OCONEE NUCLEAR STATION

HPI RELIABILITY STUDY

December 1997

Duke Power[SM]

A Duke Energy Company

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ES EXECUTIVE SUMMARY

ES.1 Background and Objectives

This report presents a detailed reliability study of the Oconee High Pressure Injection (HPI) system, which is used during the normal operation of the plant and as an accident mitigation system for certain accidents. On May 3, 1997, two HPI pumps in Oconee 3 failed while the unit was being cooled down to the cold shut down condition. This pump failure event prompted this study to fully evaluate the failure modes of the HPI system.

The Oconee HPI system consists of three high head pumps, which can take suction from the letdown storage tank (LDST, the suction source during normal plant operation) and the borated water storage tank (BWST, the suction source during the accident mitigation function). During normal plant operation, one HPI pump (A or B pump) is in service delivering flow to the reactor coolant pump (RCP) seal injection line (through HP-31) and the reactor coolant (RCS) make-up line (through the make-up control valve HP-120). For the accident mitigation function, the pumps are automatically started upon the engineered safeguard signal (ES signals 1 and 2, actuated on reactor building pressure of 3 psig or RCS pressure of 1600 psig) and deliver full flow to the RCS through two four inch HPI discharge valves and then into the four injection lines connected to each of the four RCS cold legs. The two HPI discharge headers (A and B through HP-26 and HP-27) form two trains in the discharge path for the high pressure safety injection. The capability exists to cross connect the discharge path by opening the isolation valves HP-409 and HP-410 after a loss of coolant accident to assure flow through two trains should a single failure in the HPI system occur.

The objectives of this study are:

- to obtain quantitative information on the reliability of the system for the accident mitigating functions by developing a suitable reliability model,
- to provide information on the risk significance of the various failure modes of concern,
- to facilitate identification of viable enhancements to the system, and
- to provide information on the reliability of the system for the normal operating functions.

Accident mitigation functions considered in this study include the design basis accidents analyzed in the UFSAR (Updated Final Safety Analysis Report) Chapter 15 and the accident sequences in the PRA (Probabilistic Risk Assessment) involving the HPI system.

ES.2 Methodology

The overall methodology used in this study is the PRA methodology, utilizing the fault tree and event tree methodology. The existing Oconee PRA model is modified to create a more complete reliability model of the HPI system and its interfaces. A detailed review of the Oconee and the industry operating experience related to the RCS make-up and high pressure safety injection systems is performed to identify any new failure modes of interest. The equipment failure probabilities needed for the quantification of fault trees are determined by combining generic equipment failure rates with applicable Oconee specific data. Common cause failure and human error probabilities are also studied and quantified in a manner similar to that employed in PRA studies.

The role of the HPI system in coping with the external event accident initiators and for the shutdown risk is also examined.

To define the success criteria for the accident mitigation functions of the HPI system, both the conservative UFSAR-type functional requirements (the more restrictive) and the best-estimate PRA functional requirements are considered.

Fault tree models are constructed for all unique accident mitigation functions and the normal operating functions of interest. The solutions of these fault trees provide the system reliabilities of interest.

To obtain the risk significance of the HPI system and its significant failure modes, the modified HPI system fault tree is substituted into the current Oconee PRA model and an integrated solution of the model is obtained to derive the core damage frequency results. Accident sequences containing failure modes of the HPI system are then segregated out to provide the risk significance perspective.

A number of sensitivity studies are performed to provide the information on the impact of various assumptions, alternate system configurations, and variability of data on the results and conclusions of the study.

ES.3 Results, Conclusions, and Recommendations

System Reliability Results

The reliability of the HPI system is calculated considering both the UFSAR accident mitigation functions and the PRA accident sequences. The system reliability is also determined for the various normal operating functions. Table ES-1 presents the system reliability results.

For non-LOCA UFSAR accident mitigation (primarily the steam line break and steam generator tube rupture accidents), the HPI system reliability is found to be very high (greater than 99.9 percent). The estimated failure probability of the system is 0.00028.

The principal design basis accident mitigation function of the HPI is to provide the emergency core cooling (ECCS) function (in concert with other systems such as the core flood tanks and the low pressure injection system) for small break loss of coolant accidents (LOCAs) and meet the 10 CFR 50.46 acceptance criteria. For this accident, the HPI system, taking suction from the BWST (called the injection mode), initially refills the core and establishes long-term cooling by maintaining the coolant mixture level above the top of the core.

The reliability of the HPI system for the injection mode is found to be very high (about 99.9 percent) for the most probable small break scenario (a break or leak somewhere in the reactor coolant system with an estimated annual occurrence frequency of 1E-3 per reactor year). For this case, the calculated HPI failure probability is 0.00094.

For a postulated LOCA in the HPI injection line and a small break in the RCP discharge piping, the HPI flow requirement is more restrictive than that for a random small break LOCA. For these location-specific LOCAs, the failure probability of the HPI system in the injection mode is calculated to be 0.0036.

Should continued HPI operation be required when the BWST level reaches the low level limit and if the reactor coolant system pressure remains above the value at which the low pressure injection pumps alone can continue with the long-term core cooling, the HPI system operates in the recirculation mode. The reliability of the HPI system for the post-LOCA sump recirculation mode is estimated to be 98.9% for both types of the design basis LOCA events (random small break LOCA and the HPI line and RCP discharge breaks).

In the PRA, the HPI accident sequences of interest are small and medium size LOCAs, steam generator tube rupture, and plant transients where the HPI system is relied upon for feed and bleed cooling of the core and for RCP seal injection. The reliability of the HPI system for the injection mode for all these conditions is determined to be very high, with a failure probability of 0.00094 for general LOCA and transient mitigation, 0.0025 for HPI line break or RCP discharge LOCA mitigation, 0.0012 for feed and bleed, and 0.00043 for RCP seal injection. For the PRA LOCA sequences, the HPI system recirculation reliability is also 98.9%.

For the various normal operating functions (RCS makeup, RCP seal injection, and pressurizer auxiliary spray), the HPI system reliability is estimated to be in the 93% - 98% range.

Risk Significance of HPI System Failures

Considering both internal and external events, the total core damage frequency is estimated to be 4.3E-5 per reactor year[1] using the updated Oconee PRA model and the new HPI system reliability model. The HPI system failures amount to 1.6E-5. The affected accident sequences contain the initiators of small break LOCA, medium break LOCA and various plant transients which rely on feed and bleed cooling after losing steam generator cooling.

The significant failure mode of the HPI system is during the HPI sump recirculation mode when a postulated failure to close of the check valve between the letdown storage tank and the HPI pump suction header creates the potential for flow diversion. In this analysis, credit for possible operator action to isolate the flow diversion is not taken. If this flow

[1] This figure excludes the seismic contribution. The seismic PRA model requires the use of an additional computer code to integrate the site seismic hazard with the plant system seismic fragility and random failure modes. Therefore, the seismic results are derived and presented separately from the integrated plant model solution.

diversion is isolated, the most significant failure mode of the HPI system could be ameliorated and the core damage and public health risk reduced.

Conclusions and Recommendations

The reliability of the HPI system for the various design basis accident mitigation functions is estimated to be very high, particularly during the injection mode.

The HPI system is a risk significant system, with a risk achievement worth of approximately 36. (The risk achievement worth is a measure of risk significance and is calculated as the increase in total core melt frequency if the system is assumed to fail with a probability of 1.0 instead of the calculated probability). Therefore, it is recommended that the reliability performance of this system be monitored and confirmed to be adequate on an ongoing basis **(Recommendation 1)**. (This is currently being done through the Maintenance Rule program.)

The reliability of the HPI recirculation function can be improved and the core damage significance of the HPI recirculation failure reduced by providing the capability to isolate potential flow diversion through check valve HP-97 in the HPI suction header. This can be achieved by improvements in the plant procedures and operator training or by hardware modifications if found viable. It is recommended that one of these options be implemented **(Recommendation 2)**.

A number of potential common cause failure modes were considered in the analysis. Although plant improvements have been made with respect the LDST instruments since the May 3, 1997 event, additional initiatives to reduce the common cause failure mode would be desirable. It is recommended that a more focused surveillance of the LDST level and pressure instrument strings, instead of the current refueling frequency, be considered to reduce the common cause failure probability of the LDST instruments **(Recommendation 3)**.

For the external event mitigation and for shutdown risk, no significant vulnerabilities were found for HPI system.

A number of sensitivity studies have been performed as part of this analysis to provide important perspectives on the reliability and risk significance of certain operational features of the Oconee HPI system. The results imply the following conclusions:

- The feature involving the auto-start of the second HPI pump on a low RCP seal flow signal does not have any significant adverse impact on the reliability and risk results.
- The LDST interface contributes to both beneficial and adverse impact on reliability and risk results. On the negative side, the open LDST suction header during the LOCA mitigation accounts for the LDST common cause instrument failure and HP-97 failure modes. On the positive side, this situation permits recovery from the common cause failure of the BWST suction valves HP-24 and HP-25. Also, the current arrangement preserves the HPI pump dead-heading protection and eliminates the need for operator action to isolate the HPI pump recirculation paths during the early phase of the LOCA. Based on this study, it appears that isolation of the LDST interface close to the time of HPI recirculation is the optimum configuration.
- The normally open suction header and the post-accident cross connected discharge header does not adversely affect the reliability and risk. The current arrangement enables the required HPI performance to be available when active failures of pumps and valves are considered. The impact of passive failures were found to be not significant.
- An alternate alignment of operating with HP-116 normally open was found to provide no measurable impact on plant risk.
- The Oconee HPI system is found to meet the ECCS performance requirement with adequate reliability. Further improvement in reliability can be achieved for the recirculation mode by providing the capability to isolate potential flow diversion through HP-97.

Table ES-1

HPI System Reliability Results Summary

Accident Mitigation Functions

Description	Failure Probability
Chapter 15 non-LOCA accidents	2.8E-4
Chapter 15 HPI Line Break LOCA – Injection mode	3.6E-3
PRA random-location LOCA– Injection mode	9.4E-4
PRA HPI Line Break LOCA– Injection mode	2.5E-3
Feed and Bleed Cooling– Injection mode	1.2E-3
Recirculation for Chapter 15 and PRA accidents	1.1E-2
RCP Seal Injection for Non-LOCA accidents	4.3E-4

Normal Functions

Description	Failure Probability
Normal Injection (Make-up)	5.3E-2
RCP Seal Injection	7.5E-2
Auxiliary spray	1.6E-2

1. INTRODUCTION

1.1 Background

The High Pressure Injection (HPI) system of each Oconee unit has a common suction source for the HPI pumps and does not automatically isolate the normal suction supply, the Letdown Storage Tank (LDST), on an Engineered Safeguards HPI system actuation. On May 3, 1997, Unit 3 was in cooldown when the 3A and 3B HPI pumps were rendered inoperable due to operation without an adequate suction source from the LDST. The LDST levels were erroneously indicating an adequate level when the actual level corresponded to a near empty condition. Even though the Borated Water Storage Tank (BWST) provides the primary suction for the HPI pumps during accident mitigation functions, insufficient LDST level conditions can cause HPI pump failure due to potential hydrogen ingestion from the LDST into the HPI pump suction header. The Oconee PRA model (Ref. 1) of the HPI does not contain sufficient details to account for susceptibilities of the kind implicated in this event. Therefore, in a letter from J. W. Hampton to the U. S. Nuclear Regulatory Commission, (Ref. 2), Duke Power Company committed to performing a detailed HPI System reliability study. The scope of the study was communicated to the staff in a Duke letter dated June 4, 1997.

1.2 Objective

The objective of this reliability study is to provide qualitative and quantitative information on the reliability of the HPI system to perform various accident mitigation functions, such as providing feed and bleed, RCP seal injection, and mitigation of LOCA, and SGTR events, as well as normal system functions, such as providing RCS make-up. The study will include appropriate failure modes (including those from the LDST interface) and the different configurations required for various operating situations. The results of the study will be used to formulate any recommendations with respect to potential system enhancements for failure modes of concern.

1.3 Plant Description

The Oconee Nuclear Station consists of three reactor units of the Babcock & Wilcox pressurized water reactor design, three reactor buildings, a common turbine building for all three units, and two auxiliary buildings, one servicing Units 1 and 2, and the other servicing Unit 3. At full power each unit produces 2568 MWt, generating about 860 MWe net. The design of the station began in 1967, and the units began commercial operation in 1973-1974. The balance of the plant was designed and constructed by Duke Power Company, with Bechtel Corporation designing the reactor building.

The nuclear steam supply system has two loops with two cold legs each. The two steam generators are vertical straight-tube units that produce superheated steam at constant pressure. The reactor and the nuclear steam supply system are contained within the reactor building, a prestressed, post-tensioned reinforced-concrete cylinder and dome with a steel liner. The common turbine building houses the steam and power conversion systems, electric power switchgear, and additional auxiliary systems.

The HPI system is part of the Emergency Core Cooling System (ECCS). During normal plant operation and during normal start-up and shutdown, part of the HPI system is used for reactor coolant make-up, reactor coolant pump (RCP) seal injection, and reactor coolant chemical control.

1.4 General Methodology

This study uses PRA methods such as fault trees, reliability data, success criteria, and modeling of appropriate human actions as a means to assess the reliability of the HPI System. The scope of the HPI model includes all system functions required to mitigate UFSAR Chapter 15 design basis events and probabilistically significant events of interest (i.e., includes HPI functions modeled in the Oconee Rev. 2 PRA).

An evaluation of the HPI system capability for external events (seismic, fire, tornado, and flooding events) and shutdown PRA is performed for completeness.

The model is based on Unit 3; however, due to unit similarity, the results apply to all three units. Relevant unit differences are pointed out in the report.

The modified HPI model is incorporated into the plant core melt fault tree and solved. Failures are ranked to determine their significance. Uncertainty analysis is performed on the reliability results.

This study included a walkdown of the HPI and interfacing systems as part of the system familiarization process. As the study progressed, meetings were held with the site personnel to seek clarification and obtain additional information. Finally, after the preliminary analysis and summary report were completed, a peer review was performed to ensure that the analysis results and conclusions are reasonable and meet the objectives of the study. The peer review team was composed of

- two PRA engineers
- one Safety Analysis engineer
- two site Mechanical Systems engineers
- one site I&C engineer
- two site Operations personnel, and
- one Regulatory Compliance engineer.

The final analysis and summary report incorporate the feedback from the peer review process.

2. DESCRIPTION OF THE HPI SYSTEM

The HPI System consists of three motor-driven, high pressure centrifugal pumps, with two primary suction (LDST for normal operation and BWST for emergency operation) and discharge paths. The HPI System is capable of supplying flow at a relatively high RCS pressure, with a shutoff head of 2900 psig. Each pump is capable of providing a flow rate of approximately 450 gpm at an RCS pressure of 600 psig. The design features relevant to each of the systems' three functions are described below in more detail.

The system performs both normal operating functions (including start-up and shutdown) and accident mitigation functions. The A and B HPI pumps share the normal operation and accident mitigation functions while the C pump is primarily used for accident mitigation. The system configuration is shown in Figure 2.1-1.

2.1 Normal Operation

During normal operation, one HPI pump (either the A or B pump) provides reactor coolant system (RCS) make-up, purification and chemical control and RCP seal injection. The LDST serves as the primary suction for the HPI pump in this mode of operation.

The make-up portion of the HPI System maintains the volume of the RCS within acceptable limits during most modes of plant operation. It also recirculates reactor coolant for purification, adds chemicals for the control of RCS corrosion, and controls soluble boron concentration for reactivity control. The HPI System also functions to maintain sufficient RCS volume for transient events (such as reactor trips, power reductions, etc.). Cooling for the seals of the reactor coolant pumps (RCPs) is provided by the seal injection portion of the HPI System and the Component Cooling (CC) System. The RCP seals serve to prevent the leakage of reactor coolant between the shaft and the housing of the RCPs. When the RCS is at a high temperature, the seals must be cooled to keep them from warping, to keep the seal faces from becoming cracked or eroded, and to prevent the O-rings from extruding. The prolonged interruption of cooling flow can result in seal damage, leading to increased RCS leakage or small-break LOCA conditions.

The make-up function is achieved primarily by a portion of the HPI System and by the Coolant Storage and Chemical Addition Systems. Make-up flow is supplied by either pump A or B and is controlled automatically to balance normal leakage and RCS volume imbalances due to temperature variations. Letdown flow from the RCS accommodates small increases in RCS volume due to in-leakage from the seals of the RCPs and variations in RCS temperature. The normal injection path allows for RCS inventory control during most transient conditions other than accident conditions involving Engineered Safeguards (ES) actuations. If the system is not meeting the requirements for inventory control after a reactor trip, manual action can be taken to start additional HPI pumps, establish additional discharge paths to RCS, or align to the borated water storage tank (BWST) for assurance of a sufficient suction source. Figures 2.1-1 and 2.1-2 diagram the make-up and letdown portions of the HPI System.

Seal injection flow is provided by the HPI pump that is operating to supply normal RCS make-up. Figures 2.1-3 and 2.1-4 are simplified flow diagrams of the seal injection and return portion of the HPI System. The injection flow is controlled by air-operated valve HP-31. It enters each RCP at the face of the lower seal and divides such that some flow passes to the upper seal chamber while the remainder flows downward across a recirculation device and into the RCS. Approximately 40 gpm (for Units 2 and 3; 32 gpm on Unit 1) is circulated through the lower seal chamber and an external heat exchanger, where heat is rejected to the CC System. The portion of the seal injection flow that does not leak into the RCS is returned to the LDST after being cooled by one of the two heat exchangers.

Two RCP seal filters prevent particulates from entering the pump seals. One is normally in use, with a normal operating flow of 40 gpm (for Units 2 and 3; 32 gpm for Unit 1). RCP seal flow is controlled automatically by valve HP-31.

Oconee Units 2 and 3 are equipped with RCPs manufactured by Bingham, while Unit 1 uses Westinghouse pumps. The Bingham seal design includes a recirculation impeller, which aids in seal cooling. This feature, in combination with CC System cooling through the RCP seal thermal barrier coolers, allows normal RCP operation to continue after a loss of seal injection from HPI. The Units 2 and 3 RCP seals are more tolerant to seal damage from loss of seal cooling compared to the seals on Unit 1 RCPs.

The HPI pumps are sized so that one pump can supply seal injection flow for the RCPs (approximately 40 gpm for Units 2 and 3) and the make-up required due to letdown for purification, deboration and changes in the reactor coolant volume due to small temperature changes. Pump A or B is normally in operation with the other in standby. Pump C is used as an emergency supply to injection header B.

Minimum flow (approximately 33 gpm per pump) is provided for each HPI pump to avoid pump damage from a loss of flow condition. This minimum flow is returned to the LDST through the seal return coolers.

Unless the Auxiliary Shutdown Panel is selected as the pump control station, HPI pumps A and B will automatically start on low seal injection flow when their control switch is in the AUTO position. The A and B pumps also auto-start following a loss of power under these conditions when power is recovered.

Normal make-up to the RCS is through control valve HP-120, which is controlled automatically to maintain pressurizer level. Low pressurizer level will cause HP-120 to open, which will usually result in low seal injection flow and auto-start of the second ('A' or 'B') HPI pump.

Reactor coolant is constantly let down at a rate of approximately 72 gpm through a block orifice that reduces the pressure from 2155 psig to about 50 psig. There are two parallel bypasses around the block orifices. One is manual (HP-42) and the other (HP-7) is controlled from the control room for increased flow or during low pressure operation.

Prior to reaching the block orifice, letdown coolers reduce the temperature of the letdown flow from 555°F to approximately 120°F. This is for protection of the demineralizer resins and RCP seals.

Letdown isolation valve HP-5 closes automatically on a high temperature signal from sensors downstream of the block orifice. This signal must be bypassed before HP-5 can be reopened after closing from a high temperature condition.

The letdown flow is passed through the purification demineralizers to remove reactor coolant impurities. The demineralizers may be bypassed by motor-operated valve HP-13 if larger letdown flow is desired. The effluent of the demineralizer is then routed to three-way valve HP-14, where it can be routed to the 'A' or 'B' bleed holdup tank, deborating demineralizers, or the inlet to the letdown filters. The letdown filters remove any particles already in the RCS and prevent any from entering during chemical addition or make-up from the bleed holdup tank. The two filters are in parallel, with one normally in operation.

The LDST receives water from the letdown filters and from the seal return coolers. A low-low level alarm in the LDST positions valve HP-14 to direct flow to the LDST if it has not already been so positioned. Maximum allowable LDST level is 100 inches. Normal operating level is 55 to 92 inches. Letdown entering the tank is sprayed in so that it will absorb hydrogen (for oxygen scavenging).

During most of core life, the feed and bleed method is used for boron reduction (or make-up). This is the process of periodically directing the letdown flow to a bleed holdup tank (via HP-14) while maintaining the LDST level with water at less than RCS boron concentration (via HP-16). The flow of make-up water is measured and totaled by inline flow instrumentation. In addition to the normal supply from the concentrated boric acid mix tank, there are two alternate supply lines. These supply lines are from the boric acid mix tank and are used if normal supply is restricted or blocked, ensuring boric acid can always be supplied to the RCS.

Hydrogen overpressure is maintained in the LDST to assure a slight amount of excess hydrogen in the circulating reactor coolant to control oxygen. Both hydrazine and lithium hydroxide are added from the Chemical Addition and Sampling System as required. Hydrazine is used for oxygen control and lithium hydroxide is used to control pH. Both chemicals are added upstream of the letdown filters.

During plant start-up and shutdown when normal pressurizer spray is unavailable (due to the RCPs being off), the pressurizer auxiliary spray is used for pressurizer pressure control and pressurizer boron concentration adjustment. The auxiliary spray injection is provided from the discharge of the running HPI pump.

2.2 Accident Mitigation Functions

2.2.1 UFSAR Chapter 15 Accident Mitigation

With respect to UFSAR Chapter 15 accident analysis, the main design accident mitigation function of the HPI system is to provide part of the ECCS function during loss of coolant accidents. In accomplishing this function, the HPI system automatically initiates upon an ES signal, taking suction from the BWST and injecting into the RCS cold legs through four injection lines. For large break LOCAs, the HPI function is not essential for assuring adequate core cooling since the low pressure injection system and core flood are adequate for refilling the reactor core and maintaining core cooling.

It is primarily the small break LOCA events where the LPI injection is insufficient because of RCS pressure conditions that the HPI function is essential. During the injection phase, the HPI system takes suction from the BWST and discharges into the

RCS cold legs. If the RCS pressure reaches the LPI injection conditions, the HPI function can be terminated. However, the combination of a narrow window of break sizes and RCS conditions could be such that the RCS pressure remains above the shutoff head of the LPI pumps. In this situation, the HPI suction needs to be aligned to the LPI pump discharge header when the BWST level reaches the set point for swap over to the reactor building emergency sump, where the LPI pumps take suction at this time of the accident phase. This is usually referred to as the piggy-back mode of operation. This mode of operation can be exited when the RCS pressure is reduced to the condition where LPI can inject directly into the reactor vessel.

Initiation of the HPI System in the emergency injection mode requires the opening of at least one of the suction valves, HP-24 and HP-25, that isolate the HPI pumps from the emergency suction source, the BWST. All three pumps receive ES signals on low RCS pressure and/or high RB pressure, although the signal is only confirmatory for the normally operating pump. Discharge valves HP-26 and HP-27 also receive signals to open, although valve HP-27 is normally open. When the BWST and RB Emergency Sump reach levels specified in emergency operating procedures, the HPI pumps' suction source is switched to the discharge piping of the low pressure injection (LPI) pumps to initiate the emergency recirculation mode of operation.

For ES conditions, the HPI System is initiated if RCS pressure decreases to 1600 psig or if RB pressure increases to 3 psig. Under these conditions, the following actions are automatically initiated by ES:

1. Three isolation valves (HP-3, HP-4 and HP-5) in the purification letdown line close, and two isolation valves (HP-20 and HP-21) in the seal return line close.

2. All HPI pumps start.

3. Discharge valves (HP-26 and HP-27) receive an open signal.

4. BWST outlet header valves (HP-24 and HP-25) open.

For a random small break LOCA, one HPI train is adequate for the ECCS function. Should the LOCA occur in the HPI line or in the immediate vicinity of the RCP discharge, two HPI pumps are necessary to assure adequate core cooling assuming the conventional set of conservative assumptions. To maintain this capability, the HPI pump suction header cross connect is open when the suction is aligned to the BWST. Otherwise a worst-case single failure (e.g., failure of HP-24 to open) could fail two HPI pumps. On the discharge side, cross connects are provided with isolation valves HP-409 and HP-410 to enable HPI injection by two HPI pumps should a single failure of HP-26 (failure to open) occur. The operators open HP-409 and HP-410 within 10 minutes after accident initiation to ensure injection into all four injection lines.

Automatic HPI actuation also occurs for certain non-LOCA accidents such as severe overcooling events (due to a steam line break or other excessive RCS heat removal events). For these events, the accident mitigation function is to rapidly compensate for RCS shrinkage using borated water from the BWST.

The HPI system also provides RCS makeup to compensate for inventory loss and shrink following a SGTR. For other UFSAR Chapter 15 events, HPI is used by manual action for post-transient recovery.

The success criteria for accident mitigation for the design basis accidents are presented in Section 4.4.

2.2.2 PRA Accident Sequence Mitigation

The High Pressure Injection (HPI) System performs three functions that are important with respect to the event sequences analyzed in the PRA for core damage and public risk consideration.

First, the HPI System provides core cooling in the event of a small or medium break LOCA. Second, it provides an alternative means of core heat removal if the ability to cool via the steam generators is lost (feed and bleed cooling). Third, it is relied upon to prevent RCP seal LOCA following transients if the Component Cooling to the RCP seals is lost. It should be noted that the SSF reactor coolant make-up pump provides an alternate means of RCP seal cooling if the HPI RCP seal cooling is also lost.

For LOCA core cooling the HPI system operation is identical to that described above in the design basis case described in Section 2.2.1. Only one pump with suction aligned to the BWST is needed for LOCA mitigation and feed and bleed cooling. For common cause failures of HP-24 and HP-25 to open, the operator can make use of the BWST to LPI to HPI suction alignment as a recovery action, provided the LDST is not isolated immediately after the accident, so that the HPI pumps can continue operating with the LDST suction.

For feed and bleed cooling, full HPI flow is initiated (two pumps, two injection headers) and the pilot-operated relief valve (PORV) is opened to provide a flow path out of the RCS. The HPI flow through the core and out the PORV is throttled to maintain the RCS at the desired subcooling margin and to ensure core exit thermocouple readings are decreasing. When secondary side heat removal is restored, the PORV is closed and HPI make-up and letdown are throttled to maintain RCS pressure until pressurizer temperature is sufficient to draw a pressurizer steam bubble at the desired pressure. Make-up and letdown are further throttled to allow a slow decrease in pressurizer level.

For the RCP seal cooling, only one HPI pump with suction from either the LDST or BWST is sufficient.

The success criteria for PRA sequences are further described in Section 4.4.

2.3 HPI system interfaces

Letdown Storage Tank

The 600 ft^3 (~4500 gal.) LDST functions as the collection point for purification letdown flow, RCP seal return flow, and HPI pump recirculation flow. The suction head for the HPI pumps from the LDST is made up of two components -- minimum tank level and hydrogen overpressure, which is maintained for oxygen scavenging. Limits are placed on the maximum hydrogen overpressure for the operating tank level range to assure that the gas bubble in the tank cannot expand into the HPI pump suction piping during accident mitigation if the BWST level approaches the low setpoint. This is achieved by administrative limits and alarm set points for the pressure and level combinations. Also, the low pressure is limited so that HPI pumps do not pull a vacuum on the LDST, which could cause damage to the pumps.

The normal flow into the LDST is 72 gpm through the letdown piping, 8 gpm through the RCP seal return line (2 gpm from each pump), and 33 gpm through the operating HPI pump recirculation line. At the same time, the HPI pump is supplying 40 gpm to RCS as normal makeup, 40 gpm (32 gpm on Unit 1) to the RCPs for seal injection (10 for each pump), and 33 gpm for recirculation flow. Thus, at the normal operating pressure, the operating HPI pump flow is 113 gpm and the RCS makeup flow and letdown flow are balanced. The control room LDST level indication allows operators the capability to maintain RCS volume management. Pressurizer level is automatically maintained at 220"; therefore, any RC volumetric changes will be seen in the LDST level. During normal operation, the LDST is maintained at a level between 55 and 92 inches by system operating procedure. (One inch corresponds to approximately 31 gallons over the level range of interest.) The water level lower instrument tap is at 28 inches above the bottom of the tank, with 690 gal. of water available below the low level tap.

LDST Instrumentation

The LDST level is monitored in a 0-100 inch range by two separate but identical level instrumentation loops each consisting of a differential pressure transmitter connected to a signal monitor module in an Auxiliary Control System (ACS) cabinet and sent to a dual indicator on the control board. (The reference leg for the level instrument has been modified since the May 3, 1997 event to provide separate reference legs for the two loops.) High level and low level alarm relays in the chart recorder circuitry connect to an "HP Letdown Tank Level High/Low" statalarm on unit board UB1. The power supply for the instrumentation loops is from the Auxiliary Control Power KI Bus and will transfer to the Auxiliary Control Power KU Bus on loss of voltage.

The differential pressure transmitters shown in Figure 2.3-1 are each connected to a reference leg and a level sensing leg through an isolation manifold, which has an isolation valve for each leg and an equalizing valve used in calibration of the instrument. Each instrument's reference leg contains a reservoir to ensure the reference leg remains full. Both reference legs are attached at a "T" connection and are connected to the top of the tank through a common isolation valve. The level sensing lines are similarly attached to a "T" and to the bottom of the tank through a common isolation valve.

The LDST pressure is monitored by two pressure instrumentation loops. The first is a pneumatic signal from a pneumatic transmitter that serves pressure switches (which provide high and low pressure alarms) and a pneumatic receiver gauge in the control room. The loop's air supply is from the Instrument Air system. The second is an electronic loop with an electronic pressure transmitter and a Lambda power supply mounted in Miscellaneous Terminal Cabinet MTC4 and receiving its power from 120 Vac Vital I&C Power Panelboard KVIC. This pressure signal is monitored and alarmed by the OAC.

The pressure impulse lines share a common root valve but are run separately from that point. Isolation valves are installed in both lines at the branch to provide isolation between the transmitters.

Air Systems

The Auxiliary Air and Instrument Air Systems supply air to a number of valves required for the HPI system to function in the normal make-up and RCP seal cooling modes. The pneumatic valves are identified in the system configurations in Figures 2.1-1 through 2.1-6 and in Table 2.3-1. Upon loss of air pressure, all the pneumatic valves transfer to or remain in the closed position with the exception of the control valve for seal injection flow to the RCPs, HP-31, which opens fully.

Cooling Water Systems

Cooling for the HPI pump motors and the component coolers is provided by the LPSW System. Backup cooling to the HPI pump motors is provided by the High Pressure Service Water (HPSW) System automatically through self-contained regulating valve HPSW-556.

Electrical Power Supplies

The pumps and motor-operated valves (MOVs) of the HPI system require motive power from the AC Power System. Control power for the HPI pumps is provided from the DC Power System. Control power for other pumps and MOVs is derived from the same source as the component's motive power. Some air-operated valves (AOVs) require solenoid power from the DC Power System. HPI system components and their power supplies are listed in Table 2.3-2.

External Control Systems

The HPI System is placed into its emergency injection mode upon receipt of a signal from Engineered Safeguards (ES) System channel 1 or 2 (low RCS pressure and/or high RB pressure). Table 2.3-3 lists the HPI system components that receive ES signals.

2.4 HPI System Testing

The HPI pumps are tested quarterly or after any pump maintenance. A full flow test of the HPI system is performed each refueling outage to verify pump developed head flow and pump discharge check valve operation. ES actuation of the HPI System is verified during each refueling. In addition, an on-line functional check of the ES logic sub-system and associated digital computer inputs and statalarms is perfonned each month. MOVs which are required to perform a design basis function are stroke tested and undergo verification in accordance with the NRC Generic Letter 89-10 program. A more complete rundown of HPI testing is given in Table 2.4-1.

Table 2.3-1

Unit 3 HPI System Air-Operated Valves

Valve	Description	Failure Position Loss of Air	Loss of Power
3HP-5	Letdown isolation valve	Closed	Closed
3HP-6	Letdown orifice stop valve	Closed	Closed
3HP-7	Letdown flow control valve	Closed	Closed
3HP-8	Demineralizer inlet valve	Closed	Closed
3HP-9	Spare purification demineralizer inlet valve	Closed	Closed
3HP-11	Spare purification demineralizer outlet isolation valve	Closed	Closed
3HP-13	Demineralizer bypass valve	Closed	Closed
3HP-15	LDST make-up flow control valve	Closed	Closed
3HP-16	LDST make-up isolation valve	Closed	Closed
3HP-17	Letdown filter 3A inlet valve	Closed	Closed
3HP-18	Letdown filter 3B inlet valve	Closed	Closed
3HP-19	Make-up filter bypass valve	Closed	Closed
3HP-21	RCP seal return block valve	Closed	Closed
3HP-31	Seal injection flow control valve	**Open**	**Open**
3HP-120	Normal make-up control valve	Closed	Mid-stroke

Table 2.3-2

Unit 3 HPI System Component Power Supplies

Component	Supply
HPI pump 3A*	4 kV ac switchgear 3TC Unit 8
HPI pump 3B*	4 kV ac switchgear 3TE Unit 9
HPI pump 3C*	4 kV ac switchgear 3TD Unit 9
3HP-1, Letdown cooler A inlet isolation valve	208 V ac MCC 3XO compt. R1D
3HP-2, Letdown cooler B inlet isolation valve	208 V ac MCC 3XP compt. R1C
3HP-3, Letdown cooler A outlet valve	208 V ac MCC 3XSF compt. F01C
3HP-4, Letdown cooler B outlet valve	208 V ac MCC 3XSF compt. F01D
3HP-5, Letdown isolation valve	125 V dc power panelboard 3DIB breaker 25
3HP-6, Letdown orifice stop valve	208/120 V ac power panelboard 3KD breaker 19
3HP-8, Purification demineralizer inlet valve	208/120 V ac power panelboard 3KD breaker 17
3HP-9, Spare purification demineralizer inlet valve	208/120 V ac power panelboard 3KD breaker 17
3HP-11, Spare purification demineralizer outlet valve	208/120 V ac power panelboard 3KD breaker 17
3HP-13, Purification demineralizer bypass valve	208/120 V ac power panelboard 3KD breaker 17
3HP-14, Bleed control valve	208 V ac MCC 3XL compt. 5D
3HP-15, LDST make-up flow control valve	208 V ac MCC 3XL compt. 5D
3HP-16, Make-up isolation control valve	208 V ac MCC 3XL compt. 5D
3HP-17, Letdown filter 3A isolation Valve	208/120 V ac power panelboard 3KD breaker 18

*In the event of a loss of 4 kV power, emergency power can be provided to one HPI pump from the auxiliary service water switchgear.

Table 2.3-2

Unit 3 HPI System Component Power Supplies

Component	Supply
3HP-18, Letdown filter 3B isolation valve	208/120 V ac power panelboard 3KD breaker 18
3HP-19, Letdown filter bypass valve	208/120 V ac power panelboard 3KD breaker 18
3HP-20, RCP seal return valve	208 V MCC 3XSF compt. F02C
3HP-21, RCP seal return isolation valve	125 V dc power panelboard 3DIB breaker 25
3HP-22, LDST drain valve	208/120 V ac power panelboard 3KD breaker 18
3HP-23, HPI pump suction valve	208 V ac MCC 3XL compt. 5E
3HP-24, Borated water to HPI pump 3A valve	208 V ac MCC 3XS1 compt. R1D
3HP-25, Borated water to HPI pump 3C valve	208 V ac MCC 3XS2 compt. R1A
3HP-26, HPI to loop A reactor inlet valve	208 V ac MCC 3XS1 compt. R2A
3HP-27, HPI to loop B reactor inlet valve	208 V ac MCC 3XS2 compt. R1B
3HP-98, HPI pumps suction crossover valve	208 V ac MCC 3XL compt. 6D
3HP-115, HPI pumps discharge crossover valve	208 V ac MCC 3XN compt. 5D
3HP-226, RCP 3A2 seal return isolation valve	208 V ac MCC 3XT compt. 6D
3HP-228, RCP 3A1 seal return isolation valve	208 V ac MCC 3XT compt. 5D
3HP-230, RCP 3B2 seal return isolation valve	208 V ac MCC 3XT compt. 6E
3HP-232, RCP 3B1 seal return isolation valve	208 V ac MCC 3XT compt. 5E
3HP-409, HPI isolation from HPI pump crossover valve	600 V ac MCC 3XS3 compt. 2D
3HP-410, HPI isolation from HPI pump crossover valve	600 V ac MCC 3XS3 compt. 2D
3GWD-19, LDST vent valve	208/120 V ac power panelboard 3KD breaker 19

Table 2.3-3

Unit 3 HPI System ES Actuated Components

Component	Description and Action
HPI pumps 3A, 3B, 3C	HPI pumps - start and go to full speed
3HP-3, 3HP-4, 3HP-5	Letdown line RB isolation valves - close
3HP-20 and 3HP-21	Seal return line RB isolation valves - close
3HP-24 and 3HP-25	HPI pumps suction from the BWST valves - open
3HP-26 and 3HP-27	HPI emergency injection lines valves - open

Table 2.4-1

Unit 3 HPI System Testing

Test	Frequency	Description
PT/0/A/0202/12 HPI System ES test	Each refueling	Verifies proper ES channels 1 and 2 actuation of HPI pumps and valves. Also verifies manual actuation and control of these components using RZ modules.
PT/0/A/0230/15 HPI motor cooler flow test	Each cold shutdown	Verifies proper HPI motor cooler flow from LPSW and HPSW.
PT/0/A/0251/09 HPI check valves functional test	Prior to each startup	Verifies operability of check valves 3HP-97, -101, -102, -105, -109, -113, -188, -194, -486, -487, -488, and -489.
PT/3/A/0152/11 Valve functional test	Quarterly, each refueling, and each cold shutdown	Procedure contains three enclosures to stroke test various valves including 3HP-3, -4, -20, -21, -24, -25, -26, -27; 3LP-15, -16.
PT/3/A/0202/11 HPI Pump test	Quarterly and after any maintenance.	Verifies proper HPI pump performance. Also verifies operability of respective pump discharge check valve (3HP-105, 3HP-109, 3HP-113).
PT/3/A/0230/18 HPSW to HPI motor cooler flow test	Each cold shutdown	Verifies automatic HPSW backup flow to the HPI pump motors on loss of LPSW flow.

Table 2.4-1

Unit 3 HPI System Testing

Test	Frequency	Description
IP/0/A/0310/12A, IP/0/A/0310/13A Monthly ES test	Monthly	An on-line functional check of the ES logic sub-system and associated digital computer inputs and statalarms.
PT/3/A/0150/23 System Leakage Test	Refueling	Checks for visible leakage on HPI valves outside containment.
PT/3/A/0251/24 HPI full flow test	Refueling	Verify pump developed head flow and associated check valve operation.

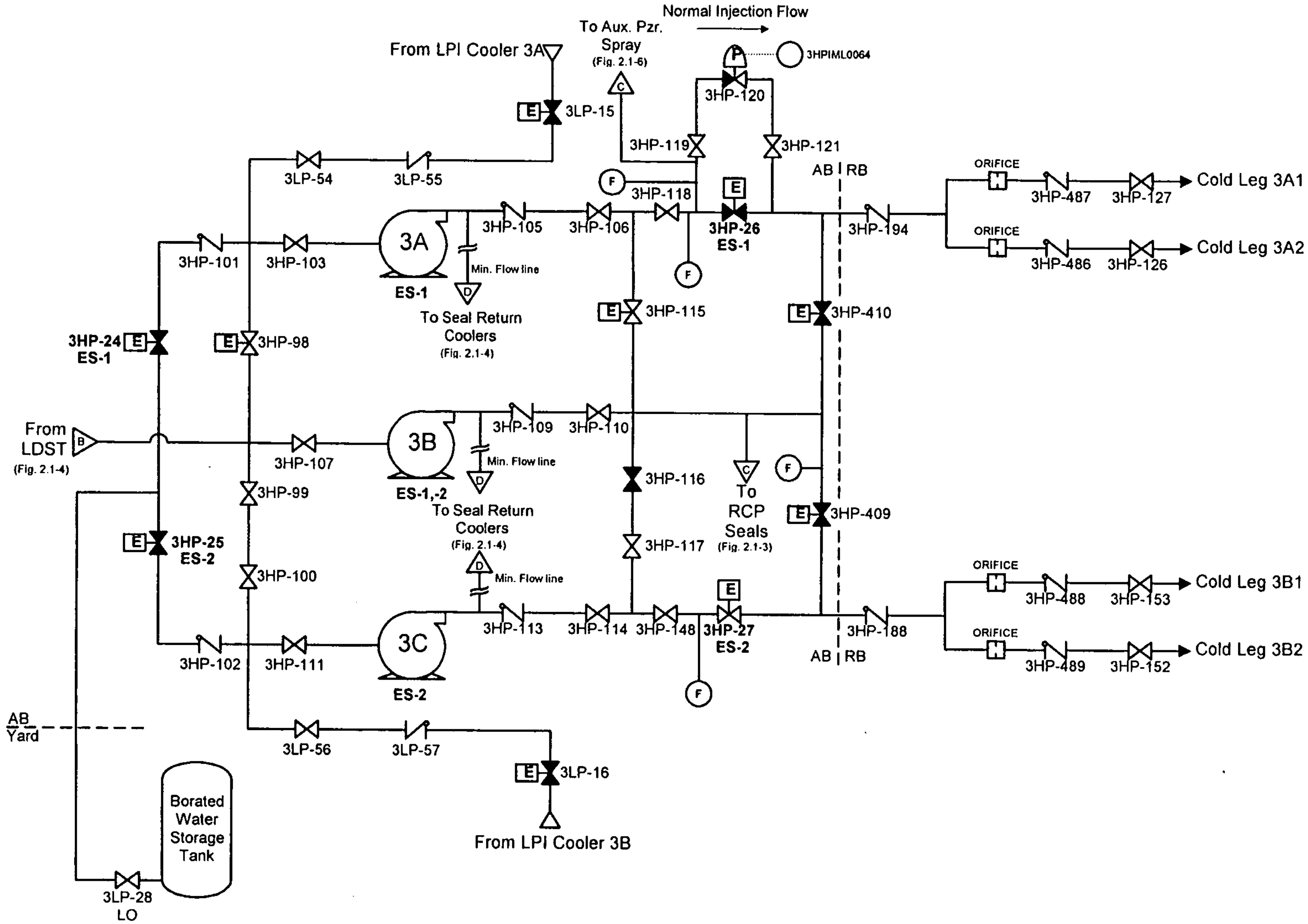


Figure 2.1-1 HPI System Configuration (Unit 3)

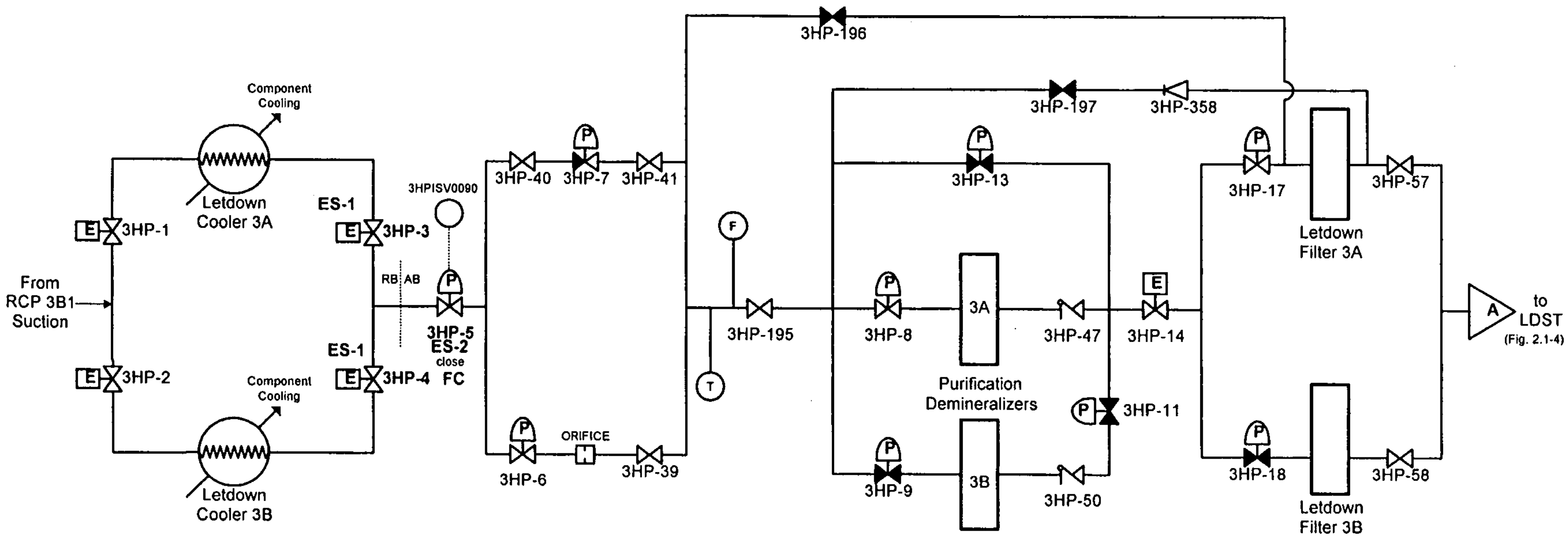


Figure 2.1-2 Normal Letdown Flow (Unit 3)

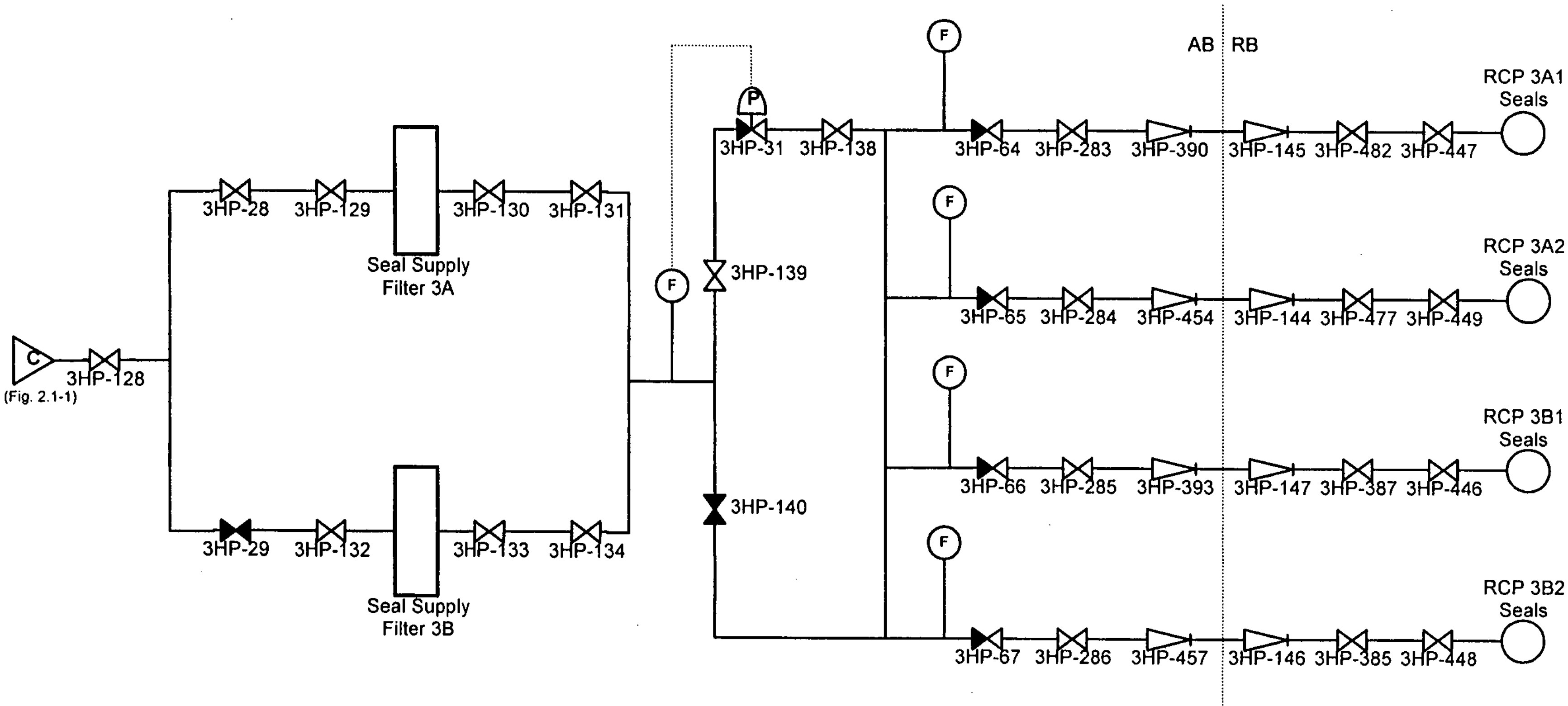


Figure 2.1-3 Reactor Coolant Pump Seal Injection (Unit 3)

