr 52/UT3 EPA54	X*										
Brkr 52/UT4 EPA60	X*										
Brkr 52/ST6 EPA09	X*										
Tie Breaker 52/UT1-ST5 EPA59	X*										
Tie Breaker 52/UT2-ST5 EPA53	X*										
Tie Breaker 52/UT3-ST6 EPA56	X*										
Tie Breaker 52/UT4-ST6 EPA61	X*										
6.9 KV Bus 1 EPA24	X*										
6.9 KV Bus 2 EPA52	X*										
6.9 KV Bus 3 EPA55	X*										
6.9 KV Bus 5 EPA02	X*										

Electric Power

Fire Zone

Component ID and Event Name	14	37A									
6.9 KV Bus 4 EPA25		X*									
6.9 KV Bus 6 EPA09		X*									
Brkr 52/SS5 EPA03		X*									
Brkr 52/SS2 EPA06		X*									
Brkr 52/SS3 EPA13		X*									
Brkr 52/SS6 EPA10		X*									
St. Serv. Xfmer 5 EPA03	X*										
St. Serv. Xfmer 2 EPA06	X*										
St. Serv. Xfmer 3 EPA13	X*										
St. Serv. Xfmer 6 EPA10	X*										
Brkr 52/5A EPA03	X*										
Brkr 52/2A EPA06	X*										
Brkr 52/3A EPA13	X*										
Brkr 52/6A EPA14	X*										

Electric Power

Fire Zone

Component ID and Event Name	10	14	101A	102A							
480V Bus 5A EPA04		X*									
480V Bus 2A EPA07		X*									
480V Bus 3A EPA14		X*									
480V Bus 6A EPA11		X*									
Tie Breaker 52/2AT5A EPA15		X*									
Tie Breaker 52/2AT3A EPA16		X*									
Tie Breaker 52/3AT6A EPA17		X*									
DG Breaker 52/EG3 EPA05		X*									
DG Breaker 52/EG1 EPA08		X*									
DG Breaker 52/EG2 EPA12		X*									
DG 33 EPA05				X*							
DG 31 EPA08	X*										
DG 32 EPA12			X*								

Electric Power

Fire Zone

Component ID and Event Name	11	14	17A	38A	39A	40A	42A	87A	ZNEAR 55A		
MCC 39 EPA18	X*										
MCC 36A EPA22			X*								
MCC 38 EPA30								X*			
MCC 36C EPA19		X*									
MCC 34 EPA27						X*					
MCC 33 EPA26					X*						
MCC 31 EPA29									X*		
MCC 32 EPA20				X*							
MCC 35 EPA28							X*				
MCC 36B EPA23			X*								
MCC 37 EPA21			X*								

Electric Power

Fire Zone

Component ID and Event Name	10	11	12	13	14	ZNEAR 55A					
Batt. Chg. 31 EPD21		X*									
Batt. Chg. 32 EPD22		X*									
Batt. Chg. 33 EPD23					X*						
Batt. Chg. 34 EPD24		X*									
Batt. 31 EPD11			X*								
Batt. 32 EPD12				X*							
Batt. 33 EPD13	X*										
Batt. 34 EPD14						X*					
125V DC Pwr. Pnl. 31 EPD01		X*									
125V DC Pwr. Pnl. 32 EPD02		X*									
125V DC Pwr. Pnl. 33 EPD03					X*						
125V DC Pwr. Pnl. 34 EPD04		X*									
125V DC Pnl. 31/32 Tie Brkr EPD3132		X*									

Electric Power

Fire Zone

Component ID and Event Name	11	15	66A								
125V DC Dist Pnl. 31 EPD01-31		X*									
125V DC Dist Pnl. 33 EPD01-33		X*									
125V DC Dist Pnl. 32 EPD02-32		X*									
125V DC Dist Pnl 34 EPD02-34		X*									
Inverter 31 EPI01	X*										
Inverter 32 EPI02	X*										
Inverter 33 EPI03	X*										
Inverter 34 EPI04	X*										
118V AC Inst. Bus 31 EPI21		X*									
118V AC Inst. Bus 32 EPI22		X*									
118V AC Inst. Bus 33 EPI23		X*									
118V AC Inst. Bus 34 EPI24		X*									
Unit Aux Xfmer EPA57			X*								

NRC FORM 335
(2-84)
NRCM 1102,
3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

1. REPORT NUMBER *(Assigned by TIDC, add Vol. No., if any)*
NUREG/CR-4207
BNL-NUREG-51872

2. TITLE AND SUBTITLE
Fault Tree Application to the Study of Systems
Interactions at Indian Point 3

3. LEAVE BLANK

4. DATE REPORT COMPLETED

MONTH	YEAR
March	1985

5. AUTHOR(S)
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6. DATE REPORT ISSUED

MONTH	YEAR
January	1986

7. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
Brookhaven National Laboratory, Upton, NY 11973
<u>Subcontractors</u>:

Impell Corporation	Analysis & Technology, Inc.
225 Broad Hollow Rd	Technology Park, P.O. Box 220
Melville, NY 11747	North Stonington, CT 06359

8. PROJECT/TASK/WORK UNIT NUMBER

9. FIN OR GRANT NUMBER
A3725

10. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
Division of Safety Technology
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

11a. TYPE OF REPORT
Technical

b. PERIOD COVERED *(Inclusive dates)*

12. SUPPLEMENTARY NOTES
Pertains to Docket No. 50-286

13. ABSTRACT *(200 words or less)*

This report describes an application of fault tree methods to search for systems interactions at Indian Point 3. This project was carried out in support of the resolution of Unresolved Safety Issue A-17 on Systems Interaction. Here, the methods are introduced, the findings are presented, and comments on the methods are offered.

Findings are presented in the following manner. Systems interactions which may <u>qualitatively</u> violate regulatory requirements (regardless of their probability) are discussed; additionally, a <u>probabilistically</u> ranked list of system interactions is provided.

This study resulted in the discovery of a previously undetected active single failure causing loss of low pressure injection. After verifying this finding, the licensee took immediate corrective actions, including a design modification to the switching logic for one of the safety buses, as well as procedural changes.

14. DOCUMENT ANALYSIS — a. KEYWORDS/DESCRIPTORS
Indian Point 3
Fault Tree
Single Failure Criterion
Multiple Failures

b. IDENTIFIERS/OPEN-ENDED TERMS

15. AVAILABILITY STATEMENT
Unlimited

16. SECURITY CLASSIFICATION
(This page)
Unclassified
(This report)
Unclassified

17. NUMBER OF PAGES

18. PRICE

☆ U.S. GOVERNMENT PRINTING OFFICE: 1986—499-489 REGION NO. 8

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

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