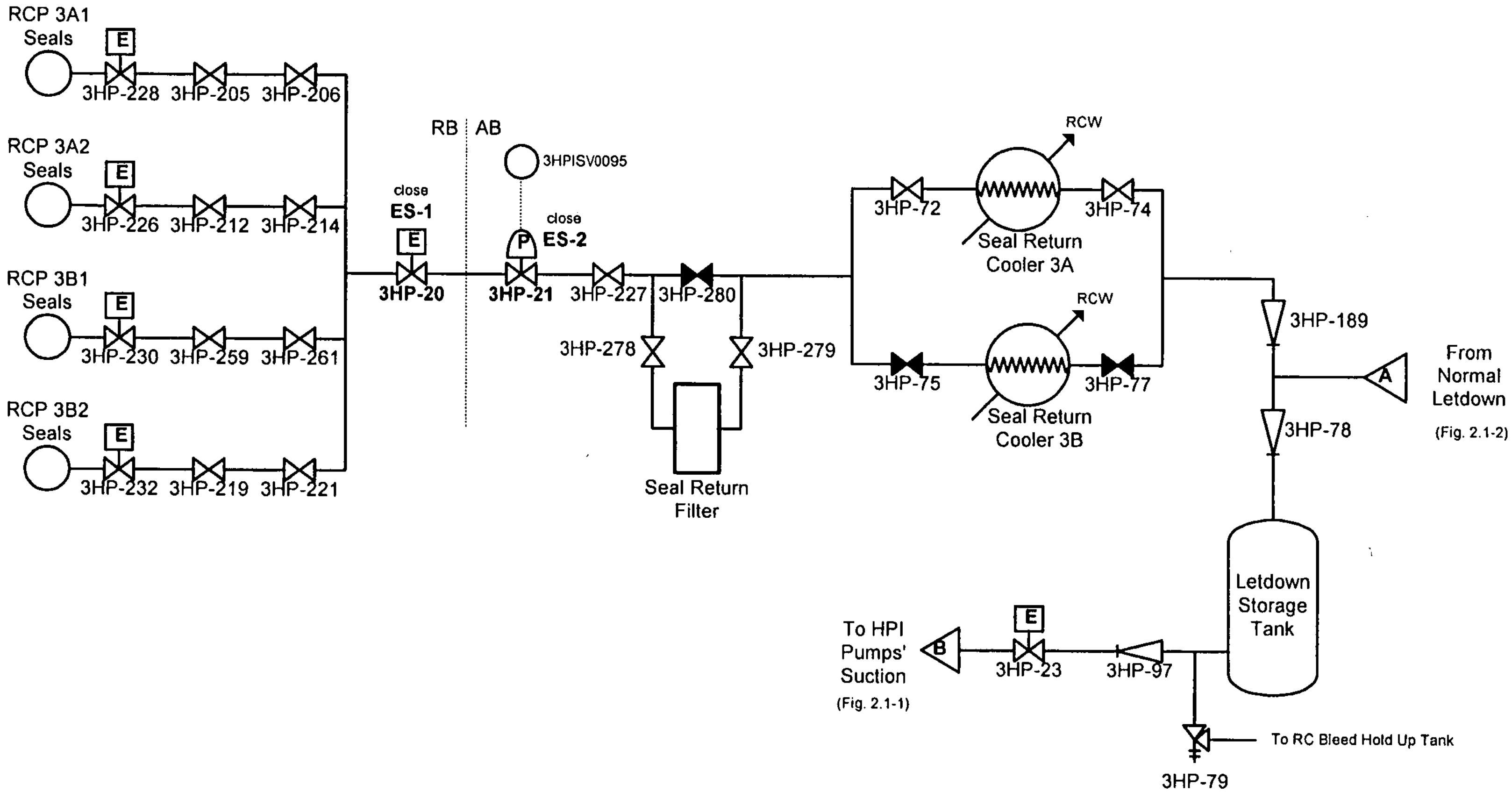


Figure 2.1-4 Reactor Coolant Pump Seal Return (Unit 3)

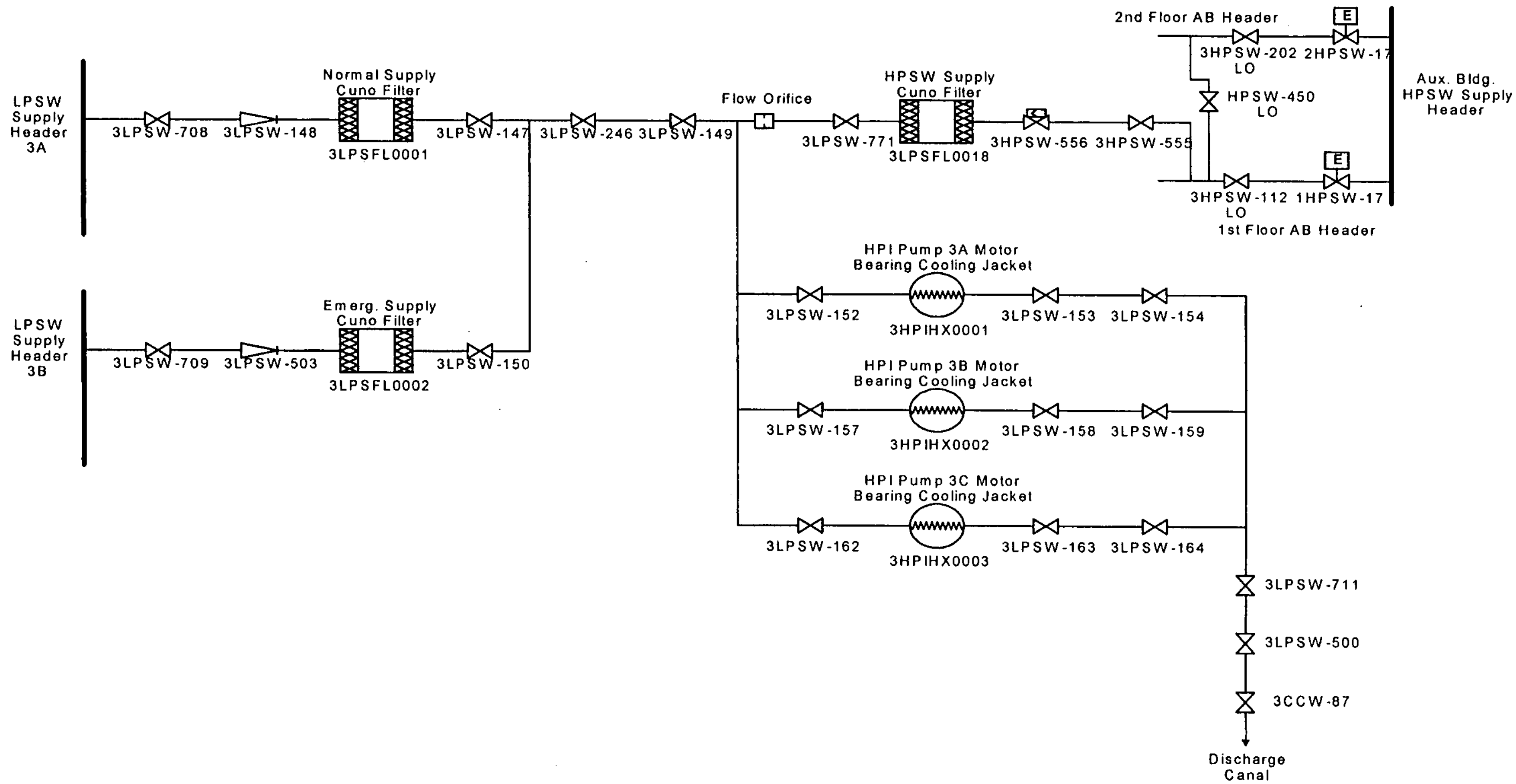


Figure 2.1-5 Cooling Water Flow to HPI Coolers (Unit 3)

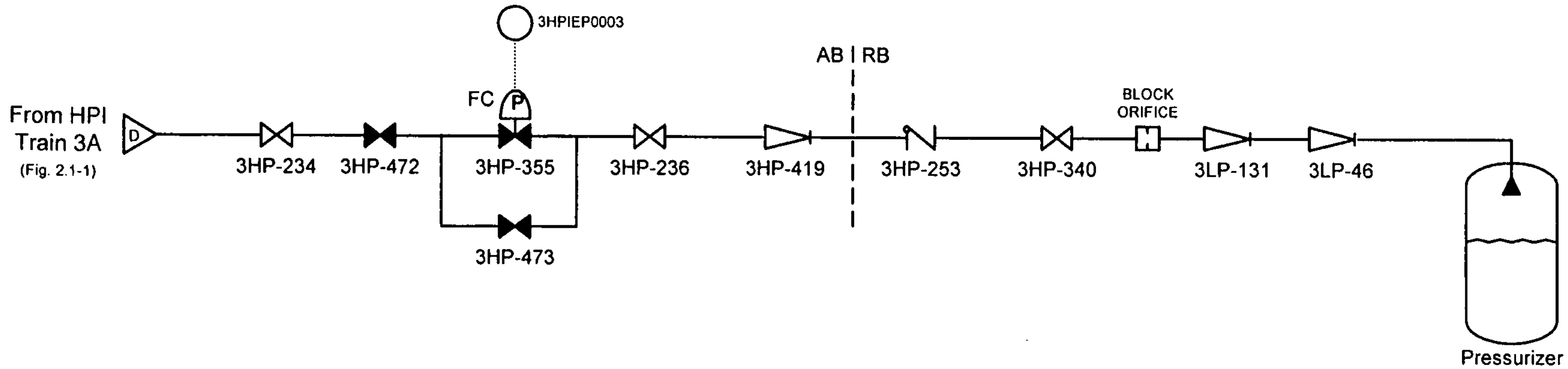
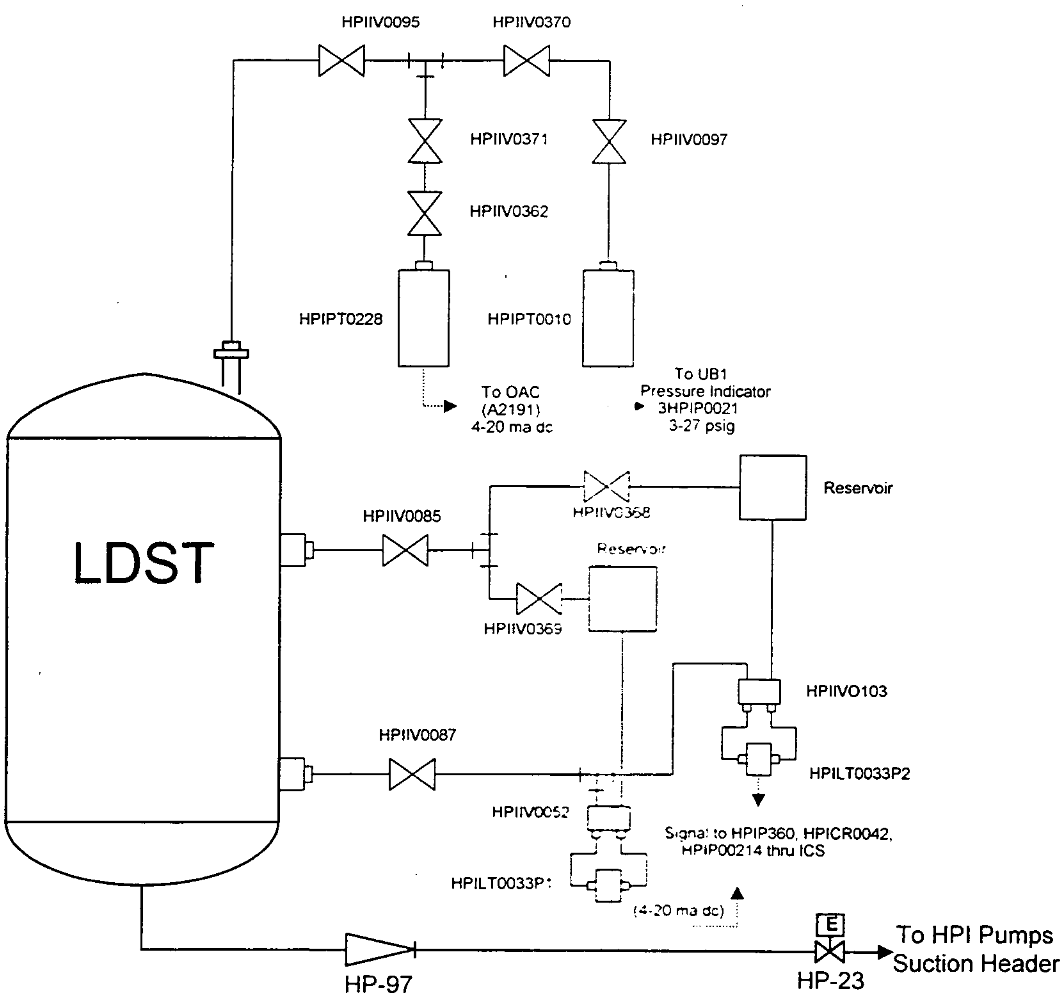


Figure 2.1-6 Auxiliary Pressurizer Spray (Unit 3)

Figure 2.3-1 Letdown Storage Tank Instrumentation



3. OPERATING EXPERIENCE OF THE HPI SYSTEM

3.1 Objectives and Process

A broad review of industry operating experience was conducted for high pressure injection and charging systems. There were two primary objectives for this review:

- Characterize industry operational experience among high pressure safety injection and charging systems according to the causes of failure, system interactions, and impact on system operation during normal and accident conditions.
- Identify new failure modes or failure mechanisms which have not previously been considered in the HPI reliability model.

The review process consisted of three parts:

- Identify items to review from industry reports, notices, bulletins, and other sources.
- Categorize items by failure cause and screen items not relevant to this study.
- Determine impact of events and issues on HPI reliability model.

A variety of information sources were reviewed including NRC Information Notices, Licensee Event Reports (LERs), Significant Event Reports (SERs), the Duke Power Operating Experience Program (OEP) Database, Problem Investigation Process (PIP) Database, INPO Operating Experience Reports, and other miscellaneous sources. The review focused both on outside industry experience and on Oconee-specific experience above and beyond the data collected for estimating equipment failure rates (see Section 4.5.1).

The industry review primarily covered the period from 1988 through 1996. Some recent events as well as some events that occurred prior to 1988 were considered for completeness. The Oconee review covered the period from the mid-1970s to the present.

The review of the Oconee operating experience is very detailed and complete due to the availability of information while the review of the industry operating experience is considered "broad". Therefore, more events (both significant and of lesser significance) are considered from the Oconee operating experience compared to the industry database, which presumably contains mostly significant events.

3.2 Industry Experience

A listing of HPI industry operating events is provided in Attachment A. 169 "events" were identified with relevant failures or problems in HPI or charging systems. A wide variety of failure causes were found. Figure 3.2-1 below shows a distribution of types of failures among the events reviewed. The impact on HPI system availability of individual events varied. In some cases, the system or component in question may have been only degraded or in an incipient failure condition. In these cases, the event was denoted as a "potential" failure to distinguish these events from those where the system or component actually failed. An example would be a design error that is found that would cause the system to fail during a loss of coolant accident.

Common cause events that degrade or disable multiple components or redundant trains of equipment are also of special interest to this study. Common cause events are denoted on Figure 3.2-1.

The impact on plant operation of individual events also varied greatly. In some cases, failures occurred in plant modes where HPI was not required and others were caused by or were worsened by plant maintenance or outage activities.

It is also important to note that many events are actually caused by a combination of different failure causes. In this case, the event was attributed to the primary or most important cause as best it could be determined. The prominent example of this were equipment problems that are combined with human error. The "Human Error" category in Figure 3.2-1 represents events that were solely attributed to human error. However, human error contributed directly or indirectly in a large fraction of the other events.

During the 1980s several generic industry issues came to light regarding HPI system reliability. One of these issues concerned the degradation of certain Westinghouse pumps due to normal wear and tear while performing the duties of seal injection and normal RCS makeup. Another issue concerned recurring pump shaft failures on certain Ingersoll-Dresser pumps supplied by Westinghouse. Neither of these issues is applicable to Oconee.

The generic industry issue which is of particular interest to Oconee is gas binding. These events are significant due to the potential to damage multiple HPI pumps due to common suction lines and connections in the suction piping for the pumps. A list of industry gas binding events is provided in Table 3.2-1.

These gas binding events were further broken down by the location where the gas came from (Figure 3.2-2), the cause of the gas accumulation or entrainment (Figure 3.2-3), and by the plant where the event occurred (Figure 3.2-4).

Another important observation made during the review of industry operating experience is the role of maintenance activities. Maintenance activity in this case refers to the entire process of how the equipment is operated, maintained, and tested. These activities can affect equipment and system reliability in several different ways. Several of the more important aspects from the operating experience review are indicated in the following table.

Maintenance Aspects Which Affect HPI System Reliability

During Normal Op	Taking Out of Service	During System Maint.	Returning to Service
Periodic Testing	Planning & Scheduling	Effective PMs	Administrative Controls
Performance Monitoring	Procedural Guidance and Training	Quality Materials And Workmanship	Independent Verification
Predictive Maintenance	Administrative Control	Proper Inspection, Diagnosis, and Repair	Post-Maintenance Functional Testing
Status Checking	Proper Frequency of Preventive Maint. (PM)	Skillful, Well-Trained Maintenance Personnel	Observation and Status Checking

Note: Shaded boxes indicate items which seek to prevent errors or failures versus trying to detect them.

Note that preventing errors and failures is only one part of the process. Detecting errors or abnormal operating conditions prior to an actual plant emergency plays an equally important role. Industry experience shows that in most cases, effective testing and monitoring will detect errors or failed equipment in a timely manner. Only in a few instances do problems go undetected for extended periods of time. For the case of HPI Systems, the primary weakness in detecting failures has occurred in detecting LDST (or VCT) level instrumentation failures and in detecting the presence of gas accumulation in HPI suction piping or LPI "piggy-back" lines.

3.3 Oconee Experience

A listing of Oconee HPI significant operating events is provided in Table 3.3-1. The types of equipment failures and human errors observed at Oconee are similar to those seen in the rest of the nuclear power industry.

One important similarity is the occurrence of three gas binding events. One of the Oconee events (the May 1997 event) was determined to be an accident precursor event (CMF>1E-6) and was the only event that resulted in actual pump damage. Due to the susceptibility of HPI pump damage from gas binding during accident mitigation, potential conditions that could induce gas entrainment to the pump suction should be minimized.

Based on this experience, defensive measures against such events should be reviewed, evaluated, and implemented where appropriate. Evaluation of such improvements is part of the overall objective of this HPI reliability study.

Component mispositioning is another important similarity. This type of human error typically involves either valves or electrical breakers that are placed in an incorrect position. Oconee, like the rest of the industry, has seen much improvement in this area in recent years due to efforts to improve human performance through improved procedures, work control processes, training, and self-checking.

As discussed earlier, an effective maintenance program is an essential part of maintaining a reliable HPI system. At Oconee the effectiveness of the total maintenance program is reflected in the number of failures and the unavailability of the system. The Maintenance Rule program implemented at Oconee monitors both functional failures and system unavailability for the HPI system and sets limits for failures and unavailability that are commensurate with the risk significance of the HPI system. Exceeding either of these limits puts the HPI system into a special actions status ("A-1") that receives additional managerial attention and oversight to ensure that corrective actions implemented are effective and that performance is improved.

A list of maintenance rule functional failures for the Oconee HPI system is provided in Table 3.2-2. Note that a functional failure under the maintenance rule definition does not necessarily constitute a functional failure of a PRA function.

In addition, a periodic assessment of plant risk is conducted for the Maintenance Rule following each operating cycle. The most recent assessment for Oconee Unit 3 (which was prior to the April and May 1997 HPI events) did not show any significant impact on core damage risk from HPI system failures or system unavailability.

Sensitivity studies have been performed (see Section 5.3) taking into account the increased HPI train unavailability and pump failure rates resulting from the May 1997 HPI event.

3.4 Incorporation of Operating Experience

The overall conclusion of this operating experience review is that the frequency and types of failures seen at Oconee are typical of the rest of the industry experience. However, several issues were identified where industry operating experience suggests improvements, additions, or further investigation for the new HPI reliability model. These issues are discussed below:

Issue	HPI Concern
Common Cause Failure	Recurring Problems with Gas Binding of Pumps
Human Errors	Misalignment of Letdown, Purification, or Related Systems
Flow Diversion of Recirculation Flow	Failures of Relief Valves or Check valves Could Lead to a Loss of Coolant Outside Containment

Common Cause Failure

Previous Oconee PRA models did not explicitly address loss of LDST water level as a common mode failure of the HPI pumps, although common cause failures were considered at a higher level. The new HPI reliability model includes several failure modes associated with the LDST interface. A specific common cause event was included to represent common cause failure of the LDST level transmitters. Quantification of this event also includes an additional factor to incorporate Oconee's experience. Common cause failure potential for the pressure instruments was also investigated.

Human Error

A number of potential human errors were previously modeled for the HPI system. However, operating experience suggests that several new events should be added to the new model. The primary issue concerns the potential for plant personnel to misposition valves that would divert letdown or charging flow and cause a loss of LDST inventory during normal operation. These added events are discussed in Section 4.5.2.

Diversion Of Recirculation Flow

During the recirculation phase of a loss of coolant accident, the HPI suction source is switched to the LPI pump discharge header by opening the valve to an operating train of LPI and closing the HPI suction valves to the BWST. Several plants reported design problems with relief valve setpoints (or piping design pressures) in the HPI suction or discharge piping. These problems stemmed from the fact that LPI discharge pressure is substantially higher than the pressure that is seen from the BWST or LDST suction sources. Lifting a relief valve during the sump recirculation will divert coolant from the HPI suction and is equivalent to a LOCA outside of containment.

The conditions of higher HPI suction pressure were determined to be applicable to Oconee and with this concern the HPI model was reviewed for possible interaction problems. Two model enhancements were identified from this concern.

First, it was noted that relief valve failures had not been previously considered. This failure mode was added for relief valve HP-79 on the LDST discharge line. Second, it was noted that should check valve HP-97 fail to close to isolate the LDST, a flow diversion could occur during piggy-back mode of operation. Presently, the LDST isolation valve HP-23 is not required to be closed following a loss of coolant accident. This failure mode was added to the fault tree and sensitivity studies were performed to assess the significance.

Table 3.2-1

Industry Gas Binding Events

Date	Plant	Event Description	Failure Mode	Real Failure?	Location
9/12/85	Palo Verde Unit 1	The common reference leg for the VCT Level Instrumentation was partially drained which cause a 20% indication when the tank was empty. This resulted in the charging pumps becoming air bound and inoperable	Level Instr.	Actual	LDST Empty
2/26/88	Farley Unit 1&2	On 2/26/88 operators vented ~50 cu ft of hydrogen gas from Unit 1 HPSI suction lines. Dissolved hydrogen from the VCT came out of solution and collected in the lines. 3 days later, gas found in same piping and found a similar gas bubble on Unit 2.	Dissolved Gas	Actual	Suction
5/13/88	South Texas Unit 2	May 13, 1988, where suction was lost to the centrifugal charging pumps due to air pocket formation in 2 high points.	Dissolved Gas	Actual	Suction
5/27/88	ANO Unit 2	During Plant Startup, low flow alarms received on charging system. All 3 HPI pumps gas bound. VCT was empty. Tubing fitting failed which drained common reference leg to both VCT level instruments.	Level Instr.	Actual	LDST Empty
7/14/88	ANO Unit 1	When the HPI system is not lined up for recirculation, the recirculation line is isolated. This line was apparently drained, which allowed gas to enter the lines.	Empty Line	Actual	Piggy-Back Line
10/12/88	Surry	Found gas pockets in line from RWST to HPSI and in line from LPSI to HPSI. Determined dissolved H_2 gas had come out of solution and collected in these lines.	Dissolved Gas	Actual	Both
10/14/88	North Anna	Found gas pockets in line from RWST to HPSI and in line from LPSI to HPSI. Determined dissolved H_2 gas had come out of solution and collected in these lines.	Dissolved Gas	Actual	Both
1/5/90	Beaver Valley	Gas Binding of Charging Pumps - Hydrogen came out of solution in the pump recirc line orifice.	Dissolved Gas	Actual	Suction

Table 3.2-1

Industry Gas Binding Events

Date	Plant	Event Description	Failure Mode	Real Failure?	Location
2/20/90	San Onofre Unit 1	Design problem on valves going to VCT. These AOVs were found to fail open on loss of IA instead of closed which could lead to gas binding of the pumps.	Valve Problem	Potential	LDST Empty
5/16/90	D. C. Cook	Potential for gas binding of charging pumps identified. This vulnerability only exists while valve realignments are made to seal return lines.	Valve Problem	Potential	Suction
7/9/90	Haddam Neck	Charging Pump Suction Vent Line Problem. Line allows hydrogen removal from the charging pump suction piping back to the Volume Control Tank (VCT).	Valve Problem	Potential	Suction
8/2/90	Haddam Neck	Determined that charging pump discharge pressure fluctuations indicated gas binding.	Not Reported / Unknown	Actual	Suction
8/22/90	Sequoyah Unit 2	"B" charging pump secured when fluctuations observed in pump motor amperage and rate of flow. Hydrogen gas bubble vented from pump suction piping and on RHR cross-over line. Bubble identified on Unit 2 on Sept 6, 1990.	Dissolved Gas	Actual	Both
9/6/90	Sequoyah Unit 2	Gas bubble found in charging pump suction line (RHR recirc line). Similar to event on 8/22/90. Determined dissolved H2 gas had come out of solution and collected in these lines.	Dissolved Gas	Actual	Piggy-Back Line
1/31/91	Calvert Cliffs 1	Gas Binding of PDP charging pumps. Gas coming out of solution.	Dissolved Gas	Actual	Suction
3/28/91	Comanche Peak Unit 1	Ultrasonic testing indicates the presence of gas bubbles in the suction piping of the Centrifugal Charging Pumps.	Dissolved Gas	Actual	Suction
8/8/91	San Onofre Unit 1	1 of 2 VCT Level Instruments failed.	Level Instr.	Potential	LDST Empty

Table 3.2-1

Industry Gas Binding Events

Date	Plant	Event Description	Failure Mode	Real Failure?	Location
9/19/91	Oconee	Oconee 1,2,3 - HPI system operating curve for LDST pressure vs. level was determined to be incorrect. Certain post accident alignments and failure could have resulted in a loss of tank level and subsequent failure of the HPI system.	Level Instr.	Potential	LDST Empty
Jul-92	Surry Unit 2	Observed pressure spikes in LHSI piping. Discovered large gas voids in LPSI cold leg discharge piping and piggyback line to HPSI. Gas believed to have come from small leakage in RCS check valves in LPSI cold leg injection line.	RCS Check valve Leak	Actual	Piggy-Back Line
8/20/96	Oconee	Letdown Storage Tank (LDST) level instrument calibration errors could have led to the High Pressure Injection (HPI) pump becoming hydrogen bound during an ECCS actuation.	Level Instr.	Potential	LDST Empty
8/28/96	Haddam Neck	Nitrogen valve leaking into VCT causing gradual loss of VCT level and introduction of nitrogen into RCS through the charging pumps.	Nitrogen Valve	Actual	LDST Empty
5/3/97	Oconee	3A and 3B HPI Pumps failed due to inadequate suction source of water from the Letdown Storage Tank. Tank level instrument common reference leg was empty and did not indicate low tank level.	Level Instr.	Actual	LDST Empty

Table 3.2-2

Maintenance Rule HPI System Functional Failures

PIP	Date	Description	Maintenance Rule Function	
5-O-95-0056	1/12/95	Letdown Relief Lifted when 1HP-8 Closed because 1KE-12 breaker tripped. Wire shorted out because too much insulation had been removed when wiring termination was made.	HPI.06	Provide RCS inventory control; provide RCS makeup water to make up for contraction in RCS volume and provide letdown capability when RCS volume increases.
2-O-96-1538	8/5/96	The tip of the valve plug on valve 2HP-355 has broken off. The valve was identified to have a seat leak. The piece is estimated to be ¼" in diameter and 1" long and made of a stainless grade material.	HPI.07	Provide auxiliary pressurizer spray.
2-O-96-1777	9/18/96	Oconee Unit 2 - During normal operation, 2B HPI pump failed due to a breakdown in the stator ground wall insulation which shorted out the motor windings and caused the pump breaker to trip on ground fault.	HPI.01 HPI.05	Inject borated water into the RC System during postulated DBEs, **AND** Provide RCP seal injection.
2-O-96-1802	9/21/96	A pinhole leak on a socket weld near 2HP-491 was discovered. This leak is located on the RCS pressure boundary. Investigation determined cracked weld.	HPI.04	Provide reactor coolant system pressure boundary integrity.
3-O-97-0092	1/6/97	Valve position indication continued to indicate open when Ops attempted to close MOV 3HP-27 from the CR. Problem was due to a sticking contact on the MCC start for 3HP-27.	HPI.01	Inject borated water into the RC System during postulated DBEs.
2-O-97-0437	2/1/97	Alarms received for 2A2 RCP Upper Seal Temperature high. Determined that 2HP-212 was left closed following test line-up. Test line-up for PT/2/A/0151/07, Penetration 4 LLRT, was changed.	HPI.12	Provide RCP seal return path
0-O-97-0710	2/25/97	Determined that the HP-120 travel stop was not properly set for LTOP protection.	RC.05	Provide RCS pressure control (includes overpressure protection).
2-O-97-1324	4/21/97	Oconee Unit 2 - Reactor coolant system (RCS) leak (2.5 gpm) was discovered. Leak occurred on the stainless steel safe-end-to-pipe weld on the 2-1/2 inch high pressure injection (HPI) and makeup line to the RCS cold leg nozzle.	RC.02	Provide a barrier to prevent the release of fission products from the reactor core to the environment. (RCS pressure boundary)

Table 3.2-2

Maintenance Rule HPI System Functional Failures

PIP	Date	Description	Maintenance Rule Function	
1-O-97-1275	4/15/97	Blown fuse in breaker for 1HP-14, -15, -16.	HPI.06 HPI.09	Provide RCS inventory control, RCS makeup and letdown capacity, **AND** a means for injecting high pressure water for purposes of purifying the RCS, controlling boric acid and chemical concentrations, and controlling fission products.
3-O-97-1428	5/3/97	3A and 3B HPI Pumps failed due to inadequate suction source of water from the LDST. Tank level instrument common reference leg was empty and did not indicate low tank level.	HPI.01 HPI.05	Inject borated water into the RC System during postulated DBEs, **AND** Provide RCP seal injection.

Table 3.3-1

Oconee HPI System Significant Operating Events
(1973-1997)

Date	Description
10/3/73	Oconee Unit 1 - 1HP-27 failed (position not recorded)
12/14/73	LDST drained into LWD System when drain line on standby RCP seal filter left opened.
12/27/73	Oconee Unit 1 - 1HP-20 failed open
7/7/74	Oconee Unit 2 - Damage to HPI pump 2A due to mispositioning valve 2HP-98
6/22/75	Oconee Unit 3 - 3HP-26 was found inoperable due to a loose control wire
12/23/75	Oconee Unit 3 - 3HP-24 failed due to torque switch contact failures
3/3/76	Oconee Unit 1 - Separation of HPI pump rotor laminations (all 3 HPI pumps)
3/21/77	Oconee Unit 2 - HPI pump 2A failed due to wear on a bearing oil seal
10/18/79	Oconee Unit 3 - HPI pump 3B failed due to dc ground, damaged cable
11/14/79	Oconee Unit 3 - HPI pump damaged due to human error, suction valve was left closed
12/17/80	Oconee Unit 2 - Repeated High Bearing Temperature Problems due to low oil level and cooling water flow problems. Bearings finally failed on 12/17/80.
2/28/82	Oconee Unit 3 - HPI normal makeup nozzle 3A2 thermal sleeve found to be displaced
3/2/82	Oconee Unit 2 - HPI normal makeup nozzle 3A2 thermal sleeve found to be displaced
5/28/82	Oconee Unit 2 - Repeated Operational Problems on HPI pump 2A due to extensive pump shaft distortion.
12/7/82	Oconee Unit 1 - Valve 1HP-25 failed to open during testing
2/3/83	Oconee Unit 2 - HPI pump 2A unscheduled maintenance due to a bad bearing (attributed to a low oil level)
2/23/83	Oconee Unit 3 - HPI train 3A found inoperable due to blown fuse control power for 3HP-24, 26
3/3/83	Oconee Unit 1 - Valve 1HP-25 failed to open fully during testing
3/9/83	Oconee Unit 2 - Valve 2HP-24 failed to open during testing
3/15/83	Oconee Unit 2 - Valve 2HP-24 failed to open fully during testing
7/27/83	Oconee Unit 3 - HPI pump 3A failed to start manually (overcurrent relay tripped)
4/10/87	Oconee Unit 3 - Breakers for 3HP-24 and 3HP-25 were red tagged open after RCS temp had exceeded 350 deg F
6/11/87	Discovered that HPI pump motor on each unit could trip on overcurrent during starting of all three unit's blackout loads
2/11/89	Oconee Unit 1 - "1C" HPI pump motor indicated high amps during pump s/u. Found locking pin in pump to motor coupling missing. Caused misalignment of pump shaft which resulted in shaft making contact with the pump wear rings and casing. (RF mode)
11/21/90	Oconee 1,2,3: This is about the HPI line break issue.
9/19/91	Oconee 1,2,3 - HPI system operating curve for LDST pressure vs. level was determined to be incorrect. Certain post accident alignments and failure could have resulted in a loss of tank level and subsequent failure of the HPI system.

Table 3.3-1

Oconee HPI System Significant Operating Events
(1973-1997)

Date	Description
9/20/91	Oconee Unit 1 - "1B" HPI Pump motor had increasing upper bearing temperatures such that the Motor had to be shut down. Thrust shoes found worn due to normal wear. Replaced Motor. (RF Mode)
2/26/97	Oconee 3 - Misposition of Valve 3HP-5 - The LDST level was observed to increase from approximately 83 inches to 100 inches and the Pressurizer level was observed to decrease from approximately 105 inches to 75 inches when 3HP-78 was opened.
4/21/97	Oconee Unit 2 - Reactor coolant system (RCS) leak (2.5 gpm) was discovered. Leak occurred on the stainless steel safe-end-to-pipe weld on the 2-1/2 inch high pressure injection (HPI) and makeup line to the RCS cold leg nozzle.
5/3/97	Oconee - 3A and 3B HPI Pumps failed due to inadequate suction source of water from the Letdown Storage Tank. Tank level instrument common reference leg was empty and did not indicate low tank level.

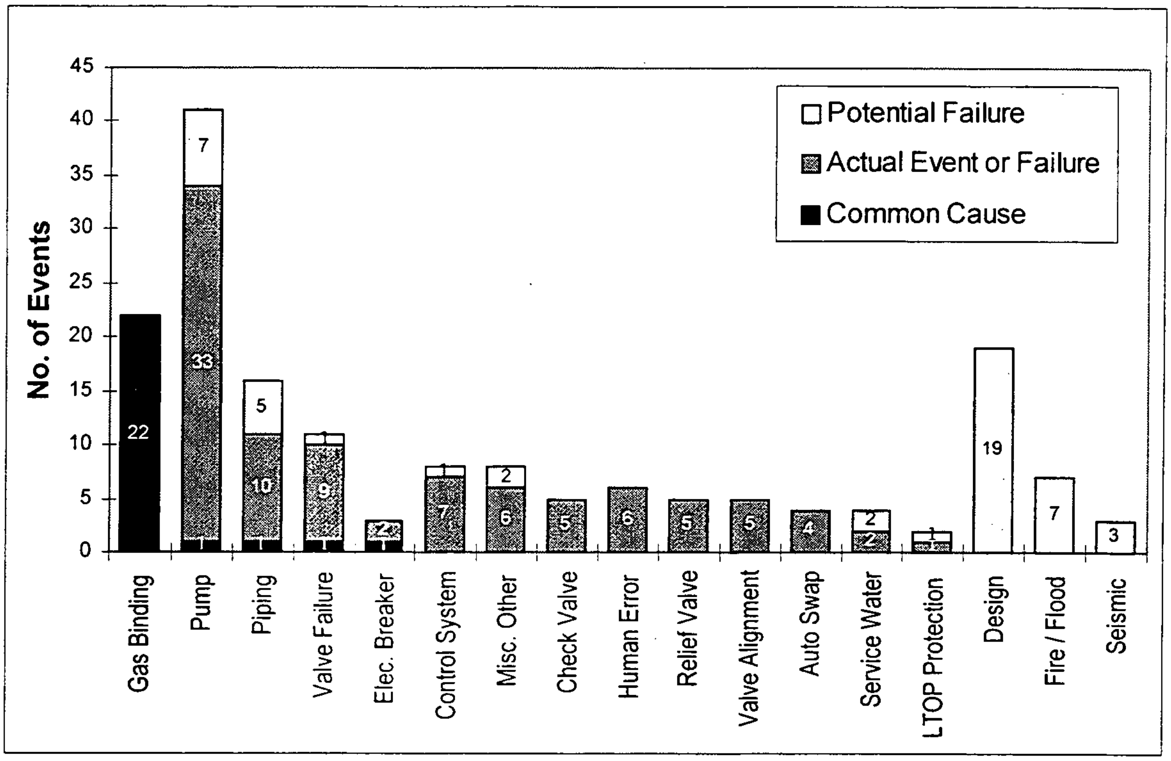


Figure 3.2-1 - HPI Operating History By Failure Cause

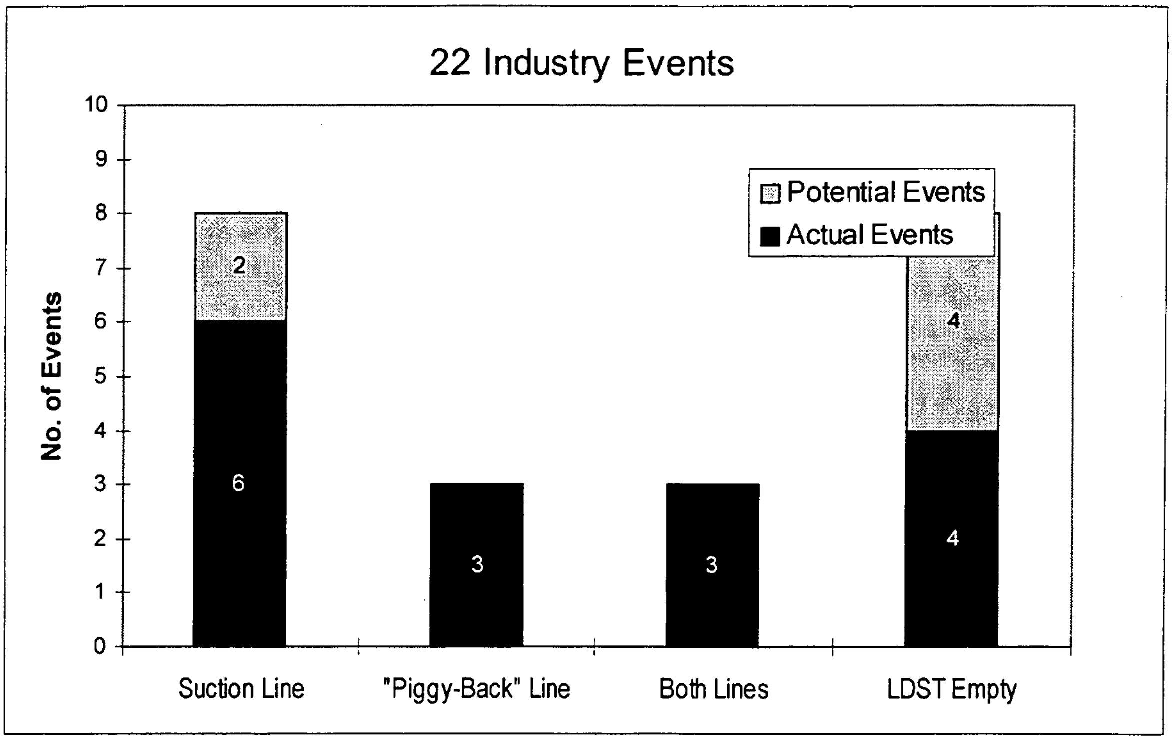


Figure 3.2-2 - HPI Gas Binding Events By Location

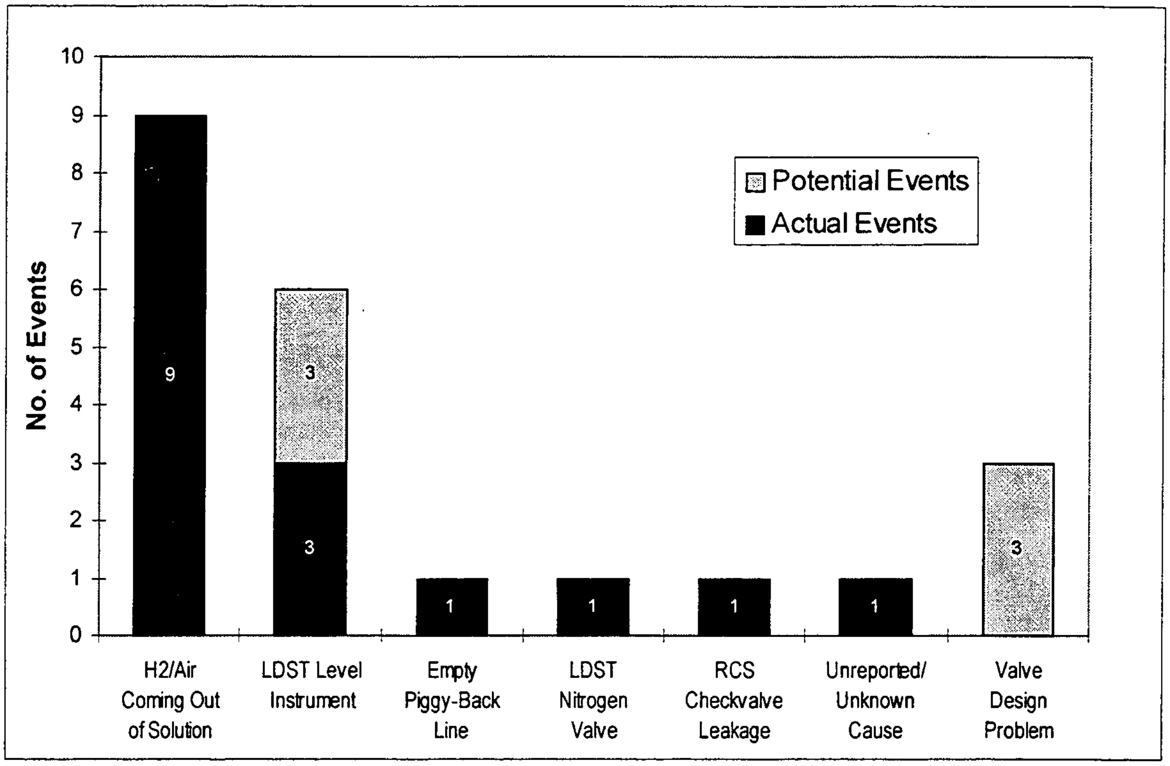


Figure 3.2-3 - Gas Binding Events By Cause

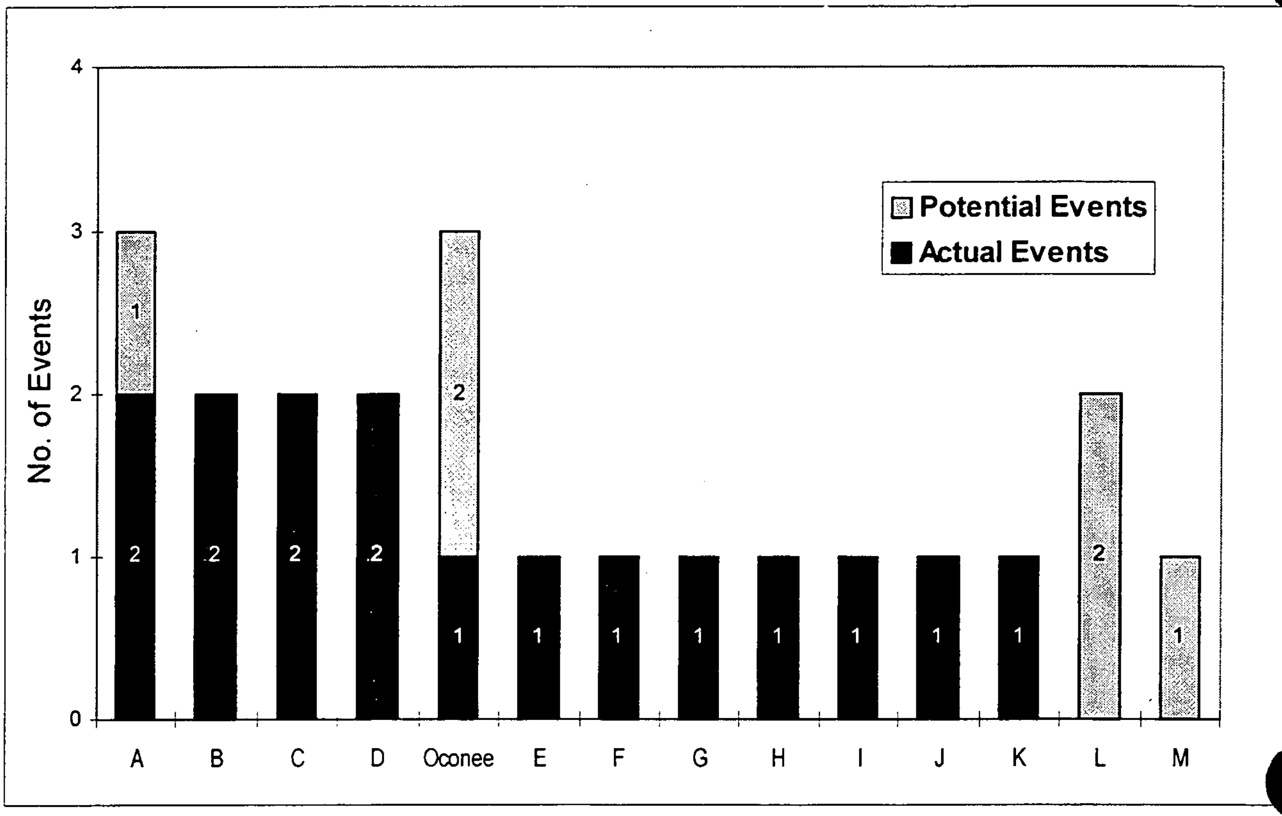


Figure 3.2-4 - Gas Binding Events By Plant

4. RISK AND RELIABILITY ANALYSIS OF THE HPI SYSTEM

4.1 Introduction

The main objective of this study is to obtain information on the reliability of the High Pressure Injection system in fulfilling the various accident mitigation functions and to provide the perspective on the risk significance of the failure modes of concern. The resulting information can be used to identify potential system enhancements to reduce the potential for any risk-significant failure modes. A satellite objective is to provide reliability estimates of the HPI system for providing various normal operating functions.

The accident mitigation functions considered in this analysis include the design basis accidents as analyzed in the UFSAR Chapter 15 as well as the accident sequences considered important in the PRA.

To provide a complete picture of the risk significance of the HPI system, an assessment of the HPI system during external events and for shutdown risk is also performed.

4.2 Approach and Methodology

The overall methodology for this study is the PRA methodology, utilizing the fault tree models, reliability data, and event sequences. This project utilizes the Oconee PRA Rev. 2 HPI system fault tree model as a starting point. The Rev. 2 model includes failure modes associated with the injection and recirculation modes of core cooling, and with RCP cooling. The present analysis adds new LDST failure modes, passive failures of various piping sections[2], and new failure modes of interest identified from the operating experience review of Section 3.

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[2] Passive failures are beyond design basis but are included in this study to examine their significance.

The fault tree structure in the PRA is modified to take into account the UFSAR accidents (LOCA and non-LOCA), based on the success criteria (flow rates or pump and flow path configuration needed for mission success) for the accidents of interest. Both conservative (UFSAR Chapter 15 assumptions) and best-estimate (PRA type) success criteria are considered for the analysis of LOCA events, particularly during the injection phase of the LOCA mitigation. As seen later, the success criteria in terms of the number of pump-flow path combinations are the same for the non-LOCA events, whether considering the UFSAR Chapter 15 type of analysis or the PRA type of analysis. The success criteria are presented in Section 4.3, and the fault tree model is detailed in Section 4.4.

To obtain quantitative reliability information, the fault tree model is solved with appropriate basic event values. Equipment failure probabilities, maintenance unavailabilities, common cause failure probabilities, and human error probabilities comprise the basic events appearing in the fault trees. The calculations of these basic events are presented in Section 4.5.

The HPI system reliability results represent the estimated failure probability to achieve specific safety functions. For example, the results for the UFSAR random small break LOCA represent the probability that the HPI system fails to meet the ECCS acceptance criteria, with all the inherent conservatisms in the ECCS analysis. On the other hand, the results for the PRA random small break LOCA represent the probability that the HPI system fails to provide adequate core cooling to avoid core damage.

System reliability results by themselves do not provide a complete picture of the safety significance of any system unreliability concern. Therefore, to obtain the safety or risk significance, the accident sequences which lead to core damage as a result of the HPI system failures are identified by incorporating the modified HPI model into the plant core melt fault tree model and by obtaining an integrated solution. Failures are ranked to determine their relative significance. Finally, an uncertainty analysis is performed on the results to convey the possible range for the calculated results.

For obtaining the reliability results for the normal HPI operating functions, new models are developed for normal RCS injection, normal seal cooling, and auxiliary pressurizer spray during unit shutdown.

4.3 Success Criteria for Design Basis and Risk Significant Accident Sequences

4.3.1 LOCA Events

The design basis LOCA is characterized by an injection phase (includes any blowdown, refill and the reflood portions) followed by the long-term cooling phase. During the injection phase, which lasts for a few minutes for the large break LOCA and over an hour for the small break LOCA, the clad temperature excursion is turned around and the mixture level in the core is regained to above the top of the active fuel region. For the long-term cooling mode, core makeup is provided at a rate to match or exceed the core boil-off rate due to continuing decay heat generation in the core. A stable core cooling mode is established when the necessary core cooling system flow can be maintained by means of suitable suction sources and pumping systems. For large break LOCAs, the long-term cooling mode is established by the LPI system taking suction initially from the BWST and subsequently from the RB emergency sump when the BWST level reaches the low level limit. For the small break LOCAs, the long term heat removal is achieved initially by the HPI system (taking suction from the BWST) and then by the LPI system, when RCS pressure decreases to a value where LPI injection into the reactor vessel can occur. For small break LOCAs, the RCS pressure remains above the shutoff head of the LPI pumps following the recovery of stable mixture level in the core. If depressurization of the RCS to LPI conditions is not successful, the HPI system would have to be operated in tandem with the LPI system when the suction of the ECCS is swapped to the RB emergency sump to maintain core cooling. This can occur at approximately 5 - 10 hours after the accident if the RB spray system did not actuate and that the HPI system injection flow is balanced and throttled by the operators to maintain the core subcooling margin and at the same time reduce the RCS pressure. If the RB spray system actuation did occur and if the operators did not secure the spray, the low BWST level limit and the subsequent RB emergency sump suction swap-over would occur sooner (possibly about an hour after the LOCA).

Considering the equipment and operator actions necessary for LOCA mitigation and for the purpose of this study, the HPI injection phase and the HPI recirculation phase are used to define the HPI LOCA mitigation functions, instead of the ECCS injection and long-term cooling phases used in the conventional ECCS analyses. The injection function envelopes the ECCS injection phase and extends to the point where HPI suction is switched from the BWST to the RB emergency sump. The recirculation function includes the HPI system taking suction from the RB emergency sump through the LPI pump discharge in the so-called piggy-back mode, although not all small break LOCAs would require this mode.

Long-term cooling is considered to be established once the RCS has depressurized to the point that LPI can provide core cooling.

The LOCA events of interest for this study are:

- the UFSAR random small break LOCA
- the UFSAR small break LOCA in the immediate vicinity of the RCP discharge piping, in which the HPI injection through that nozzle can spill out of the break
- the UFSAR HPI line break where the HPI injection through that nozzle is assumed to be lost through the break.

UFSAR Success Criteria

The conservative success criteria are those that are used to demonstrate conformance to the 10 CFR 50.46 ECCS acceptance criteria. These success criteria are conservative compared to those derived from best estimate type analyses. The success criteria resulting from the existing UFSAR ECCS analyses (Ref. 3 and 4) are as follows:

For the random small break LOCA one HPI pump taking suction from the BWST and injecting into the RCS cold legs through any two of the four injection nozzles would meet the ECCS acceptance criteria for the HPI injection function.

For the location-specific small break LOCAs (in the vicinity of the RCP discharge and the HPI line break), one HPI pump injecting into two nozzles and another HPI pump injecting into two more nozzles at ten minutes would meet the ECCS acceptance criteria for the HPI injection function.[3]

For the HPI recirculation function, one LPI pump taking suction from the RB sump and discharging into the HPI suction header and one HPI pump discharging into two RCS HPI nozzles (for the HPI line break/ RCP discharge break the HPI injection would have to occur in the unaffected loop) would meet the ECCS acceptance criteria.

PRA Success Criteria

The success criteria for the PRA LOCA events are established from best estimate thermal hydraulic analyses using the MAAP code (Ref. 5). In PRA LOCA analyses, the small break LOCA event is categorized into small (3/8 inch to 1.5 inch diameter) and medium (1.5 inch to 4 inch diameter) break events on the basis of the RCS pressure response and SG cooling status which affects the core melt progression. The initiating event frequencies are different for the two break sizes. However, the success criteria with respect to the HPI system are the same for the two break sizes for the random location LOCA.

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[3] The **Core Flood line break** is a special case of LOCA requiring HPI system operation. This break will behave like a random small break LOCA, requiring one train of HPI.

Small LOCAs (3/8" to 1.5" in diameter)

For breaks in this range the reactor coolant system remains pressurized at or above the steam generator secondary pressure for an extended period of time. Success criteria for breaks in this category have been developed using a 1" diameter break as representative of the spectrum of breaks in the range. For these small break sizes no HPI flow is assumed to be lost through the break.

The resulting success criterion for breaks in this range is one HPI pump injecting into two cold legs. Secondary side heat removal is not required to be available to prevent core damage for this break size.

Medium LOCAs (1.5" to 4.0" in diameter)

For breaks in this range the reactor coolant system depressurizes rapidly to less than the steam generator secondary pressure. The availability of secondary side heat removal is not a consideration for breaks in this range. Success criteria for breaks in this category have been developed using a 2.5" diameter break as representative of the spectrum of breaks in the range.

Two special cases for breaks in this range have been identified. Breaks in the reactor coolant pump discharge are identified in the UFSAR as the worst case RCS break location. For breaks in this location, the HPI flow into the broken cold leg is assumed to be lost thus reducing the injected flow to 50% of the pump capacity. For breaks in the HPI line, the broken loop sees the containment pressure as the back pressure and even less flow is delivered to the intact loop than in the RCS pump discharge break.

Other break locations do not involve HPI flow exiting the break directly and, therefore, the full flow of the pump(s) is available to the reactor coolant system.

Each of these break locations have been considered separately in the success criteria development.

1. RCS random location breaks

   For random break location LOCAs (breaks other than at the RCP pump discharge or the HPI lines), the full flow from the operating HPI pumps is injected into the reactor coolant system. For this case, one HPI pump injecting into two cold legs provides adequate flow to prevent core damage.

2. RCS pump discharge

   For breaks at the pump discharge, 50% of the injected flow is assumed to be lost from the break. Success in this case is achieved by having an HPI pump inject through the header that does not contain the broken loop. This is achieved by having two HPI pumps each injecting into a different header, thus assuring that a pump is injecting into the intact header. Or, if only a single HPI pump is operating, there is a 0.5 chance that the pump is injecting into the intact loops. This also satisfies the requirement for prevention of core damage.

3. HPI line break

   The situation for these breaks is very similar to that of the RCP discharge breaks. The success criteria are the same.

For the HPI recirculation function, the PRA LOCA success criterion is the same as the UFSAR success criterion discussed previously.

4.3.2 Non- LOCA Events

UFSAR Non-LOCA Events

Steam Generator Tube Rupture (SGTR) and the steam line break are the two non-LOCA FSAR design basis events where the automatic actuation of the HPI system is considered in the accident analysis. For the SGTR event, auto-actuation could occur if the tube break size is large enough to cause the RCS depressurization to HPI actuation setpoint. If the depressurization is slow, the operator manually initiates the HPI to maintain pressurizer level and RCS subcooling. For this event, the HPI function is to provide RCS makeup to compensate for the coolant loss through the broken tube. During a steam line break, a rapid overcooling of the RCS occurs, causing the reactor coolant shrinkage and consequent decrease in the RCS pressure. The HPI system is automatically actuated when the RCS pressure decreases to the HPI actuation setpoint. The function of the HPI during the steam line break accident is to provide rapid RCS makeup to compensate for the coolant shrinkage and to add borated water to the core to compensate for any positive reactivity feedback from the RCS cooldown and core moderator negative reactivity coefficient. The HPI success criteria for SGTR and the steam line break accident is one HPI pump with suction from the BWST and RCS injection into two of the four nozzles. Unlike the LOCA events, the HPI function would be terminated well before the BWST low level limit is reached, and HPI recirculation is not necessary. In obtaining the system reliability results, cut sets involving potential hydrogen entrainment are therefore not included.

In addition to the SGTR and steam line break non-LOCA accidents where the HPI system is explicitly considered as an accident mitigation function in the UFSAR accident analysis, the HPI system is implicitly considered, in a limited way, in other UFSAR Chapter 15 events, primarily for the post transient recovery (RCS make-up and RCP seal injection). This function is very similar to the normal operating function.

Table 4.3-1 presents functional requirements of the HPI system for the various design basis Chapter 15 events and the PRA sequences.

4.3.3 Feed and Bleed

In the PRA, some non-LOCA scenarios may require HPI to function in a feed and bleed mode of core cooling (also referred to as HPI forced cooling). These sequences are characterized by a loss of secondary side heat removal as a result of an initiating event and subsequent multiple system failures. HPI injection in these sequences must occur at relatively high system pressures, however, the absence of any RCS breaks precludes the need to assume any loss of injected flow.

Successful feed and bleed cooling (injection phase) requires two HPI pumps injecting into at least 2 cold legs. HPI is initiated automatically when the reactor building pressure rises to 3 psig. The containment pressure rises to the setpoint at about 30 minutes into the transient, approximately 10 minutes after the quench tank rupture disk failure.

If the steam generator cooling is re-established, the feed and bleed cooling mode can be terminated. However, if continued feed and bleed cooling is necessary when the BWST low level setpoint is reached, HPI recirculation must be initiated by means of the LPI interface. The success criteria for the feed and bleed HPI recirculation is the same as that for LOCA events discussed earlier.

4.4 Fault Tree Model

Fault tree top events are defined for each of the distinct HPI functions considering the system success criteria discussed earlier. For the accident mitigation functions, the following specific fault trees have been developed.

HPI Accident Mitigation Functions Model

The emergency functions fault tree model contains the following top events[4]:

- Failure to provide emergency injection where only one HPI train is needed. (This fault tree applies to a random small break LOCA for the Chapter 15 success criteria and the PRA success criteria, the PRA medium break LOCA, and the UFSAR non-LOCA events.)

- Failure to provide emergency injection for the HPI line break and RCP pump discharge using Chapter 15 assumptions.

- Failure to provide emergency injection for the HPI line break and RCP pump discharge using PRA assumptions.

- Failure to provide feed and bleed injection.

- Failure to provide recirculation. (This applies to all events requiring HPI recirculation except the HPI Line Break or RCP pump discharge break cases.)

- Failure to provide recirculation for an HPI Line Break or RCP pump discharge break.

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[4] A **top event** represents the failure of interest. Its' probability is estimated by developing and quantifying a fault tree which should contain the most likely ways that the event can occur.

Potential failure modes from the LDST interface are now included in the injection and recirculation fault trees. In the injection mode, the LDST failure mode of concern is the potential for HPI pump failure from hydrogen entrainment from the LDST if the LDST pressure/level parameters are outside their acceptable ranges (level too low or pressure too high) when the BWST approaches the low level limit. When the BWST reaches a lower water level, and hence a lower pressure, hydrogen could be entrained from the LDST to the HPI suction header and cause failure of the HPI pumps. One such failure mode is a possible common mode failure of LDST level and pressure instruments. Another potential failure mode is a pre-LOCA condition where the LDST level was forced to be low due to excessive draw down of the LDST and failure to compensate for the draw down.

In the recirculation mode, LDST discharge check valve HP-97 should isolate the LDST from the recirculation flow path. If however, this check valve fails to remain closed, sump recirculation flow could be diverted to the LDST where the relief valve could be challenged, possibly diverting part of the coolant inventory. The current operating procedures do not provide guidance to recognize and isolate the LDST if this failure were to occur. This failure mode is included in the recirculation fault tree.

On both the suction and discharge portions of the HPI system, component failures (both active and passive), latent human errors, and maintenance unavailabilities are modeled.

HPI RCP seal injection

The RCP seal injection function of interest is the ability of HPI to provide seal injection following a non-LOCA initiator for a 24 hour mission time.

Successful RCP seal cooling requires one HPI pump to provide flow to all four seal packages. With this in mind, the top event is postulated to occur via various failure mechanisms.

Failure of flow from all three HPI pumps to any of the four seal injection lines leads to the top event. Seal cooling can also be failed if cooling water flow through the HPI Pump motor bearing cooling jackets (from LPSW and back-up HPSW) is lost. Common cause failures of the system, such as an unisolated pipe break in a seal injection line are also included in the fault tree.

For the HPI pump suction to fail, both the LDST and the BWST sources must fail.

Normal HPI Functions Model

The normal functions fault tree model contains the following top events:

1) Failure to provide normal RCP seal injection
2) Failure to provide normal make-up
3) Failure to provide auxiliary pressurizer spray

<u>Normal RCP seal injection</u>

Successful RCP seal cooling requires one HPI pump to provide flow to all four seal packages.

The top logic of this tree includes failure of both the 'A' and 'B' HPI pumps, loss of flow into any of the four RCP seal injection lines, and pipe rupture in seal injection line. (LDST failure modes are also included in the normal operation trees.)

<u>Normal injection</u>

Normal injection requires one HPI pump and one cold leg injection nozzle.

The top logic of this tree includes failure of both the 'A' and 'B' HPI pumps, loss of flow into both the A1 and A2 cold legs, and pipe rupture in the HPI pumps' discharge lines.

Auxiliary pressurizer spray

Auxiliary pressurizer spray requires one HPI pump and availability of the auxiliary spray flow path.

The top logic of this tree includes failure of both the 'A' and 'B' HPI pumps, loss of flow into the auxiliary spray flow path, and auxiliary spray line rupture.

The following table summarizes the HPI study fault tree top gates.

HPI Accident Mitigation Functions

Top Gate	Description	Success Criteria
HPI001	HPI Injection for random small and medium break LOCAs, and non-LOCA Chapter 15 events	1 train of HPI and 2 of the 4 RCS injection nozzles
HCH15INJ	HPI Injection for **Chapter 15** HPI line break/RCP discharge break	1 train of HPI initially and a second train at 10 minutes and 4 injection nozzles
HPIBREAKI	HPI Injection for **PRA** HPI line break/RCP discharge break	1 train of HPI initially and a second train at 10 minutes and 2 intact injection nozzles
HFNBINJ	Feed and Bleed, Injection mode	2 trains and 2 injection nozzles
HPR001	HPI RB Emergency Sump Recirculation	1 train of HPI and 2 injection nozzles
HPIBREAKR	HPI RB Emergency Sump Recirculation for HPI Line Break/RCP discharge break	1 train of HPI and 2 intact injection nozzles
HPS001	RCP Seal Injection following a non-LOCA initiating event	1 train of HPI and 4 RCP seal injection paths

Normal HPI Functions

Top Gate	Description	Success Criteria
HPINORMINJ	Normal Injection	1 train of HPI and 1 of the 'A' RCS injection nozzles
HPISEALINJ	Seal Injection	1 train of HPI and 4 RCP seal injection paths
HPZRSPRAY	Auxiliary spray	1 train of HPI and the auxiliary spray path

Fault Tree Assumptions

The fault trees are constructed with the following assumptions:

Operational Assumptions

1) HPI train A is assumed to be in service.
2) HPI pumps A and B are swapped in service on a monthly basis.
3) HP-14 is assumed to be in its NORMAL position, aligned to the LDST.
4) RCP seal supply filter train A is assumed to be in service.
5) As the BWST level is drawn down during LOCA mitigation and flow alternates between the BWST and the LDST, it is assumed that LDST check valve HP-79 is required to close ten times.

Modeling Assumptions

1) Since pump A is modeled as the operating pump, its maintenance probability is lumped onto pump B. Pump C has its own maintenance event probability.
2) Failures in the RCP seal return line, up to the connection with normal letdown, are not modeled since they should not fail seal injection flow to the RCPs.
3) Failures of the calibrated power supply and E/P converter for HP-7 are represented by the "valve transfers open" failure mode for air-operated valve HP-7.

4.5 Data

The databases used for the reliability solves contain four types of data: equipment failure rates, maintenance unavailabilities, human action failure rates, and common cause failure rates. To obtain core melt frequency results, the initiating event frequencies are additionally required.

Best estimate equipment failure rates are developed by combining generic failure rates with those experienced at Oconee. Maintenance unavailabilities are selected based on review of the most recent unavailability data. Human error probabilities are estimated by considering factors such as whether the action is proceduralized, familiarity with the action, ease of performing, and level of checking or verification. Common cause failure probabilities are quantified by multiplying equipment random failure probabilities by an appropriate common cause factor estimated from industry data or selected from generic sources. Additional information on the quantification of these events is provided below.

Three new databases were developed for the HPI reliability study. One is used to assess the reliability of the HPI system in mitigating DBA and PRA-significant accidents, and is based on a 24 hour mission time. The second is used to determine HPI system reliability for providing normal RC make-up and seal injection based on a one year mission time. The third is used to determine HPI system reliability for providing the auxiliary spray function based on a 24 hour mission time. Appendix C1 provides the data used in the accident mitigation model, Appendix C2 provides the data for the normal RC make-up and seal injection model, and Appendix C3 provides the data for the auxiliary spray model.

For the HPI system reliability solves, a nominal value is used for transfer basic events[5]. The intent is to provide a more complete picture of overall system reliability by including support system failure probabilities. The event values were estimated by solving the Oconee Rev. 2 model for the transfer gate of interest.

For the plant level solve, the accident mitigation model database is imported into the Oconee PRA Rev. 2 database.

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[5] **Transfer** basic events represent a branch out of one tree into another. For example, the HPI tree transfers out to support trees such as the ac power tree, Low Pressure Service Water tree, and Engineered Safeguards tree.

4.5.1 Equipment Failure Rate Data

For this study, generic failure rate data (SAROS database -- Ref. 6) was Bayesian updated with Oconee specific data. The SAROS generic failure aggregates many sources of generic data, such as other nuclear plant PRAs, WASH-1400, IEEE-500 (Ref. 7) and INEL's Generic Component Failure Data Base For Light Water and Liquid Sodium Reactor PRAs (Ref. 8). For equipment not represented in References 6, 7, or 8, other sources were used, such as NSAC 60 (Ref. 9).

For the plant-specific equipment failure data, the PIP database was searched for Maintenance Rule functional failures which occurred on all three units at Oconee over the 600 day period from July 23, 1995 to March 14, 1997. (This period coincided with a complete fuel cycle on Unit 3.) This information was added to any previously collected data over the period from January 1988 to December 1993. For equipment modeled in the PRA, the number of demands or hours of service over a one year period were estimated. From this data, plant-specific evidence was compiled.

The generic failure rates were then Bayesian-updated with the plant-specific evidence. In a few cases where generic failure rates are not readily available and the plant experience is sufficiently large, plant-specific failure rates are used. The resulting failure rates are shown in Table 4.5.1-1.

4.5.2 Human Reliability Analysis

The main purposes of this HRA is to validate the HRA results of the current Oconee PRA (Rev 2) for the HPI System events and to provide quantification of any new human reliability events modeled as a result of this study. The validation process involved re-examination of the HPI human error events in the current Oconee PRA model to assure appropriate assumptions and modeling techniques were applied. Applicable plant procedures were reviewed and, when necessary, station training personnel were contacted.

In most cases, the human reliability event values used in the current version of the Oconee PRA were found to be appropriate. However, some actions were re-quantified with either higher or lower values based on new information or modeling considerations. A number of new human events were identified that were quantified using similar techniques or were assigned screening values.

Several types of human reliability events are modeled. The two main types of events are pre-initiator events and post-initiator events. Post-initiator events are further partitioned on the basis of whether or not they are proceduralized. Another special class of post-initiator human events was also examined in this study to cover potential errors of commission. For this study, human error events are designated by the last three letters of the basic event name as follows:

- LHE This designates a pre-initiator latent human error.
- CHE This designates a post-initiator commission human error.
- DHE This designates a proceduralized post-initiator human error.
- RHE This designates a non-proceduralized post-initiator human error. (No RHE events were identified for the HPI system)

Latent Human Error Quantification

A model for Latent Human Error (LHE) events was developed for the Keowee PRA at Duke (Ref. 10). This model is based on numbers from the THERP manual (Ref. 11 4.11). Quantification of an LHE event based on this model is based on such factors as independent verification, functional testing, tag-out steps and checks during shift turnover and rounds.

Four classifications were identified in the Keowee analysis for the LHE events as listed in the following table.

	Error Classification	Error Probability
1.	Post maintenance errors for components which are independently verified, but are neither functionally tested nor checked during the daily rounds.	3.2E-3
2.	Post maintenance errors for components which are not functionally tested but are checked on the daily rounds.	3.2E-4
3.	Post maintenance errors for components which are functionally tested.	2.6E-4
4.	Post maintenance errors for components which are functionally tested and which have red tags (or keys) associated with their maintenance.	5.2E-5

In the current Oconee PRA, the HPI pre-initiator events were assigned a screening value of 3.0E-3. This value roughly corresponds to Keowee PRA case 1 (above). For this study, the HPI system LHEs can be classified according to their level of testing and checking, and assigned a value based on the table above. A list of the HPI system LHEs and their resultant classification is provided in the table below.

HPI System Latent Human Error Events

Event Name	Description	Error Class
HEMERLILHE	*Latent Human Error Associated with Interlock Maintenance Occurs (associated only with proposed "auto-swap" mod)	1
HHP0024LHE	MOV 3HP-24 Suction Train Is Left Unavailable After Test Or Maint.	4
HHP0025LHE	MOV 3HP-25 Suction Train Is Left Unavailable After Test Or Maint.	4
HHP0SGOLHE	HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance	1
HHP0TRBLHE	HPI Train 3B Is Left Unavailable After Test Or Maintenance	4
HHP0TRCLHE	HPI Train 3C Is Left Unavailable After Test Or Maintenance	4
HLP0054LHE	Manual Valve 3LP-54 Is Left Closed After Test Or Maintenance	1
HLP0056LHE	Manual Valve 3LP-56 Is Left Closed After Test Or Maintenance	1
HSTLVS1LHE	*Latent Human Error during Maintenance of LDST Lvl String #1	1
HSTLVS2LHE	*Latent Human Error during Maintenance of LDST Lvl String #2	1
HYDSHUTLHE	*Operator Error Causes LDST to Be Overcharged with Hydrogen	1

*Note: These are new events that were not modeled in the Oconee PRA Rev. 2.

Commission Human Error Quantification

Industry operating experience indicates that human error is a common type of failure and that many of these events caused a reduction or loss of LDST inventory. Improper positioning of valves is often cited as the cause. Considering this experience, three new events were postulated which consider that a plant operator may take actions which inadvertently affect LDST level either through an unintended action (i.e., operator makes a mistake) or an intentional action that has an unrecognized or unintended effect on the system. This type of error has characteristics similar to a latent human error and to an error of commission, but is henceforth referred to as a commission human error.

The events of interest are listed below. An evaluation of all the procedures and plant activities which could lead to such an error has not been performed. Based on Ref. 11, a screening value of 0.03 was assumed for each CHE event.

HPI System Commission Human Error Events

NAME	DESCRIPTION	PROB
HLDDIVTCHE	*Operators Inadvertently Divert Letdown Flow	3.00E-2
HLDSTLPCHE	*Operator Error Causes Low Pressure Condition	3.00E-2
HLDISOLCHE	*Operators Inadvertently Isolate Letdown	3.00E-2

*Note: These are new events that were not modeled in the Oconee PRA Rev. 2.

Post-Initiator Human Reliability Events

The values used in the post-initiator human reliability analysis are based on the methods and techniques used in the current revision of the Oconee PRA (Rev. 2). Previously quantified HPI human events from the Oconee PRA were reviewed to confirm assumptions and quantification. These event values were determined to still be valid.

A list of all HPI System dynamic human error events is provided below, followed by a brief discussion of each new event.

HPI System Dynamic Human Error Events

NAME	DESCRIPTION	PROB
CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	2.00E-3
H00HP97RHE	*Operators Fail to Isolate Diversion Flow From RB Sump to LDST	1
HHP0409DHE	†Operators Fail to Open 3HP-409 (-410)	1.00E-3
HHPHPR0DHE	Operators Fail to Initiate High Pressure Recirculation	2.20E-3
HHPOP3CDHE	†Failure to Start the C HPI Pump	1.50E-3
HLDFLOWDHE	*Operator Fails to Check Unit Board Letdown Flow Receiver Gauge	1
HLDSTL1DHE	*Operator Fails to Maintain LDST Level > 40 " thru Appropriate Monitoring	1.00E-3
HLP1516DHE	†Operators Fail To Feed HPI Pumps Through LP-15/16 when LP-24/25 Fail	5.00E-2
HNMOPLVDHE	*Operators Fail to Recognize Level Instrument Failure	1
HNVNTRYDHE	*Dynamic Human Error in Maintaining LDST Level	1.00E-1
HOPOVPRDHE	*Inadequate Operator Guidance Regarding LDST Overpressure	1.00E-3
HOPUNPRDHE	*Inadequate Operator Guidance Regarding LDST Underpressure	1.00E-3
HPRESSRDHE	*Dynamic Human Error in Maintaining LDST Pressure	1.00E-1
IBSBWSTDHE	†Failure to Swap HPI to SFP During a Flood	5.00E-2
T3TB1UXDHE	†Failure to Recover Using Available LPI or HPI (after T3 & a PORV LOCA)	1.50E-3
TSGTHRLDHE	Operators Fail To Throttle High Pressure Injection Following A SGTR	1.50E-3
TTRHPITDHE	Operators Fail To Throttle HPI Following A Transient	1.00E-2

*Note: These are new events that were not modeled in the Oconee PRA Rev. 2.

†Note: These events are applied as "recovery events" in the recovery rule file in addition to appearing in the fault tree model.

H00HP97RHE

This event represents failure of operators to recognize that HP-97 has failed to close, and is allowing flow to be diverted from the LPI discharge header to the LDST. Since this action is not included in the emergency procedure, no credit is taken for detecting the diversion flow, and this event is assigned a probability of 1.0.

HLDFLOWDHE

This event represents failure of operators to recognize a change in letdown flow by checking the Unit Board letdown flow receiver gauge. The gauge is primarily used in the adjustment of flow and is not continuously monitored (although it is checked during control room rounds). The model takes credit for LDST flow and level alarms and pressurizer level alarm as means for detecting low LDST level and does not rely on operator action to check the letdown flow receiver gauge. Accordingly, this event is assigned a probability of 1.0.

HLDSTL1DHE

This event represents failure of operators to maintain LDST level > 40" through monitoring level during normal plant operation. In the quantification of this event, it is assumed that LDST level instrumentation is working properly to provide level indication and low level alarms. Prompt operator intervention is then needed to restore level by aligning coolant makeup sources as needed. This event was assigned a value of 1E-3.

<u>**HNMOPLVDHE**</u>

This event represents failure of operators to recognize that LDST level instrument have failed. Based on recent experience, this action is assigned a probability of 1.0.

<u>**HNVNTRYDHE**</u>

This event represents a failure of operator to respond to level changes in the LDST during a plant cooldown. Failure of operators to monitor level and respond to level changes is considered more likely during plant cooldown due to other activities (or distractions) that require operator attention and also due to the higher likelihood of experiencing level changes. This event is assigned a value of 0.1.

<u>**HOPOVPRDHE**</u> / <u>**HOPUNPRDHE**</u>

This event represents a failure of operators to respond to LDST overpressure or underpressure conditions during normal plant operation. Alarm response procedures provide instructions and guidance to restore proper hydrogen pressure in the LDST. Each event is assigned a value of 1E-3.

<u>**HPRESSRDHE**</u>

This event represents a failure of operator to respond to LDST pressure changes during a plant cooldown. Failure of operators to monitor pressure and respond to pressure changes is considered more likely during plant cooldown due to other activities (or distractions) that require operator attention and also due to the higher likelihood of experiencing level changes. This event is assigned a value of 0.1.

4.5.3 Common Cause Analysis

Introduction

Common cause events which were identified during the development of the system model were quantified based on methods and procedures provided in NUREG/CR-4780 (Ref. 12) and related documents. Because of the rarity of common cause events, available industry information was used to quantify common cause basic events modeled in the system fault trees. In cases where industry data is inadequate to estimate component specific common cause parameters, generic common cause parameters were used or engineering judgment applied.

The common cause basic event probabilities are calculated by multiplying the component failure "independent" failure probabilities by a common cause multiplier. The common cause multipliers were derived using the Multiple Greek Letter (MGL) method using plant specific and generic parameter values.

Common Cause Operating Experience

Industry operating experience is used in three aspects of common cause analysis:

1. identifying important common cause failure modes for the HPI system,
2. providing event data for detailed Common Cause Parameter Quantification, and
3. providing information for qualitative adjustment of generic parameters.

The primary types of HPI system common mode failures seen in the industry experience are the following:

- Pump Gas Binding (Loss of LDST Level and other causes)
- Pump Mechanical Failure
- Electrical Breaker Misposition (For Pumps or Valves)
- Valve Misposition

Previous Oconee PRA models did not explicitly address loss of LDST water level as a common mode failure of the HPI pumps. The May 3, 1997 Oconee event in particular demonstrated the need to include this type of failure mode in the Oconee HPI model. A specific common cause event was included in the LDST portion of the new model to represent common cause failure of the LDST level transmitters. This Oconee experience was also factored into the selection of a common cause multiplier for the LDST level transmitters and is discussed in the Event Quantification section below. A similar event involving common cause failure of the LDST pressure instrumentation was also identified as a result of this same event.

The previous Oconee HPI model had included common cause pump failure (mechanical failure and breaker failure) and common cause failure of redundant valves (mispositioned or breaker failure). Industry data was used to the extent possible to quantify these events either through detailed analysis or other analyses.

Selection of MGL Parameters

Because actual common cause events are very infrequent at any given nuclear plant, it is necessary to use generic data from the entire industry to provide a reasonable estimate of common cause potential. The drawback is that generic estimates of common cause probabilities generally assume that a common cause failure event at one plant has equal potential to occur at any plant. However, due to differences in design, operation, maintenance, testing, etc., these events do not generally have the same likelihood at every plant.

One of two different methods is used to select a set of MGL parameters for a given component -- Detailed Data Analysis or Qualitative Adjustment of Generic CCF Values. Detailed Data Analysis involves the review and analysis of plant failure events and also industry events following procedural guidance from industry developed sources (Ref.12, 13, 14). The CCDAT computer software (Ref. 15) can also be used to implement these procedures. Detailed Data Analysis requires a significant effort to collect plant data, assemble industry data, compile a database, and analyze the data. Generally, detailed analysis provides lower estimates of common cause failure probability because industry events that are not applicable to the analyzed plant are removed or weighted lightly.

The Qualitative Adjustment approach works on the premise that generic common cause values are generally conservative or at least average. In this approach, the subject group of components on the analyzed plant is reviewed to determine if the design, operation, maintenance, and testing features of the group appear to be more or less vulnerable than an "average" plant. If the component group appears to be significantly better or worse than the "average" plant at defending against common cause failure mechanisms, then the generic common cause value can be adjusted up or down accordingly. In many cases, however, a generic common cause value is adopted without adjustment because it is difficult to substantiate that the given system is better or worse than an "average" plant.

Both of these methods require engineering judgment. Careful review and comparison to other published common cause analyses helps ensure that the selected values are reasonable.

Common Cause Event Quantification

For the HPI and LDST models, six types of components were identified for common cause quantification. These components and their corresponding quantification method are listed below.

COMPONENT	QUANTIFICATION METHOD	SOURCE
HPI Pumps	Detailed Data Analysis	Oconee Specific Analysis of EPRI CCF Data
Motor-Operated Valves (MOVs)	Generic Value Assumed	ALWR Reference Document (Ref. 4.16)
Cooling Water Filters	Generic Value Assumed	NUREG/CR-5801
Level Transmitters	Qualitatively Adjusted Generic Value	Adjusted value from NUREG/CR-5801
Pressure Transmitters	Generic Value Assumed	NUREG/CR-5801
Flow Transmitters	Generic Value Assumed	NUREG/CR-5801

This list of components was selected based on a review of the redundant components in the HPI and LDST models and failures which were seen in the industry operating experience. A complete listing of common cause basic events and their probabilities is provided in Table 4.5.3-1. MGL parameters for the HPI pumps were estimated using

EPRI industry data found in References 14 and 17. A complete discussion of this detailed data analysis is provided in the HPI Pump section below.

Although adequate industry data is available, a detailed analysis for the various combinations of motor-operated valves was not performed for two reasons. First, it is difficult to distinguish the design and operating characteristics of MOVs between the industry plants and Oconee in order to assess the relative strength or weakness of Oconee common cause defensive strategies. Second, it is desirable to have consistent values with other MOV failures modeled in the Oconee PRA. Therefore, the generic MGL parameters for MOVs used in the Oconee PRA Rev. 2 were retained. These parameters values were taken from the ALWR Reference Document (Ref. 4.17)

In the case of the filters and transmitters, generic data must be used because plant specific and industry CCF data on those components are not available. NUREG/CR-5801 (Ref. 4.13) provides a set of MGL parameter values for reliability analyses where no data is available. These values are provided in the following table.

Generic MGL Parameters*						
System Size	Failure to Start			Failure to Run		
	β	γ	δ	β	γ	δ
2	0.10	-	-	0.05	-	-
3	0.10	0.27	-	0.05	0.27	-

*Generic MGL Parameters are based on NUREG/CR-5801 - Section 5.5.2

These values were used without modification except in the case of LDST Level Transmitters. In this case, the generic beta factor of 0.05 was increased to 0.07 based on a qualitative judgment of Oconee's experience. The recent modifications to the level and pressure instruments have reduced the likelihood of recurrence of previous common cause failures.

HPI Pump Assessment

The process of a detailed common cause data analysis began with a survey of available common cause information on the component of interest. Reference 4.14 is the primary source of information for the HPI pumps although other sources were also consulted to review additional events and descriptions (Ref. 4.16 and 4.17). Although there were six "common cause failure to start" events, there were no HPI/HPSI pump "common cause failure to run" events. To compensate for this problem, the scope of data was widened to all types of PWR safety injection pumps which includes LPI and RHR pump data. The inclusion of this data was deemed appropriate after reviewing the LPI/RHR event reports that showed that the causes of failure were generically related to "safety injection pumps" and not related to any specific features of low pressure pumps or RHR systems. Note that this approach of combining LPI/RHR pumps with HPI pump data was also used for quantification of MGL parameters in Reference 4.16.

Using this data on safety injection pumps, the CCDAT software program (Ref. 4.15) was used to "align" the industry data by thoroughly reviewing it for applicability to the Oconee HPI pumps. Careful consideration was given to the root causes, coupling mechanisms, system design, and operating conditions in these events in determining their full or partial applicability. Reference 4.13 provides some guidance in the selection cause and coupling applicability factor, and mapping parameters.

Due to the different operating configurations and functions modeled in the HPI model, it was necessary to perform this alignment process for HPI as a "3-Train System" and as a "2-Train System". The assessments performed for each industry event and system size were documented in the project files. The results of this detailed analysis are provided in the following table.

CCDAT Results For Oconee HPI Pumps						
System Size	Failure to Start			Failure to Run		
	β	γ	δ	β	γ	δ
2	0.075	-	-	0.006 (See Note 3)	-	-
3	0.101	0.503	-	0.033	0.580	-

It is important to note the basic event **HHP2-2RCOM** (CCF Of 2 of 2 HPI Pumps to Run) is a special case representing the failure of both HPI pumps to run during normal operation (i.e., during a very long mission time for the system). Typically, a common cause failure to run event is postulated to occur within a relatively short mission time (e.g., 24 hrs), and thus no credit is given for repair or replacement of failed equipment. However, in the case of event HHP2-2RCOM, one HPI pump is running providing RCP seal cooling and normal injection, and the other pump is in standby. If the running pump fails, the standby pump must start and run at least as long as it takes to repair or replace the other pump but does not have to run for the remainder of the system mission time. A coupling factor was applied within the CCDAT alignment database (for the 2 pump case only) to account for the likelihood that a failure event could be repaired prior to the standby pump failing to run.

4.5.4 Initiator Frequency Data

The HPI system is relied upon to mitigate LOCAs in the small and medium range. This section describes the manner in which the frequencies for these accident initiators has been estimated for this study. The years from 1980 to 1996 are used as the time period for data collection for the analysis. Industry experience for the years 1994 through 1996, since the Oconee PRA update, which used the 1980 through 1993 (606.2 PWR reactor-years), have been reviewed for any incidents that deserve classification as LOCAs. None were identified during this review. The additional 177 PWR years that have accumulated and additional Oconee reactor years (7.3) are used to update the frequencies of the LOCA initiators. Where needed the plant capacity factor for Oconee is assumed to be 0.9.

Small LOCAs

The small LOCA frequency is calculated by considering the occurrence of LOCAs in the industry during the time period considered. A single event (ANO RCP seal failure) occurred during this period. This industry experience is then assumed to be a lognormal distribution and used as a prior to be updated by Oconee specific experience. The resulting lognormal distribution for the industry experience has a mean value of
$\lambda = 1.28E\text{-}3/ry$.

After updating with the Oconee specific experience, the mean value of the resulting lognormal distribution is used as the small LOCA frequency for this analysis. The resulting small LOCA frequency is,
$\lambda_{SL} = 1E\text{-}3/yr$.

Medium LOCAs

The medium LOCA frequency is calculated by considering the occurrence of a LOCA that is "not small" (i.e., medium or large). No LOCAs in these ranges have occurred. The frequency is estimated as the mean of a distribution that results from performing a Bayesian update with the observed occurrences, 0, using a noninformative prior distribution. This technique is described in the PRA Procedures Guide, NUREG/CR-2300.

$$\lambda = \frac{1}{2T} = \frac{1}{2 \times 783} = 6.4E-04$$

$$\text{var} = \frac{1}{2T^2} = 8.16E-07$$

It is further assumed that this frequency is equally split between medium and large LOCAs. The resulting frequency for medium LOCAs used in this analysis is, therefore,

$\lambda_{ML} = 3E\text{-}4/yr$.

Additionally, this HPI reliability study is interested in identifying frequencies for some medium LOCAs in specific locations. These are the HPI line or the RCP discharge piping. These frequencies are some fraction of the total medium LOCA frequency. A description of the methodology used to establish these fractions follows.

An EPRI-sponsored methodology for estimating piping failure frequencies that is described in Reference 18. This report describes a technique of establishing the number of piping segments in a system and then applying the failure frequencies for piping segments to calculate a total frequency of failure. The technique used here is to estimate the total frequency of LOCAs that have an equivalent diameter of 2 inches to 6 inches using the method described in the EPRI report. It is noted here that the range of break sizes that are classified in the medium range in the Oconee PRA is from 1.5 inches to 4 inches. This difference between the EPRI pipe size range and the Oconee PRA medium LOCA range is not expected to be significant. The frequency of pipe breaks that occur in segments that are considered to be HPI line or RCP discharge are also calculated. The ratios of these frequencies to the total pipe break frequency are used as the split fractions for breaks in these locations. This analysis produces the following results:

Fraction of MLs in the RCP discharge	0.06
Fraction of MLs in the HPI line	0.31

Thus the annual frequency of the RCP discharge break is 2E-5/yr and the annual frequency for the HPI line break is 9E-5/yr.

Discussion of Alternative Methods

Other alternatives are available for estimating the medium LOCA frequency. The EPRI methodology which has been used here to estimate the split fractions could have been used directly to calculate the various medium LOCA frequencies. The total medium LOCA frequency calculated for Oconee by this technique is 9E-6/yr. This value is considerably lower than that arrived at by considering the experience base. The HPI line break frequency is found to be 3E-6/yr and the RCP discharge break is estimated at 5E-7/yr.

Other estimators of the mean also could have been applied. The χ^2 variate at the 50% confidence level has also been used to provide a point estimate for the frequency of initiators when none have occurred. If a distribution is needed, an error factor must be assumed if this method is applied. The selection of the degrees of freedom to be used in this calculation is not well established. Degrees of freedom of 1 or 2 have been used in various applications. The point estimates for the medium LOCA frequency as shown below:

Using two degrees of freedom,

$$\chi^2(\alpha,2n+2)/2T = 1.386/2T = .693/T, \text{ for } \alpha = 50\% \text{ and } n = 0$$
$$= 8.8E-4/ry$$

Using one degree of freedom,

$$\chi^2(\alpha,2n+1)/2T = 0.455/2T = .227/T, \text{ for } \alpha = 50\% \text{ and } n = 0$$
$$= 2.9E-4/ry$$

Another possible approach would be to obtain estimates using a variety of techniques (some of which have been provided above) and take the high and low to establish the upper and lower confidence limits. These two values can be used to calculate the mean and other parameters of a lognormal distribution. Using the techniques presented here, 9E-6/yr (the low value) and 8E-4/yr (the high value) could be assumed to be the 5th and 95th percentile values, respectively. The resulting mean is calculated to be 2E-4/yr for the assumed lognormal distribution.

The process for establishing frequencies or failure rates with no occurrence history is not well established. Many approaches have been applied in various studies. The approach applied in this HPI study provides a reasonable estimate which is within the range of other approaches considered.

4.6 Fault Tree and PRA Integrated Model Quantification

After the data base and fault tree models have been developed, the HPI fault tree models are ready for solution. After solving at a truncation limit of 1E-8, the cut sets are recovered using a recovery rule file. The resulting cut sets are reviewed for validity and to assess whether additional recoveries might be applied.

To assess the impact on plant risk, an integrated plant model is built. The model is constructed by integrating all of the system fault trees (HPI system, LPI system, AC Power system, etc.) with the top logic, which defines the various core damage sequence types. Once this model is built and any circular logic is broken, the model is solved, and cut sets are recovered and reviewed. Finally, all valid cut sets above the truncation limit of 1E-8 are summed to produce the core melt frequency result. This result represents the core melt sequence contribution from all internal accident initiators. The core melt sequence contribution from HPI system failures are segregated to determine the risk significance of various failure modes of concern.

Sensitivity studies are performed on the system reliability results and the core melt frequency results for specific issues of interest.

4.7 Assessment Of HPI Reliability During External Events

4.7.1 Seismic Assessment

The seismic core damage risk for Oconee is analyzed in the existing Oconee seismic PRA. In addition to seismic PRA techniques, seismic margin methodology has also been used in the seismic analysis as a part of the Individual Plant Examination of External

Events (IPEEE) program (see Reference 19). Extensive seismic walkdowns of the HPI System on all three units were conducted in 1994 and 1995 consistent with the intent of the guidelines described in Reference 20. In addition, these walkdowns also addressed USI A-46, "Seismic Qualification of Equipment in Operating Plants," using the methodology in the Generic Implementation Procedure (GIP) For Seismic Verification of Nuclear Plant Equipment.

The purpose of these walkdowns was to confirm the validity of the existing PRA fragility assessments, to review equipment with respect to seismic experience caveats, to verify seismic adequacy of equipment anchorage, and to identify any other seismic concerns, such as potential seismic spatial interactions in the "as-built" plant configuration. The walkdowns also included a review of the potential for fires, floods and toxic gas releases in the plant resulting from a seismic event.

The results from these walkdowns and associated evaluations did not identify any recommended enhancements to improve the seismic adequacy of the HPI system. The HPI pumps and injection flow path valves meet the seismic screening criteria.

However, several enhancements to the electrical support system components providing power to the HPI System were identified. These enhancements consist of proposed modifications near switchgear and motor control centers to prevent potential relay chatter concerns resulting from seismic interaction with adjacent equipment. Also, some minor anchorage repairs on several motor control centers were identified. These modifications will be completed in accordance with the schedule being developed by Duke to incorporate the plant enhancements recommended by the USI A-46 and IPEEE program results.

The relay chatter evaluation for Oconee is still ongoing. However, there are no relay chatter concerns associated with the HPI system. The results of this portion of the SQUG and IPEEE programs will be issued in December 1997.

Equipment anchorage capacities govern many of the equipment fragility assessments for the electrical support components. Since the IPEEE and Oconee PRA revision 2 submittals, reassessment of these capacities using more exact techniques rather than conservative bounding calculations has resulted in higher capacities for some components. These fragility updates are currently being incorporated into the PRA seismic model along with the relay chatter information.

In addition to the comprehensive A-46 and IPEEE program walkdowns, abbreviated seismic walkdowns of portions of the HPI System and support systems were conducted for the HPI System Reliability Study to confirm the results obtained from the USI A-46 and IPEEE studies. No additional concerns were identified.

4.7.2 Fire Assessment

The impact of fire on the HPI system was assessed by reviewing the documentation from the IPEEE fire review as well as Oconee PRA Revision 2. Extensive fire walkdowns were conducted for the fire IPEEE. The results from these walkdowns were used to update the PRA fire model. In addition, a supplementary fire walkdown focused on the HPI system and supporting systems was conducted as part of this HPI reliability study.

For a postulated fire in the HPI pump room, it was concluded that the fire would lead to a normal shutdown rather than an accident initiator sequence. Therefore, this area was screened from further fire consideration.

The conclusions of the fire analyses is that the fire risk at Oconee is dominated by the risk of fire in the Turbine Building and to a much lesser extent the cable shaft area in the Auxiliary Building. Power for the HPI system as well as other systems goes through both of these areas. Review of the existing documentation along with the supplementary walkdown findings support this conclusion. Therefore, the controlling fire risk reliability factor for the HPI system is the power train coming through the Turbine Building.

4.7.3 Internal Flooding Assessment

The Oconee PRA Rev. 2 internal flooding analysis concluded that the HPI pump room is the critical area in the Auxiliary Building from a flooding perspective. Industry data on previous Auxiliary Building flooding events was used in the PRA to estimate the frequency of HPI pump flooding, resulting in a flooding frequency of 8.8E-4. For the HPI reliability study, an alternate estimate was made assuming the BWST as the potential flood source and using pipe failure frequency data from Reference 18 to estimate potential for flooding the HPI pump room from the BWST by pipe rupture. This estimate resulted in a lower frequency than the current PRA estimate. Even using the current PRA flood frequency estimate of 8.8E-4, the estimated core damage frequency due to HPI pump room flooding is only 1.4E-8. Therefore, the HPI pump room flooding sequences are probabilistically insignificant to the total core damage frequency.

A flood in the Turbine Building is the dominant internal flooding sequence. This flood affects systems which support HPI. The dominant flooding sequence consists of a large non-isolable turbine building flood (failure of emergency feedwater and low pressure service water assumed) followed by failure to maintain HPI injection because of HPI pump motor cooling service water source failure or suction source inventory failure.

4.7.4 External Flooding Assessment

Two potential events were found that could lead to external flooding of the Oconee site. The first is a general flooding of the rivers and reservoirs in the area due to a rainfall in excess of the probable maximum precipitation (PMP). The second source of external flooding is a possible random failure of the Jocassee Dam. Seismically-induced failure of the dam is considered in the seismic analysis section.

The PMP postulated for the Oconee site is 26.6 inches within 48 hours. The Keowee and Jocassee reservoirs are designed to contain and control the floods that could result from a PMP. Thus, in order to flood the plant site, rainfall exceeding the PMP must occur. The frequency of exceeding the PMP was analyzed and used as a bounding estimate of the frequency of core damage due to rain-induced external flooding. The calculated mean frequency of the PMP is more than an order of magnitude less than that due to the governing random failure of the Jocassee Dam, which would also flood the site.

The Oconee site has a yard grade elevation a few feet below the full-pond level of Lake Keowee. Lake Jocassee has a full-pond elevation about 300 feet above Lake Keowee. If a sudden failure of the Jocassee Dam were to occur, and a rapid enough release of the impounded water into Lake Keowee resulted, the flood wave generated in Lake Keowee would overtop the Keowee Dam and the Oconee intake dike, flooding the plant. Using data from previous dam failures, the random dam failure frequency is estimated to be 1.3E-5/yr. The conditional probability of flooding the Oconee site given a catastrophic failure of the Jocassee Dam is conservatively estimated as 1.0.

The random failure of the Jocassee Dam is not a design basis event for Oconee and is assessed to be a low probability event. Although not a licensing commitment, the addition of the 5-foot hydrostatic barrier wall for the Standby Shutdown Facility (SSF), a separate building in the Oconee yard, was a low cost modification that provided additional safety margin for Oconee in the event of a Jocassee Dam failure. The SSF has an independent diesel generator and provides the capability for reactor coolant pump seal cooling and reactor core heat removal when the normal plant safety systems are not available. The SSF is available to mitigate external flooding sequences less than or equal to 5 ft. The probability of flooding levels exceeding the 5 ft. barriers is estimated to be 0.2.

In the event of an external flood of the magnitude to flood the Oconee yard, it is assumed that off-site and station power will be lost due to flooding in the switchyard. The SSF Diesel Generator is used to supply an independent source of power to the SSF equipment in the event of loss of offsite and station power. It is also assumed that the turbine building basement will be flooded; therefore, main and emergency feedwater will be lost. The SSF Auxiliary Service Water System (ASW) is used to provide a backup supply of water to the steam generators in the event of a total loss of all main and emergency feedwater. Therefore, secondary side heat removal is then dependent upon the availability of the SSF ASW System. Also, the lower levels of the Auxiliary Building will be flooded; therefore, high pressure injection and component cooling will be lost. The SSF Reactor Coolant Makeup (RCM) System is designed to provide reactor coolant pump seal cooling flow to all three Oconee units in the event of a total loss of HPI and a loss of thermal barrier cooling from the Component Cooling (CC) System. Hence, the ability to provide reactor coolant pump seal integrity is, under these conditions, dependent upon the availability of the SSF RCM System .

Therefore, in the event of an external flood of the magnitude to flood the Oconee yard, the SSF is expected to provide the necessary functions provided by the HPI System to lead to safe shutdown of the plant. The dominant flooding sequence consists of failure of the Jocassee dam when the flood level exceeds 5 feet. This results in failure of both the in-plant equipment and the SSF.

4.7.5 Tornado Assessment

The HPI pumps are located in the basement of the Auxiliary Building and are considered protected from the effects of tornado winds or missiles. Under accident conditions, these pumps draw suction from the BWST. The BWST is located outside next to the outer wall of the West Penetration Room and is exposed to full tornado wind loads. Analysis has shown that winds with speeds slightly higher than 168 mph will produce a pressure loading sufficient to fail the BWST. Therefore, it is assumed that F-3 category tornado winds will fail the BWST.

The station has a tornado protected, 3000 gpm Auxiliary Service Water (ASW) pump located in the Auxiliary Building basement for use after tornado events. It can simultaneously provide the EFW needs for all three units. The ASW pump is powered from its own independent 4160 V switchgear adjacent to the pump. This switchgear is connected directly to the CT4 transformer and is not powered through the unprotected 4160 main switchgear in the Turbine Building. The ASW pump, its switchgear, power cables and suction piping are all protected from tornado damage. The ASW pump must be manually aligned and started to provide feedwater flow. In addition to its feedwater capabilities, the ASW pump can supply cooling water flow to the HPI pump motor coolers.

Loss of RCP seal integrity, resulting in a LOCA, occurs when HPI seal injection and CC flow fails. Since these flow paths pass through the west penetration room for two of the four RCPs, they are assumed to fail when a tornado impact fails the exterior wall of the room. Seal injection from the SSF also fails when structural failure of the West Penetration Room occurs due to failure of the power cables running from the SSF to the RCM pumps through this room. Therefore, an RCP seal LOCA is assumed to occur whenever a tornado of intensity F-4 or higher impacts.

The HPI pumps and motor-operated valves are powered from the 4160V ac switchgear in the Turbine Building which is vulnerable to tornado-induced damage. Emergency power to an HPI pump can be recovered by reconnecting the power cable to the ASW switchgear which is in the Auxiliary Building and protected from tornado-induced damage. HPI injection lines passing through the west penetration room are assumed to fail if the room's exterior collapses, while injection lines passing through the east penetration room have a limited probability of failure.

The Oconee tornado core damage frequency is dominated by failure of the Keowee Hydro Station, failure to establish SSF seal cooling, and failure of the West Penetration Room exterior wall. Loss of emergency power from Keowee renders all Oconee plant systems unavailable following a tornado strike except for the TD EFW pump and the SSF. Damage caused by West Penetration room exterior wall failures lead to RCP seal LOCAs and can render SSF recovery systems unavailable.

4.7.6 *Conclusion of External Events Assessment*

An additional HPI system walkdown, focused on external event impact, and reviews of existing external event analyses have been performed as part of the HPI reliability study. The letdown storage tank instrumentation modifications were also reviewed for external events impact and were found not to affect the existing analyses. As can be seen from the discussion of the different events, plant-wide effects from external events dominate the risk results. No unique HPI vulnerabilities to external events were identified.

4.8 Role of HPI in Shutdown Risk

The risk of the shutdown operation for Oconee has been analyzed by means of the ORAM software (Reference 21). For the shutdown risk evaluation, the mode of plant operation is cold shutdown-to-refueling and then refueling-to-cold shutdown. In these modes, the HPI system is not required to be operable but is available on a limited basis through operator recovery action. The HPI system can provide core inventory makeup when all other injection capabilities (various LPI injection modes and BWST gravity feed) are lost and for possible "fill and spill" if the Steam Generator heat sink is also lost. In the current outage work schedule, a relatively high unavailability value (36% during the condition where HPI injection is useful) is assumed in the shutdown risk calculation. Assuming the HPI system is totally unavailable in this condition, the shutdown risk impact for a typical outage is estimated to be small. For example, for the Oconee 1 end-of-Cycle 16 outage the increase in the total outage core damage frequency due to the HPI system being assumed to be totally unavailable is 5E-7 (from 4.8E-6 to 5.3E-6).

Thus, the HPI system is not considered to have a significant role with respect to the shutdown risk.

Table 4.3-1

HPI Injection Success Criteria

Plant Condition	HPI Function	Actuation	Success Criteria
A. Normal operation	RCS makeup; RCP seal injection RCS chemistry & RCS boration during cooldown	manual	1 pump, normal makeup path, and 4 seal injection paths
B. UFSAR Chapter 15 Events:			
15.1 Uncompensated operating reactivity changes	post-transient recovery	manual	1 pump, 1 SI path
15.2 Startup accident	"	"	"
15.3 Rod withdrawal	"	"	"
15.4 Moderator dilution	"	"	"
15.5 Cold water accident	"	"	"
15.6 Loss of coolant flow	"	"	"
15.7 Control rod misalignment	"	"	"
15.8 Loss of electric load	"	"	"
15.9 SGTR	RCS makeup to compensate for inventory loss and shrink	auto	"
15.10 Waste gas tank rupture	N/A	N/A	N/A
15.11 Fuel handling accident	N/A	N/A	N/A
15.12 Rod ejection	post-accident recovery	manual	1 pump, 1 SI path
15.13 Steam line break	RCS makeup and boration	auto	"

Table 4.3-1
HPI Injection Success Criteria

Plant Condition	HPI Function	Actuation	Success Criteria
15.14 LOCA			
a) small break	ECCS	auto	1 pump, 1 SI path
b) HPI line break & cold leg RCP discharge break	ECCS	auto and manual	2 pumps, 2 SI paths
C. **PRA Events and Functions:**			
1. Small break LOCA	core injection	auto or manual	1 pump, 1 SI path
2. Medium break LOCA a) General b) HPI Line/RCP discharge	"	"	1) " 2) 2 pumps, 2 SI paths
3. SGTR	"	auto	"
4. Feed-bleed cooling	"	auto or manual	2 pumps, 1 SI path
5. RCP seal cooling	RCP seal injection	manual	1 pump, 4 seal injection paths

Table 4.5.1-1

Equipment Failure Rate Data

		Plant-Specific Data			Generic Failure Rates		Bayesian-Updated Failure Rates	
Type Code	Description	Failures	Demands	Time	Mean	Error Factor	Mean	Error Factor
ACF	SSF Suction Accumulator Fails	0		43200	4.90E-07	5.6	4.60E-07	5.8
AMF	Alarm Module Fails to Operate on Demand	0		183960	3.73E-06	2.1	3.26E-06	2.0
APR	SSF ASW Pump Fails To Run	0		197	2.40E-05	3.2	2.38E-05	3.2
APS	SSF ASW Pump Fails To Start	1	131		3.10E-03	3.2	3.79E-03	2.8
AVC	Air Operated Valve Fails To Close On Demand	3	192		2.20E-03	2.8	4.61E-03	2.4
AVO	Air Operated Valve Fails To Open On Demand	0	715		2.20E-03	2.8	1.40E-03	2.3
AVT	Air Operated Valve Transfers Position	0		764985	2.70E-06	10	6.35E-07	4.6
BAF	Buffer Amplifier Fails	0		259200	4.49E-06	16	1.06E-06	7.4
BCF	Battery Charger Fails	21		914400	1.10E-05	4.9	2.17E-05	1.4
BDF	DC Power Bus Fails	0		1766880	6.10E-07	5.2	2.99E-07	3.5
BHF	4 KV Or Greater High Voltage AC Power Bus Fails	2		1560240	5.30E-07	5.1	8.27E-07	2.8
BID	Bistable Fails To Operate On Demand	0	261		2.20E-05	42	1.16E-05	41.4
BLF	600 V Or Less AC Power Bus Fails	9		9145440	3.60E-07	6.4	8.61E-07	1.7
BYF	Battery Fails	0		44	3.20E-03	23	1.57E-03	18.2
C4C	4 KV AC Circuit Breaker Fails To Close On Demand	0	1780		1.20E-03	4	5.31E-04	2.8
C4O	4 KV AC Circuit Breaker Fails To Open On Demand	0	118		3.00E-04	4	2.87E-04	3.9
C4T	4 KV AC Circuit Breaker Transfers Position	0		1167066	1.90E-06	5.7	6.38E-07	3.3
CBD	Logic Buffer Fails To Trip	0	222		1.70E-04	14	1.28E-04	13.2
CDT	DC Circuit Breaker Transfers Position	0		3477353	1.90E-06	5.7	3.54E-07	2.8
CHC	High Voltage PCB 200 to 300 kV Fails To Close	0	59		7.20E-06	10	6.42E-06	10.0
CHT	High Voltage PCB 200 to 300 kV Transfers Position	0		129600	3.00E-07	10	2.47E-07	9.5
CLC	Low Voltage Circuit Breaker Fails To Close On Demand	0	44		1.20E-03	4	1.13E-03	3.9
CLO	Low Voltage Circuit Breaker Fails To Open On Demand	0	39		1.20E-03	4	1.14E-03	3.9
CLT	Low Voltage Circuit Breaker Transfers Position	2		6208333	1.90E-06	5.7	4.62E-07	2.2
CMR	Air Compressor Fails To Run	1		117365	1.50E-04	5.1	2.22E-05	2.2

Table 4.5.1-1

Equipment Failure Rate Data

		Plant-Specific Data			Generic Failure Rates		Bayesian-Updated Failure Rates	
Type Code	**Description**	**Failures**	**Demands**	**Time**	**Mean**	**Error Factor**	**Mean**	**Error Factor**
CMS	Air Compressor Fails To Start On Demand	1	2160		2.90E-02	17	8.10E-04	2.8
CPR	Condenser Circulating Water Pump Fails To Run	3		515570	2.40E-05	3.2	8.95E-06	1.8
CTR	Lee Combustion Turbines Fail To Run	3		715	N/A	N/A	7.70E-04[6]	5
CTS	Lee Combustion Turbine Fails To Start On Demand	3	656		N/A	N/A	6.40E-03[6]	5
CTT	Circuit Breaker Auxiliary Contact Spurious Operation	0	1296000		7.10E-08	6.9	5.84E-08	6.5
CVC	Check Valve Fails To Close On Demand	0	59		9.70E-04	5.2	8.81E-04	5.1
CVO	Check Valve Fails To Open On Demand	0	3600		1.90E-04	8.9	8.15E-05	5.4
CVR	Check Valve Ruptures	0		129600	7.60E-08	6.5	7.11E-08	7.2
CVT	Check Valve Transfers Closed	0		1156680	4.50E-07	20	1.38E-07	12.5
DCR	Diesel Air Compressor Fails To Run For The Required Time	0		256	N/A	N/A	1.40E-02[6]	5
DCS	Diesel Air Compressor Fails To Start On Demand	0	256		N/A	N/A	5.00E-03[6]	5
DGR	SSF Diesel Generator Fails To Run	2		168	2.30E-03	6.7	6.00E-03	3.4
DGS	SSF Diesel Generator Fails To Start On Demand	1	183		1.80E-02	5	8.23E-03	2.6
DIF	Isolating Diode Fails	0		1209600	1.22E-06	10	3.42E-07	5.0
DMO	Damper Fails To Open On Demand	0	128		3.50E-03	6.3	2.10E-03	4.6
DMT	Damper Spurious Operation	0		129245	3.00E-07	10	2.47E-07	9.5
DPR	SSF Reactor Coolant Makeup Pump Fails To Run	1		144	2.40E-05	3.2	3.78E-05	3.2
DPS	SSF Reactor Coolant Makeup Pump Fails To Start On Demand	3	151		3.10E-03	3.2	7.12E-03	2.5
DYC	Time Delay Relay Fails To Close On Demand	0	256		3.20E-06	3.5	3.17E-06	3.5
FLF	Filter / Strainer Fails	0		796572	1.20E-05	6.6	1.58E-06	2.9

[6] For this equipment type, only plant-specific data is used. A Bayesian update was not performed.

Table 4.5.1-1

Equipment Failure Rate Data

		Plant-Specific Data			Generic Failure Rates		Bayesian-Updated Failure Rates	
Type Code	Description	Failures	Demands	Time	Mean	Error Factor	Mean	Error Factor
FNR	Fan Fails To Run For The Required Time	0		172445	9.10E-06	3.8	4.73E-06	2.8
FNS	Fan Fails To Start On Demand	0	513		3.50E-03	15	6.80E-04	6.3
FRF	Raw Water Filter Or Strainer Plugs	0		284331	1.20E-05	6.6	2.89E-06	3.4
FTF	Flow Transmitter Fails to Respond (Hourly)	0		86400	1.80E-06	3.6	1.61E-06	3.3
GPR	Generic Pump Fails To Start On Demand	0		43210	2.40E-05	3.2	1.59E-05	2.6
GPS	Generic Pump Fails To Start On Demand	0	197		3.10E-03	3.2	2.34E-03	2.8
HPR	High Pressure Injection Pump Fails To Run	2		182404	2.40E-05	3.2	1.47E-05	2.0
HPS	High Pressure Injection Pump Fails To Start On Demand	1	2252		3.10E-03	3.2	1.18E-03	2.1
HXF	Heat Exchanger Fails	1		1062592	3.40E-06	8.2	1.21E-06	3.0
HYR	Keowee Hydro Unit Fails To Run For The Required Time	5		5772	N/A	N/A	8.66E-04[6]	5.0
HYS	Keowee Hydro Unit Fails To Start On Demand	9	2609		N/A	N/A	3.45E-03[6]	5.0
IEF	I-E Converter Fails To Function Properly	0		43200	5.60E-07	1.8	5.58E-07	1.8
IVF	Inverter Fails	59		1708560	2.90E-05	11	3.42E-05	1.2
JPR	Jockey Pump Fails To Run	0		95374	2.40E-05	3.2	1.22E-05	2.4
LLD	Limit Switch Fails On Demand	0	39		2.50E-04	5.1	2.40E-04	5.3
LMD	Logic Module Fails On Demand	0	276		1.70E-04	14	1.25E-04	13.0
LMF	Logic Module Fails To Function	0		129600	1.80E-06	7.3	1.23E-06	5.8
LPR	Low Pressure Injection Pump Fails To Run	2		17288	2.40E-05	3.2	4.19E-05	2.7
LPS	Low Pressure Injection Pump Fails To Start On Demand	5	1611		3.10E-03	3.2	2.95E-03	1.8
LSD	Level Switch Fails on Demand	0	0		1.60E-03	4.3	1.79E-04	1.9
LTF	Level Transmitter Fails	0		129600	4.60E-07	2	4.55E-07	2.0
MPR	Motor-Driven EFW Pump Fails To Run	2		634	2.40E-05	3.2	5.50E-05	2.5
MPS	Motor-Driven EFW Pump Fails To Start On Demand	0	772		3.10E-03	3.2	1.55E-03	2.4
MVC	Motor Operated Valve Fails To Close On Demand	0	311		3.50E-03	2.2	2.81E-03	2.0

Table 4.5.1-1

Equipment Failure Rate Data

		Plant-Specific Data			Generic Failure Rates		Bayesian-Updated Failure Rates	
Type Code	**Description**	**Failures**	**Demands**	**Time**	**Mean**	**Error Factor**	**Mean**	**Error Factor**
MVO	Motor Operated Valve Fails To Open On Demand	0	562		3.50E-03	2.2	2.47E-03	1.9
MVR	Motor Operated Valve Transfers Position	0		43200	4.30E-08	2.6	4.29E-08	2.6
MVT	Motor Operated Valve Transfers Position	0		2217536	3.70E-07	16	1.04E-07	8.3
ORF	Orifice Is Plugged	0		164850	8.60E-09	100	2.56E-09	99.7
PBC	Pushbutton Fails To Close On Demand	0	0		4.30E-07	5	3.88E-07	4.8
PDF	Pushbutton Spuriously Closes	0		64	4.90E-07	5.6	4.67E-07	7.1
PLO	Dropout Plate Fails To Operate On Demand	0	0		1.00E-06	10	6.61E-07	8.5
POF	120 V AC Regulated Power Supply Fails	0		259200	5.88E-06	9.1	1.72E-06	4.7
PPR	High Pressure Service Water Pump Fails To Run	1		55	2.40E-05	3.2	3.79E-05	3.2
PPS	High Pressure Service Water Pump Fails To Start On Demand	0	306		3.10E-03	3.2	2.11E-03	2.6
PRC	Pilot-Operated Relief Valve 3RC-66 Fails To Close On Demand	0	0		1.80E-02	6.9	7.70E-03	4.3
PRO	Pilot-Operated Relief Valve 3RC-66 Fails To Open On Demand	0	0		6.30E-03	4.7	4.62E-03	3.9
PSO	Pressure Switch Fails To Close	0	404		2.60E-04	8.1	2.01E-04	7.6
PST	Pressure Switch Spurious Operation	0		518400	8.50E-07	4.6	5.93E-07	3.7
PTF	Pressure Transmitter Fails	0		259215	4.90E-07	5.6	4.07E-07	5.1
PTK	Pressure Transmitter Output Fails High	0		129600	1.50E-06	3.3	1.34E-06	3.1
PTL	Pressure Transmitter Output Fails Low	0		302400	1.50E-06	3.3	1.19E-06	2.9
RGO	Self Regulating Valve Fails To Open On Demand	0	4320		2.20E-03	2.8	6.66E-04	1.9
RGT	Self Regulating Valve Spurious Operation	0		359295	2.70E-06	10	9.27E-07	5.4
RTK	Resistance Temperature Detector Output Fails High	0		259200	6.70E-07	3.6	5.93E-07	3.3
RVC	Safety Relief Valve Fails To Reseat On Demand	0	20		7.50E-03	4.6	6.42E-03	4.2

Table 4.5.1-1

Equipment Failure Rate Data

		Plant-Specific Data			Generic Failure Rates		Bayesian-Updated Failure Rates	
Type Code	Description	Failures	Demands	Time	Mean	Error Factor	Mean	Error Factor
RVO	Safety Relief Valve Fails To Open On Demand	0	0		3.00E-04	6.1	1.55E-05	1.5
RVT	Safety Relief Valve Spurious Operation	0		43200	1.70E-06	4.2	1.57E-06	4.0
RYD	Relay Fails To Operate On Demand	0	1548		1.90E-04	9	1.11E-04	6.5
RYT	Relay Spurious Operation	0		43200	1.00E-06	5	9.28E-07	4.9
SMF	Summer Module Fails To Function Properly	0		43200	8.30E-07	1.8	8.26E-07	1.8
STC	Static Transfer Switch Fails To Swap On Demand	1	233		4.90E-03	31	3.12E-03	4.6
SVO	Solenoid Valve Fails To Open On Demand	0	138		2.80E-03	7.5	1.62E-03	5.3
SVT	Solenoid Valve Transfers Position	0		119214	4.10E-07	3	3.98E-07	2.9
SWC	Control Switch Fails To Open On Demand	0	5		1.00E-05	5	9.73E-06	5.2
SWT	Control Switch Spurious Operation	0		216000	1.00E-06	10	6.14E-07	7.7
T4F	4 KV / 600 V AC Transformer Fails	0		518400	2.10E-06	6.4	9.01E-07	4.0
THF	High Voltage Transformer Fails	0		216000	2.10E-06	7	1.20E-06	4.9
TKF	Tank Fails	0		172800	7.50E-07	6.3	6.03E-07	5.6
TLF	600 V / 208 V AC Transformer Fails	0		777600	1.90E-06	8.8	5.78E-07	4.6
TPR	Turbine Driven EFW Pump Fails To Run	6		350	1.30E-03	13	8.92E-03	1.1
TPS	Turbine Driven EFW Pump Fails To Start On Demand	0	308		2.10E-02	2.9	7.37E-03	2.0
TTF	Temperature Transmitter Fails To Operate	0		43200	1.50E-06	4.4	1.39E-06	4.2
TVT	Temperature Control Valve Spurious Operation	0		303465	4.20E-08	8.7	3.74E-08	8.6
UCD	Unit Control Module Fails To Trip On Demand	0	79		6.00E-08	2.1	6.00E-08	2.1
VGF	Voltage Regulator Fails	0		86400	7.10E-06	2.9	5.59E-06	2.6
VVT	Manual Valve Transfers Position	0		9032237	8.00E-08	7.3	3.75E-08	4.7
WPR	Low Pressure Service Water Pump Fails To Run	6		357195	2.40E-05	3.2	1.75E-05	1.7

Table 4.5.1-1

Equipment Failure Rate Data

		Plant-Specific Data			Generic Failure Rates		Bayesian-Updated Failure Rates	
Type Code	**Description**	**Failures**	**Demands**	**Time**	**Mean**	**Error Factor**	**Mean**	**Error Factor**
WPS	Low Pressure Service Water Pump Fails To Start On Demand	0	1011		3.10E-03	3.2	1.39E-03	2.3

Table 4.5.3-1

Oconee HPI Common Cause Events

*NAME	Event Description	CCF Multiplier	MGL Source (See Note 1)	Relevant Type Code	Exp. Time (See Note 2)	Independent Failure Rate	Independent Failure Probability	Basic Event Probability
HHP2-2RCOM	CCF Of 2 of 2 HPI Pumps To Run	0.006	See Note 3	HPR	7884	1.47E-05	1.16E-01	7.22E-04
HHP23SICOM	CCF Of 2 of 3 HPI Pumps To Start During Injection	0.101	CCDAT	HPS	#	1.18E-03	1.18E-03	1.19E-04
HHP33SICOM	CCF Of 3 of 3 HPI Pumps To Start During Injection	0.051	CCDAT	HPS	#	1.18E-03	1.18E-03	5.98E-05
HHP23RICOM	CCF Of 2 of 3 HPI Pumps To Run During Injection	0.033	CCDAT	HPR	2	1.47E-05	2.95E-05	9.57E-07
HHP33RICOM	CCF Of 3 of 3 HPI Pumps To Run During Injection	0.019	CCDAT	HPR	2	1.47E-05	2.95E-05	5.55E-07
HHP33RRCOM	CCF Of 3 of 3 HPI Pumps To Run During Recirculation	0.019	CCDAT	HPR	22	1.47E-05	3.24E-04	6.11E-06
HHPPMPSCOM	Common Cause Failure of HPI Pumps 3B and 3C to Start	0.075	CCDAT	HPS	#	1.18E-03	1.18E-03	8.87E-05
HHPSVLVCOM	CCF Of MOVs 3HP-24 And 3HP-25 To Open On Demand	0.05	ALWR #22	MVO	#	2.47E-03	2.47E-03	1.24E-04
HLPSVLVCOM	CCF Of MOVs 3LP-15 And 3LP-16 To Open On Demand	0.05	ALWR #22	MVO	#	2.47E-03	2.47E-03	1.24E-04
HLSFILTCOM	CCF Of Cuno Filters 3LPSFL0001, 0002, And 0018	0.05	Generic	FLF	24	1.58E-06	3.80E-05	1.90E-06
HLDXMTRCOM	CCF Of LDST Level Transmitters (2 of 2)	0.07	See Note 4	LTF	6570	4.55E-07	2.99E-03	2.09E-04
HPIFT6XCOM	CCF Of Letdown Flow Transmitters (2 of 2)	0.05	Generic	FTF	6570	1.61E-06	1.06E-02	5.29E-04
HLDPXTRCOM	CCF Of LDST Pressure Transmitters (2 of 2)	0.05	Generic	PTF	6570	4.07E-07	2.67E-03	1.34E-04

1 - "ALWR" refers to the ALWR Utility Requirements Document (Reference 4.16). The reference number listed corresponds to the Item Number or Source Number used in Annex A of the ALWR report. "Generic" implies that generic values from NUREG/CR-5801 were used. "CCDAT" refers to an Oconee specific analysis performed on the HPI pumps using the CCDAT computer software developed by EPRI.

2 - "Exp. Time" refers to the exposure time or mission time for the component. The "injection" mission time for the HPI pumps is assumed to be 2 hours and 22 hours for the "recirculation" mission time.

3 - The common cause database (CCDAT) alignment for 2 of 2 HPI pumps failing to run is a special case performed under an assumption of a long mission time (normal plant operation) with 1 pump running and 1 pump in standby. This specific common cause parameter would not be appropriate for a case of 2 of 2 pumps failing to run over a shorter mission time. Typically, a common cause failure to run event is postulated to occur within a specified mission time. Usually, this mission time is relatively short (e.g., 24 hrs) and thus no credit is given for repair or replacement of failed equipment. Loss of both HPI pumps (A & B) would involve the failure of the normal operating (running) pump and the failure of the standby pump to start and run until the first pump is repaired which should be on the order of 1 - 3 days. A coupling factor was applied within the CCDAT alignment database to account for the likelihood of failure.

Table 4.5.3-1

Oconee HPI Common Cause Events

4 - Typically, a generic common cause factor of 0.05 would be used in this situation. However, due to the recent common cause failure event on these level transmitters, a value of 0.07 was assumed. This value qualitatively accounts for the adverse experience with these transmitters, but also considers that modifications made to provide a separate reference leg for each transmitter should prevent the reoccurence of this same failure mode again.

CCDAT Results For Oconee HPI Pumps

System Size	Failure to Start			Failure to Run		
	β	γ	δ	β	γ	δ
2	0.075	-	-	0.006 (See Note 3)	-	-
3	0.101	0.503	-	0.033	0.580	-

5. RESULTS

5.1 Results of System Reliability Analysis

Table 5.1-1 presents the system reliability results for the HPI system for the various accident mitigation functions and for the normal plant operating functions. The results are further discussed in the following sub-sections.

5.1.1 Reliability for Chapter 15 Non-LOCA Accidents

To respond to non-LOCA design basis accidents, the HPI system must be capable of supplying two cold leg injection nozzles from one HPI pump train. Only the SGTR and MSLB accidents would require drawing inventory from the BWST. For these accidents, BWST level is not expected to be drawn low enough to allow hydrogen entrainment from the LDST.

The, failure probability for these accidents is estimated to be 2.8E-4. Thus, the estimated reliablity is better than 99.9%

5.1.2 Reliability for UFSAR LOCA Events

The most probable UFSAR LOCA event is a random small break LOCA (with an estimated annual frequency of 1E-3/ry) for which one HPI train is adequate to meet the ECCS performance criteria. The failure probability of the HPI system is calculated to be 9.4E-4 during injection phase and 1.1E-2 during the recirculation phase. Thus, the reliability of the HPI system in meeting the design basis small break LOCA function is approximately 99.9% during the injection phase and 98.9% during the recirculation phase.

The failure modes controlling HPI system reliability for this event are the same as those discussed in Section 5.1.3.

The most demanding design basis LOCAs (viz. HPI line and RCP discharge breaks) require two HPI pumps and four injection nozzles during the injection phase of accident mitigation. For these special small break LOCAs, the HPI system failure probability during the injection phase is estimated to be 3.6E-3 (corresponding to a reliability of about 99.6%) and 1.1E-2 during the recirculation phase (or 98.9% reliability).

The dominant contributors to system unreliability for the injection phase are presented in Table 5.1.2-1. The top two cut sets contain the failure of either the A1 or A2 cold leg injection check valve (HP-486 or HP-487) to remain open, based on their long exposure time during normal plant operation. (It is assumed that if either one of these valves transferred closed during normal operation, the failure would not be detected.) Common cause failure of the LDST level and pressure instruments show up as the next failure mode, with a failure probability in the E-4 range. Table 5.1.2-2 presents the importance measures of basic events associated with the HPI injection fault tree. It is seen that with the requirement to have injection through all four HPI nozzles, the HPI nozzle check valve failure is the top failure mode of the system for these special small break LOCAs.

During the recirculation phase of the accident, additional system interfaces (LPI system, RB emergency sump, and operator action) are needed in addition to the HPI system. Therefore, the reliability of the function is expected to be lower than in the injection phase. The calculated recirculation mode failure probability is 1.1E-2. Dominant cut sets and important failure modes contributing to system failure are shown in Table 5.1.2-3, and Table 5.1.2-4, respectively.

As seen, failure of check valve HP-97 to remain closed is an important failure mode for the HPI recirculation function. The failure probability assigned to this check valve is 8.8E-3, assuming ten valve demands during the initial LDST-to-BWST swap-over of the

HPI pump suction and a valve failure rate of 8.8E-4 per demand. There is some likelihood that the operators could recognize the increasing LDST level and pressure if the check valve were to remain stuck open while the LPI discharge is feeding the HPI pump suction. In the current plant procedures, the necessary operator action to recognize this failure and to isolate the check valve (by closing MOV HP-23) is not included. Therefore, the operator failure probability is assumed to be 1.0. If the credit for operator action is instead 0.1, the cut set value would become 8.8E-4 and the HPI recirculation failure would be approximately 3.3E-3.

The reliability results for the UFSAR LOCA events imply that the Oconee HPI system can perform the ECCS functions reliably. The reliability is very high (99.9%) during the injection phase. For the recirculation phase, the reliability is lower than the injection phase due to the potential for additional failure modes. Improvement in HPI recirculation reliability appears feasible if action is taken to isolate check valve HP-97 should it stick open during the piggy-back mode of the HPI-LPI sump recirculation.

5.1.3 PRA LOCA EVENTS

Small break and medium break LOCAs are the PRA LOCA events of interest for the HPI system. Considering that only one HPI pump and two injection nozzles are required, the failure probability for the HPI system is calculated to be 9.4E-4 for the injection function and 1.1E-2 for the recirculation function. The dominant cut sets and importance measures for the injection function are presented in Tables 5.1.3-1 and 5.1.3-2, respectively. The failure modes and importance measures for the recirculation function for the PRA LOCA events are identical to the UFSAR LOCA events discussed in Section 5.1.2.

For the location-specific LOCA (HPI line break/RCP discharge break), the HPI injection failure probability is calculated to be 2.5E-3, using the best estimate success criteria. Table 5.1.3-3 contains the dominant cut sets for the injection function, and Table 5.1.3-4 identifies the dominant contributors to unreliability. For the HPI recirculation function, the results presented in the UFSAR LOCA case of Section 5.1.2 apply for this case also.

5.1.4 Reliability for Feed and Bleed Cooling

For feed and bleed cooling, the PRA requires two HPI pumps injecting into at least two cold legs. HPI failure probability for this mode of operation is estimated to be 1.2E-3. The dominant contributors to system unreliability are:

- failure of the LDST level instrument failures
- and failure of BWST suction valves HP-24, -25 to open.

Dominant cut sets contributing to system failure and important events for the injection phase are shown in Tables 5.1.4-1 and 5.1.4-2, respectively.

The recirculation mode results for the feed and bleed function are identical to the LOCA results discussed earlier in Section 5.1.2.

5.1.5 Reliability for Seal Injection Following a Non- LOCA Event

For successful RCP seal injection, the PRA requires one HPI pump to provide flow to all four seal packages. HPI failure probability to provide this function is estimated to 4.3E-4. Dominant cut sets and important failure events contributing to system failure are shown in Tables 5.1.5-1 and 5.1.5-2, respectively.

5.1.6 Reliability During Normal Plant Operation

During normal plant operation, the HPI system requirement for the RCS make-up is for one HPI pump to supply at least one of the 'A' cold leg injection nozzles. (For normal operation, no credit is taken for HPI pump 'C'.) HPI failure probability to provide this function over a one year period is estimated to be 5.3E-2. Pertinent cut sets and failure events contributing to system failure are shown in Tables 5.1.6-1 and 5.1.6-2, respectively.

Normal RCP seal injection requires one HPI pump to provide flow to all four RCP seal packages. HPI failure probability to provide this function over a one year period is estimated to be 7.5E-2. Pertinent cut sets and failure events contributing to system failure are shown in Tables 5.1.6-3 and 5.1.6-4, respectively.

The auxiliary pressurizer spray function requires one HPI pump to provide flow through the auxiliary spray line to the pressurizer. The failure probability to provide this function per unit shutdown event is estimated to be 1.6E-2. Dominant events and cut sets contributing to system failure are shown in Tables 5.1.6-5 and 5.1.6-6, respectively.

5.2 Impact of HPI System Failure Modes on Core Damage Frequency

To assess the impact of HPI system failure modes on core damage frequency, the revised HPI fault tree was substituted into the Oconee plant model, and the model re-solved. The new CDF (excluding seismic events) is 4.3E-5[7].

Failures attributed to the HPI system sum to 1.5E-5, or 35% of the CDF. The HP-97 failure mode (failure of the check valve to close during the HPI sump recirculation mode) represents 1.2E-5 and is the dominant contributor. Failure of the operators to initiate high pressure recirculation contributes 2.2E-6 to the CDF. The common cause failure of the LDST instrumentation (level and pressure) with potential HPI pump failure from hydrogen entrainment is calculated to be 5E-7. Recovering the LDST interface failure cut sets with an operator action to isolate the LDST (set at a conservatively achievable value of 1E-2) effectively eliminates these cut sets, reducing the CDF to 3.1E-5.

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[7] This figure excludes the seismic contribution. The seismic PRA model requires the use of an additional computer code to integrate the site seismic hazard with the plant system seismic fragility and random failure modes. Therefore, the seismic results are derived and presented separately from the integrated plant model solution. The HPI system is considered seismically rugged and failures involving the HPI system do not show up in the top seismic core melt frequency cut sets.

Table 5.2-1 shows the top 50 cut sets. Table 5.2-2 lists the hardware failures and human failure events which dominate the top cut sets. Table 5.2-3 lists the failure events which, if *assured* to occur, would have the greatest impact on core damage frequency.

5.3 Sensitivity Studies

Auto-Start of Second HPI Pump

Auto-start of a second HPI pump on low RCP seal flow provides a reliable method of maintaining seal cooling flow following the loss of the running HPI pump or the occurrence of transients (for example, overcooling events) which starve the RCP seal injection flow. This auto-start feature also assures that the potential for loss of pressurizer level is minimized. In the absence of the auto-start feature, timely operator action would be required to manually start the second pump on receipt of the low seal flow alarm to provide RCS make-up and seal injection flow.

To provide a perspective on the role of the auto-start feature, the following analysis considers the core damage frequency impact for three possible scenarios.

One possible scenario involves the condition that two HPI pumps are failed due to inadequate LDST level or pressure (instead of just one) before an accident. The estimated annual probability of this condition is approximately 7E-4. The scenario starts with the failure of the running HPI pump, auto start of the second pump, and finally, failure of the second pump. Under these conditions the Unit would be placed in a shutdown mode or a mode where the HPI function is not required, as required by Technical Specifications. If an HPI line break or RCP discharge break LOCA were to occur for such an initial condition, the HPI system would be unable to meet the success criterion of two HPI pumps. Considering a time window of 24 hours for this initial condition, the probability of one of these specific LOCAs occurring is approximately 3.0E-7. Thus these sequences are on the order of 2E-10 and are not risk significant. Further, note that if the LOCA were to occur prior to restoration of the HPI suction header to a functional state, the second HPI pump could fail after being started by the ES signal.

Another event which might require starting the second HPI pump is an overcooling transient. These events are estimated to occur three times per year. For these events, the demand for HPI flow may be great enough to require two HPI pumps, but not enough to generate an ES signal. Following an overcooling transient, the second HPI pump normally starts and, together with the first HPI pump, supplies the needed RCS make-up flow and seal injection flow. One way for these transients to lead to reduced HPI system accident mitigation capability is through an operator error which fails both running HPI pumps, such as a failure to maintain an adequate suction source to the pumps. With two HPI pumps unavailable, the occurrence of an HPI line break or RCP discharge break LOCA has the potential to lead to core damage. Again considering a time window of 24 hours for this condition, the probability of a one of these LOCAs occurring is approximately 3.0E-7. Thus, given that an overcooling event occurs, these sequences are approximately 9E-9 (assuming a screening value of 0.03 for the operator error) and are not risk significant.

A third example of a situation which would lead to auto-start of the second HPI pump is a random failure of the running HPI pump. In this case, the auto-start feature is somewhat irrelevant with respect to core damage potential from a LOCA, since all HPI pumps would be started by an ES signal. However, in the absence of an ES signal, the auto-start feature reduces the need for operator action to maintain seal cooling and RCS make-up flows.

As seen from this analysis, failures of two HPI pumps due to the auto-start feature which lead to core damage are not probabilistically significant.

Isolation of the LDST on ES Signal

Currently, the LDST remains aligned to the HPI suction header during the LOCA mitigation, serving as an alternate source of suction. The HPI pump recirculation flow is routed to the LDST. If the LDST is isolated immediately after an ES signal, the LDST level and pressure will increase, possibly opening the LDST relief valve. Although operator action can be taken to isolate or reroute the recirculation flow, this is considered to be an operator burden immediately following a LOCA. During the HPI sump recirculation phase, the pump minimum recirculation flow is rerouted to the LPI header by operator action. The open LDST suction also provides the capability to mitigate a potential common cause failure of BWST suction valves HP-24 and HP-25 to open by making use of the LPI discharge, with the available LDST inventory to avoid immediate HPI pump failure.

The unisolated LDST creates the potential for HPI pump failure from hydrogen entrainment if the LDST pressure and level are outside their permissible ranges due to common cause failure. The failure probability of the HPI system due to such a failure mode is calculated to be 6.6E-4. The core damage impact of these failure modes is relatively small (6E-7). Therefore, the expected safety benefit of LDST isolation during the injection phase is considered small and possibly could result in a net decrease in safety.

For the recirculation phase, failure of HP-97 to close is the most significant failure mode. The calculated HPI system failure probability due to this failure mode is 8.8E-3. Isolation of the LDST (and HP-97) by closing HP-23 would eliminate this failure mode. The negative impact of closing HP-23 during the HPI recirculation mode is not significant. Assuming operator action to close HP-23 (with a screening failure probability of 0.01), the HPI system recirculation failure probability is estimated to be 2.5E-3 compared to the base case probability of 1.1E-2. If an automatic system is relied upon to achieve this isolation (with a screening failure probability of 0.001), the HPI system recirculation failure probability is estimated to be 2.4E-3. Thus, either manual or automatic isolation of the LDST during the recirculation phase would provide an appreciable improvement in the HPI recirculation reliability.

The core damage impact of these failure modes is approximately 1.2E-5 with the existing plant configuration (LDST not isolated). If the LDST is isolated, the significance of these sequences would be greatly reduced.

Addition of Local LDST Gauges and Revised Calibration Frequency

Various sensitivity studies were performed to examine the impact of:

- changing the LDST level and pressure transmitter calibrations to a staggered six month basis,
- adding a local level gauge and comparing with control room indication once a week,
- adding a local pressure gauge and comparing with control room indication once a week, and
- adding local level and pressure gauges and comparing with control room indications once a week.

These changes have the effect of reducing the exposure times for the common cause failures. The six month calibration interval reduces the average exposure time from the nominal value of nine months to three months; a weekly check of LDST instruments reduces their average exposure time to half of a week.

The impact on HPI system reliability during the injection mode is shown in the following table.

Sensitivity study case	CCF probability of level or pressure instrumentation	Injection mode failure probability	Decrease from nominal probability.
Nominal injection-mode value	6.39E-4	3.6E-3	--
Add a local level gauge	3.83E-4	3.3E-3	8%
Add a local pressure gauge	2.64E-4	3.2E-3	11%
Implement staggered 6 mo. calibration of level and pressure transmitters	2.13E-4	3.1E-3	14%
Add a local level and pressure gauges	8.17E-6	2.9E-3	19%

These changes result in some improvement in HPI system reliability. In particular, weekly surveillance using an additional level and pressure gauge appears to effectively reduce the LDST instrumentation common cause failure potential. However, the changes do not translate into significant changes in core damage frequency. For example, addition of local level and pressure gauges results an estimated 2% reduction in CDF.

Auto-swap to BWST on low LDST Level

Automatically swapping the HPI suction from the LDST to the BWST on low LDST level is a proposed modification. This would eliminate the operator burden of swapping the HPI pump suction to the BWST for non-ES conditions should the LDST level decrease below the low level limit.

For LOCA mitigation, the HPI suction is automatically swapped to the BWST by the ES signals. Therefore, the impact of the auto-swap on low LDST level is not significant.

HPI Pump Run Failure Rate

HPI pumps 3A and 3B were rebuilt because of damage they incurred on May 3, 1997 when they were operated without an adequate suction source. Pump rebuilding is commonly performed after a pump failure or following an inspection that reveals that some degradation has occurred. Pump reliability is expected to vary about some average value. To assess the case where pump reliability might be lower due to replacement of some components, a sensitivity analysis is performed by increasing the pump start, run, and common cause failure rates by a factor of 10. (Note: The impact of the May 1997 pump failures result in a 23% increase in the start failure probability and a 26% increase in the run failure rate.)

For the most probable LOCA case (random small break), the injection mode failure probability increases by about 80%. For the recirculation mode, the higher failure rates lead to no significant increase in failure probability. To translate the higher pump failure rates into the risk impact, the higher values are substituted into the plant model. The solution of this model yields a CDF of 4.5E-5/ry, an increase of less than 5% over the base case value. Therefore, the potential for higher than usual pump failure rates does not significantly impact plant risk.

HPI Train Separation

Advantages and disadvantages of train separation are considered in this portion of the analysis.

One aspect of train separation involves the impact of passive failures within the HPI system. Passive failures of HPI system piping sections are included in the model for

- the suction paths from the BWST through HP-24 or HP-25 to the HPI suction header,
- the cooling water lines from LPSW and HPSW,
- the discharge paths from the HPI pumps to the 'A' or 'B' RCS cold legs
- the seal injection line, and
- the letdown line.

The probabilities of some of these events have been estimated using Reference 18, and were determined to be on the order of 6E-8 for a 24 hour mission time. Thus, although pipe failures represent single-event system failures, their probabilities are very small in comparison with other failure modes. Also, if a pipe break is not isolated, it allows for loss of inventory, submersion of equipment, and flow diversion resulting in reduced injection flow. Thus, train separation does not impact the system reliability in a measurable way insofar as passive failure are concerned.

With the HPI trains isolated at the suction header, failures due to the LDST interface would not impact the 'C' pump train. However, from a deterministic standpoint, with the trains separated, the system is unable to meet the single failure criterion to maintain two pumps available. For example, failure of HP-24 to open or failure of the 'A1' cold leg injection check valve (HP-487) to remain open would lead to failure of HPI. The impact on HPI reliability can be seen by re-solving for the DBA LOCA injection mode case. With HP-99 or HP-100 assumed to be closed, the failure probability for this case increases to 1.1E-2, up significantly from the base case value of 3.6E-3. In the recirculation mode, in which only one HPI pump is required, there is no change in the base case value with HP-99 closed.

On the HPI pump discharge side, the open configuration following an HPI line break or RCP discharge break LOCA permits the HPI function to be maintained in the event of an active failure (such as failure of HP-26 to open). If the HPI discharge crossconnect (HP-409/410) is not opened during accident mitigation, the failure probability is estimated to be 1.6E-2, also a significant increase over the base case value of 3.6E-3. For the recirculation mode, the failure probability is unchanged.

Thus it is seen that operation with the HPI trains isolated from each other at their suction or discharge leads to a reduction in HPI system reliability.

Operation with HP-116 Normally Open

The current HPI system normal alignment has HP-116 closed and HP-27 open. A possible alternate alignment of operational interest is to keep HP-116 open, with HP-27 closed, thereby cross-connecting the discharges of the HPI pumps. This would allow HPI pump C to supply either the 'A' loop cold legs or 'B' loop cold legs. Similarly, HPI pumps 'A' and 'B' could supply either 'A' or 'B' loop cold legs.

Leaving HP-116 open allows one HPI pump to supply all four cold legs (if the other HPI pumps fail). However, requiring HP-27 to open introduces new failure modes. This sensitivity study assesses whether or not the proposed HPI system alignment would result in a change in the core damage frequency.

As seen in section 5.2, the base case CDF for Oconee (excluding seismic events) is 4.3E-5. With HP-116 open and HP-27 closed, the CDF is also 4.3E-5. Although new failure events are introduced (such as mechanical failure of HP-27 to open, common cause failure of HP-26 and -27 to open, and new and power and control failures for HP-27), the resulting cut sets (failure event combinations) fall below the truncation limit of 1E-8. Similarly, cut sets now eliminated by the availability of the HPI pumps' discharge cross-connect are below the truncation limit. Therefore, from a PRA standpoint, switching to the proposed HPI system alignment provides no measurable impact on plant risk.

Uncertainty Analysis

By their very nature, the results of a reliability assessment are estimates and not exact values. There are uncertainties involved in various aspects of the reliability calculational process. An analysis of the uncertainties involved can produce the information on the range within which the actual result might fall.

One source of uncertainty is the variability of data used in the model. Variables include the way in which failures are captured and categorized, as well as statistical uncertainty due to the sample size. In estimating human error probabilities, there are uncertainties associated with the methodologies utilized for event quantification (and with the approach taken when applying the methods).

For example, failure of LDST discharge check valve HP-97 to close or remain closed during the recirculation mode of core cooling are important failure modes with respect to the core damage risk results. This check valve is currently flow tested and reverse leak rate tested on a refueling frequency. Sources of uncertainty associated with the quantification of these failure events include (1) the failure rates used, (2) the number of times valve would be challenged to close as the suction to the HPI pumps alternates between the LDST and BWST, and (3) whether or not failure of the valve would lead to core damage. The model conservatively assumes that the diversion flow rate to the LDST would be sufficiently large to fail core cooling and that the operators would fail to notice the diverted flow.

Uncertainty also results from modeling imperfections and limitations. For this study, a systematic effort was employed to identify failure modes, system interactions, and the necessary model detail. Furthermore, an elaborate search of operating experience was performed to ensure that all relevant failure modes are captured. Therefore, it is felt that the uncertainty contribution from the model incompleteness and unknown failure modes would be small.

To assess the significance of the uncertainty in the data (initiating events, equipment failure rates, human error probabilities, etc.), a Monte-Carlo simulation of key results was performed considering the mean values and by assigning an error factor[8] for the basic events within the model.

Figure 5.3-1 provides the results of the uncertainty analysis for the design basis LOCA injection mode case. As noted earlier, the mean value (considering no uncertainty) for this top event is 3.6E-3. Using the CAFTA Uncertainty Analysis program with 5000 samples, the estimated mean value is 3.5E-3, the fifth percentile value is 1.23E-3, and the 95th percentile value is 8.3E-3. The error factor is computed to be 2.6.

Figure 5.3-2 provides the results of the uncertainty analysis for the recirculation mode case. The point estimate value for this top event is 1.1E-2. Again using 5000 samples,

[8] The **error factor** may be defined as the square root of the ratio of the 95th percentile value to the fifth percentile value.

the estimated mean value is 1.1E-2, the fifth percentile value is 2.0E-3, and the 95th percentile value is 3.3E-2. The error factor in this case is computed to be 4.1.

Table 5.5-1

HPI System Reliability Results Summary

Accident Mitigation Functions

Description	Failure Probability
Chapter 15 non-LOCA accidents	2.8E-4
Chapter 15 HPI Line Break LOCA – Injection mode	3.6E-3
PRA random-location LOCA– Injection mode	9.4E-4
PRA HPI Line Break LOCA– Injection mode	2.5E-3
Feed and Bleed Cooling– Injection mode	1.2E-3
Recirculation for Chapter 15 and PRA accidents	1.1E-2
RCP Seal Injection for Non-LOCA accidents	4.3E-4

Normal Functions

Description	Failure Probability
Normal Injection (Make-up)	5.3E-2
RCP Seal Injection	7.5E-2
Auxiliary spray	1.6E-2

Table 5.1.2-1

Dominant Cut Sets For Ch. 15 HPI Line Break LOCA: Injection Mode

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	HCH15BREAK	HPI Line Break Occurs on Another HPI Line	7.50E-01	6.71E-04
	HHP0486CVT	Check Valve 3HP-486 Transfers Closed	8.94E-04	
2	HCH15BREAK	HPI Line Break Occurs on Another HPI Line	7.50E-01	6.71E-04
	HHP0487CVT	Check Valve 3HP-487 Transfers Closed	8.94E-04	
3	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	2.46E-04
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
	HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	
4	HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	2.09E-04
	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	
5	HCH15BREAK	HPI Line Break Occurs on Another HPI Line	7.50E-01	1.82E-04
	HHP0126VVT	Manual Valve 3HP-126 Transfers Closed	2.43E-04	
6	HCH15BREAK	HPI Line Break Occurs on Another HPI Line	7.50E-01	1.82E-04
	HHP0127VVT	Manual Valve 3HP-127 Transfers Closed	2.43E-04	
7	HCH15BREAK	HPI Line Break Occurs on Another HPI Line	7.50E-01	1.82E-04
	HHP0152VVT	Manual Valve 3HP-152 Transfers Closed	2.43E-04	
8	HCH15BREAK	HPI Line Break Occurs on Another HPI Line	7.50E-01	1.82E-04
	HHP0153VVT	Manual Valve 3HP-153 Transfers Closed	2.43E-04	
9	HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	1.34E-04	1.34E-04
	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
10	HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	1.24E-04
11	HHP23SICOM	Common Cause Failure Of 2 Of 3 HPI Pumps To Restart For Injection After LOOP	1.19E-04	1.19E-04
	HLOCALOOP	LOCA/LOOP Occurs	1.00E+00	
12	LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	8.15E-05
13	HCH15BREAK	HPI Line Break Occurs on Another HPI Line	7.50E-01	6.11E-05
	HHP0188CVO	Swing Check Valve 3HP-188 Fails To Open On Demand	8.15E-05	
14	HCH15BREAK	HPI Line Break Occurs on Another HPI Line	7.50E-01	6.11E-05
	HHP0488CVO	Check Valve 3HP-488 Fails To Open On Demand	8.15E-05	
15	HCH15BREAK	HPI Line Break Occurs on Another HPI Line	7.50E-01	6.11E-05
	HHP0489CVO	Check Valve 3HP-489 Fails To Open On Demand	8.15E-05	
16	HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	2.68E-05
	HHPHX3CHXF	Heat Exchanger On HPI Pump 3C Clogs	1.34E-03	
17	LLP0028LHE	3LP-28 Left Closed Due to Human Error	2.60E-05	2.60E-05
18	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	2.50E-05
	HPI0085DEX	Instrument Root Valve (Ref. Legs Common) 3HPII0085 Transfers Closed	2.50E-05	
19	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	2.50E-05
	HPI0087DEX	Instrument Root Valve (Sensing Lines Common) 3HPII0087 Transfers Closed	2.50E-05	

Table 5.1.2-1

Dominant Cut Sets For Ch. 15 HPI Line Break LOCA: Injection Mode

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
20	HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	2.36E-05
	HHPPU3CHPS	HPI Pump 3C Fails To Start On Demand	1.18E-03	

TOP EVENT PROBABILITY = 3.6E-3

Table 5.1.2-2

HPI Importance Values For Ch. 15 HPI Line Break LOCA: Injection Mode

Event Name	Description	Probability	F-V[†]
HHP0486CVT	Check Valve 3HP-486 Transfers Closed	8.94E-04	18.7%
HHP0487CVT	Check Valve 3HP-487 Transfers Closed	8.94E-04	18.7%
HNMOPRSDHE	Operators Overcharge the LDST	1	10.6%
HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1	10.6%
HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1	7.2%
HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	6.9%
HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	5.8%

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.1.2-3

Dominant Cut Sets For DBA LOCAs: Recirculation Mode

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	H00HP97RHE	Operators Fail to Isolate Diversion Flow From RB Sump to LDST	1.00E+00	8.81E-03
	HHP0097CVC	Check Valve 3HP-97 Fails To Close On Demand	8.81E-03	
2	HHPHPR0DHE	Operators Fail to Initiate High Pressure Recirculation	2.20E-03	2.20E-03
3	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	6.20E-05
	HLPSVLVCOM	Common Cause Failure Of MOVs 3LP-15 And 3LP-16 To Open On Demand	1.24E-04	
4	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	6.20E-05
	HLPSVLVCOM	Common Cause Failure Of MOVs 3LP-15 And 3LP-16 To Open On Demand	1.24E-04	
5	HHP33RRCOM	Common Cause Failure Of 3 Of 3 HPI Pumps To Run During Recirculation	6.11E-06	6.11E-06
6	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	5.12E-06
	HLP0054LHE	Manual Valve 3LP-54 Is Left Closed After Test Or Maintenance	3.20E-03	
	HLP0056LHE	Manual Valve 3LP-56 Is Left Closed After Test Or Maintenance	3.20E-03	
7	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	5.12E-06
	HLP0054LHE	Manual Valve 3LP-54 Is Left Closed After Test Or Maintenance	3.20E-03	
	HLP0056LHE	Manual Valve 3LP-56 Is Left Closed After Test Or Maintenance	3.20E-03	
8	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	3.95E-06
	HLP0015MVO	Motor-Operated Valve 3LP-15 Fails To Open On Demand	2.47E-03	
	HLP0056LHE	Manual Valve 3LP-56 Is Left Closed After Test Or Maintenance	3.20E-03	
9	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	3.95E-06
	HLP0016MVO	Motor-Operated Valve 3LP-16 Fails To Open On Demand	2.47E-03	
	HLP0054LHE	Manual Valve 3LP-54 Is Left Closed After Test Or Maintenance	3.20E-03	
10	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	3.95E-06
	HLP0015MVO	Motor-Operated Valve 3LP-15 Fails To Open On Demand	2.47E-03	
	HLP0056LHE	Manual Valve 3LP-56 Is Left Closed After Test Or Maintenance	3.20E-03	
11	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	3.95E-06
	HLP0016MVO	Motor-Operated Valve 3LP-16 Fails To Open On Demand	2.47E-03	
	HLP0054LHE	Manual Valve 3LP-54 Is Left Closed After Test Or Maintenance	3.20E-03	

Table 5.1.2-3

Dominant Cut Sets For DBA LOCAs: Recirculation Mode

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
12	H00HP97RHE	Operators Fail to Isolate Diversion Flow From RB Sump to LDST	1.00E+00	3.31E-06
	HHP0097CVT	Check Valve 3HP-97 Transfers Position	3.31E-06	
13	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	3.05E-06
	HLP0015MVO	Motor-Operated Valve 3LP-15 Fails To Open On Demand	2.47E-03	
	HLP0016MVO	Motor-Operated Valve 3LP-16 Fails To Open On Demand	2.47E-03	
14	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	3.05E-06
	HLP0015MVO	Motor-Operated Valve 3LP-15 Fails To Open On Demand	2.47E-03	
	HLP0016MVO	Motor-Operated Valve 3LP-16 Fails To Open On Demand	2.47E-03	
15	HLSFILTCOM	Common Cause Failure Of Cuno Filters 3LPSFL0001, 0002, And 0018	1.90E-06	1.90E-06
16	HLS0500VVT	Manual Valve 3LPSW-500 Transfers Closed	9.00E-07	9.00E-07
17	HLS0711VVT	Manual Valve 3LPSW-711 Transfers Closed	9.00E-07	9.00E-07
18	WCW0087VVT	Manual Valve 3CCW-87 Transfers Closed	9.00E-07	9.00E-07
19	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	3.89E-07
	HLP0054LHE	Manual Valve 3LP-54 Is Left Closed After Test Or Maintenance	3.20E-03	
	HLP0056VVT	Manual Valve 3LP-56 Transfers Closed	2.43E-04	
20	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	3.89E-07
	HLP0054VVT	Manual Valve 3LP-54 Transfers Closed	2.43E-04	
	HLP0056LHE	Manual Valve 3LP-56 Is Left Closed After Test Or Maintenance	3.20E-03	

TOP EVENT PROBABILITY = 1.1E-2

Table 5.1.2-4

HPI Importance Values For DBA LOCAs: Recirculation Mode

Event Name	Description	Probability	F-V[†]
H00HP97RHE	Operators Fail to Isolate Diversion Flow From RB Sump to LDST	1.00E+00	78.7%
HHP0097CVC	Check Valve 3HP-97 Fails To Close On Demand	8.81E-03	78.7%
HHPHPR0DHE	Operators Fail to Initiate High Pressure Recirculation	2.20E-03	19.5%

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.1.3-1

Dominant Cut Sets For PRA LOCA: Injection Mode

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	2.46E-04
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
	HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	
2	HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	2.09E-04
	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	
3	HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	1.34E-04	1.34E-04
	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
4	HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	1.24E-04
5	LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	8.15E-05
6	LLP0028LHE	3LP-28 Left Closed Due to Human Error	2.60E-05	2.60E-05
7	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	2.50E-05
	HPI0085DEX	Instrument Root Valve (Ref. Legs Common) 3HPII0085 Transfers Closed	2.50E-05	
8	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	2.50E-05
	HPI0087DEX	Instrument Root Valve (Sensing Lines Common) 3HPII0087 Transfers Closed	2.50E-05	
9	CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	2.00E-03	2.00E-05
	HEXCMAKEUP	Excessive RC Makeup Is Required	1.00E-02	
	PREMOD	Premod Condition	1.00E+00	
10	LLP0BWTTKF	Borated Water Storage Tank Ruptures	1.45E-05	1.45E-05
11	HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	1.24E-05
	HHP0025TRM	MOV 3HP-25 Suction Train In Maintenance	5.00E-03	
12	HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	5.00E-03	1.24E-05
	HHP0025MVO	Motor-Operated Valve 3HP-25 Fails To Open On Demand	2.47E-03	
13	HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	6.10E-06
	HHP0025MVO	Motor-Operated Valve 3HP-25 Fails To Open On Demand	2.47E-03	
14	LLP0061CVT	Vacuum-Breaker Valve 3LP-61 Transfers Closed	3.31E-06	3.31E-06
15	LLP0028VVT	Manual Valve 3LP-28 Transfers Closed	9.00E-07	9.00E-07
16	HHP33RICOM	Common Cause Failure Of 3 Of 3 HPI Pumps To Run During Injection	5.55E-07	5.55E-07
17	HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	5.00E-03	4.07E-07
	HHP0102CVO	Tilting Disk Check Valve 3HP-102 Fails To Open On Demand	8.15E-05	
18	HHP0025TRM	MOV 3HP-25 Suction Train In Maintenance	5.00E-03	4.07E-07
	HHP0101CVO	Tilting Disk Check Valve 3HP-101 Fails To Open On Demand	8.15E-05	

Table 5.1.3-1

Dominant Cut Sets For PRA LOCA: Injection Mode

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
19	HHP0024LHE	MOV 3HP-24 Suction Train Is Left Unavailable After Test Or Maintenance	5.20E-05	2.60E-07
	HHP0025TRM	MOV 3HP-25 Suction Train In Maintenance	5.00E-03	
20	HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	5.00E-03	2.60E-07
	HHP0025LHE	MOV 3HP-25 Suction Train Is Left Unavailable After Test Or Maintenance	5.20E-05	

TOP EVENT PROBABILITY = 9.4E-4

Table 5.1.3-2

HPI Importance Values For PRA LOCA: Injection Mode

Event Name	Description	Probability	F-V[†]
HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	40.3%
HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	40.3%
HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	27.4%
HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	26.0%
HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	22.1%
HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	1.34E-04	14.2%
HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	13.1%
LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	8.6%

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.1.3-3

Dominant Cut Sets For HPI Line Break: Inj. Mode (PRA success criteria)

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	4.47E-04
	HHP0486CVT	Check Valve 3HP-486 Transfers Closed	8.94E-04	
2	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	4.47E-04
	HHP0487CVT	Check Valve 3HP-487 Transfers Closed	8.94E-04	
3	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	2.46E-04
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
	HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	
4	HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	2.09E-04
	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	
5	HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	1.34E-04	1.34E-04
	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
6	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	1.22E-04
	HHP0152VVT	Manual Valve 3HP-152 Transfers Closed	2.43E-04	
7	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	1.22E-04
	HHP0153VVT	Manual Valve 3HP-153 Transfers Closed	2.43E-04	
8	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	1.22E-04
	HHP0126VVT	Manual Valve 3HP-126 Transfers Closed	2.43E-04	
9	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	1.22E-04
	HHP0127VVT	Manual Valve 3HP-127 Transfers Closed	2.43E-04	
10	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	6.20E-05
	HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	
11	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	6.20E-05
	HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	
12	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	4.07E-05
	HHP0188CVO	Swing Check Valve 3HP-188 Fails To Open On Demand	8.15E-05	
13	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	4.07E-05
	HHP0488CVO	Check Valve 3HP-488 Fails To Open On Demand	8.15E-05	
14	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	4.07E-05
	HHP0489CVO	Check Valve 3HP-489 Fails To Open On Demand	8.15E-05	
15	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	4.07E-05
	LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	
16	H3BBREAK	HPI Line Break Occurs on 3B Side	5.00E-01	4.07E-05
	LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	
17	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	2.50E-05
	HPI0085DEX	Instrument Root Valve (Ref. Legs Common) 3HPII0085 Transfers Closed	2.50E-05	
18	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	2.50E-05
	HPI0087DEX	Instrument Root Valve (Sensing Lines Common) 3HPII0087 Transfers Closed	2.50E-05	

Table 5.1.3-3

Dominant Cut Sets For HPI Line Break: Inj. Mode (PRA success criteria)

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
19	CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	2.00E-03	2.00E-05
	HEXCMAKEUP	Excessive RC Makeup Is Required	1.00E-02	
	PREMOD	Premod Condition	1.00E+00	
20	H3ABREAK	HPI Line Break Occurs on 3A Side	5.00E-01	1.30E-05
	LLP0028LHE	3LP-28 Left Closed Due to Human Error	2.60E-05	

TOP EVENT PROBABILITY = 2.5E-3

Table 5.1.3-4

HPI Importance Values For HPI Line Break: Inj. Mode (PRA success criteria)

Event Name	Description	Probability	F-V†
HNMOPRSDHE	Operators Overcharge the LDST	1	27.8%
HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1	27.8%
HHP0486CVT	Check Valve 3HP-486 Transfers Closed	8.94E-04	15.1%
HHP0487CVT	Check Valve 3HP-487 Transfers Closed	8.94E-04	15.1%
HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	10.3%
HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	9.8%
HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	8.3%
HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	1.34E-04	5.3%
HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	4.9%

† The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.1.4-1

Dominant Cut Sets For Feed and Bleed

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	2.46E-04
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
	HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	
2	HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	2.09E-04
	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	
3	HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	1.34E-04	1.34E-04
	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
4	HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	1.24E-04
5	HHPPMPSCOM	Common Cause Failure of HPI Pumps 3B and 3C to Start	8.87E-05	8.87E-05
6	LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	8.15E-05
7	HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	2.68E-05
	HHPHX3CHXF	Heat Exchanger On HPI Pump 3C Clogs	1.34E-03	
8	LLP0028LHE	3LP-28 Left Closed Due to Human Error	2.60E-05	2.60E-05
9	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	2.50E-05
	HPI0085DEX	Instrument Root Valve (Ref. Legs Common) 3HPII0085 Transfers Closed	2.50E-05	
10	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	2.50E-05
	HPI0087DEX	Instrument Root Valve (Sensing Lines Common) 3HPII0087 Transfers Closed	2.50E-05	
11	HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	2.36E-05
	HHPPU3CHPS	HPI Pump 3C Fails To Start On Demand	1.18E-03	
12	CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	2.00E-03	2.00E-05
	HEXCMAKEUP	Excessive RC Makeup Is Required	1.00E-02	
	PREMOD	Premod Condition	1.00E+00	
13	HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	5.00E-03	1.60E-05
	HHP0SGOLHE	HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance	3.20E-03	
14	LLP0BWTTKF	Borated Water Storage Tank Ruptures	1.45E-05	1.45E-05
15	HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	1.24E-05
	HHP0025TRM	MOV 3HP-25 Suction Train In Maintenance	5.00E-03	
16	HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	5.00E-03	1.24E-05
	HHP0025MVO	Motor-Operated Valve 3HP-25 Fails To Open On Demand	2.47E-03	
17	HHP0TRCTRM	HPI Train 3C Is In Maintenance	1.00E-02	1.18E-05
	HHPPU3BHPS	HPI Pump 3B Fails To Start On Demand	1.18E-03	
18	HAC0D09C4C	4160 V ac Switchgear 3TD Breaker 9 Fails To Close (HPI Pump 3C)	5.31E-04	1.06E-05
	HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	

Table 5.1.4-1

Dominant Cut Sets For Feed and Bleed

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
19	HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	7.90E-06
	HHP0SGOLHE	HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance	3.20E-03	
20	HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	7.06E-06
	HHPPU3AHPR	HPI Pump 3A Fails To Run	3.53E-04	

TOP EVENT PROBABILITY = 1.2E-3

Table 5.1.4-2

HPI Importance Values For Feed and Bleed

Event Name	Description	Probability	F-V[†]
HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	32.0%
HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	32.0%
HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	21.8%
HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	20.7%
HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	17.6%
HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	1.34E-04	11.3%
HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	10.4%
HHPPMPSCOM	Common Cause Failure of HPI Pumps 3B and 3C to Start	8.87E-05	7.5%
HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	7.2%
LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	6.9%

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.1.5-1

Dominant Cut Sets For Seal Injection Following a Non- LOCA Event

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	1.24E-04
	T	Transient Causes An Engineered Safeguards Actuation	1.00E+00	
2	LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	8.15E-05
	T	Transient Causes An Engineered Safeguards Actuation	1.00E+00	
3	HHP0SFAFLF	Reactor Coolant Pump Seal Supply Filter 3A Clogs	3.79E-05	3.79E-05
4	LLP0028LHE	3LP-28 Left Closed Due to Human Error	2.60E-05	2.60E-05
	T	Transient Causes An Engineered Safeguards Actuation	1.00E+00	
5	HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	5.00E-03	1.60E-05
	HHP0SGOLHE	HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance	3.20E-03	
	T	Transient Causes An Engineered Safeguards Actuation	1.00E+00	
6	HHP0031AVT	Air-Operated Valve 3HP-31 Transfers Closed	1.52E-05	1.52E-05
7	LLP0BWTTKF	Borated Water Storage Tank Ruptures	1.45E-05	1.45E-05
	T	Transient Causes An Engineered Safeguards Actuation	1.00E+00	
8	HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	1.24E-05
	HHP0025TRM	MOV 3HP-25 Suction Train In Maintenance	5.00E-03	
	T	Transient Causes An Engineered Safeguards Actuation	1.00E+00	
9	HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	5.00E-03	1.24E-05
	HHP0025MVO	Motor-Operated Valve 3HP-25 Fails To Open On Demand	2.47E-03	
	T	Transient Causes An Engineered Safeguards Actuation	1.00E+00	
10	HHP0191SVT	Solenoid Valve 3HPISV0191 Transfers Position, Closing 3HP-31	9.55E-06	9.55E-06
11	HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	7.90E-06
	HHP0SGOLHE	HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance	3.20E-03	
	T	Transient Causes An Engineered Safeguards Actuation	1.00E+00	
12	HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	7.06E-06
	HHPPU3AHPR	HPI Pump 3A Fails To Run	3.53E-04	
13	HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	6.10E-06
	HHP0025MVO	Motor-Operated Valve 3HP-25 Fails To Open On Demand	2.47E-03	
	T	Transient Causes An Engineered Safeguards Actuation	1.00E+00	
14	HHP0144CVT	Check Valve 3HP-144 Transfers Closed	3.31E-06	3.31E-06
15	HHP0145CVT	Check Valve 3HP-145 Transfers Closed	3.31E-06	3.31E-06
16	HHP0146CVT	Check Valve 3HP-146 Transfers Closed	3.31E-06	3.31E-06
17	HHP0147CVT	Check Valve 3HP-147 Transfers Closed	3.31E-06	3.31E-06
18	HHP0390CVT	Check Valve 3HP-390 Transfers Closed	3.31E-06	3.31E-06

Table 5.1.5-1

Dominant Cut Sets For Seal Injection Following a Non- LOCA Event

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
19	HHP0393CVT	Check Valve 3HP-393 Transfers Closed	3.31E-06	3.31E-06
20	HHP0454CVT	Check Valve 3HP-454 Transfers Closed	3.31E-06	3.31E-06

TOP EVENT PROBABILITY = 4.3E-4

Table 5.1.5-2

HPI Importance Values For Seal Injection Following a Non- LOCA Event

Event Name	Description	Probability	F-V[†]
HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	28.6%
LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	18.8%
HHP0SFAFLF	Reactor Coolant Pump Seal Supply Filter 3A Clogs	3.79E-05	8.8%
HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	5.00E-03	6.9%
HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	6.2%
LLP0028LHE	3LP-28 Left Closed Due to Human Error	2.60E-05	6.0%
HHP0SGOLHE	HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance	3.20E-03	5.7%

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.1.6-1

Dominant Cut Sets For Normal Injection

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	HHP0079RVT	Relief Valve 3HP-79 Spurious Operation	1.24E-02	1.24E-02
2	HLDDIVTCHE	Operators Inadvertently Divert Letdown Flow	1.00E-02	1.00E-02
3	HLDSTLPDHE	Operator Error Causes Low Pressure Condition	1.00E-02	1.00E-02
4	CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	2.00E-03	6.00E-03
	HEXCMAKEUP	Excessive RC Makeup Is Required	3.00E+00	
	HNOMOD	Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED	1.00E+00	
5	HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	2.32E-03
	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	
6	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	1.65E-03
	HHPPU3BHPS	HPI Pump 3B Fails To Start On Demand	1.42E-02	
7	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	1.16E-03
	HHPTRNBDHE	Operators Fail to Align HPI Train 3B	1.00E-02	
8	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	1.14E-03
	P3TE	Loss Of Power From 4160 V ac Switchgear 3TE	9.80E-03	
9	HHP0194CVT	Check Valve 3HP-194 Transfers Closed	1.09E-03	1.09E-03
10	HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1.00E+00	1.00E-03
	HOPUNPRDHE	Inadequate Operator Guidance Regarding LDST Underpressure	1.00E-03	
11	HAC0E09C4C	4160 V ac Switchgear 3TE Breaker 9 Fails To Close (HPI Pump 3B)	6.37E-03	7.39E-04
	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	
12	HHP2-2RCOM	Common Cause Run Failure of HPI Pumps 3A and 3B	7.22E-04	7.22E-04
13	AUXAIRTOP	Loss of Auxiliary Air System Pressure	4.32E-02	4.32E-04
	HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1.00E+00	
	HOACSERDEX	OAC Is OOS	1.00E-02	
14	HEXCMAKEUP	Excessive RC Makeup Is Required	3.00E+00	3.72E-04
	HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	
	HNOMOD	Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED	1.00E+00	
15	HHP0TRBLHE	HPI Train 3B Is Left Unavailable After Test Or Maintenance	3.00E-03	3.48E-04
	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	
16	HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1.00E+00	2.46E-04
	HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	
17	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	2.46E-04
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
	HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	

Table 5.1.6-1

Dominant Cut Sets For Normal Injection

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
18	HEXCMAKEUP	Excessive RC Makeup Is Required	3.00E+00	2.45E-04
	HNOMOD	Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED	1.00E+00	
	LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	
19	HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1.00E+00	2.14E-04
	HOACSERDEX	OAC Is OOS	1.00E-02	
	HPT004LAMF	Alarm Module Fails to Operate on Demand	2.14E-02	
20	HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	2.09E-04
	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	

TOP EVENT PROBABILITY = 5.3E-2

Table 5.1.6-2

HPI Importance Values For Normal Injection

Event Name	Description	Probability	F-V[†]
HHP0079RVT	Relief Valve 3HP-79 Spurious Operation	1.24E-02	22.7%
HLDDIVTCHE	Operators Inadvertently Divert Letdown Flow	1.00E-02	18.3%
HLDSTLPDHE	Operator Error Causes Low Pressure Condition	1.00E-02	18.3%
HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	13.7%
HEXCMAKEUP	Excessive RC Makeup Is Required	3	13.0%
CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	2.00E-03	11.0%

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.1.6-3

Dominant Cut Sets For Normal Seal Injection

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	HHP0079RVT	Relief Valve 3HP-79 Spurious Operation	1.24E-02	1.24E-02
2	HLDDIVTCHE	Operators Inadvertently Divert Letdown Flow	1.00E-02	1.00E-02
3	HLDSTLPDHE	Operator Error Causes Low Pressure Condition	1.00E-02	1.00E-02
4	CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	2.00E-03	6.00E-03
	HEXCMAKEUP	Excessive RC Makeup Is Required	3.00E+00	
	HNOMOD	Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED	1.00E+00	
5	HHP0031AVT	Air-Operated Valve 3HP-31 Transfers Closed	5.01E-03	5.01E-03
6	HHP0191SVT	Solenoid Valve 3HPISV0191 Transfers Position, Closing 3HP-31	3.14E-03	3.14E-03
7	HHP0TRBTRM	HPI Train 3B Is In Maintenance	2.00E-02	2.32E-03
	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	
8	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	1.65E-03
	HHPPU3BHPS	HPI Pump 3B Fails To Start On Demand	1.42E-02	
9	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	1.16E-03
	HHPTRNBDHE	Operators Fail to Align HPI Train 3B	1.00E-02	
10	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	1.14E-03
	P3TE	Loss Of Power From 4160 V ac Switchgear 3TE	9.80E-03	
11	HHP0144CVT	Check Valve 3HP-144 Transfers Closed	1.09E-03	1.09E-03
12	HHP0145CVT	Check Valve 3HP-145 Transfers Closed	1.09E-03	1.09E-03
13	HHP0146CVT	Check Valve 3HP-146 Transfers Closed	1.09E-03	1.09E-03
14	HHP0147CVT	Check Valve 3HP-147 Transfers Closed	1.09E-03	1.09E-03
15	HHP0390CVT	Check Valve 3HP-390 Transfers Closed	1.09E-03	1.09E-03
16	HHP0393CVT	Check Valve 3HP-393 Transfers Closed	1.09E-03	1.09E-03
17	HHP0454CVT	Check Valve 3HP-454 Transfers Closed	1.09E-03	1.09E-03
18	HHP0457CVT	Check Valve 3HP-457 Transfers Closed	1.09E-03	1.09E-03
19	HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1.00E+00	1.00E-03
	HOPUNPRDHE	Inadequate Operator Guidance Regarding LDST Underpressure	1.00E-03	
20	HAC0E09C4C	4160 V ac Switchgear 3TE Breaker 9 Fails To Close (HPI Pump 3B)	6.37E-03	7.39E-04
	HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	

TOP EVENT PROBABILITY = 7.5E-2

Table 5.1.6-4

HPI Importance Values For Normal Seal Injection

Event Name	Description	Probability	F-V[†]
HHP0079RVT	Relief Valve 3HP-79 Spurious Operation	1.24E-02	15.6%
HLDDIVTCHE	Operators Inadvertently Divert Letdown Flow	1.00E-02	12.5%
HLDSTLPDHE	Operator Error Causes Low Pressure Condition	1.00E-02	12.5%
HHPPU3AHPR	HPI Pump 3A Fails To Run	1.16E-01	9.4%
HEXCMAKEUP	Excessive RC Makeup Is Required	3	8.9%
CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	2.00E-03	7.5%
HHP0031AVT	Air-Operated Valve 3HP-31 Transfers Closed	5.01E-03	6.3%

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.1.6-5

Dominant Cut Sets For Auxiliary Spray

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	HHP0472DHE	Operators Fail to Align Auxiliary Pressurizer Spray by Opening 3HP-472	1.00E-02	1.00E-02
2	HHP0355AVO	Air Operated Valve 3HP-355 Fails To Open On Demand	1.40E-03	1.40E-03
3	HLDDIVTCHE	Operators Inadvertently Divert Letdown Flow	1.00E-03	1.00E-03
4	HLDSTLPDHE	Operator Error Causes Low Pressure Condition	1.00E-03	1.00E-03
5	HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1.00E+00	1.00E-03
	HOPUNPRDHE	Inadequate Operator Guidance Regarding LDST Underpressure	1.00E-03	
6	HHP0234VVT	Manual Valve 3HP-234 Transfers Closed	2.43E-04	2.43E-04
7	HHP0236VVT	Manual Valve 3HP-236 Transfers Closed	2.43E-04	2.43E-04
8	HHP0340VVT	Manual Valve 3HP-340 Transfers Closed	2.43E-04	2.43E-04
9	HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1.00E+00	2.14E-04
	HOACSERDEX	OAC Is OOS	1.00E-02	
	HPT004LAMF	Alarm Module Fails to Operate on Demand	2.14E-02	
10	AUXAIRTOP	Loss of Auxiliary Air System Pressure	1.20E-04	1.20E-04
11	HHP0253CVO	Check Valve 3HP-253 Fails To Open On Demand	8.15E-05	8.15E-05
12	HHP0419CVO	Check Valve 3HP-419 Fails To Open On Demand	8.15E-05	8.15E-05
13	RLP0046CVO	Check Valve 3LP-46 Fails To Open On Demand	8.15E-05	8.15E-05
14	RLP0131CVO	Check Valve 3LP-131 Fails To Open On Demand	8.15E-05	8.15E-05
15	HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1.00E+00	5.58E-05
	HOACSERDEX	OAC Is OOS	1.00E-02	
	HPIPS04PSL	Pressure Switch 3HPIPS004 Fails Low	5.58E-03	
16	HHP0079RVT	Relief Valve 3HP-79 Spurious Operation	3.77E-05	3.77E-05
17	HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1.00E+00	2.14E-05
	HPIPRS1PRM	LDST Pressure String #1 Is in Maintenance	1.00E-03	
	HPT004LAMF	Alarm Module Fails to Operate on Demand	2.14E-02	
18	CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	2.00E-03	2.00E-05
	HEXCMAKEUP	Excessive RC Makeup Is Required	1.00E-02	
	HNOMOD	Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED	1.00E+00	
19	D3KVIC	Loss of Power from 120 Vac Power Panelboard 3KVIC	1.70E-05	1.70E-05
20	HHP0355AVT	Air Operated Valve 3HP-355 Transfers Closed	1.52E-05	1.52E-05

TOP EVENT PROBABILITY = 1.6E-2

Table 5.1.6-6

HPI Importance Values For Auxiliary Spray

Event Name	Description	Probability	F-V[†]
HHP0472DHE	Operators Fail to Align Auxiliary Pressurizer Spray by Opening 3HP-472	1.00E-02	62.3%
HHP0355AVO	Air Operated Valve 3HP-355 Fails To Open On Demand	1.40E-03	8.7%
HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	1	8.1%
HOPUNPRDHE	Inadequate Operator Guidance Regarding LDST Underpressure	1.00E-03	6.2%
HLDDIVTCHE	Operators Inadvertently Divert Letdown Flow	1.00E-03	6.2%
HLDSTLPDHE	Operator Error Causes Low Pressure Condition	1.00E-03	6.2%

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
1	H00HP97RHE	Operators Fail to Isolate Diversion Flow From RB Sump to LDST	1.00E+00	8.81E-06
	HHP0097CVC	Check Valve 3HP-97 Fails To Close On Demand	8.81E-03	
	SL	Small Break Loss Of Coolant Accident Initiator	1.00E-03	
2	H00HP97RHE	Operators Fail to Isolate Diversion Flow From RB Sump to LDST	1.00E+00	2.64E-06
	HHP0097CVC	Check Valve 3HP-97 Fails To Close On Demand	8.81E-03	
	ML	Medium Break Loss Of Coolant Accident Initiator	3.00E-04	
3	XEFLOODDEX	Flood Height Exceeds 5 ft. SSF Flood Barriers	2.00E-01	2.60E-06
	XFLOOD	Random Failure of Jocassee Dam	1.30E-05	
4	HHPHPR0DHE	Operators Fail to Initiate High Pressure Recirculation	2.20E-03	2.20E-06
	SL	Small Break Loss Of Coolant Accident Initiator	1.00E-03	
5	NSF0RCMDHE	Operators Fail To Align The SSF RCM System For Operation	1.00E-01	1.70E-06
	TBFIRE	Turbine Building Fire Initiating Event	1.70E-05	
6	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	1.28E-06
	-BACKHF4DEX	F4 Tornado Hits Keowee Hydro Station And Fails Emergency Power To CT4	2.24E-01	
	BEFPIPEDEX	Piping In East Pen. Room Is Damaged Given West Room Damaged	3.00E-01	
	BTOWINDDEX	F4+ Tornado Winds Damage West Pen Room Structure & BWST	1.70E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
7	NSF0RCMDHE	Operators Fail To Align The SSF RCM System For Operation	1.00E-01	1.17E-06
	TRCSRV0DEX	RCS Safety Relief Valve Does Not Stick Open After Relieving Liquid	9.00E-01	
	XFLOOD	Random Failure of Jocassee Dam	1.30E-05	
8	RPV	Failure of The Reactor Pressure Vessel	1.00E-06	1.00E-06
	RPVFAILRHE	Failure to Prevent Core Damage Following an RPV Failure	1.00E+00	
9	-BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	8.61E-07
	-BACKHF2DEX	F2 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	6.20E-02	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	F2TORNAD	Annual Frequency Of An F2 Intensity Tornado Striking Oconee Unit 3	5.37E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
10	-BTOWINDDEX	F4+ Tornado Winds Damage West Pen Room Structure & BWST	1.70E-01	8.34E-07
	-BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BACKHF4DEX	F4 Tornado Hits Keowee Hydro Station And Fails Emergency Power To CT4	2.24E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
11	-BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	7.98E-07
	BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	
12	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	7.28E-07
	-NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation	3.10E-02	
	-BTOWINDDEX	F4+ Tornado Winds Damage West Pen Room Structure & BWST	1.70E-01	
	BACKHF4DEX	F4 Tornado Hits Keowee Hydro Station And Fails Emergency Power To CT4	2.24E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
13	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	6.96E-07
	-NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation	3.10E-02	
	BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	
14	HHPHPR0DHE	Operators Fail to Initiate High Pressure Recirculation	2.20E-03	6.60E-07
	ML	Medium Break Loss Of Coolant Accident Initiator	3.00E-04	

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
15	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	6.15E-07
	BACKHF4DEX	F4 Tornado Hits Keowee Hydro Station And Fails Emergency Power To CT4	2.24E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BTOWINDDEX	F4+ Tornado Winds Damage West Pen Room Structure & BWST	1.70E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
16	-BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	5.18E-07
	-BF3BWSTDEX	Tornado Winds or Missiles Cause Failure of BWST	1.30E-01	
	-BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	
17	NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation	3.10E-02	4.74E-07
	TBFIRE	Turbine Building Fire Initiating Event	1.70E-05	
	TRCSRV0DEX	RCS Safety Relief Valve Does Not Stick Open After Relieving Liquid	9.00E-01	
18	-BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	4.16E-07
	BACKHF2DEX	F2 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	6.20E-02	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F2TORNAD	Annual Frequency Of An F2 Intensity Tornado Striking Oconee Unit 3	5.37E-05	
19	BACKHF4DEX	F4 Tornado Hits Keowee Hydro Station And Fails Emergency Power To CT4	2.24E-01	4.02E-07
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
20	-BTOWINDDEX	F4+ Tornado Winds Damage West Pen Room Structure & BWST	1.70E-01	3.95E-07
	-BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	
	-BACKHF4DEX	F4 Tornado Hits Keowee Hydro Station And Fails Emergency Power To CT4	2.24E-01	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	
21	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	3.69E-07
	BACKHF4DEX	F4 Tornado Hits Keowee Hydro Station And Fails Emergency Power To CT4	2.24E-01	
	BEFPIPEDEX	Piping In East Pen. Room Is Damaged Given West Room Damaged	3.00E-01	
	BTOWINDDEX	F4+ Tornado Winds Damage West Pen Room Structure & BWST	1.70E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
22	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	3.63E-07
	-NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation	3.10E-02	
	BACKHF2DEX	F2 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	6.20E-02	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F2TORNAD	Annual Frequency Of An F2 Intensity Tornado Striking Oconee Unit 3	5.37E-05	
23	NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation	3.10E-02	3.63E-07
	TRCSRV0DEX	RCS Safety Relief Valve Does Not Stick Open After Relieving Liquid	9.00E-01	
	XFLOOD	Random Failure of Jocassee Dam	1.30E-05	
24	FLN	Large, Non-Isolable Turbine Building Flood	3.40E-04	3.40E-07
	IBSBWSTDHE	Failure to Swap HPI to SFP During a Flood	5.00E-02	
	RRC0004DEX	PORV Block Valve Is Closed During Power Operation	2.00E-01	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
25	LL	Large Break Loss Of Coolant Accident Initiator	3.38E-04	3.38E-07
	LLPLPR0DHE	Operators Fail to Initiate Low Pressure Recirculation	1.00E-03	
26	LL	Large Break Loss Of Coolant Accident Initiator	3.38E-04	3.38E-07
	LLPVATHDHE	Operators Fail To Throttle LPI Flow To Prevent Pump Run- out Given Large LOC	1.00E-03	
27	BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	3.19E-07
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	
28	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	3.05E-07
	BTOWINDDEX	F4+ Tornado Winds Damage West Pen Room Structure & BWST	1.70E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	
29	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	2.46E-07
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
	HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	
	SL	Small Break Loss Of Coolant Accident Initiator	1.00E-03	
30	-BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	2.39E-07
	-BACKHF2DEX	F2 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	6.20E-02	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F2TORNAD	Annual Frequency Of An F2 Intensity Tornado Striking Oconee Unit 3	5.37E-05	
31	-BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	2.26E-07
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BF3BWSTDEX	Tornado Winds or Missiles Cause Failure of BWST	1.30E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
32	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	2.13E-07
	-BACKHF4DEX	F4 Tornado Hits Keowee Hydro Station And Fails Emergency Power To CT4	2.24E-01	
	BEF0ASWDHE	Operators Fail to Depressurize SGs and Align ASW (Tornado) Pump	1.00E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BTOWINDDEX	F4+ Tornado Winds Damage West Pen Room Structure & BWST	1.70E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
33	HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	2.09E-07
	HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	1.00E+00	
	SL	Small Break Loss Of Coolant Accident Initiator	1.00E-03	
34	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	2.09E-07
	-NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation	3.10E-02	
	-BACKHF2DEX	F2 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	6.20E-02	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F2TORNAD	Annual Frequency Of An F2 Intensity Tornado Striking Oconee Unit 3	5.37E-05	
35	-BHP0SFPDHE	Crew Fails to Recover HPI Suction With Spent Fuel Pool Alignment	6.30E-02	2.01E-07
	-BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	-BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BF3BWSTDEX	Tornado Winds or Missiles Cause Failure of BWST	1.30E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
36	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	1.94E-07
	-BEF0ASWDHE	Operators Fail to Depressurize SGs and Align ASW (Tornado) Pump	1.00E-01	
	-BACKHF2DEX	F2 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	6.20E-02	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F2TORNAD	Annual Frequency Of An F2 Intensity Tornado Striking Oconee Unit 3	5.37E-05	
37	ATWS	ATWS Core Melt Sequence	1.00E+00	1.85E-07
	E	Moderator Temperature Coefficient Unfavorable	5.00E-01	
	QRPRODSDEX	Insufficient Number Of CRAs Drop Into Core Upon Scram	1.00E-06	
	T2	Loss Of Main Feedwater Initiating Event	3.70E-01	
38	BEFPIPEDEX	Piping In East Pen. Room Is Damaged Given West Room Damaged	3.00E-01	1.83E-07
	BTOWINDDEX	F4+ Tornado Winds Damage West Pen Room Structure & BWST	1.70E-01	
	F4TORNAD	Annual Frequency Of An F4 Intensity Tornado Striking Oconee Unit 3	3.59E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	
39	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	1.76E-07
	-NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation	3.10E-02	
	-BHP0SFPDHE	Crew Fails to Recover HPI Suction With Spent Fuel Pool Alignment	6.30E-02	
	-BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BF3BWSTDEX	Tornado Winds or Missiles Cause Failure of BWST	1.30E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
40	BACKHF2DEX	F2 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	6.20E-02	1.66E-07
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	F2TORNAD	Annual Frequency Of An F2 Intensity Tornado Striking Oconee Unit 3	5.37E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	
41	-BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	1.65E-07
	-BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	
42	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	1.63E-07
	-BHP0SFPDHE	Crew Fails to Recover HPI Suction With Spent Fuel Pool Alignment	6.30E-02	
	-BEF0ASWDHE	Operators Fail to Depressurize SGs and Align ASW (Tornado) Pump	1.00E-01	
	-BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BF3BWSTDEX	Tornado Winds or Missiles Cause Failure of BWST	1.30E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	
43	-BACKHF2DEX	F2 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	6.20E-02	1.56E-07
	-BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BHXLPSWDEX	Tornado Winds or Missiles Fail LPSW Suction	1.00E-01	
	F2TORNAD	Annual Frequency Of An F2 Intensity Tornado Striking Oconee Unit 3	5.37E-05	
	TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
44	LL	Large Break Loss Of Coolant Accident Initiator	3.38E-04	1.55E-07
	LLPPMPSCOM	CCF Of LPI Pumps To Start	4.60E-04	
45	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	1.44E-07
	-NSF0ASWDHE	Operators Fail To Align The SSF ASW System For Operation	3.10E-02	
	-BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	
46	-BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	1.36E-07
	-BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	-BACKHF2DEX	F2 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	6.20E-02	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F2TORNAD	Annual Frequency Of An F2 Intensity Tornado Striking Oconee Unit 3	5.37E-05	
	BHP0SFPDHE	Crew Fails to Recover HPI Suction With Spent Fuel Pool Alignment	6.30E-02	
47	HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	1.34E-04	1.34E-07
	HNMOPRSDHE	Operators Overcharge the LDST	1.00E+00	
	HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	1.00E+00	
	SL	Small Break Loss Of Coolant Accident Initiator	1.00E-03	

Table 5.2-1

Top 50 CDF Cut Sets

Cut Set No.	Inputs	Description	Event Probability	Cut Set Probability
48	-TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	1.34E-07
	-BEF0ASWDHE	Operators Fail to Depressurize SGs and Align ASW (Tornado) Pump	1.00E-01	
	-BACKHF3DEX	F3 Tornado Hits Keowee Hydro Station and Fails Emergency Power To CT4	1.55E-01	
	BAC4160DEX	Tornado Winds Fail 4160 Switchgear In Turbine Building	3.80E-01	
	BEFUSTWDEX	The Upper Surge Tanks Are Failed By Tornado Winds	5.00E-01	
	BHP0ASWDHE	Crew Fails to Recover Power To HPI Pump and Align Suction	1.00E-01	
	BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	
	F3TORNAD	Annual Frequency Of An F3 Intensity Tornado Striking Oconee Unit 3	4.12E-05	
49	NSF3PU1DPM	SSF Unit 3 RCM Pump Train Is In Maintenance	7.79E-03	1.32E-07
	TBFIRE	Turbine Building Fire Initiating Event	1.70E-05	
50	NSF3PU1DPS	Unit 3 SSF RCM Pump Fails To Start	7.12E-03	1.21E-07
	TBFIRE	Turbine Building Fire Initiating Event	1.70E-05	

TOP EVENT PROBABILITY = 4.3E-5

Table 5.2-2

Importance Values For CDF Cut Sets

Sorted by Fussell-Vesely Importance

Event Name	Description	Probability	Fus-Ves[†]	RAW[9]
H00HP97RHE	Operators Fail to Isolate Diversion Flow From RB Sump to LDST	1	26.8%	1
HHP0097CVC	Check Valve 3HP-97 Fails To Close On Demand	8.81E-03	26.8%	31.2
BSFFAILDEX	Failure To Provide SSF RCMUP Seal Injection In Time To Prevent RCP Seal LOCA	2.50E-01	15.3%	1.5
TRCSRVLDEX	Either Primary Safety Relief Valve Fails To Close After Liquid Relief	1.00E-01	9.6%	1.9
NSF0RCMDHE	Operators Fail To Align The SSF RCM System For Operation	1.00E-01	8.3%	1.7
TRCSRV0DEX	RCS Safety Relief Valve Does Not Stick Open After Relieving Liquid	9.00E-01	7.4%	1.0
HHPHPR0DHE	Operators Fail to Initiate High Pressure Recirculation	2.20E-03	6.6%	30.9

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

[9] The Risk Achievement Worth (RAW) represents the ratio of the CDF with the failure probability for the event of interest set to 1 (i.e., assumed to be always failed) to the nominal CDF.

Table 5.2-3

Importance Values For CDF Cut Sets

Sorted by Risk Achievement Worth Importance

Event Name	Description	Probability	RAW[10]	Fus-Ves[†]
LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	50.9	0.4%
LLP0028LHE	3LP-28 Left Closed Due to Human Error	2.60E-05	36.2	0.1%
HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	1.34E-04	34.6	0.5%
HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	2.09E-04	34.6	0.7%
HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	2.46E-04	34.6	0.8%
HHP0097CVC	Check Valve 3HP-97 Fails To Close On Demand	8.81E-03	31.2	26.8%
HHPHPR0DHE	Operators Fail to Initiate High Pressure Recirculation	2.20E-03	30.9	6.6%
HHP0191SVT	Solenoid Valve 3HPISV0191 Transfers Position, Closing 3HP-31	9.55E-06	26.4	0.0%
LLP0BWTTKF	Borated Water Storage Tank Ruptures	1.45E-05	24.1	0.0%
HPI0085DEX	Instrument Root Valve (Ref. Legs Common) 3HPII0085 Transfers Closed	2.50E-05	24.1	0.1%
HPI0087DEX	Instrument Root Valve (Sensing Lines Common) 3HPII0087 Transfers Closed	2.50E-05	24.1	0.1%
LLP1920COM	CCF Of MOVs 3LP-19 & 3LP-20 To Open	1.51E-04	15.7	0.2%
LLPPMPSCOM	CCF Of LPI Pumps To Start	4.60E-04	11.8	0.5%

[10] The Risk Achievement Worth (RAW) represents the ratio of the CDF with the failure probability for the event of interest set to 1 (i.e., assumed to be always failed) to the nominal CDF.

[†] The **F-V Importance** equals the sum of the cut sets which contain the event of interest divided by the sum of all of the cut sets (top event probability).

Table 5.2-3

Importance Values For CDF Cut Sets

Sorted by Risk Achievement Worth Importance

Event Name	Description	Probability	RAW	Fus-Ves
PACXN01C4O	4160 V ac Breaker N1 Fails To Open	2.87E-04	11.6	0.3%
PACXN02C4O	4160 V ac Breaker N2 Fails To Open	2.87E-04	11.6	0.3%
PACN1OPLHE	Breaker N1 Fails To Open Due To Latent Human Error	2.60E-04	10.8	0.3%
PACN2OPLHE	Breaker N2 Fails To Open Due To Latent Human Error	2.60E-04	10.8	0.3%
PACN1N2COM	CCF Of Breakers N1 And N2 To Open	2.93E-05	9	0.0%
LLP1718COM	CCF Of MOVs 3LP-17 & 3LP-18 To Open	1.51E-04	8.79	0.1%
LLPLPR0DHE	Operators Fail to Initiate Low Pressure Recirculation	1.00E-03	8.79	0.8%
LLPVATHDHE	Operators Fail To Throttle LPI Flow To Prevent Pump Run- out Given Large LOC	1.00E-03	8.79	0.8%
FEF1516COM	CCF Of Air-Operated Valves FDW-315 and 316 To Open	1.59E-04	8.05	0.1%
HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	1.24E-04	7.92	0.1%
HLPSVLVCOM	Common Cause Failure Of MOVs 3LP-15 And 3LP-16 To Open On Demand	1.24E-04	7.92	0.1%
PACXCT4THF	Transformer CT4 Fails	4.61E-04	6.63	0.3%
PACMFB1BHM	Main Feeder Bus 1 Is In Maintenance	1.00E-03	6.58	0.6%
PACMFB2BHM	Main Feeder Bus 2 Is In Maintenance	1.00E-03	6.58	0.6%
FEFWUSTLHE	Insufficient Inventory In UST For EFW Pump Suction	1.00E-04	6.55	0.1%

Uncertainty Analysis Summary

Input Options

Filename	: C:\CAFTA\HPI\HCH15.CUT
Module Name	: HCH15INJ
Sample Size	: 5000
Seed	: 2511632
Point Estimate	: 3.57E-03
Number of Modules	: 1
Total Cutsets In All Modules	: 275
Number of Basic Events	: 123
Number of Type Codes	: 18
Inputs Missing Distribution	: 9

Moments
(With 95% Confidence)

	Low	Estimate	High
Mean	3.40E-03	3.50E-03	3.61E-03
Standard Deviation	3.83E-03	3.76E-03	3.69E-03
Skewness	-	9.30E+00	-
Kurtosis	-	1.51E+02	-

Percentiles
(With 95% Confidence)

	Low	Estimate	High
Minimum	-	5.08E-04	-
2.5	1.06E-03	1.09E-03	1.11E-03
5.0	1.20E-03	1.23E-03	1.26E-03
10.0	1.39E-03	1.41E-03	1.43E-03
20.0	1.68E-03	1.71E-03	1.74E-03
25.0	1.81E-03	1.84E-03	1.88E-03
30.0	1.95E-03	1.98E-03	2.02E-03
40.0	2.24E-03	2.28E-03	2.31E-03
50.0	2.55E-03	2.60E-03	2.66E-03
60.0	2.94E-03	3.00E-03	3.06E-03
70.0	3.47E-03	3.56E-03	3.65E-03
75.0	3.83E-03	3.93E-03	4.03E-03
80.0	4.25E-03	4.36E-03	4.47E-03
90.0	5.88E-03	6.10E-03	6.37E-03
95.0	7.99E-03	8.30E-03	8.74E-03
97.5	1.04E-02	1.15E-02	1.26E-02
Maximum	-	9.43E-02	-

Figure 5.3-1 Uncertainty Analysis Summary For DBA LOCA, Injection Mode

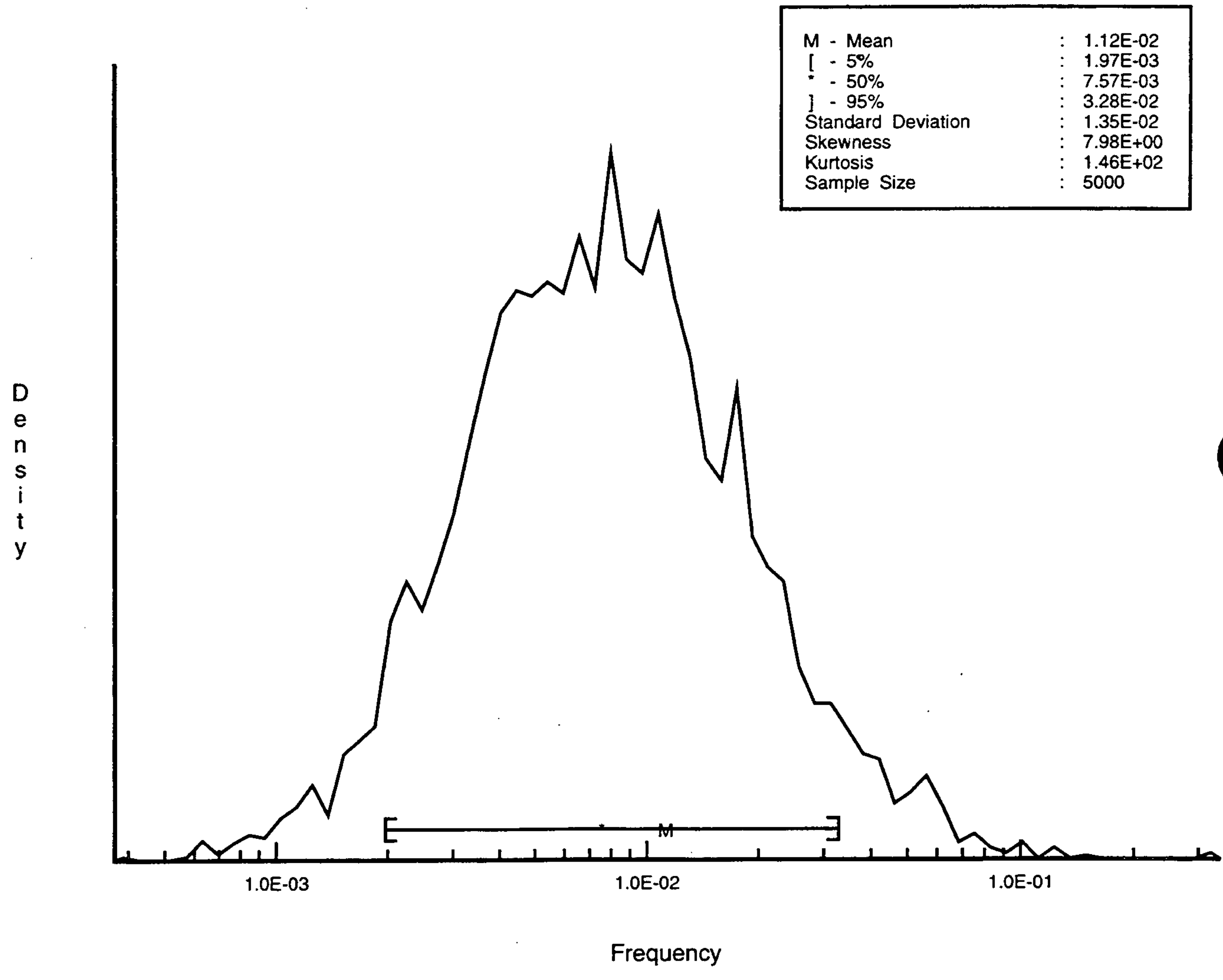

Figure 5.3-1 Uncertainty Analysis Summary For DBA LOCA, Injection Mode

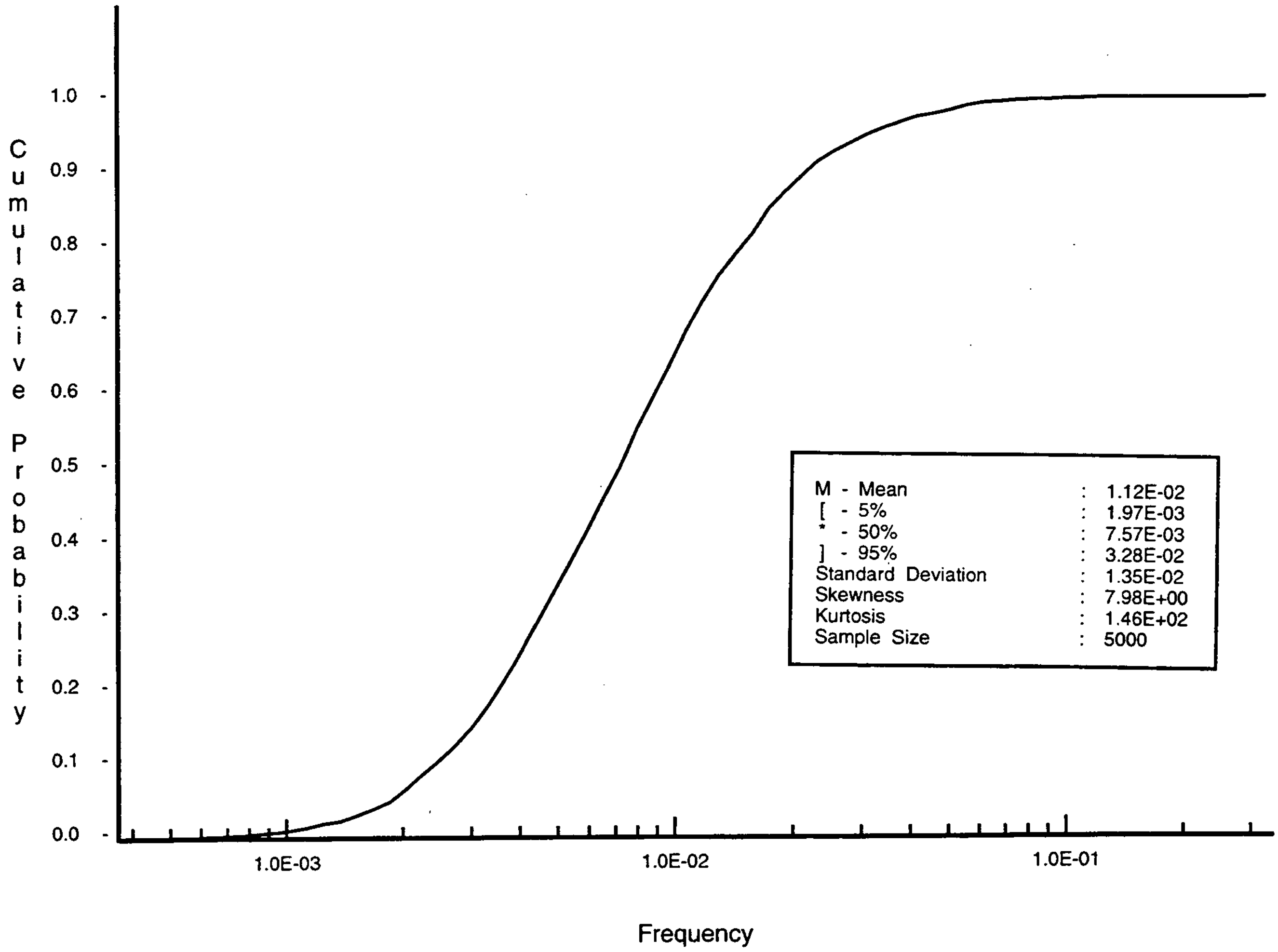

Figure 5.3-1 Uncertainty Analysis Summary For DBA LOCA, Injection Mode

Uncertainty Analysis Summary

Input Options

Filename	: C:\CAFTA\HPI\HR.CUT
Module Name	: HPR001
Sample Size	: 5000
Seed	: 2548465
Point Estimate	: 1.12E-02
Number of Modules	: 1
Total Cutsets In All Modules	: 58
Number of Basic Events	: 44
Number of Type Codes	: 9
Inputs Missing Distribution	: 3

Moments
(With 95% Confidence)

	Low	Estimate	High
Mean	1.08E-02	1.12E-02	1.16E-02
Standard Deviation	1.37E-02	1.35E-02	1.32E-02
Skewness	-	7.98E+00	-
Kurtosis	-	1.46E+02	-

Percentiles
(With 95% Confidence)

	Low	Estimate	High
Minimum	-	3.69E-04	-
2.5	1.41E-03	1.50E-03	1.58E-03
5.0	1.84E-03	1.97E-03	2.05E-03
10.0	2.46E-03	2.55E-03	2.67E-03
20.0	3.57E-03	3.69E-03	3.81E-03
25.0	4.08E-03	4.19E-03	4.34E-03
30.0	4.61E-03	4.72E-03	4.88E-03
40.0	5.83E-03	5.99E-03	6.22E-03
50.0	7.29E-03	7.57E-03	7.78E-03
60.0	9.08E-03	9.32E-03	9.60E-03
70.0	1.13E-02	1.17E-02	1.21E-02
75.0	1.28E-02	1.32E-02	1.38E-02
80.0	1.51E-02	1.56E-02	1.63E-02
90.0	2.20E-02	2.28E-02	2.37E-02
95.0	3.11E-02	3.28E-02	3.49E-02
97.5	4.19E-02	4.43E-02	4.97E-02
Maximum	-	3.42E-01	-

Figure 5.3-2 Uncertainty Analysis Summary For DBA LOCA, Recirculation Mode

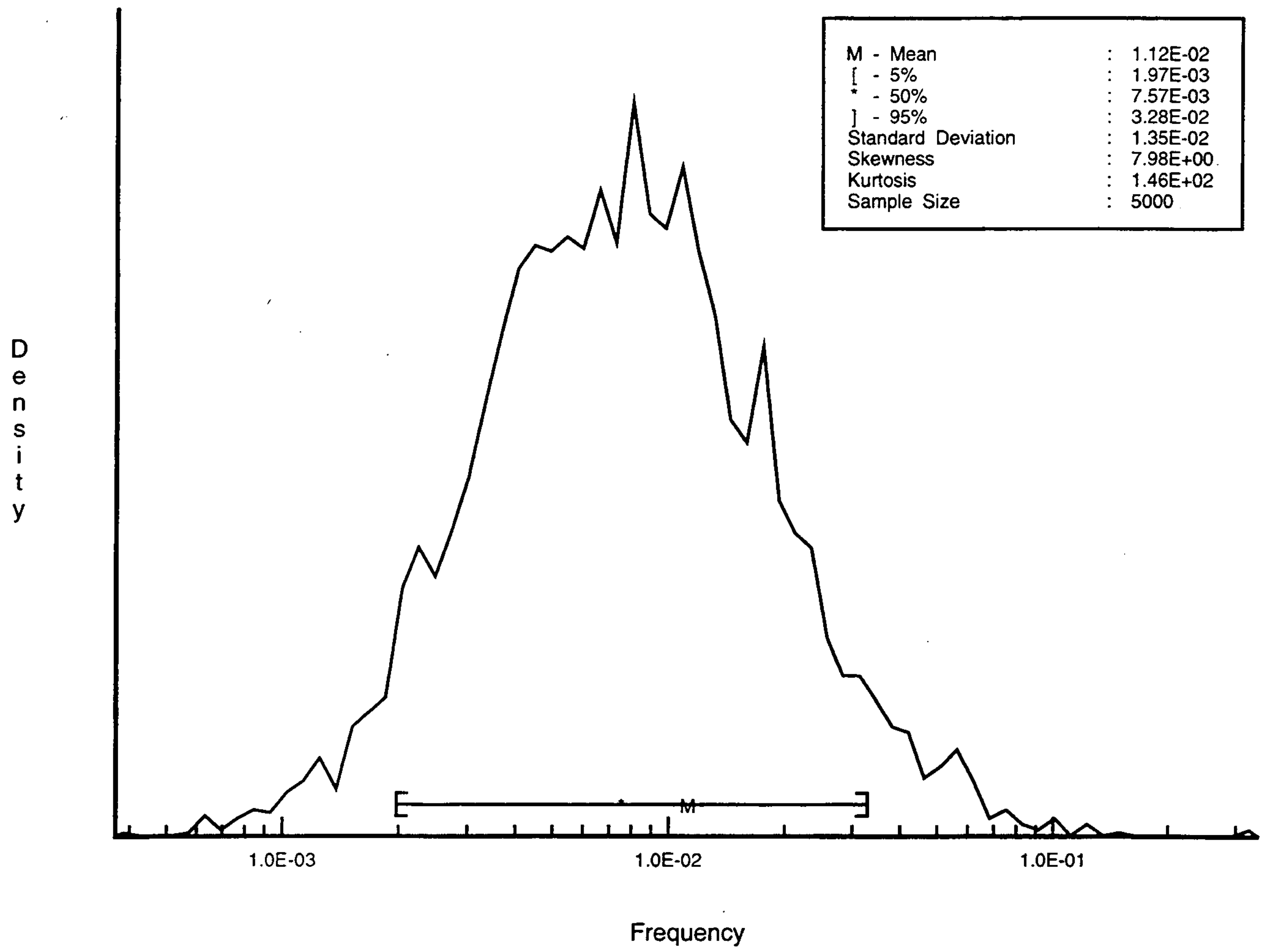

Figure 5.3-2 Uncertainty Analysis Summary For DBA LOCA, Recirculation Mode

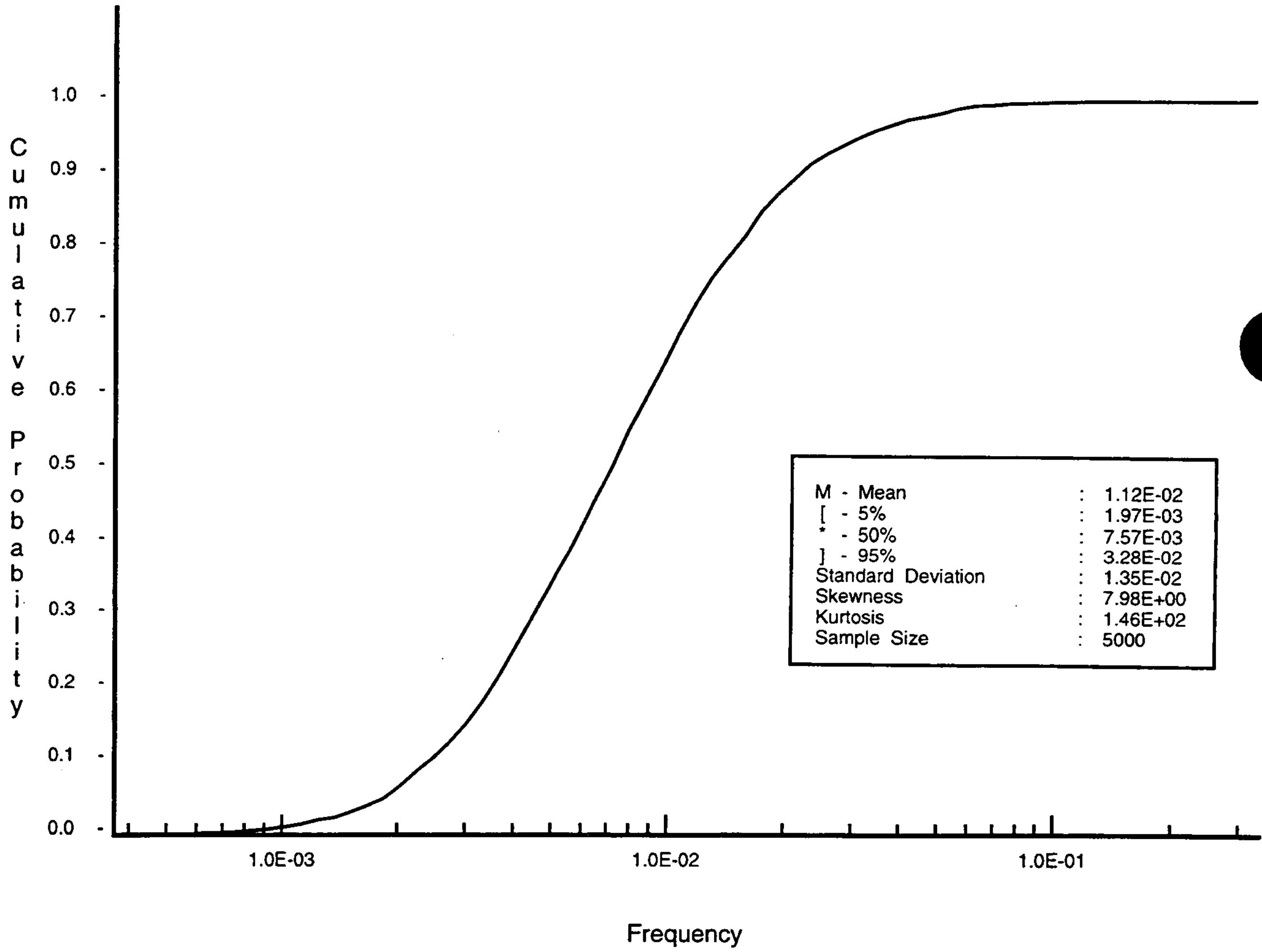

Figure 5.3-2 Uncertainty Analysis Summary For DBA LOCA, Recirculation Mode

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The following conclusions are drawn based on the results discussed in Section 5.

1. The reliability of the HPI system for mitigation of the design basis UFSAR Chapter 15 accidents is found be in the desired high range, with a calculated reliability of approximately
   - 99.9% for non-LOCA accidents
   - 99.6% for LOCA mitigation during the injection mode

2. For the accident sequences of interest in PRA studies, the reliability of the HPI system in the injection mode is also found to be very high (approximately 99.9%).

3. If HPI sump recirculation is needed for continued core cooling, the HPI system operates in tandem with the LPI system. For this HPI recirculation function, the combined system reliability is estimated to be 98.9% for the design basis LOCA events and the PRA accident sequences.

4. For the HPI injection function (during the design basis and PRA sequences), no single failure mode appears to constrain the injection reliability. Several failure modes of relatively small probability aggregate to an overall injection failure probability of 9.4E-4 to 3.6E-3.

5. Failure modes associated with the LDST interface appear among the top cut sets for the injection function. These are mainly common cause failure of the level and pressure instrument strings which could produce the conditions for HPI pump failure from potential hydrogen entrainment in the HPI pump suction when the BWST level reaches the low level limit.

6. For the HPI recirculation function, a postulated failure of the LDST isolation check valve HP-97 to close is an important failure mode, although there is some uncertainty on the likelihood of this valve failure to cause the system failure. This valve currently receives a reverse leakage test each refueling outage in addition to forward flow tests. With the conservative treatment of this failure mode in this analysis, this failure mode accounts for approximately 79% of the calculated HPI recirculation failure probability. If the check valve is isolated by closing the motor operated valve HP-23 as part of the HPI recirculation procedure, improvement in the HPI recirculation reliability can be achieved.

7. In the current system configuration, the HPI system failure modes account for a core damage frequency of approximately 1.6E-5 per reactor year out of a total core damage frequency (including internal and external events but not seismic) of 4.3E-5 per reactor year. Action to isolate potential failure of HP-97, as recommended below, can reduce the core damage frequency impact by approximately 1.2E-5.

8. The HPI system should be treated as a risk-significant system since the risk achievement worth (an importance measure calculated as the ratio of total core damage frequency assuming the system fails with a failure probability of 1.0 to the total core damage frequency assuming the nominal failure probability) is approximately 36.

9. Examination of the HPI function for shutdown risk and external event mitigation did not identify any concerns with respect to the HPI system reliability or vulnerability.

A number of sensitivity studies have been performed as part of this analysis to provide important perspectives on the reliability and risk significance of certain operational features of the Oconee HPI system. The results imply the following conclusions:

- The feature involving the auto-start of the second HPI pump on a low RCP seal flow signal does not have any significant adverse impact on the reliability and risk results.
- The LDST interface contributes to both beneficial and adverse impact on reliability and risk results. On the negative side, the open LDST suction header during the LOCA mitigation accounts for the LDST common cause instrument failure and HP-97 failure modes. On the positive side, this situation permits recovery from the common cause failure of BWST suction valves HP-24 and HP-25. Also, the current arrangement preserves the HPI pump dead-heading protection and eliminates the need for operator action to isolate the HPI pump recirculation paths during the early phase of the LOCA. Based on this study, it appears that isolation of the LDST interface close to the time of HPI recirculation is the optimum configuration.
- The normally open suction header and the post-accident cross connected discharge header did not adversely affect the reliability and risk. The current arrangement enables the required HPI performance to be available when active failures of pumps and valves are considered. The impact of passive failures were found to be not significant.
- The configuration with HP-116 open and HP-27 closed eliminates some low probability cut sets and adds others, with no net change in CDF. Therefore, from a PRA standpoint, operating with HP-116 normally open provides no measurable impact on plant risk.
- The Oconee HPI system is found to meet the ECCS performance requirement with adequate reliability. Further improvement in reliability can be achieved for the recirculation mode by providing the capability to isolate potential flow diversion through HP-97.

6.2 Recommendations

Considering the results and conclusions of this analysis, the following recommendations are made:

1. Recognizing that the HPI system is a risk significant system, it is recommended that equipment failures and unavailabilities in the system be monitored to ensure that the desired reliability for the accident mitigation function is being maintained. This is currently being accomplished through the Maintenance Rule reliability monitoring program.

2. With the current arrangement of the open LDST interface of the HPI pumps during the post-LOCA operation, failure of HP-97 to close is a potentially risk significant failure mode. It is recommended that a system enhancement (either operator action or automatic action) to close HP-23 during the recirculation phase of LOCA mitigation be implemented. Such a plant enhancement would reduce the core damage risk of accident sequences involving the HPI system and improve the reliability of the HPI recirculation function, if it were needed.

3. Although the most recent improvements in the LDST instrumentation system have reduced the potential for common cause failures, which contribute to HPI injection failures, this failure mode deserves continuing vigilance with the open LDST interface. It is recommended that a more focused surveillance of the LDST level and pressure instrument strings be implemented, to provide defense in depth against common mode failure.

7.0 References

1 Oconee Nuclear Station PRA Revision 2 Summary Report, Duke Power Co., December 1996.

2 Duke Letter From J. W. Hampton to US Nuclear Regulatory Commission, dated May, 16, 1997.

3 Oconee Nuclear Station Updated Final Safety Analysis Report, Chapter 15, "Accident Analyses," 1996 Update.

4 Duke Letter From J. W. Hampton to US Nuclear Regulatory Commission, dated March 31, 1997.

5 . MAAP 3b Computer Code, Rev. 16, EPRI.

6 SAROS Generic Equipment Failure Rate Database, SAAG File No. 342, Duke Power Company, November 1995.

7 IEEE Guide to the Collection and Presentation of Electrical, Electronic, Sensing Component, and Mechanical Equipment Reliability Data for Nuclear Power Generating Stations, IEEE Std 500-1984, Institute of Electrical and Electronic Engineers, Inc., 1983.

8 Generic Component Failure Data Base For Light Water and Liquid Sodium Reactor PRAs, EGG-SSRE-8875, Idaho National Engineering Laboratory, 1990.

9 A Probabilistic Risk Assessment of Oconee Unit 3, NSAC 60, EPRI, June 1984.

10 Oconee Nuclear Station Keowee Reliability Analysis, Duke Power Company, June 1995.

11 Swain, A. D., H. E. Guttmann, Handbook of Human Reliability Analysis with Emphasis on Nuclear Plant Applications Final Report, Sandia National Laboratories, NUREG/CR-1278, August 1983.

12 Mosleh, A., et al., Procedures for Treating Common Cause Failures in Safety and Reliability Studies (Vol. I: *Procedural Framework and Examples*), NUREG/CR-4780 (EPRI NP-5613), January 1988.

13 Mosleh, A., et al., Procedures for Treating Common Cause Failures in Safety and Reliability Studies, NUREG/CR-5801, April 1993.

14 Fleming, K. N., et al., A Database of Common-Cause Events for Risk and Reliability Applications, Electric Power Research Institute, EPRI TR-100382, June 1992.

15 Common Cause Data Analysis Tool (CCDAT) User's Manual, Electric Power Research Institute, EPRI TR-102747, August 1993.

16 Advanced Light Water Reactor Utility Requirements Document (Vol. II: *ALWR Evolutionary Plant*), EPRI NP-6780, Chapter 1, Appendix A - *PRA Key Assumptions and Groundrules*, Revision 4, April 1992.

17 Fleming, K. N., et al., Classification and Analysis of Reactor Operating Experience Involving Dependent Events, EPRI NP-3967, June 1985.

18 Pipe Failure Study Update, EPRI TR-102266, April 1993.

19 Oconee Nuclear Station IPEEE Submittal Report, Duke Power Company, December 1995.

20 A Methodology of Assessment of Nuclear Power Plant Seismic Margin, EPRI NP-6041, August 1991.

21 Outage Risk Assessment and Management Duke Power Company Oconee Nuclear Station -PSSA Model—with Refueling Outage Evaluations, EPRI TR-106978, December 1996.

APPENDIX A

INDUSTRY OPERATING EXPERIENCE

Operating Experience Review
High Pressure Injection and Charging Systems

0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
1		7/10/73	HPI pump 1B inoperable	Oconee Unit 1 - HPI pump 1B inoperable from auxiliary shutdown panel	Control Systems	
2		10/3/73	1HP-27 Failed	Oconee Unit 1 - 1HP-27 failed (position not recorded)	Valve Failure	
3		12/14/73	LDST drained into LWD System	LDST drained into LWD System when drain line on standby RCP seal filter left opened.	Human	
4		12/27/73	1HP-20 failed open	Oconee Unit 1 - 1HP-20 failed open	Valve Failure	
6		1/22/74	RCP 2B2 seal failure	Oconee Unit 2 - RCP seal failure due to actions taken to repair seal injection line weld leak	Misc.	Unknown Cause
5		1/22/74	Weld leak on RCP 2A1 seal injection line	Oconee Unit 2 - Weld leak on RCP 2A1 seal injection line	Piping Failure	
7		6/17/74	3HP-4 failed to close	Oconee Unit 3 - 3HP-4 failed to close	Valve Failure	
8		7/7/74	Damaged HPI pump 2A	Oconee Unit 2 - Damage to HPI pump 2A due to mispositioning valve 2HP-98	Human	
9		9/3/74	Weld failure on seal injection line	Oconee Unit 3 - Weld failure on seal injection line to RCP-3B2	Piping Failure	
10		12/24/74	Gasket leak on letdown filter 2A	Oconee Unit 2 - Gasket leak on letdown filter 2A	Misc.	
11		6/22/75	3HP-26 found inoperable	Oconee Unit 3 - 3HP-26 was found inoperable due to a loose control wire	Valve Failure	
12		6/24/75	RCS Leak from valve 1HP-43	Oconee Unit 1 - RCS Leak from valve 1HP-43	Valve Failure	
13		12/23/75	3HP-24 failed	Oconee Unit 3 - 3HP-24 failed due to torque switch contact failures	Valve Failure	
14		3/3/76	HPI Pump Motor Degradation	Oconee Unit 1 - Separation of HPI pump rotor laminations (all 3 HPI pumps)	Pump Failure	Common Cause Event
15		7/7/76	Letdown Cooler Leak	Oconee Unit 1 - Letdown Cooler leaking into Component Cooling System	Misc.	
16		11/1/76	HPI Train 3B Inoperable	Oconee Unit 3 - HPI Train 3B was found inoperable due to closed valves 3HP-152 and 3HP153	Human	
17		12/4/76	LDST leak resulting from improper valve positioning	Oconee Unit 2 - LDST leak resulting from improper positioning of 2HP-78 & 62	Human	
18		12/12/76	3HP-120 Failed Closed	Oconee Unit 3 - 3HP-120 failed (transferred) closed due to a diaphram failure	Valve Failure	
19		1/10/77	Improper isolation of valve CA-18	Oconee Unit 1 - Improper isolation of valve CA-18 (loss of LDST water)	Human	
20		2/25/77	Valve 1HP-5 Failed	Oconee Unit 1 - Valve 1HP-5 failed due to a solenoid failure	Valve Failure	
21		3/21/77	HPI pump 2A failed	Oconee Unit 2 - HPI pump 2A failed due to wear on a bearing oil seal	Pump Failure	
22		3/20/78	Valve 3HP-24 Failed	Oconee Unit 3 - 3HP-24 failed to cycle during testing	Valve Failure	
23		11/5/78	Valve 2HP-127 discovered closed.	Oconee Unit 2 - Valve 2HP-127 discovered closed. Unavailable 8/1/77 thru 11/5/78.	Human	

Operating Experience Review
High Pressure Injection and Charging Systems

0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
24		10/18/79	HPI pump 3B Failed	Oconee Unit 3 - HPI pump 3B failed due to dc ground, damaged cable	Pump Failure	
25		10/19/79	Valve 3HP-410 Inadvertently opened	Oconee Unit 3 - Valve 3HP-410 Inadvertently opened	Human	
26		11/14/79	HPI pump 3A damaged	Oconee Unit 3 - HPI pump damaged due to human error, suction valve was left closed	Human	
27		6/12/80	Checkvalve Leak overheats HPI line	Oconee Unit 1 - Overheating in HPI loop B due to checkvalve 1HP-152 leak	Checkvalve	
28		12/17/80	Bad HPI Pump Bearing	Oconee Unit 2 - Repeated High Bearing Temperature Problems due to low oil level and cooling water flow problems. Bearings finally failed on 12/17/80.	Pump Failure	
29		12/9/81	Cable Separation criteria not met for 1HP-26	Oconee Unit 1 - Control cables to 1HP-26 do not meet separation criteria	Design	
30		2/28/82	HPI normal makeup nozzle thermal sleeve displaced	Oconee Unit 3 - HPI normal makeup nozzle 3A2 thermal sleeve found to be displaced	Piping Failure	
31		3/2/82	HPI normal makeup nozzle thermal sleeve displaced	Oconee Unit 2 - HPI normal makeup nozzle 3A2 thermal sleeve found to be displaced	Piping Failure	
32		5/28/82	HPI Pump Shaft Distortion	Oconee Unit 2 - Repeated Operational Problems on HPI pump 2A due to extensive pump shaft distortion.	Pump Failure	
33		8/11/82	Valve 2HP-21 transferred closed	Oconee Unit 2 - Valve 2HP-21 closed during ES on-line test of valves	Valve Failure	
34		12/7/82	Valve 1HP-25 failed to open	Oconee Unit 1 - Valve 1HP-25 failed to open during testing	Valve Failure	
35		2/3/83	Low oil level cause HPI pump bearing failure	Oconee Unit 2 - HPI pump 2A unscheduled maintenance due to a bad bearing (attributed to a low oil level)	Pump Failure	
36		2/23/83	Blown control power fule for HPI valves	Oconee Unit 3 - HPI train 3A found inoperable due to blown fuse control power for 3HP-24, 26	Control Systems	
37		3/3/83	Valve 1HP-25 failed to open	Oconee Unit 1 - Valve 1HP-25 failed to open fully during testing	Valve Failure	
38		3/9/83	Valve 2HP-24 failed to open	Oconee Unit 2 - Valve 2HP-24 failed to open during testing	Valve Failure	
39		3/15/83	Valve 2HP-24 failed to open	Oconee Unit 2 - Valve 2HP-24 failed to open fully during testing	Valve Failure	
40		3/21/83	Valve 1HP-16 failed to open	Oconee Unit 1 - Valve 1HP-16 failed to open	Valve Failure	
41		4/28/83	RCP seal flow lost for 5 minutes	Oconee Unit 2 - RCP seal flow lost for 5 minutes when RCP seal supply filter A was not put in service before removing B filter	Human	
42		5/25/83	DC power breaker tranferred open	Oconee Unit 3 - Valves 3HP-21 and 3CC-8 failed "as is" and valve 3HP-5 transferred closed when dc breaker 3DIB-25 transferred open	Breaker	
43		7/27/83	HPI pump 3A failed to start manually	Oconee Unit 3 - HPI pump 3A failed to start manually (overcurrent relay tripped)	Pump Failure	

Operating Experience Review
High Pressure Injection and Charging Systems

0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
331		9/12/85	SER 54-85, Loss of Non-Vital Buses and Charging Pumps During Load Rejection Test	Palo Verde Unit 1 - The common reference leg for the VCT Level Instrumentation was partially drained which cause a 20% indication when the tank was empty. This resulted in the charging pumps becoming air bound and inoperable.	Gas Binding	
44		1/9/86	Reduced seal injection flow	Oconee Unit 3 - Reduced seal injection flow to RCP seal 3B1	Misc.	Unknown Cause
45		4/24/86	Valve 1HP-120 and 1LP-25 failed	Oconee Unit 1 - Valve 1HP-120 failed open and valve 1LP-25 failed to reseat.	Valve Failure	
46		7/3/86	BWST suction valves to HPI leaked	Oconee Unit 3 - Seat leak in HPI pump suction valves from BWST resulted in inleakage of highly borated water affecting RCS leakage calculations and makeup concentrations. No TS violation.	Valve Failure	
47		9/1/86	2HP-20 Failed	Oconee Unit 2 - "Non-EQ" motor for 2HP-20 replaced with "EQ" motor. Replacement motor failed post-installation test due to motor running in wrong direction. Unit in Cold S/D.	Valve Failure	Not really an actual failure since it was detected prior to being put in service.
48		4/10/87	TS Violation - 2 HPI Trains Inop	Oconee Unit 3 - Breakers for 3HP-24 and 3HP-25 were red tagged open after RCS temp had exceeded 350 deg F	Human	Common Cause Event
49		6/11/87	Overcurrent Trip Setpoint Problem	Discovered that HPI pump motor on each unit could trip on overcurrent during starting of all three unit's blackout loads	Design	Common Cause Event (Potential)
342	627	1/19/88	LOSS OF BORIC ACID INJECTION FLOW PATHWAY DUE TO INACCURATE	Problems with Charging Pump's electrical breakers.	Breaker	More of an electrical breaker problem than anything concerning HPI reliability.
355	1425	2/2/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 02-FEB-88	Brainwood Unit 2 (1/25/88): Operator Error caused loss of power to feeder bus while at cold S/D. Charging pump recovered during event.	Human	
343	667	2/5/88	W-2 CONTROL ROOM SWITCH FAILURE	TIHANGE 1 NUCLEAR POWER PLANT IN BELGIUM: Charging Pump failed to start due to bad control switch in ctrl room.	Control Systems	
357	1433	2/10/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 10-FEB-88	Catawba Unit 2, 2/9/88, Operator test error caused ECCS Actuation which started NV Pumps and swapped their suction to the RWST.	Human	
358	1435	2/12/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 12-FEB-88	Oconee Unit 1 2/11/88: 4 workers contaminated by packing leak on HPI flow instrument isolation valve.	Misc.	Oconee Event
359	1439	2/22/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 22-FEB-88	Sequoyah Unit 2, 2/12/88, DISCOVERED THE PACKING GLAND BOLTS OF THE SPEED CHANGER OF THE #2A CENTRIFUGAL CHARGING PUMP WERE LOOSE. ON 2/17/88, BOLTS ON #2B CHARGING PUMP SPEED CHANGER WERE ALSO FOUND LOOSE.	Pump	COMMON CAUSE EVENT
344	712	2/24/88	INTERNAL FLOODING OF POWER PLANT BUILDINGS	DESCRIBES SEVERAL DEFICIENCIES RELATED TO INTERNAL FLOOD PROTECTION SYSTEMS AND COMPONENTS THAT WERE IDENTIFIED AND CORRECTED AT THE TROJAN NUCLEAR PLANT	Flood	

Operating Experience Review
High Pressure Injection and Charging Systems

0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
333	22	3/17/88	BORIC ACID CORROSION OF CARBON STEEL REACTOR PRESSURE BOUND	At ANO Unit 1, leakage from a high pressure injection valve dripped onto the high pressure injection nozzle. The max depth of corrosion was 0.5 in, which represented a 67% penetration of the pressure boundary. (IE Information Notice No. 86-108)	Piping Failure	RCS Pressure Boundary
346	808	4/6/88	INADEQUATE TECH SPEC OPERABILITY REQUIREMENTS FOR CHARGING A	Palisades Design Review determined that the charging pump P-55B would not auto start on a pressurizer low level signal coincident with a safety injection signal (SIS).	Control Systems	This is a design problem and not an actual failure.
335	65	5/12/88	NRC INFORMATION NOTICE NO. 88-23: POTENTIAL FOR GAS BINDING	February 26, 1988; Farley Unit 1; Operators vented ~50 cu ft of hydrogen gas was vented from HPSI suction lines. Dissolved hydrogen from the VCT came out of solution and collected in the lines.	Gas Binding	**Make sure that reliability model has this covered or verify that this is not a concern for Oconee HPI system.** - Done.
347	927	5/27/88	ARKANSAS NUCLEAR ONE - UNIT 2 LOSS OF VCT LEVEL	ANO Unit 2 - During Plant Startup, low flow alarms received on charging system. VCT was empty. Tubing fitting failed which drained common reference leg to both VCT level instruments.	Gas Binding	
348	992	6/24/88	IONIC IMPURITIES IN REACTOR COOLANT SYSTEM	Indian Point Unit 3: Charging Pump packing material found to result in unacceptable levels of calcium, chloride, and fluoride in primary coolant.	Misc.	
349	1007	7/7/88	DEBRIS FOUND DURING REACTOR VESSEL INSPECTION	DAVIS-BESSE 7/1/88: INSPECTIONS REVEALED THAT THE NORMAL MAKEUP (MU) / HIGH PRESSURE INJECTION (HPI) LINE THERMAL SLEEVE WAS SEVERED AT THE END THAT PROTUDES INTO THE REACTOR COOLANT SYSTEM (RCS) COLD LEG PIPING. FRAGMENTS FOUND IN RX VESSEL.	Piping Failure	RCS Pressure Boundary
366	1532	7/19/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS: 18-JUL-88	Catawba Unit 2, TS UNIT S/D FOR REPLACEMENT OF THE 2A CHARGING PUMP - but don't know why?	Pump	
367	1548	8/8/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 08-AUG-88	Haddam Neck 8/5/88: SHAFT BROKE ON 07/31/88 ON THE HIGH HEAD CHARGING PUMP	Pump Failure	
368	1558	8/22/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 22-AUG-88	Salem Unit 1, 8/20/88: TS SHUT DOWN DUE TO REPAIRS OF A BAD BEARING ON THE "12" CHARGING PUMP	Pump Bearing	
351	1131	8/30/88	HPI/MAKEUP PUMP OPERATION IN THE PIGGYBACK MODE	ANO Unit 1; 7/14/88; LER No 50-313: When the HPI system is not lined up for recirculation,the recirculation line is isolated. This line was apparently drained, which allowed gas to enter the lines.	Gas Binding	
339	129	9/14/88	NRC INFORMATION NOTICE NO. 88-74: POTENTIALLY INADEQUATE PE	Oconee and Turkey Point: Throttling of LPI discharge flow found not provide adequate NPSH for HPI pump in piggy-back mode.	Pump	Not actual failure events; Design Review discovered inadequate NPSH concern.

Operating Experience Review
High Pressure Injection and Charging Systems

0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
369	1575	9/16/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 16-SEP-88	Trojan (10/12/88): CONTROL POWER WAS LOST TO THE "A" TRAIN SUPPLY VALVE DUE TO BLOWN FUSE. "B" TRAIN WAS INOPERABLE AT THE TIME	Control Systems	
371	1601	10/20/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 20-OCT-88	Surry, 10/19.88: CHARGING PUMP SERVICE WATER PUMPS MAY BE VUNERABLE TO FAILURE IN APPENDIX R SCENARIO.	Fire	N/A
372	1604	10/25/88	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 25-OCT-89	Trojan, 10/24/88: B CENTRIFUGAL CHARGING PUMP HAD 2400 cc/hr mechanical seal leakage.	Pump Failure	
336	66	1/5/89	NRC INFORMATION NOTICE NO. 88-23, SUPPLEMENT 1: POTENTIAL F	In addition to event above, describes event at South Texas Plant U2, May 13, 1988, where suction was lost to the centrifugal charging pumps due to air pocket formation in 2 high points. Also, on Oct 14, 1988, North Anna found air pockets in HPSI piping.	Gas Binding	**Same as above**; North Anna found gas in line from RWST to HPSI and in line from LPSI to HPSI.
381	1779	1/19/89	MAINTENANCE ERROR RESULTING IN REACTOR TRIP	Waterford: loss of power to the CVC isolation relays caused letdown to isolate and charging pump suction to swap from VCT to RWST.	Auto Swap	
376	1680	1/20/89	SER 1-89, IMPACT OF FAILED FUEL ON PLANT OPERATION	Having higher Primary System Activitiy and small leaks from pumps and valves has resulted in many areas of the auxiliary building having high gaseous activity background levels.	Pump	N/A
502		2/11/89	89024246-01	Oconee Unit 1 - "1C" HPI pump motor indicated high amps during pump s/u. Found locking pin in pump to motor coupling missing. Caused misalignment of pump shaft which resulted in shaft making contact with the pump wear rings and casing. (RF mode)	Pump Failure	
382	1851	2/27/89	PIGGYBACK PIPING DECLARED INOPERABLE	ANO Unit 1 - Jan 1989 - Design Problem Identified - Piggyback line not analyzed for expected coolant temperatures during High Pressure Recirculation.	Design	Not an actual failure event.
399	2462	3/20/89	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: (03-MAR-89)	ANO 1 - Design Issue Discovered over the HPI line break scenario and how HPI flow will go into RCS and how much out the break. No actual failures occurred.	Design	Not an actual failure event.
383	1916	4/4/89	Design Calculation Deficiencies in ES System Pipin	ANO Unit 1 - Feb 1989 - Design Problem Identified - HPI pump seals not analyzed for expected coolant temperatures during High Pressure Recirculation. Also, BWST suction line not analyzed for full range of temperatures allowed during normal operation.	Design	Not an actual failure event.
384	1925	4/10/89	High Pressure Injection Check Valve MU-34B Leaks By	ANO Unit 1 1/20/89: Rx Trip, HPI used to restore Pzr level - HPI Check Valve MU-34B failed to seat - Leaks By Causing Backflow of RCS - combusible materials on pipe overheat filling room with smoke.	Checkvalve	

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401	2487	4/24/89	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT (24-APR-89)	Turkey Point: ALL CHARGING PUMPS MAY BE VUNERABLE TO FAILURE IN APPENDIX R SCENARIO.	Fire	N/A
396	2391	5/2/89	O&MR 352, INADEQUATE CONTROL OF SLIDING LINKS RESULTS	McGuire 1 - 8/29/88 - an open sliding link defeated auto closure of a VCT outlet valve on either an SI signal or low-low VCT level. Oconee 1, 10/14/88, auto start on loss of power to MFB for a HPI pump & a CC pump was defeated due to open sliding link.	Control Systems	
388	2091	6/30/89	HIGH PRESSURE INJECTION SYSTEM DEGRADED	Davis-Besse June 1989 - Design problem involving load sequencing of HPI pumps. No actual failures involved.	Design	Not an actual failure event.
405	2566	8/15/89	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 15-AUGUST-89	Surry Unit 2, Aug 1989 - Autostart of B CCP due to failure to properly engage control switch during pump test.	Control Systems	
389	2170	8/28/89	POSITIVE DISPLACEMENT CHARGING PUMP OUT OF SERVICE	DIABLO CANYON UNIT 2 - June 1989 - Appendix R Design Problem for charging pump controls - No actual failures involved.	Fire	Not an actual failure event.
407	2608	10/12/89	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 12-OCT-89	Seabrook 10/11/89: LOSS OF 4kV POWER DURING UNIT S/D. SAFETY INJECTION VALVE FROM THE CHARGING PUMPS #SI-139 WENT FROM THE CLOSED TO THE INTERMEDIATE POSITION UNEXPECTEDLY.	Control Systems	
408	2622	11/1/89	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 01-NOV-89	Crystal River - 10/31/89 - 3 LETDOWN & MAKEUP SYSTEM VALVES WERE FOUND CLOSED INSTEAD OF BEING TAGGED OPEN ON THEIR RESPECTIVE MCCs (Appendix R related)	Valve Alignments	
410	2639	11/27/89	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 27-NOV-89	Catawba 1 11/20/89: TS required S/D due to inoperable NV pump. Pump showed significant pump flow degradation.	Pump Failure	
392	2340	12/6/89	Incorrect Installation of Oil Slinger Ring Resulti	Zion Unit 2 - Incorrect Installation of Oil Slinger Ring (on Inboard Bearing) Resulted in Charging Pump Failure	Pump Failure	
393	2355	12/14/89	EXCESSIVE VIBRATION OF THE HPI LINES DURING TESTING	ANO Unit 1 - 12/10/89 - Excessive HPI line vibration during test - vibration opened two vent valves and caused a threaded pipe cap to come off the vent line. New flow venturi's were removed pending further investigation.	Piping Failure	This is only a minor pipe failure at this point.
395	2379	12/27/89	INADEQUATE HPI INSTRUMENTATION	ANO identified problem with "HPI LINE BREAK" scenario. HPI flow instrumentation not accurate enough to re-balance flow properly. Installed narrow range flow instrument.	Human	**This should be reviewed further for Oconee HPI requirements. -** Done
414	2698	1/5/90	RECURRING SIGNIFICANT EVENT NOTIFICATION: 89-02 A	Beaver Valley - Gas Binding of Charging Pumps - Hydrogen came out of solution in the pump recirc line orifice.	Gas Binding	
433	3376	1/5/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 05-JAN-90	Salem 2, 1/5/90: Math error found in charging pump testing results. Determined that test criteria were not met. Unit shut down to rerun flow test.	Human	

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415	2705	1/10/90	SEN 66, General Electric CR 2940 Control Switches	Defective switch caused SCRAM at one plant - Other defective switches found. These switches are used in many types of systems including safety injection systems	Control Systems	
434	3384	1/17/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 17-JAN-90	Salem Unit 2 - 1/17/90 - LEAK ON A WELDED PIPE CAP ON THE COLD LEG INJECTION LINE - (8 gpm leak)	Piping Failure	
416	2709	1/26/90	RECURRING SIGNIFICANT EVENT NOTIFICATION: 89-04 O	McGuire 1, 9/5/89: overpressurization of the charging pump suction piping during valve stroke testing occurred at the end of the July 1988 outage.	Piping Failure	
437	3401	2/9/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 9-FEB-90	COMANCHE PEAK 1: Inadvertant swapover of charging pump suction from VCT to RWST.	Auto Swap	N/A
439	3409	2/21/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 21-FEB-90	SAN ONOFRE 1 - Design problem on valves going to VCT. These AOVs were found to fail open on loss of IA instead of closed which could lead to gas binding of the pumps.	Gas Binding	Needs further review - make sure we have this in model. --> OK
440	3418	3/5/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 05-MAR-90	SAINT LUCIE 2 - 13-18 GPM (TECH SPEC LIMIT 10 GPM) LEAK FROM THE DISCHARGE VALVE COVER FOR THE 2A CHARGING PUMP WAS DISCOVERED AND ISOLATED. GASKET FAILURE ON VALVE. 250 gallons of coolant lost.	Valve Failure	
424	2948	5/1/90	ECCS FLOW INCONSISTENCIES AT SALEM	Salem: Errors in design flow rate calculations. Testing found charging pump flow rate degraded. During pump rotor replacement, significant cracks were found in pump inner cladding.	Pump Degradation	
426	2989	5/16/90	POTENTIAL FOR GAS BINDING OF HIGH-HEAD SI PUMPS	D. C. COOK: Potential for gas binding of charging pumps identified. This vulnerability only exists while valve realignments are made to seal return lines.	Gas Binding	
447	3480	5/30/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 29-MAY-90	SAN ONOFRE 1 - CHARGING PUMP FLOW RATE COULD EXCEED THE FLOW CAPACITY OF THE OPM (Overpressure Mitigation) SYSTEM ASSUMED BY THE EVENT ANALYSES. (INADEQUATE ADMINISTRATIVE CONTROLS)	LTOP	
448	3510	7/10/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 10-JUL-90	Haddam Neck 1 - CHARGING PUMP SUCTION VENT LINE PROBLEM. LINE ALLOWS HYDROGEN REMOVAL FROM THE CHARGING PUMP SUCTION PIPING BACK TO THE VOLUME CONTROL TANK (VCT).	Gas Binding	
449	3523	7/27/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 27-JUN-90	COMANCHE PEAK 1: Inadvertant swapover of charging pump suction from VCT to RWST.	Auto Swap	N/A
428	3105	7/27/90	COOLANT CHARGING AND SAFETY INJECTION PUMP WELDS	Westinghouse identified potential problem with welds on certain model pumps. improper welds could fail due to nozzle or seismic loads and cause pump shaft misalignment.	Seismic	Not an actual failure event.
450	3526	8/1/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 01-AUG-90	Diablo Canyon 1 - 7/26/90 - A WELD LEAK ON THE SUCTION LINE TO #13 PDP CHARGING PUMP WAS DISCOVERED.	Piping Failure	

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451	3529	8/3/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 03-AUG-90	HADDAM NECK - Determined that charging pump discharge pressure fluctuations indicated possible gas binding.	Gas Binding	
453	3555	9/7/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 07-SEPT-90	Sequoyah 2, 9/6/90, Gas bubble found in charging pump suction line (RHR recirc line). Similar to event on 8/22/90.	Gas Binding	
431	3172	9/14/90	GAS BINDING OF A CENTRIFUGAL CHARGING PUMP	Sequoyah 2, August 20, 1990: Centrifugal Charging Pump (CCP) B-B was shutdown during test due to fluctuation in flow rate and motor amps. Hydrogen gas had accumulated suction lines.	Gas Binding	
432	3208	10/5/90	SIGNIFICANT DEFECTS FOUND IN ASME CLASS 1 PIPE DURING FABRIC	ANO 1, 10/5/90: during modification of HPI piping, welder idenified potential defect in piping material. Defect was verified and all stock of same supplier was removed from use.	Piping Failure	Not an actual failure event.
419	2768	10/29/90	Recurring Significant Event Notification (RSEN) 90-3	Diablo Canyon 2, 7/26/90: 2-1/2 inch through-wall crack was discovered on the suction piping of a positive displacement pump in the charging system. The suction pipe was not isolable from the common suction header to the PD pump and the CCPs.	Piping Failure	COMMON CAUSE EVENT
458	3595	11/2/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 02-NOV-90	NORTH ANNA 1 - 11/1/90 - Tagged out "A" charging pump. Operator sent to tag out "A" breaker but racked out "B" charging pump breaker. An interlock also tripped off the "C" pump. (Recovered easily)	Breaker	COMMON CAUSE EVENT
461	3608	11/21/90	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 21-NOV-90	Oconee 1,2,3: This is about the HPI line break issue.	Piping Failure	Included in new model
337	68	12/10/90	NRC INFORMATION NOTICE NO. 88-23, SUPPLEMENT 3: POTENTIAL F	August 20,1990, Sequoyah Unit 2, "B" charging pump secured when fluctuations observed in pump motor amperage and rate of flow. Hydrogen gas bubble vented from pump suction piping and on RHR cross-over line. Bubble identified on Unit 2 on Sept 6, 1990.	Gas Binding	Same as above.
482	4444	1/11/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 11-JAN-91	Salem 2 - 1/10/91 - SERVICE WATER SYSTEM THROUGH WALL LEAK ON SUPPLY PIPE TO CHARGING PUMP	Service Water	N/A
485	4471	2/19/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 19-FEB-91	SEQUOYAH 1 - -2/18/91 - Charging Pump Impeller failed. Potentially due to impingement of boric acid crystals from the boric acid line.	Pump Failure	
469	3881	3/24/91	INOPERABLE CENTRIFUGAL CHARGING PUMP	Sequoyah - Charging pump shaft failure due to high cycle fatigue. A gas slug is also suspected to have contributed to pump failure.	Pump Failure	(Gas Slug was also a contributor)
490	4500	3/29/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 29-MAR-91	Comanche Peak 1 - 3/28/91 - ULTRASONIC TESTING INDICATES THE PRESENCE OF GAS BUBBLES IN THE SUCTION PIPING OF THE CENTRIFUGAL CHARGING	Gas Binding	

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470	3931	4/15/91	INSUFFICIENT AUXILIARY PRESSURIZER SPRAY	CALVERT CLIFFS UNIT 1 & 2 - March 26, 1991 - checkvalve pressure setpoint problem prevented use of charging pumps from providing pressurizer auxiliary spray.	Design	Not an actual failure event.
494	4541	5/29/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 28-MAY-91	NORTH ANNA - 5/24/91 - Welding on a section of out of service charging pump suction line caused an explosion inside the pipe. Hydrogenated water leaking into the line caused hydrogen to come out of solution and build up to explosive levels.	Fire	Not applicable to plant operation.
495	4545	6/3/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT 06-JUN-91	CRYSTAL RIVER - 5/31/91 - Isolated HPI crossover valve left only 2 of 4 HPI nozzles available when a minimum of 3 of 4 are required by some safety analyses.	Valve Alignments	
474	4048	6/18/91	GAS BINDING IN THE NO. 11 CHARGING PUMP	CALVERT CLIFFS UNIT 1 - January 1991 - Gas binding of charging pump. Gas coming out of solution.	Gas Binding	
465	3694	7/31/91	Recurring Significant Event Notification: 91-02 A	North Anna 1 - May 24, 1991 - Hydrogen Fire on charging pump suction pressure instrument.	Fire	
497	4594	8/9/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 09-AUG-91	AN ONOFRE UNIT 1 - 8/8/91 - 1 of 2 VCT Level Instruments failed.	Gas Binding	
498	4603	8/23/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 23-AUG-91	Surry 1 & 2 - 8/22/91 - EXISTING BREAKER INTERLOCKS WOULD PREVENT AN AUTOSTART OF THE "A" HIGH HEAD SAFETY INJECTION PUMP ON A LOSS OF OFFSITE POWER (Design Problem)	Design	Not Applicable because additional "single failures" were postulated.
476	4202	9/3/91	Simulator Scenario Identifies Design Basis Concern	D. C. Cook Units 1 & 2 - Scenario identified where charging pumps and VCT provide a potential path for loss of primary coolant into CVCS holdup tanks (I.e., containment bypass)	Design	Containment Bypass Concern
500	4609	9/3/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 3-SEP	SEQUOYAH 1 & 2 - 8/30/91 - Scenario found where during HPR that would cause a relief valve in the charging system to lift. (containment bypass)	Design	Containment Bypass Concern
501	4612	9/6/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 06-SEPT-91	Salem 1 - Room Coolers Unavailable due to service water system leak repair - affected operability but not availability of certain ECCS pumps (including charging pumps)	Service Water	N/A
505	4624	9/20/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 20-SEPT-91	Oconee 1,2,3 - 9/19/91 - HPI system operating curve for LDST pressure vs. level was determined to be incorrect. Certain post accident alignments and failure could have resulted in a loss of tank level and subsequent failure of the HPI system.	Gas Binding	
504		9/20/91	Oconee Reactor Log	Oconee Unit 1 - "1B" HPI Pump motor had increasing upper bearing temperatures such that the Motor had to be shut down. Thrust shoes found worn due to normal wear. Replaced Motor. (RF Mode)	Pump Failure	

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506	4635	10/7/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 07-OCT-91	DIABLO CANYON - 1/4/91 - Charging System valve leak found. During sump recirc phase, this specific leak would have introduced radioactivity into control room and exceeded habitability requirements.	Valve Failure	Control Room Habitability - Don't think CR Habitability is a problem for Oconee in this instance.
507	4639	10/11/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 11-OCT-91	ARKANSAS NUCLEAR Unit 1 - HPI Pump Lube Oil System - Not Applicable	Pump Failure	N/A
466	3712	11/7/91	Recurring Significant Event Notification: 91-03 J	Calvert Cliffs 1 - January 31, 1991 - Gas Binding of PDP charging pumps	Gas Binding	
509	4669	11/25/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 25-NOV-91	Wolf Creek - 11/22/91 - Unable to declutch several MOVs in order to manually open. Related to loss of control room procedure.	Valve Failure	N/A
510	4677	12/9/91	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 09-DEC-91	Crystal River Event 12/8/91 is not applicable. Wolf Creek - 12/8/91 - Insufficient thrust to close RWST supply line valve to CCP in DBA.	Design	
480	4411	12/23/91	2A Charging Pump Found Sheared	Zion 2 - 10/11/91 - Centrifical Charging Pump Speed Changer bearing failure occurred due to improper lubricant and insufficient preventive maintenance program.	Pump Failure	
516	4899	1/15/92	UNIT 2 PLANT TRIP - - PS 2478 UPDATE	CALVERT CLIFFS UNIT 2 - 1/2/92 - During a plant trip on FDW Heater steam leak, a charging pump tripped. Investigation determined that trip was due to faulty pump suction pressure switch which was unrelated to the plant transient.	Pump Failure	
530	5630	1/21/92	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 21-JAN-92	POINT BEACH 1 - Normal boration path failed due to boron solidification	Misc.	
518	4991	2/27/92	SHAFT FAILURE OF CENTRIFUGAL CHARGING PUMP	Callaway - 2/3/92 - CCP pump shaft sheared on the outboard end of the pump between the balance drum lock nut and balance drum mating area.	Pump Failure	
532	5656	2/27/92	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 27-FEB-92	Oconee - 2/26/92 - LTOP protection system - HPI components not de-energized as required.	LTOP	N/A
520	5097	4/22/92	POTENTIAL PATHWAY FOR POST-LOCA PRIMARY WATER LEAKAGE	DIABLO CANYON UNITS 1 AND 2 - Identified Post LOCA recirculation path which could potentially lift VCT relief valve. (Containment Bypass)	Design	Containment Bypass Concern
519	5093	4/22/92	"TORQUE SWITCH ROLL PIN FAILURE FOUND DURING VOTES DIAGNOSTI	Maine Yankee - March 1992 - Volume Control Tank outlet valve to charging pump suction failed	Valve Failure	
536	5704	4/30/92	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 30-APR-92	CRYSTAL RIVER - 4/29/92 - Potential to overload EDG by loading two HPI pumps to 1 EDG.	Design	N/A
523	5167	5/21/92	Broken "Puffer Tube" Prevents Charging Pump Auto Start	D. C. Cook Unit 2 - 3/1/92 - 4 kV breaker failed to close to start charging pump	Breaker	

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524	5273	7/2/92	INCORRECT LUBE OIL CAUSES VISCOSITY STABILITY PROBLEM.	Trojan - 6/19/92 - INCORRECT GEARBOX OIL USED IN CENTRIFICAL CHARGING PUMP (CCP) SPEED INCREASER - NO FAILURE EXPERIENCED	Pump Failure	Not an actual failure event.
538	5781	8/19/92	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 19-AUG-92	TROJAN 8/18/92 - CCP excessive leakage	Pump Leakage	Control Room Habitability - Don't think CR Habitability is a problem for Oconee in this instance.
541	5799	9/14/92	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 14-SEP-92	CRYSTAL RIVER - 9/14/92 - Valves not able to close under certain DBA conditions	Design	N/A
526	5448	9/28/92	REPLACEMENT VALVE PART RESULTS IN LOW FLOW IN HIGH PRESSURE	Arkansas Nuclear One - Unit 2 - Incorrect disk assemblies installed in five of eight high pressure injection valves, three on one safety train and two on another train. Both trains failed to provide flow capacity assumed in safety analyses.	Valve Failure	COMMON CAUSE EVENT
546	5856	12/9/92	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 09-DEC-92	MILLSTONE 3 - 12/9/92 - Low outside temperatures and room heating problems caused a portion of charging system and boration system to be declared inoperable. (HVAC)	Misc.	
338	69	12/18/92	NRC INFORMATION NOTICE 88-23, SUPPLEMENT 4: POTENTIAL FOR G	Surry Unit 2, July 1992, observed pressure spikes in LHSI piping. Discovered large gas voids in LPSI cold leg discharge piping and piggyback line to HPSI. Gas believed to have come from small leakage in RCS checkvalves in LPSI cold leg injection line.	Gas Binding	Same as above except this is a different source of gas than the other events.
547	5866	12/23/92	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 23-DEC-92	Diablo Canyon - 12/22/92 - VALVES SUSCEPTIBLE TO SEISMICALLY INDUCED VIBRATION (DE-CLUTCHING ISSUE). (included charging pump suction valves to the RWST)	Seismic	N/A
557	6107	1/5/93	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 05-JAN-93	Zion 1 - 1/4/93 - WITH THE 1B SAFETY INJECTION PUMP OUT OF SERVICE FOR REPAIRS THE 1A CHARGING PUMP WAS DECLARED INOPERABLE DUE TO VIBRATION READINGS OUTSIDE THE ACCEPTABLE RANGE	Pump Failure	
561	6162	3/24/93	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 24-MAR-93	McGuire 2 - 3/22/93 AN IMPULSE LINE FOR THE CHARGING SYSTEM PRESSURE TRANSMITTER RUPTURED, RESULTING IN A LOSS OF INVENTORY(APPROX 600 GALS)	Piping Failure	
563	6198	5/13/93	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 13-MAY-93	Robinson - 5/12/93 - RCS LEAK - LEAK WAS A RELIEF VALVE ON THE SUCTION OF THE SHUTDOWN CHARGING PUMP ("A") WHICH OPENED AT 10 PSIG INSTEAD OF ITS SETPOINT OF 75 PSIG	Relief Valve	
554	6063	5/27/93	SER 12-93, Dual-Unit Scram During Switchyard Circuit	Sequoyah 1 and 2 - 12/31/92 - Loss of charging pump suction following a LOOP event.	Valve Failure	
566	6237	7/8/93	HIGHLIGHTS OF NRC DAILY PLANT STATUS REPORT: 08-JUL-93	Crystal River - 7/7/93 - BWST OUTLET VALVES ON HPI SYSTEM UNABLE TO OPEN DUE TO REDUCED VOLTAGE DURING DBA EVENT.	Design	N/A

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568	6277	8/31/93	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 31-AUG-93	Zion 1 - 8/30/93 - CCP BACKUP SUCTION SOURCE (CONTAINMENT SUMP) ISOLATION VALVE DISCOVERED TO BE OUT OF SERVICE IN EXCESS OF ADMINISTRATIVE 7 DAY LCO. (It was left closed following maintenance)	Human	
579	6585	1/10/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 10-JAN-94	Sequoyah 2 - 1/7/94 - BROKEN SHAFT ON THE 2B-B CENTRIFUGAL PUMP	Pump Failure	
665	10953	1/15/94	OE-6443 Inadvertent Repositioning of a Motor Operated Val	1/15/94 - Increased seal injection flow was identified - CCP discharge bypass valve (CV-MOV-8348) was open in violation of Technical Specification	Valve Alignments	
582	6600	1/31/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 31-JAN-94	DIABLO CANYON - 1/24/94 - Charging configuration used that may not provide seal injection under some accident conditions.	Design	N/A
584	6616	2/24/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 24-FEB-94	Zion 1 - 2/23/94 - HHSI pump did not meet flow criteria. Throttle valves adjusted to increase flow. Unknown cause for low flow.	Misc.	Potential Failure - (Latent Human Error?)
585	6630	3/16/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 16-MARCH 9	Haddam Neck - 3/15/94 - POTENTIAL FOR CHARGING HEADER PRESSURE TO EXCEED THE SETPOINT OF THE METERING PUMP (PD CHARGING PUMP) DISCHARGE RELIEF VALVE DURING POST-LOCA SUMP RECIRC (Combination of SI & charging pump & containment pressure)	Design	Containment Bypass Concern
586	6638	3/28/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 28-MARCH 9	Zion 1 - 3/26/94 - FAILURE OF TWO CHARGING PUMP SUCTION VALVES FROM THE RWST. Auto-close function disabled. CR manual switch still operable (2 wires were lifted for VOTES test but were not replaced)	Valve Failure	
588	6667	5/4/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 04-MAY-94	PALO VERDE UNIT 2 - 3/12/94 - Recirc line to RWST found open - ~28000gal of reactor coolant dirverted to RWST.	Valve Alignments	
602	7000	5/27/94	NRC Information Notice 94-29	During Palo Verde SGTR event 3/14/93, charging pump tripped due to inadequate suction pressure because too many pumps were aligned to a single suction path (3" line). (3 charging and a boron recycle pump were drawing suction through same line)	Pump Failure	
590	6688	6/2/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 02-JUN-94	North Anna 2 - 6/1/94 - REACTOR COOLANT PUMP SEAL INJECTION LINE PRESSURE BOUNDARY LEAKAGE GREATER THAN TS ALLOWED. (report didn't say what component failed other than pressure boundary)	Piping Failure	

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0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
591	6705	6/27/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 27-JUN-94	South Texas 2 - 6/25/94 - Not Applicable Diablo Canyon - 6/24/94 - INADEQUATE COOLING WATER FLOW TO CCP LUBE OIL COOLERS DURING ACCIDENT CONDITIONS (Throttled position OK for Normal Oper.)	Valve Alignments	
592	6718	7/15/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 15-JUL-94	ZION 1 - Appendix R issue on CCP power cables.	Fire	N/A
593	6726	7/27/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 27-JUL-94	Millstone 3 - 7/26/94 - TRAIN B CHARGING PUMP COOLING PUMP OIL LEVEL WAS LOW WHILE TRAIN A PUMP WAS OOS FOR SURVEILLANCE TEST. (Pump did not experience an actual failure.)	Pump Failure	
604	7039	9/8/94	NRC Information Notice 94-63	North Anna Unit 1 - Severe corrosion damage of the carbon steel casing of a high head safety injection pump. Boric acid penetrated stainless steel inner cladding and attacked pump casing.	Pump Failure	
595	6757	9/8/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 08-SEPT-94	Prairie Island 1 - 9/6/94 - CVCS LETDOWN ISOLATION VALVE CLOSED ON A BREAKER INTERLOCK WHEN THE OPERATING CHARGING PUMP TRIPPED ON MOTOR OVERLOAD	Pump Failure	
672	11397	9/14/94	OE-7056 OE AT INDIAN POINT #2-#23 CHARGING PUMP TRIPPED	#23 Charging pump tripped on low oil pressure. Inspection found broken copper oil line inside the pump. #22 charging pump was immediately started but tripped. However, operators were able to restart #22 pump without further problems.	Pump Failure	
596	6767	9/22/94	HIGHLIGHTS OF THE NRC DAILY PLANT STATUS REPORT: 22-SEPT-94	Salem 2 - 9/22/94 -HIGH VIBRATION WAS DETECTED IN THE SPEED INCREASER FOR THE #21 CENTRIFUGAL CHARGING PUMP	Pump Failure	
606	7055	11/2/94	NRC Information Notice 94-76	Discussion of pump shaft failures at Sequoyah 1&2, Callaway, Shearon Harris, DC Cook 2, and Braidwood 1. Seem to all be Westinghouse pumps manufactured by Pacific Pump (now Ingersoll-Dresser Pump Co.)	Pump Failure	2 duplicates - 4 new events - Harris (3/28/93), Braidwood 1 (9/15/93), DC Cook 2 (7/93), Sequoyah 2 (2/7/94)
599	6852	12/5/94	PLANT EVENT - MAINE YANKEE: 05-DEC-94	MAINE YANKEE - 12/4/94 - Cooling Water Valves not aligned properly.	Service Water	N/A
608	7228	1/19/95	SEN 124, Recurring Events, October - December, 1994	Waterford 3 - 8/19/94 - Check valve in the boric acid pump discharge line malfunctioned and restricted the flow of boric acid to the VCT causing an undesired boron dilution and perturbations in Rx power. Also had a series of VCT low level conditions.	Checkvalve	Reactivity Control Issue

0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
679	11558	3/2/95	OE 7127 SEQUOYAH NUCLEAR PLANT-POTENTIAL POST-LBLOCA CCP/SIP	SEQUOYAH NUCLEAR PLANT - POTENTIAL POST-LBLOCA CCP/SIP RUNOUT DAMAGE DUE TO THROTTLE/BALANCE VALVE SEAT EROSION CAUSED BY HIGH DP	Pump Failure	
618	7789	5/2/95	PLANT EVENT - BEAVER VALLEY: 02-MAY-95	Beaver Valley - 5/1/95 - FORTY-GALLON OIL SPILL FROM THE CHARGING PUMP OIL COOLER DUE TO A TUBE LEAK	Pump Failure	
619	7973	6/21/95	PLANT EVENT - CRYSTAL RIVER: 21-JUNE-95	Crystal River - 6/20/95 - WHEN "A" HIGH PRESSURE INJECTION (HPI) PUMP IS ALIGNED TO ITS ALTERNATE COOLING WATER SOURCE ITS COOLING WATER FLOW RATE IS LESS THAN ITS DESIGN BASIS VALUE	Design	
620	7975	6/21/95	PNO - ROBINSON: 21-JUNE-95	THE "A" CHARGING PUMP RELIEF VALVE WAS LIFTING DIVERTING PRIMARY COOLANT	Relief Valve	
621	8080	7/25/95	PLANT EVENT - ROBINSON: 25-JUL-95	Robinson - 7/24/95 -THE DISCHARGE RELIEF VALVE FOR THE "C" CHARGING PUMP HAD BEEN LEAKING WHEN A LEAK DEVELOPED NEAR A FLANGE ASSOCIATED WITH THE DISCHARGE RELIEF VALVE FOR THE "A" CHARGING PUMP. (total = 15 gpm leak)	Relief Valve	
630	8516	11/17/95	PLANT EVENT - HADDAM NECK: 17-NOV-95	11/7/95, A MINOR LEAK (4 DROPS PER MINUTE) WAS DISCOVERED ON ONE OF THE TWO CHARGING PUMP DISCHARGE LINES	Piping Failure	N/A - Probably not a failure.
631	8546	11/28/95	PLANT EVENT - COOK: 28-NOV-95	CCP TRIPPED DURING TESTING AFTER 7 MINUTES OF OPERATION DUE TO AN OVERLOAD PROTECTION RELAY THAT WAS INADVERTENTLY SET TOO LOW.	Pump Failure	
613	7279	12/1/95	SEN 129, Significant Event Notification Recurring Events,	Kola Unit 2 (VVER-440) - March 3, 1994, during plant cooldown, a primary makeup line ruptured, spilling approximately 11,000 gallons of borated water into plant buildings	Piping Failure	
637	9002	1/11/96	PLANT EVENT - SALEM: 11-JAN-96	MOTOR OPERATED VALVES WHICH WOULD NOT BE CAPABLE OF FULFILLING THEIR SAFETY RELATED FUNCTION OF MOVING TO THE OPEN POSITION DUE TO PRESSURE LOCKING OR THERMAL BINDING. (INCLUDED HIGH HEAD CENTRIFUGAL CHARGING PUMP DISCHARGE VALVES)	Valve Failure	
636	8936	1/16/96	DISCS IN 3-INCH CHECK VALVES FOUND STUCK OPEN	Sequoyah 1 - 9/24/95 - inspection of 3-inch primary (inboard) check valve for normal charging injection into the RCS was found to be stuck open. The cause appeared to be improper manufacture of the disc assembly.	Checkvalve	
641	9239	2/2/96	PLANT EVENT - DIABLO CANYON 02-FEB-96	CLOSING OF CENTRIFUGAL CHARGING PUMP MINIMUM FLOW RECIRCULATION LINE DUR TESTING PLACES UNITS IN UNANALYZED CONDITION (could cause 100 gpm more flow in a SGTR than assumed in DBA analysis)	Design	N/A

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0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
644	9308	2/20/96	PLANT EVENT - CRYSTAL RIVER: 20-FEB-96	DETERMINED THAT THE POST ACCIDENT MONITORING INSTRUMENTATION DOES NOT MEET THE TECH SPEC REQUIREMENTS FOR HIGH PRESSURE INJECTION (HPI) SYSTEM FLOW	Misc.	N/A
646	9374	2/29/96	Charging Pump Miniflow Orifice Erosion & Pump Runout Potenti	Diable Canyon - The charging recirculation orifices were determined to be badly eroded, resulting in considerably higher recirculation flows than designed for and providing the potential for exceeding pump runout limits.	Pump Failure	Recirc/Min Flow
653	9709	4/3/96	SCRAM - CALLAWAY: 03-APRIL-96	Callaway 4/2/96 - Fdw Trip followed later with CCP suction swap to RWST. Discharge relief valve lifted on charging system (don't know why or if it was supposed to)	Relief Valve	
654	9817	4/17/96	Positive Displacement Pump Discharge Relief Valve Seat Leaka	Salem 1 - 5/13/95 - Leakage was detected through the seat of the pump discharge relief valve. cause was chatter-induced seat leakage.	Relief Valve	
656	10188	5/17/96	PLANT EVENT - INDIAN POINT: 17-MAY-96	INDIAN POINT #2 - (1) INSTRUMENT BUS MALFUNCTION RESULTED IN VCT OUTLET VALVE CLOSURE AND CHARGING PUMP REALIGNMENT FROM THE VCT TO THE RWST, then (2) A coolant makeup pump was running and had a higher disch press than RWST which caused a boron dilution.	Auto Swap	Reactivity Control Issue
663	10791	7/15/96	PLANT EVENT - SAINT LUCIE: 15-JULY-96	St. Lucie Unit 2 - 7/13/96 - REACTOR COOLANT SYSTEM (RCS) LEAKAGE GREATER THAN 10 GALLONS PER MINUTE (GPM) CAUSED BY A PACKING LEAK ON 2B CHARGING PUMP	Pump Failure	
668	11293	8/21/96	PLANT EVENT - OCONEE: 21-AUG-96	Oconee - 8/20/96 - LETDOWN STORAGE TANK (LDST) LEVEL INSTRUMENT CALIBRATION ERRORS COULD HAVE LED TO THE HIGH PRESSURE INJECTION (HPI) PUMP BECOMING HYDROGEN BOUND DURING AN ECCS ACTUATION.	Gas Binding	
674	11422	8/27/96	Loss of Charging Flow Due to Failure of Charging Pump Discha	Same event as OEP-10791. However, this report explains that most of the leak was not through the packing but instead through a stuck open check valve on the 2C charging train which allowed coolant to flow back to the VCT through the 2C pump recirc line.	Checkvalve	
675	11463	8/30/96	PLANT EVENT - OCONEE: 30-AUG-96	VALVE 1HP-153, A VELAN STOP CHECK VALVE IN A HIGH PRESSURE INJECTION ECCS INJECTION FLOW PATH, FAILED TO PASS THE REQUIRED FLOW RATE. After inspection, cleaning, and polishing, the checkvalve was retested and passed the require flow.	Checkvalve	

Operating Experience Review
High Pressure Injection and Charging Systems

0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
676	11474	9/3/96	PLANT EVENT - MILLSTONE: 03-SEPT-96	Millstone 3 - 8/30/96 - DURING SUMP RECIRCULATION PHASE, THE HIGH HEAD SAFETY INJECTION PUMPS AND CHARGING PUMPS COULD EXPERIENCE A RUNOUT CONDITION. (Throttling adjustments had never considered the additional pressure of the low head pumps in piggy-back)	Design	
681	11668	9/17/96	PLANT EVENT - MILLSTONE: 17-SEPT-96	Millstone 3 - 9/16/96 - CHARGING SYSTEM POTENTIALLY INOPERABLE DURING A LOSS OF INSTRUMENT AIR. Loss of air causes the cooling water valves to the pump to fail wide-open. At very the low service water temps, the lub oil would be overcooled.	Service Water	
503		9/18/96	PIP 2-O96-1777	Oconee Unit 2 - During normal operation (mode 1), the 2B HPI pump failed due to a breakdown in the stator ground wall insulation witch shorted out the motor windings and caused the pump breaker to trip on ground fault.	Pump Failure	
682	11725	9/23/96	PLANT EVENT - OCONEE: 23-SEPT-96	9/18/92, AT 0132, THE "B" HIGH PRESSURE INJECTION PUMP TRIPPED DUE TO AN ELECTRICAL SHORT IN THE PUMP MOTOR	Pump Failure	
683	11726	9/23/96	PLANT EVENT - OCONEE: 23-SEPT-96	SMALL LEAK IDENTIFIED ON VALVE 2HP-491 AT THE SOCKET WELD ON THE INLET SIDE OF THE VALVE. 2HP-491 IS A DRAIN VALVE ON A 1 INCH LINE THAT TAPS OFF OF THE 2A1 HIGH PRESSURE INJECTION LINE.	Piping Failure	
684	11769	9/27/96	Inadvertent Nitrogen Leak Into Reactor Coolant System Result	CONNECTICUT YANKEE - 9/1/96 - Nitrogen valve leaking into VCT causing gradual loss of VCT level and introduction of nitrogen into RCS through the charging pumps.	Gas Binding	
687	11827	10/4/96	PLANT EVENT - NORTH ANNA: 04-OCT-96	IDENTIFIED A SINGLE FAILURE IN THE CONTROL POWER SYSTEM THAT COULD CAUSE THE LOSS OF TWO CHARGING PUMPS	Design	N/A
694	12223	11/13/96	PLANT EVENT - THREE MILE ISLAND: 13-NOV-96	4kV breakers not seismically qualified	Seismic	N/A
697	12426	12/11/96	NRC INFORMATION NOTICE 96-65: UNDETECTED ACCUMULATION OF G	Referred NRC IN 94-36, Undetected Accumulation of Gas in RCS. Described where VCT temps were very low due to excessive cooling water flow to letdown cooler. This caused higher dissolved H2 gas concentrations which came out of solution in RCS.	Misc.	
278	3-O97-0092	1/6/97	MOV 3HP-27 Fails To Close On Demand	Oconee Unit 3 - Valve position indication continued to indicate open when Ops attempted to close MOV 3HP-27 from the CR. Problem was due to a sticking contact on the MCC start for 3HP-27. Aux contact was replaced.	Valve Failure	

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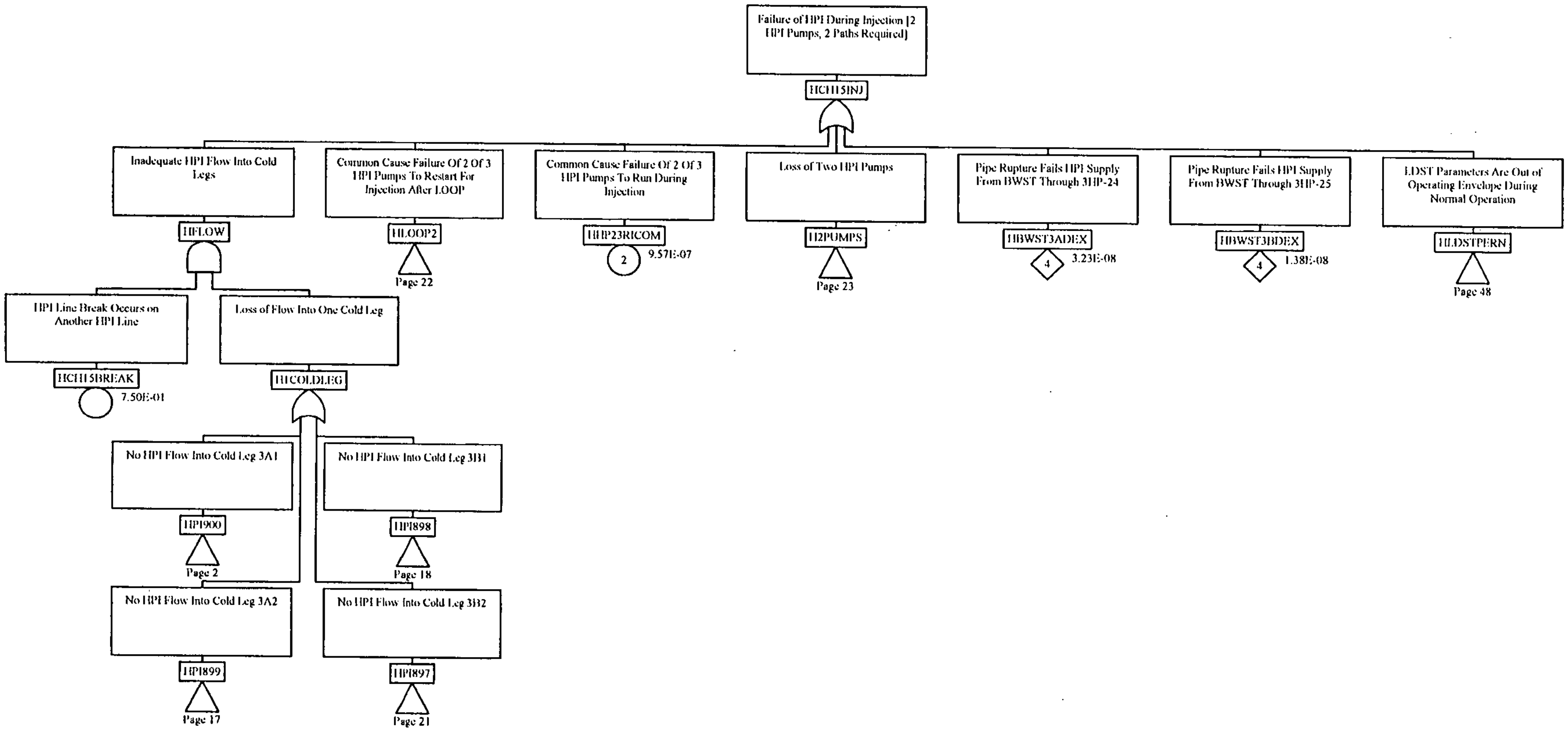
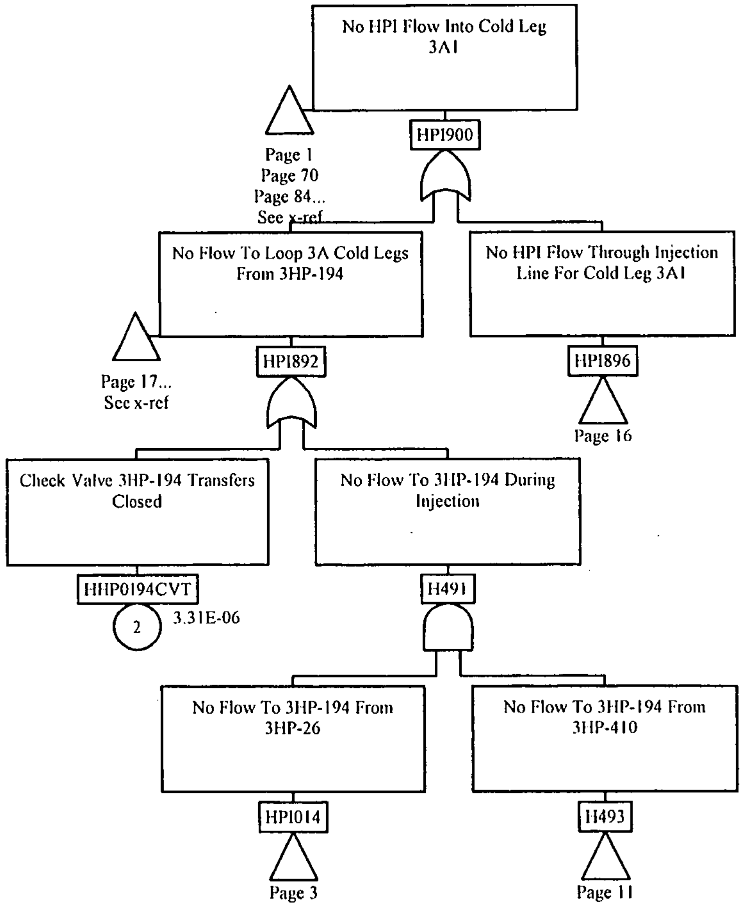
0	Item	Date	Item Summary	Description	Event Class	PRA Review Comments
702	12935	2/7/97	Centrifugal Charging Pump Speed Increaser Failure	Vogtle Unit 2 - 12/27/96 - Failure of the speed increaser for A train centrifugal charging pump caused by fatigue failure of a bearing on the high speed shaft and other damage caused by subsequent heating and misalignment in this bearing.	Pump Failure	
703	13104	2/25/97	PLANT EVENT - THREE MILE ISLAND: 25-FEB-97	SUCTION PIPING OF IDLE HIGH PRESSURE INJECTION (MAKEUP) PUMP MAY HAVE BEEN OVER PRESSURIZED DURING ESFAS TESTING.	Piping Failure	N/A
285	3-O-97-0726	2/26/97	Cause Analysis - While placing HPI in service per OP/3/A/110	Oconee 3 - Misposition of Valve 3HP-5 - The LDST level was observed to increase from approximately 83 inches to 100 inches and the Pressurizer level was observed to decrease from approximately 105 inches to 75 inches when 3HP-78 was opened.	Human	
713	14390	3/7/97	Network SEN 167	Zion Unit 2 - Gas accumulated in the RxV head requiring an inventory addition of 6900 gal to restore RxV level.	Misc.	
287	3-O-97-0857	3/8/97	Description - After being manually closed, 3HP-133 (RCP Seal	Oconee Unit 3 - After being manually closed, 3HP-133 (RCP Seal Filter 3B Outlet) opened without operator action.	Valve Failure	
707	13533	4/7/97	SAFETY INJECTION TANK TEST LINE REDUNDANT HIGH PRESSURE INJE	Palisades - Safety Injection Tank Test Line Redundant High Pressure Injection Isolation Valve failed to change position during post maintenance testing (AOV air supply)	Valve Failure	
709	13813	5/6/97	LOSS OF 3A AND 3B HIGH PRESSURE INJECTION PUMPS	Oconee - 3A and 3B HPI Pumps failed due to inadequate suction source of water from the Letdown Storage Tank. Tank level instrument common reference leg was empty and did not indicate low tank level.	Gas Binding	
712	14027	5/30/97	SEN 163, Recurring Event, High Pressure Injection Line Leak	Oconee Unit 2 - 4/21/97 - Reactor coolant system (RCS) leak (2.5 gpm) was discovered. Leak occurred on the stainless steel safe-end-to-pipe weld on the 2-1/2 inch high pressure injection (HPI) and makeup line to the RCS cold leg nozzle.	Piping Failure	
329		7/4/97	Oconee PIP - Bailey controller tripped PIP 3-O97-2049	Oconee Unit 3 - 3HP-120 Bailey controller tripped to manual, decreasing RC makeup flow and causing PZR level to decrease. 3HP-120 was placed in Auto and PZR level returned to normal.	Control Systems	

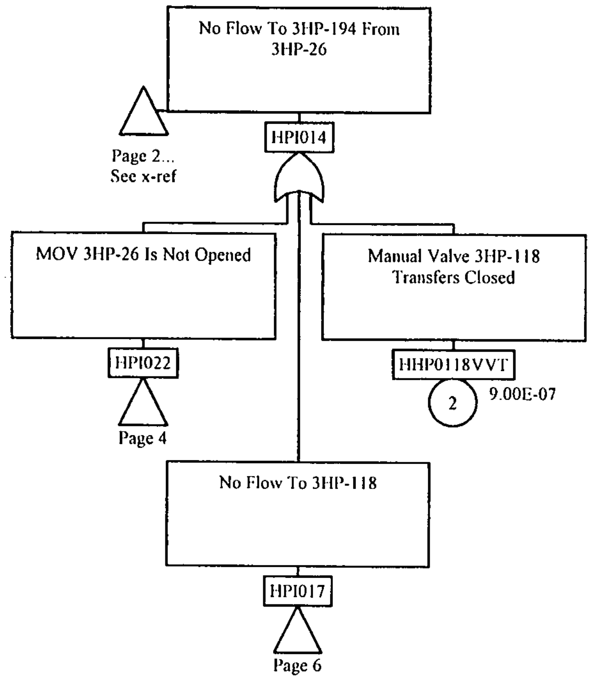
APPENDIX B1

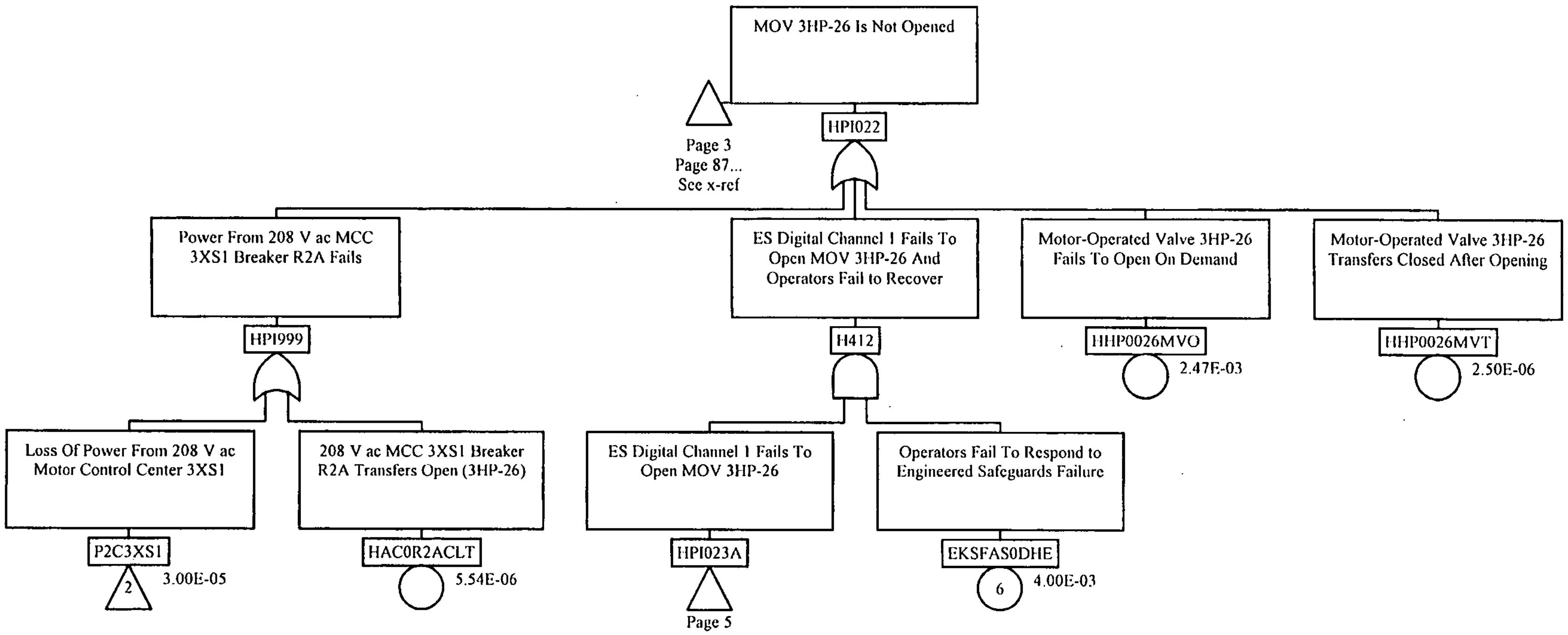
HPI SYSTEM
ACCIDENT MITIGATION FAULT TREE

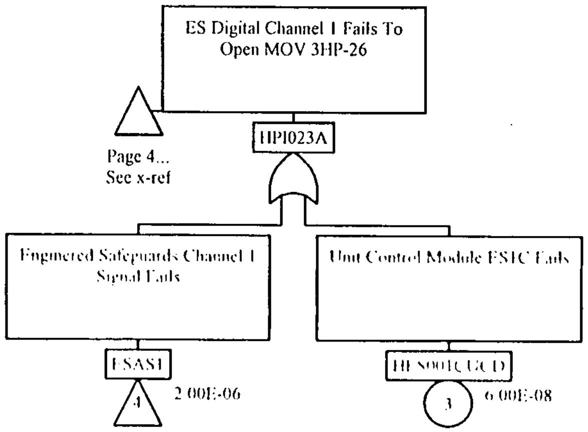


Failure of HPI During Injection [2 HPI Pumps, 2 Paths Required]
HCH15INJ
Inadequate HPI Flow Into Cold Legs
HFLOW
Common Cause Failure Of 2 Of 3 HPI Pumps To Restart For Injection After LOOP
HLOOP2
Page 22
Common Cause Failure Of 2 Of 3 HPI Pumps To Run During Injection
HHP23RICOM
2
9.57E-07
Loss of Two HPI Pumps
H2PUMPS
Page 23
Pipe Rupture Fails HPI Supply From BWST Through 3HP-24
HBWST3ADEX
4
3.23E-08
Pipe Rupture Fails HPI Supply From BWST Through 3HP-25
HBWST3BDEX
4
1.38E-08
LDST Parameters Are Out of Operating Envelope During Normal Operation
HLDSTPERN
Page 48
HPI Line Break Occurs on Another HPI Line
HCH15BREAK
7.50E-01
Loss of Flow Into One Cold Leg
HCOLDLEG
No HPI Flow Into Cold Leg 3A1
HPI900
Page 2
No HPI Flow Into Cold Leg 3B1
HPI898
Page 18
No HPI Flow Into Cold Leg 3A2
HPI899
Page 17
No HPI Flow Into Cold Leg 3B2
HPI897
Page 21

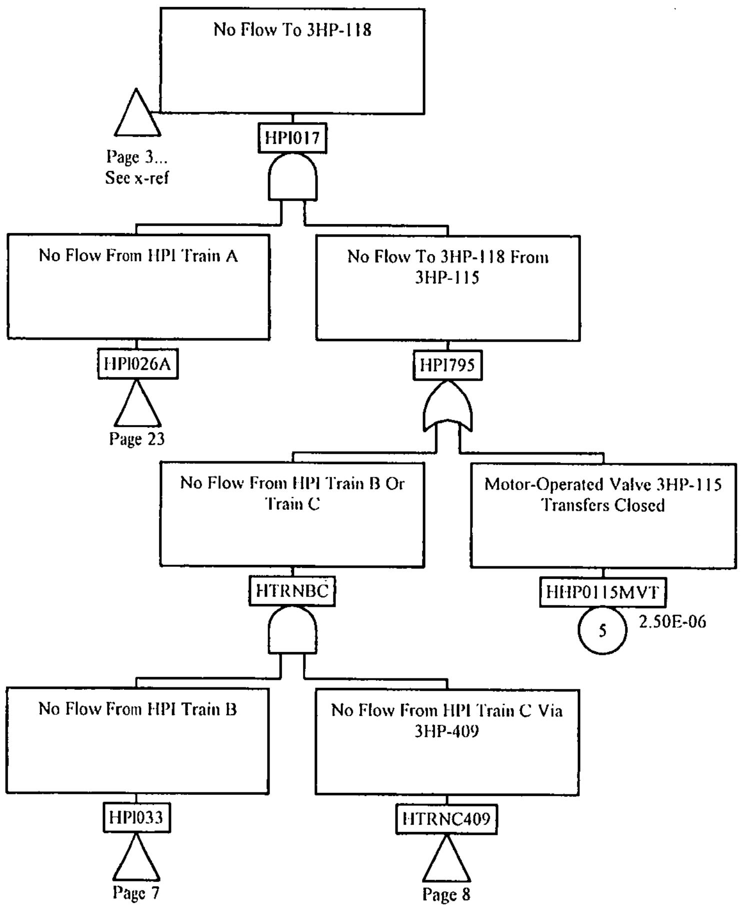

No HPI Flow Into Cold Leg 3A1
HPI900
Page 1
Page 70
Page 84...
See x-ref
No Flow To Loop 3A Cold Legs From 3HP-194
No HPI Flow Through Injection Line For Cold Leg 3A1
HPI892
HPI896
Page 17...
See x-ref
Page 16
Check Valve 3HP-194 Transfers Closed
No Flow To 3HP-194 During Injection
HHP0194CVT
H491
2
3.31E-06
No Flow To 3HP-194 From 3HP-26
No Flow To 3HP-194 From 3HP-410
HPI014
H493
Page 3
Page 11

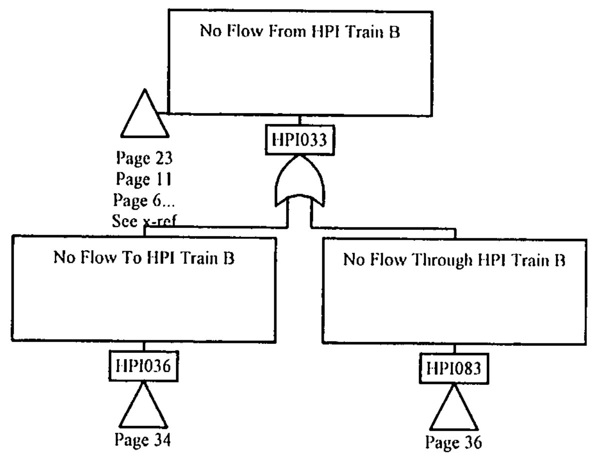

No Flow To 3HP-194 From 3HP-26
Page 2...
See x-ref
HPI014
MOV 3HP-26 Is Not Opened
HPI022
Page 4
Manual Valve 3HP-118 Transfers Closed
HHP0118VVT
2
9.00E-07
No Flow To 3HP-118
HPI017
Page 6


MOV 3HP-26 Is Not Opened
HPI022
Page 3
Page 87...
See x-ref
Power From 208 V ac MCC 3XS1 Breaker R2A Fails
HPI999
ES Digital Channel 1 Fails To Open MOV 3HP-26 And Operators Fail to Recover
H412
Motor-Operated Valve 3HP-26 Fails To Open On Demand
HHP0026MVO
2.47E-03
Motor-Operated Valve 3HP-26 Transfers Closed After Opening
HHP0026MVT
2.50E-06
Loss Of Power From 208 V ac Motor Control Center 3XS1
P2C3XS1
2
3.00E-05
208 V ac MCC 3XS1 Breaker R2A Transfers Open (3HP-26)
HAC0R2ACLT
5.54E-06
ES Digital Channel 1 Fails To Open MOV 3HP-26
HPI023A
Page 5
Operators Fail To Respond to Engineered Safeguards Failure
EKSFAS0DHE
6
4.00E-03

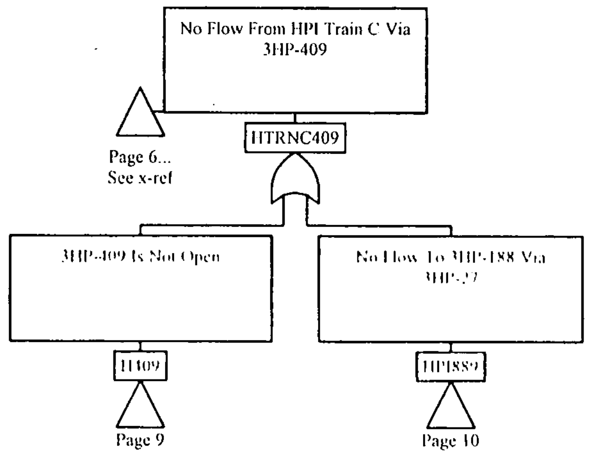


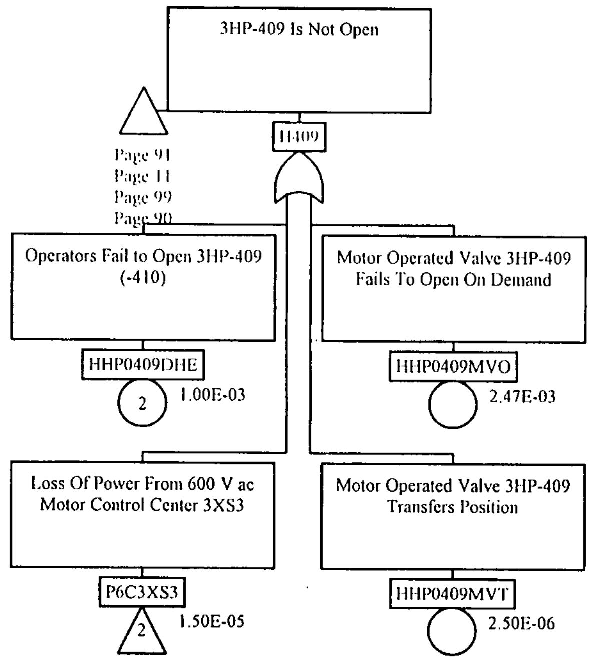
ES Digital Channel 1 Fails To Open MOV 3HP-26
HPI023A
Page 4...
See x-ref
Engineered Safeguards Channel 1 Signal Fails
Unit Control Module ESTC Fails
ESAS1
2.00E-06
4
3
6.00E-08

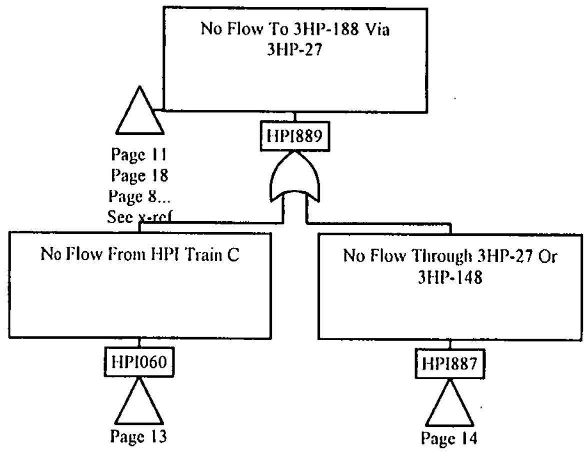

No Flow To 3HP-118
Page 3...
See x-ref
HPI017
No Flow From HPI Train A
HPI026A
Page 23
No Flow To 3HP-118 From 3HP-115
HPI795
No Flow From HPI Train B Or Train C
HTRNBC
Motor-Operated Valve 3HP-115 Transfers Closed
HHP0115MVT
5
2.50E-06
No Flow From HPI Train B
HPI033
Page 7
No Flow From HPI Train C Via 3HP-409
HTRNC409
Page 8

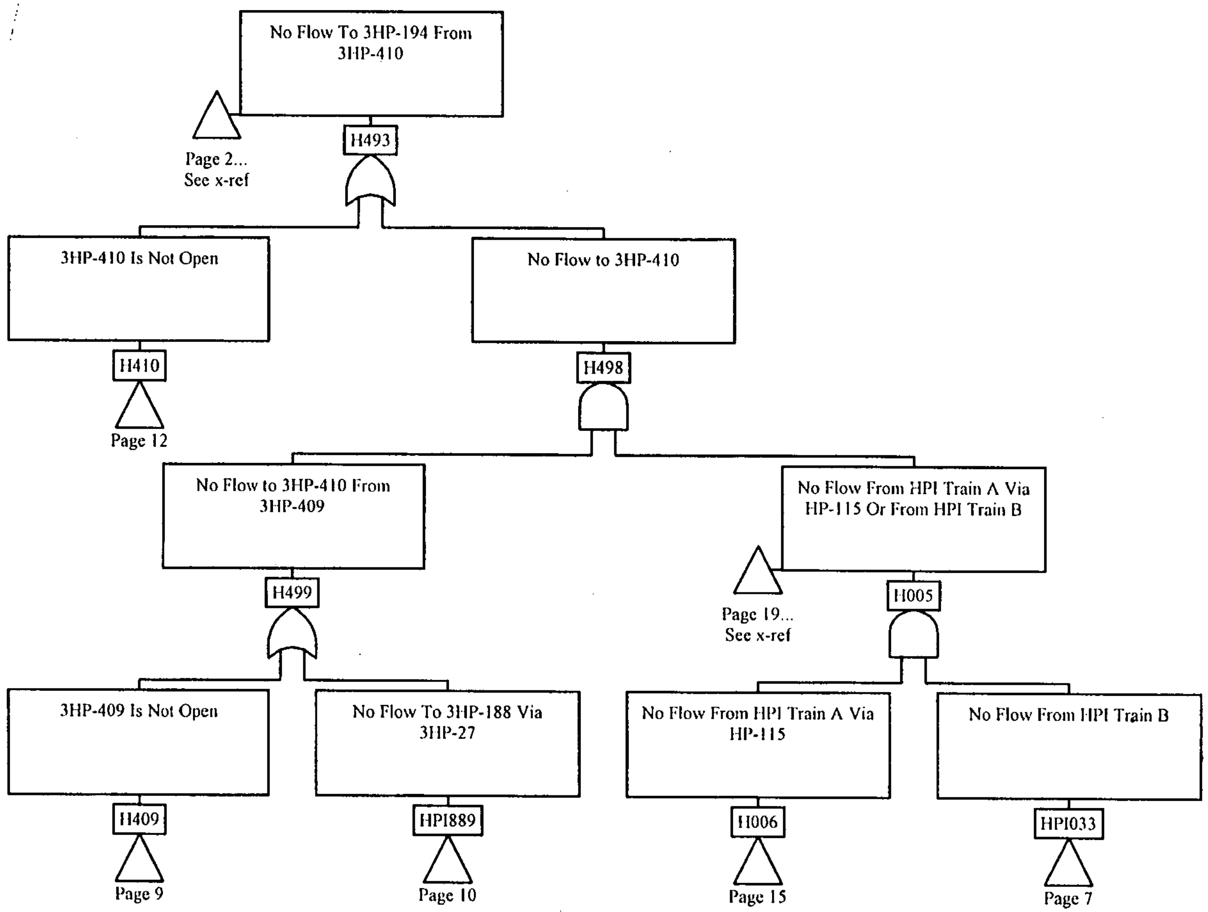


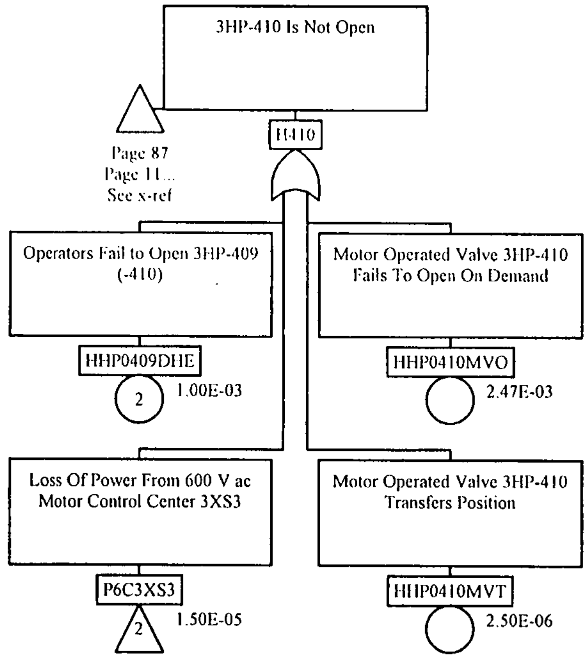
No Flow From HPI Train B
HPI033
Page 23
Page 11
Page 6...
See x-ref
No Flow To HPI Train B
No Flow Through HPI Train B
HPI036
HPI083
Page 34
Page 36

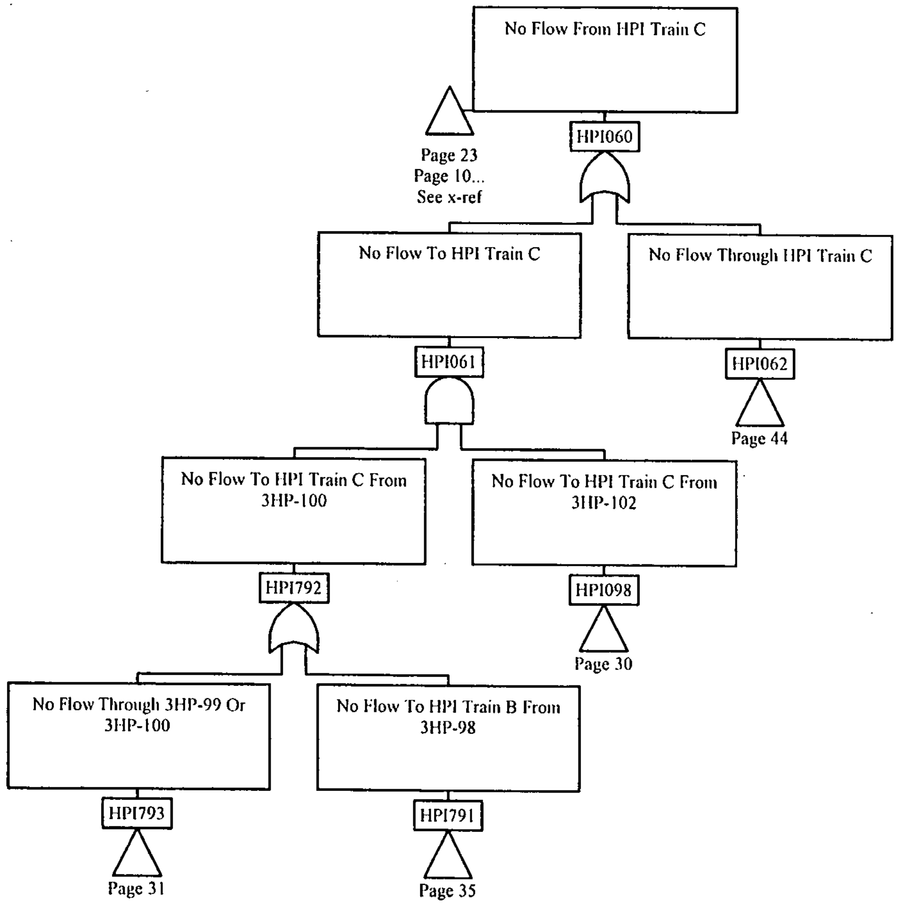

No Flow From HPI Train C Via 3HP-409
HTRNC409
Page 6...
See x-ref
3HP-409 Is Not Open
No Flow To 3HP-188 Via
Page 9
Page 10

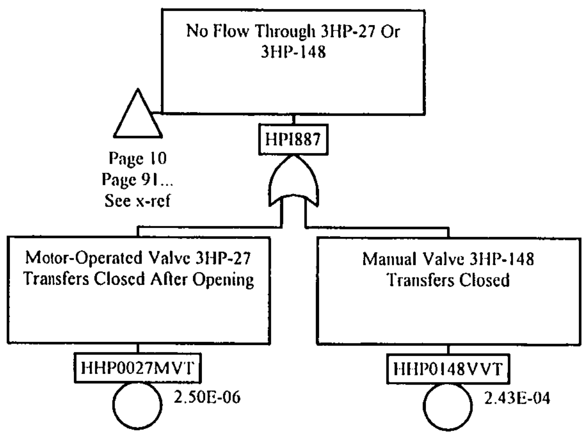

3HP-409 Is Not Open
H409
Page 91
Page 11
Page 99
Page 90
Operators Fail to Open 3HP-409 (-410)
HHP0409DHE
2
1.00E-03
Motor Operated Valve 3HP-409 Fails To Open On Demand
HHP0409MVO
2.47E-03
Loss Of Power From 600 V ac Motor Control Center 3XS3
P6C3XS3
2
1.50E-05
Motor Operated Valve 3HP-409 Transfers Position
HHP0409MVT
2.50E-06


No Flow To 3HP-188 Via 3HP-27
HPI889
Page 11
Page 18
Page 8...
See x-ref
No Flow From HPI Train C
HPI060
Page 13
No Flow Through 3HP-27 Or 3HP-148
HPI887
Page 14

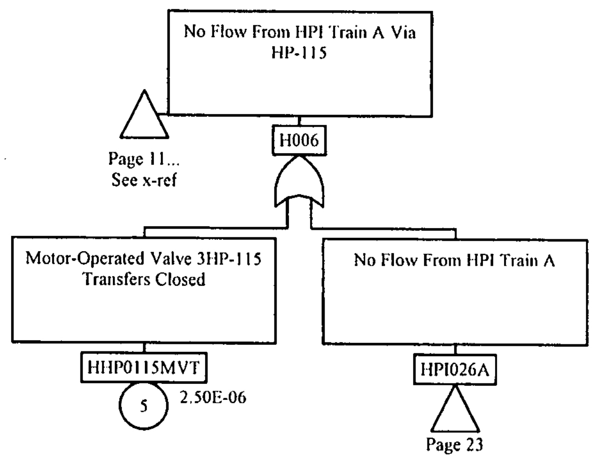

No Flow To 3HP-194 From 3HP-410
Page 2... See x-ref
H493
3HP-410 Is Not Open
No Flow to 3HP-410
H410
Page 12
H498
No Flow to 3HP-410 From 3HP-409
No Flow From HPI Train A Via HP-115 Or From HPI Train B
H499
Page 19... See x-ref
H005
3HP-409 Is Not Open
No Flow To 3HP-188 Via 3HP-27
No Flow From HPI Train A Via HP-115
No Flow From HPI Train B
H409
HPI889
H006
HPI033
Page 9
Page 10
Page 15
Page 7

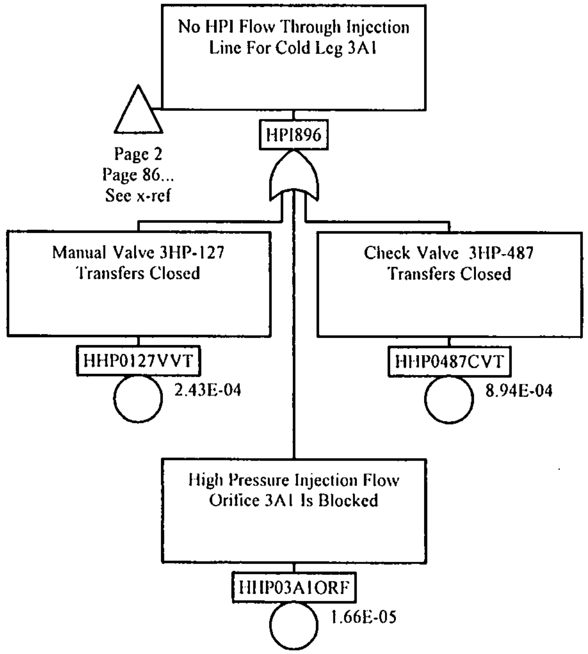

3HP-410 Is Not Open
H410
Page 87
Page 11...
See x-ref
Operators Fail to Open 3HP-409 (-410)
HHP0409DHE
2
1.00E-03
Motor Operated Valve 3HP-410 Fails To Open On Demand
HHP0410MVO
2.47E-03
Loss Of Power From 600 V ac Motor Control Center 3XS3
P6C3XS3
2
1.50E-05
Motor Operated Valve 3HP-410 Transfers Position
HHP0410MVT
2.50E-06


No Flow From HPI Train C
HPI060
Page 23
Page 10...
See x-ref
No Flow To HPI Train C
HPI061
No Flow Through HPI Train C
HPI062
Page 44
No Flow To HPI Train C From 3HP-100
HPI792
No Flow To HPI Train C From 3HP-102
HPI098
Page 30
No Flow Through 3HP-99 Or 3HP-100
HPI793
Page 31
No Flow To HPI Train B From 3HP-98
HPI791
Page 35

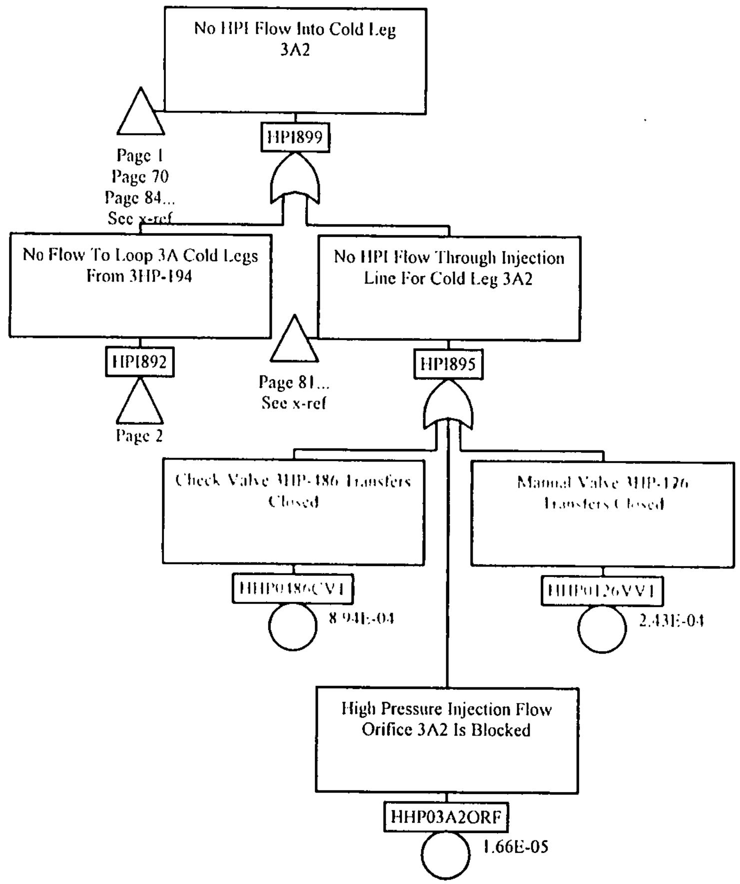


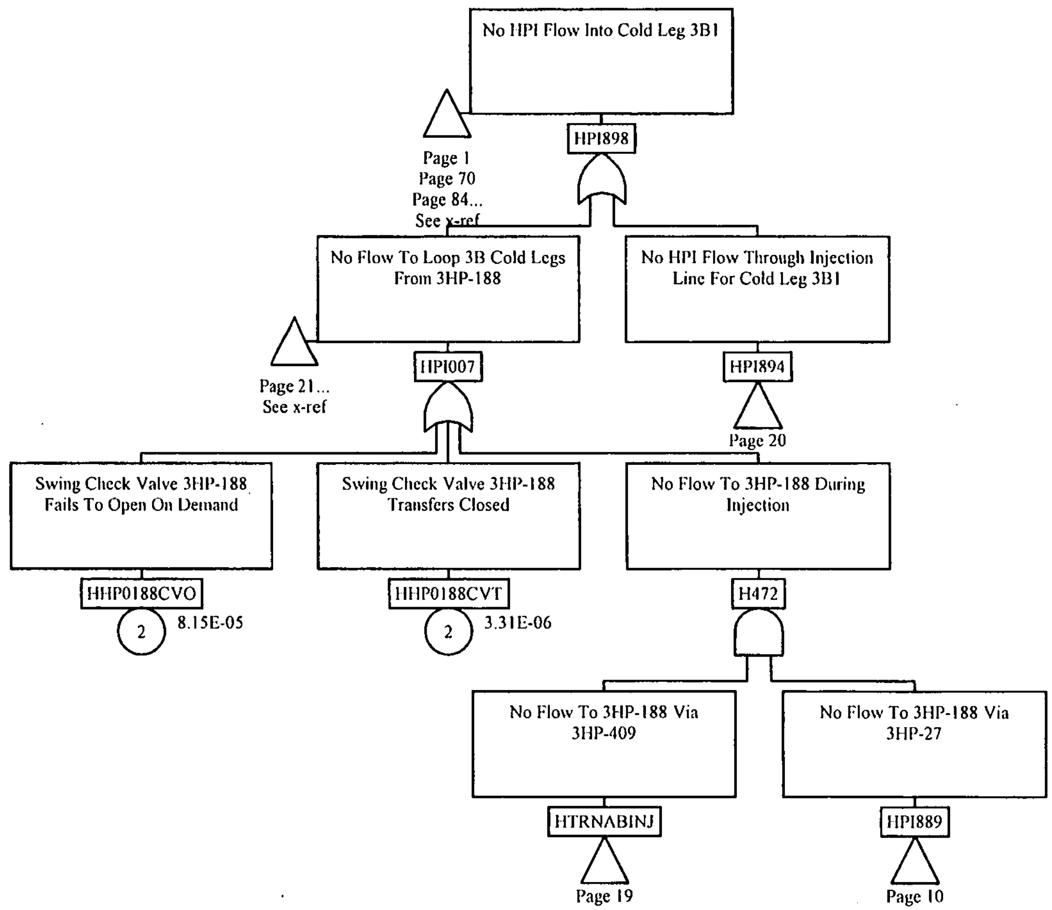
No Flow Through 3HP-27 Or 3HP-148
HPI887
Page 10
Page 91...
See x-ref
Motor-Operated Valve 3HP-27 Transfers Closed After Opening
Manual Valve 3HP-148 Transfers Closed
HHP0027MVT
2.50E-06
HHP0148VVT
2.43E-04

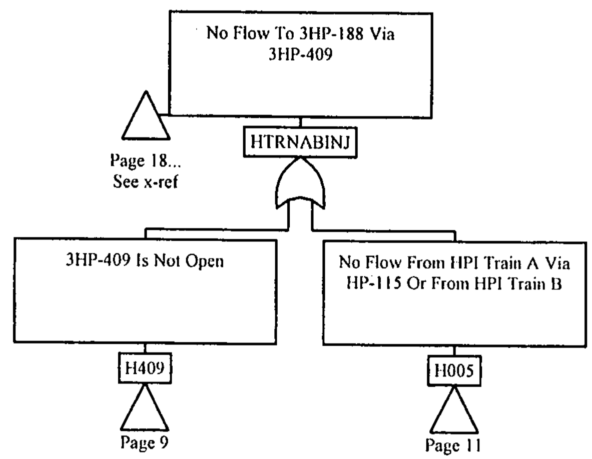

No Flow From HPI Train A Via HP-115
H006
Page 11...
See x-ref
Motor-Operated Valve 3HP-115 Transfers Closed
HHP0115MVT
5
2.50E-06
No Flow From HPI Train A
HPI026A
Page 23



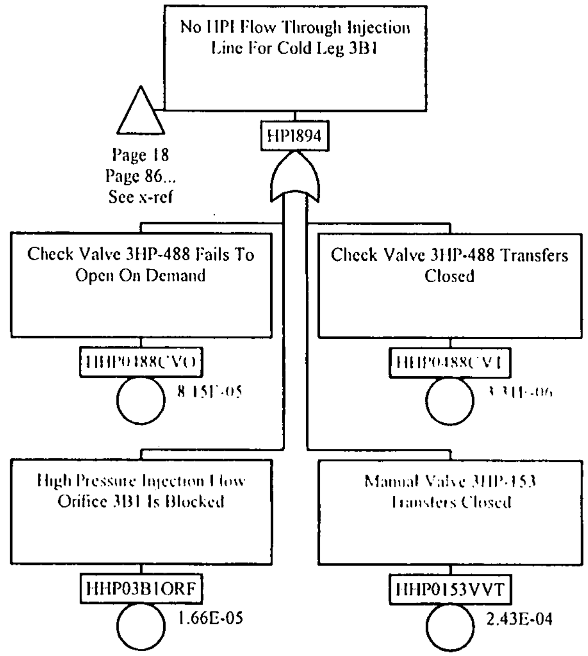
No HPI Flow Through Injection Line For Cold Leg 3A1
HPI896
Page 2
Page 86...
See x-ref
Manual Valve 3HP-127 Transfers Closed
HHP0127VVT
2.43E-04
Check Valve 3HP-487 Transfers Closed
HHP0487CVT
8.94E-04
High Pressure Injection Flow Orifice 3A1 Is Blocked
HHP03A1ORF
1.66E-05

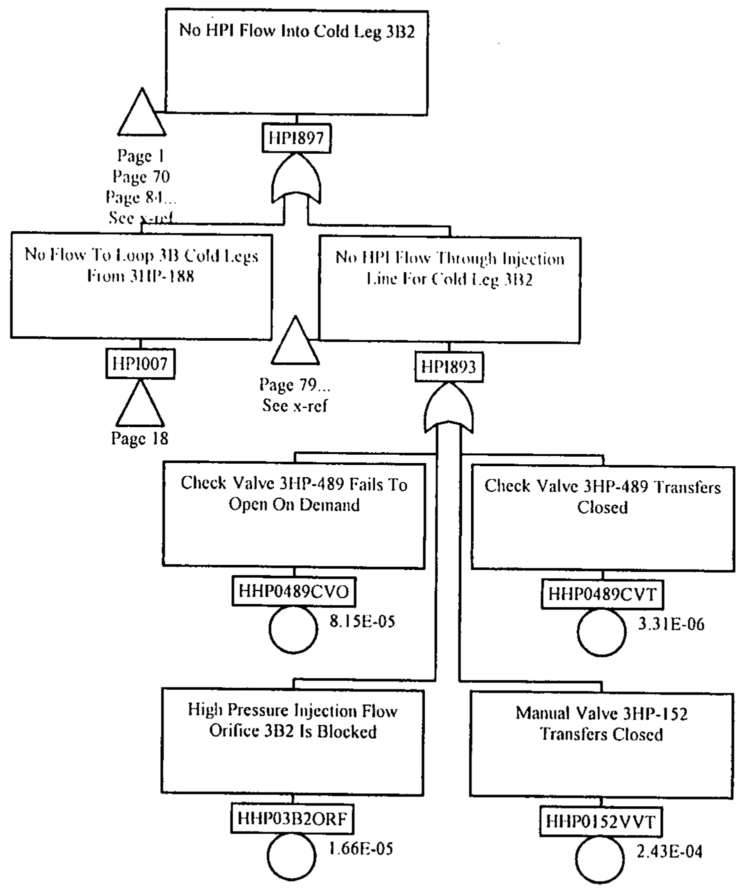

No HPI Flow Into Cold Leg 3A2
HPI899
Page 1
Page 70
Page 84...
See x-ref
No Flow To Loop 3A Cold Legs From 3HP-194
HPI892
Page 2
Page 81...
See x-ref
No HPI Flow Through Injection Line For Cold Leg 3A2
HPI895
Check Valve 3HP-186 Transfers Closed
HHP0186CV1
8.94E-04
Manual Valve 3HP-126 Transfers Closed
HHP0126VV1
2.43E-04
High Pressure Injection Flow Orifice 3A2 Is Blocked
HHP03A2ORF
1.66E-05

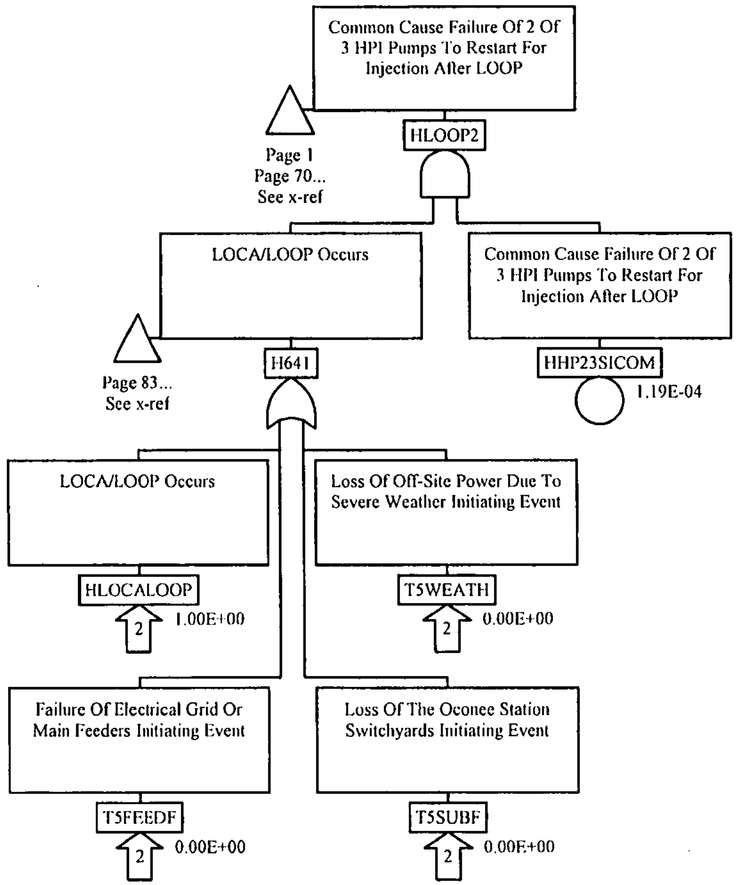

No HPI Flow Into Cold Leg 3B1
HPI898
Page 1
Page 70
Page 84...
See x-ref
No Flow To Loop 3B Cold Legs From 3HP-188
No HPI Flow Through Injection Line For Cold Leg 3B1
Page 21...
See x-ref
HPI007
HPI894
Page 20
Swing Check Valve 3HP-188 Fails To Open On Demand
Swing Check Valve 3HP-188 Transfers Closed
No Flow To 3HP-188 During Injection
HHP0188CVO
2
8.15E-05
HHP0188CVT
2
3.31E-06
H472
No Flow To 3HP-188 Via 3HP-409
No Flow To 3HP-188 Via 3HP-27
HTRNABINJ
Page 19
HPI889
Page 10



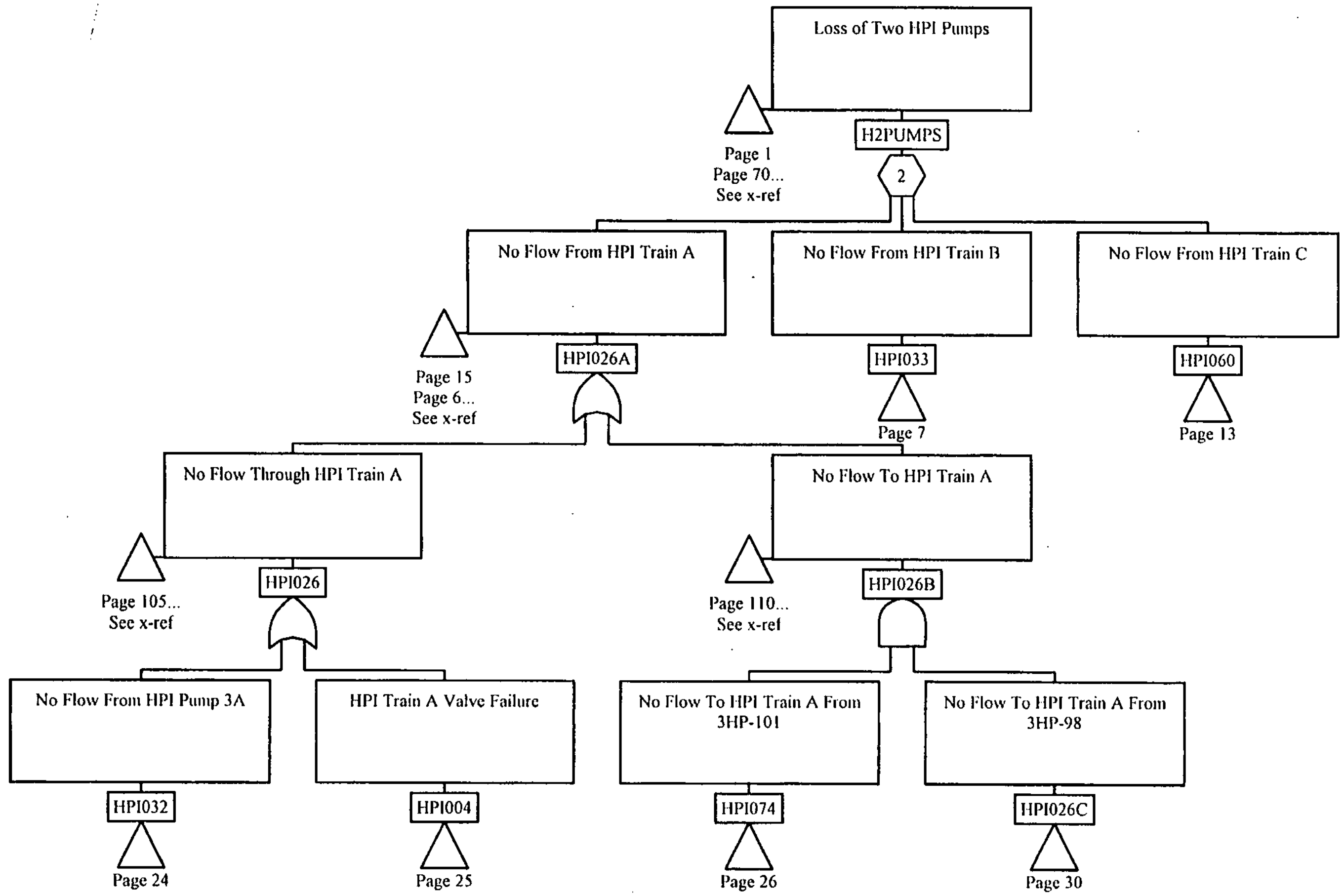
No Flow To 3HP-188 Via 3HP-409
HTRNABINJ
Page 18... See x-ref
3HP-409 Is Not Open
H409
Page 9
No Flow From HPI Train A Via HP-115 Or From HPI Train B
H005
Page 11

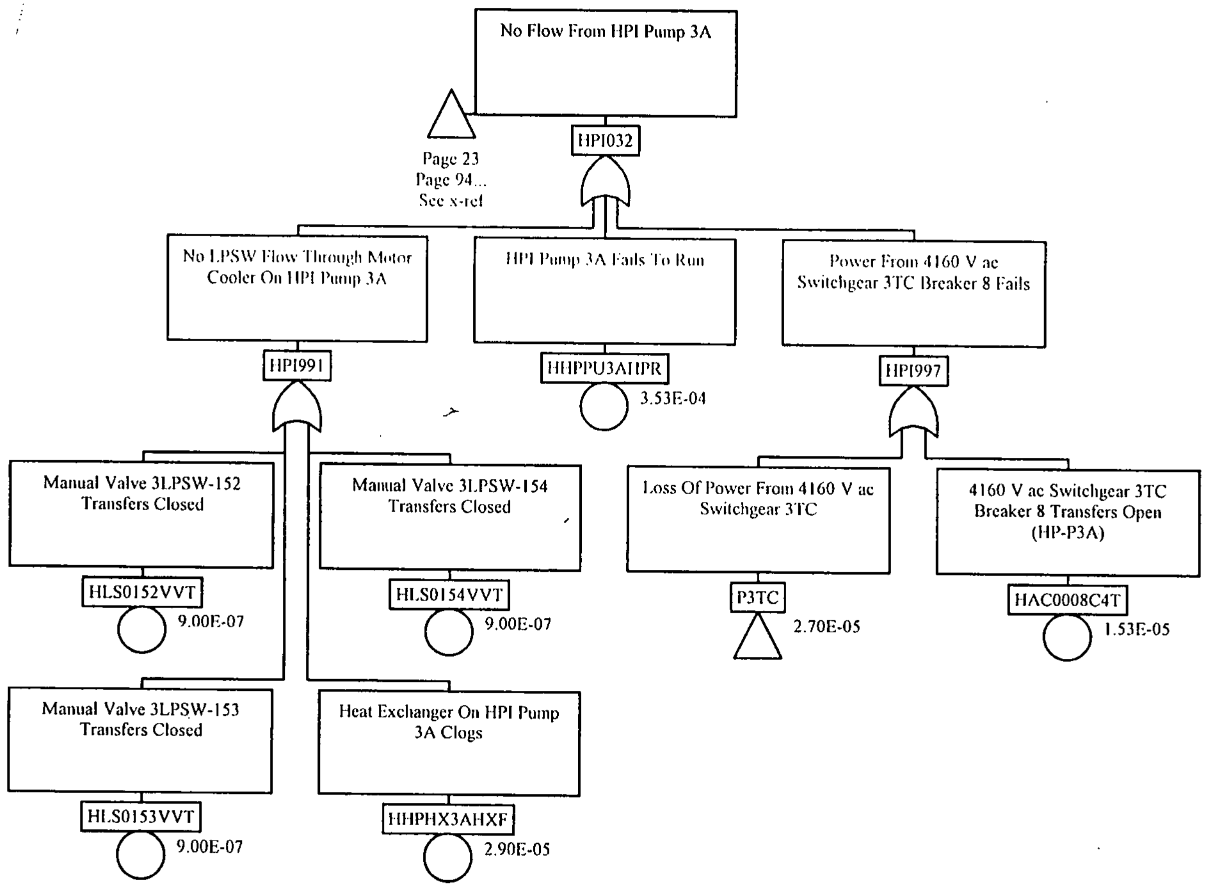

No HPI Flow Through Injection Line For Cold Leg 3B1
HPI894
Page 18
Page 86...
See x-ref
Check Valve 3HP-488 Fails To Open On Demand
HHP0488CVO
8.15E-05
Check Valve 3HP-488 Transfers Closed
HHP0488CVT
High Pressure Injection Flow Orifice 3B1 Is Blocked
HHP03B1ORF
1.66E-05
Manual Valve 3HP-153 Transfers Closed
HHP0153VVT
2.43E-04

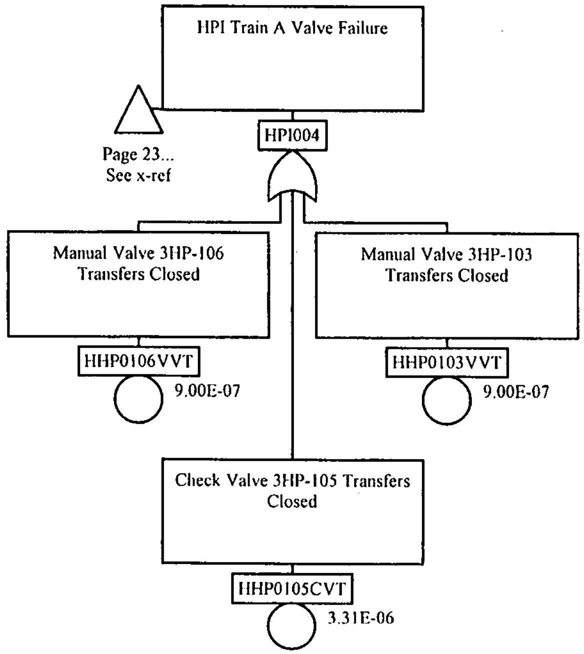

No HPI Flow Into Cold Leg 3B2
HPI897
Page 1
Page 70
Page 84...
See x-ref
No Flow To Loop 3B Cold Legs From 3HP-188
HPI007
Page 18
Page 79...
See x-ref
No HPI Flow Through Injection Line For Cold Leg 3B2
HPI893
Check Valve 3HP-489 Fails To Open On Demand
HHP0489CVO
8.15E-05
Check Valve 3HP-489 Transfers Closed
HHP0489CVT
3.31E-06
High Pressure Injection Flow Orifice 3B2 Is Blocked
HHP03B2ORF
1.66E-05
Manual Valve 3HP-152 Transfers Closed
HHP0152VVT
2.43E-04

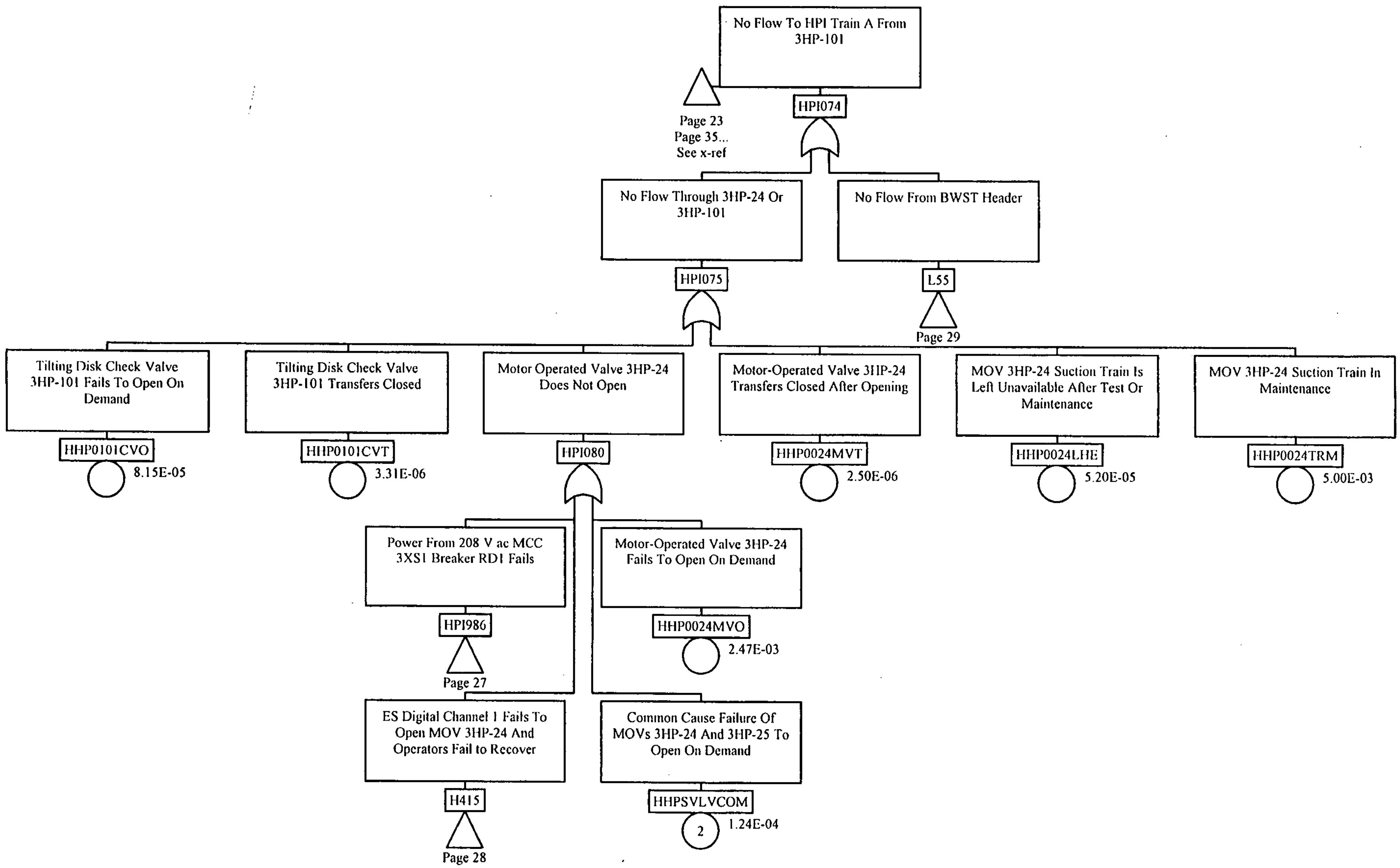


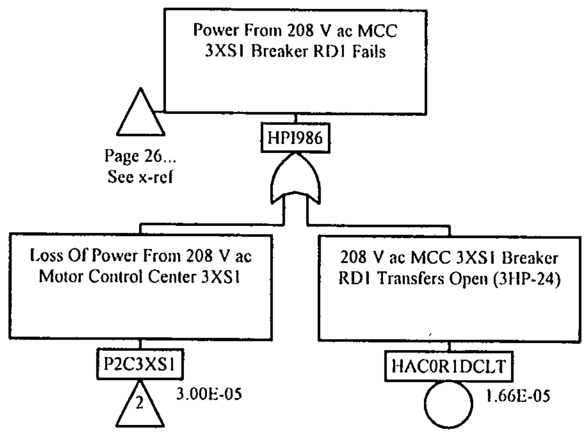
Common Cause Failure Of 2 Of 3 HPI Pumps To Restart For Injection After LOOP
HLOOP2
Page 1
Page 70...
See x-ref
LOCA/LOOP Occurs
H641
Page 83...
See x-ref
Common Cause Failure Of 2 Of 3 HPI Pumps To Restart For Injection After LOOP
HHP23SICOM
1.19E-04
LOCA/LOOP Occurs
HLOCALOOP
2
1.00E+00
Loss Of Off-Site Power Due To Severe Weather Initiating Event
T5WEATH
2
0.00E+00
Failure Of Electrical Grid Or Main Feeders Initiating Event
T5FEEDF
2
0.00E+00
Loss Of The Oconee Station Switchyards Initiating Event
T5SUBF
2
0.00E+00


Loss of Two HPI Pumps
H2PUMPS
Page 1
Page 70...
See x-ref
2
No Flow From HPI Train A
HPI026A
Page 15
Page 6...
See x-ref
No Flow From HPI Train B
HPI033
Page 7
No Flow From HPI Train C
HPI060
Page 13
No Flow Through HPI Train A
HPI026
Page 105...
See x-ref
No Flow To HPI Train A
HPI026B
Page 110...
See x-ref
No Flow From HPI Pump 3A
HPI032
Page 24
HPI Train A Valve Failure
HPI004
Page 25
No Flow To HPI Train A From 3HP-101
HPI074
Page 26
No Flow To HPI Train A From 3HP-98
HPI026C
Page 30

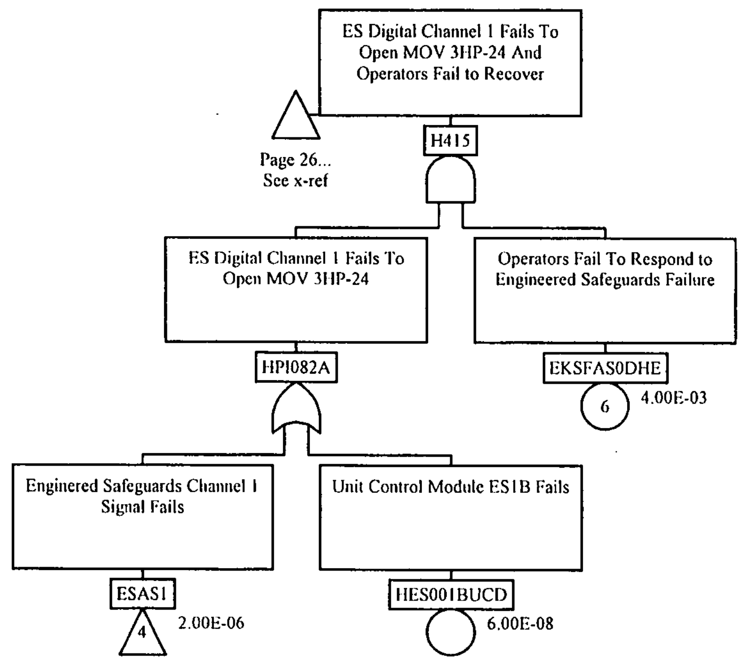

No Flow From HPI Pump 3A
HPI032
Page 23
Page 94...
See x-ref
No LPSW Flow Through Motor Cooler On HPI Pump 3A
HPI Pump 3A Fails To Run
Power From 4160 V ac Switchgear 3TC Breaker 8 Fails
HPI991
HHPPU3AHPR
3.53E-04
HPI997
Manual Valve 3LPSW-152 Transfers Closed
Manual Valve 3LPSW-154 Transfers Closed
Loss Of Power From 4160 V ac Switchgear 3TC
4160 V ac Switchgear 3TC Breaker 8 Transfers Open (HP-P3A)
HLS0152VVT
9.00E-07
HLS0154VVT
9.00E-07
P3TC
2.70E-05
HAC0008C4T
1.53E-05
Manual Valve 3LPSW-153 Transfers Closed
Heat Exchanger On HPI Pump 3A Clogs
HLS0153VVT
9.00E-07
HHPHX3AHXF
2.90E-05


HPI Train A Valve Failure
HPI004
Page 23...
See x-ref
Manual Valve 3HP-106 Transfers Closed
HHP0106VVT
9.00E-07
Manual Valve 3HP-103 Transfers Closed
HHP0103VVT
9.00E-07
Check Valve 3HP-105 Transfers Closed
HHP0105CVT
3.31E-06

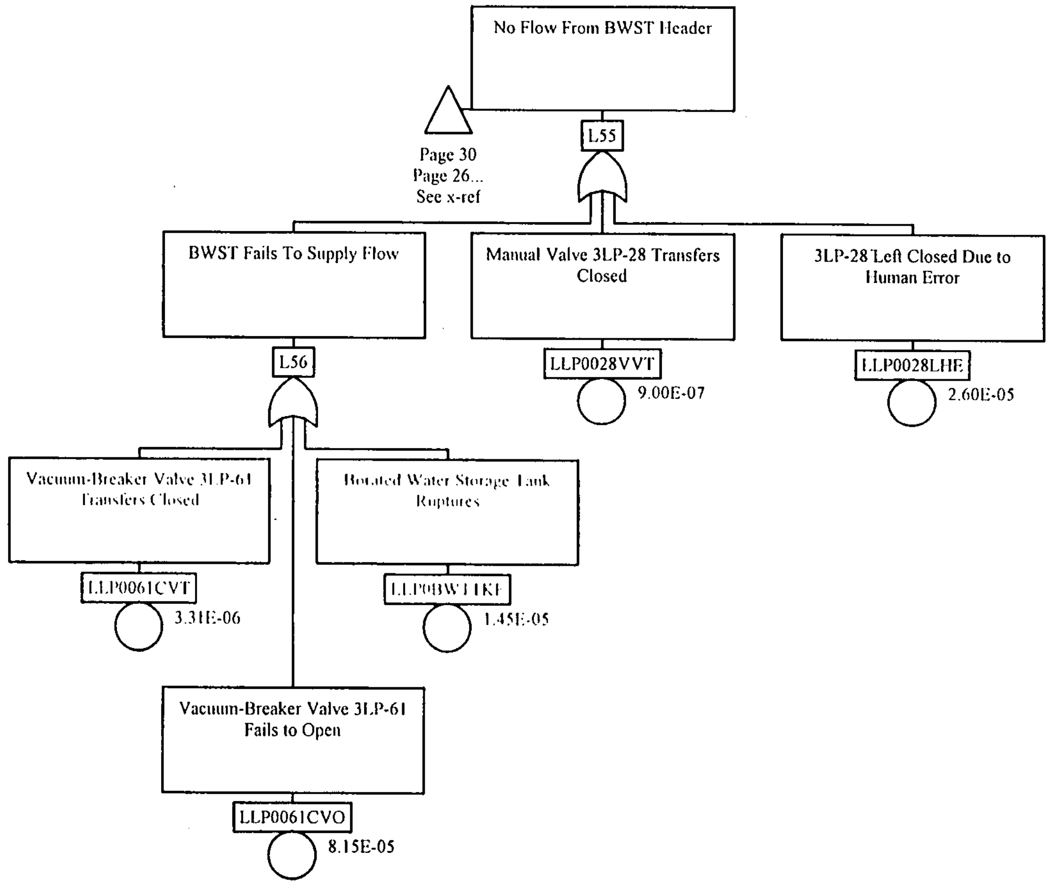

No Flow To HPI Train A From 3HP-101
HPI074
Page 23
Page 35...
See x-ref
No Flow Through 3HP-24 Or 3HP-101
HPI075
No Flow From BWST Header
L55
Page 29
Tilting Disk Check Valve 3HP-101 Fails To Open On Demand
HHP0101CVO
8.15E-05
Tilting Disk Check Valve 3HP-101 Transfers Closed
HHP0101CVT
3.31E-06
Motor Operated Valve 3HP-24 Does Not Open
HPI080
Motor-Operated Valve 3HP-24 Transfers Closed After Opening
HHP0024MVT
2.50E-06
MOV 3HP-24 Suction Train Is Left Unavailable After Test Or Maintenance
HHP0024LHE
5.20E-05
MOV 3HP-24 Suction Train In Maintenance
HHP0024TRM
5.00E-03
Power From 208 V ac MCC 3XS1 Breaker RD1 Fails
HPI986
Page 27
Motor-Operated Valve 3HP-24 Fails To Open On Demand
HHP0024MVO
2.47E-03
ES Digital Channel 1 Fails To Open MOV 3HP-24 And Operators Fail to Recover
H415
Page 28
Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand
HHPSVLVCOM
2
1.24E-04

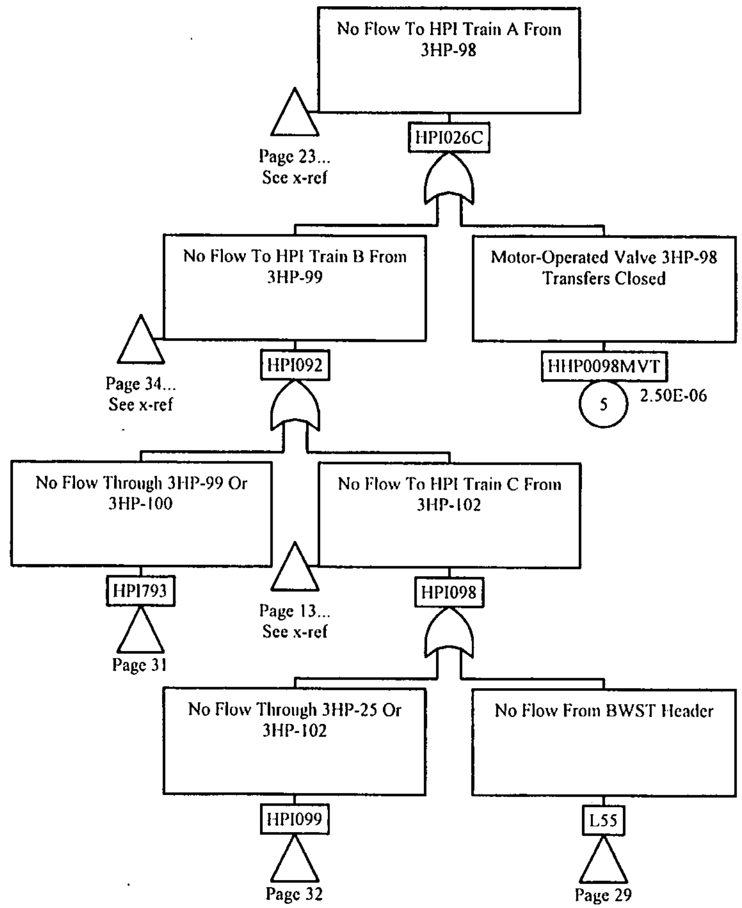


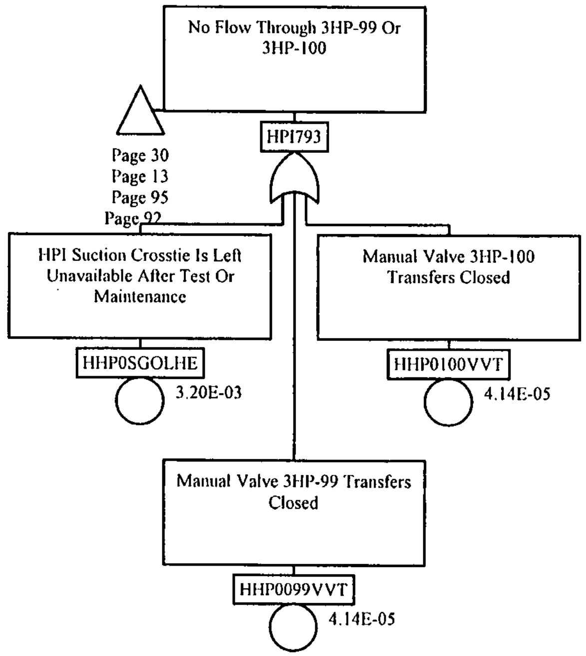
Power From 208 V ac MCC
3XS1 Breaker RD1 Fails
Page 26...
See x-ref
HPI986
Loss Of Power From 208 V ac
Motor Control Center 3XS1
P2C3XS1
2
3.00E-05
208 V ac MCC 3XS1 Breaker
RD1 Transfers Open (3HP-24)
HACOR1DCLT
1.66E-05



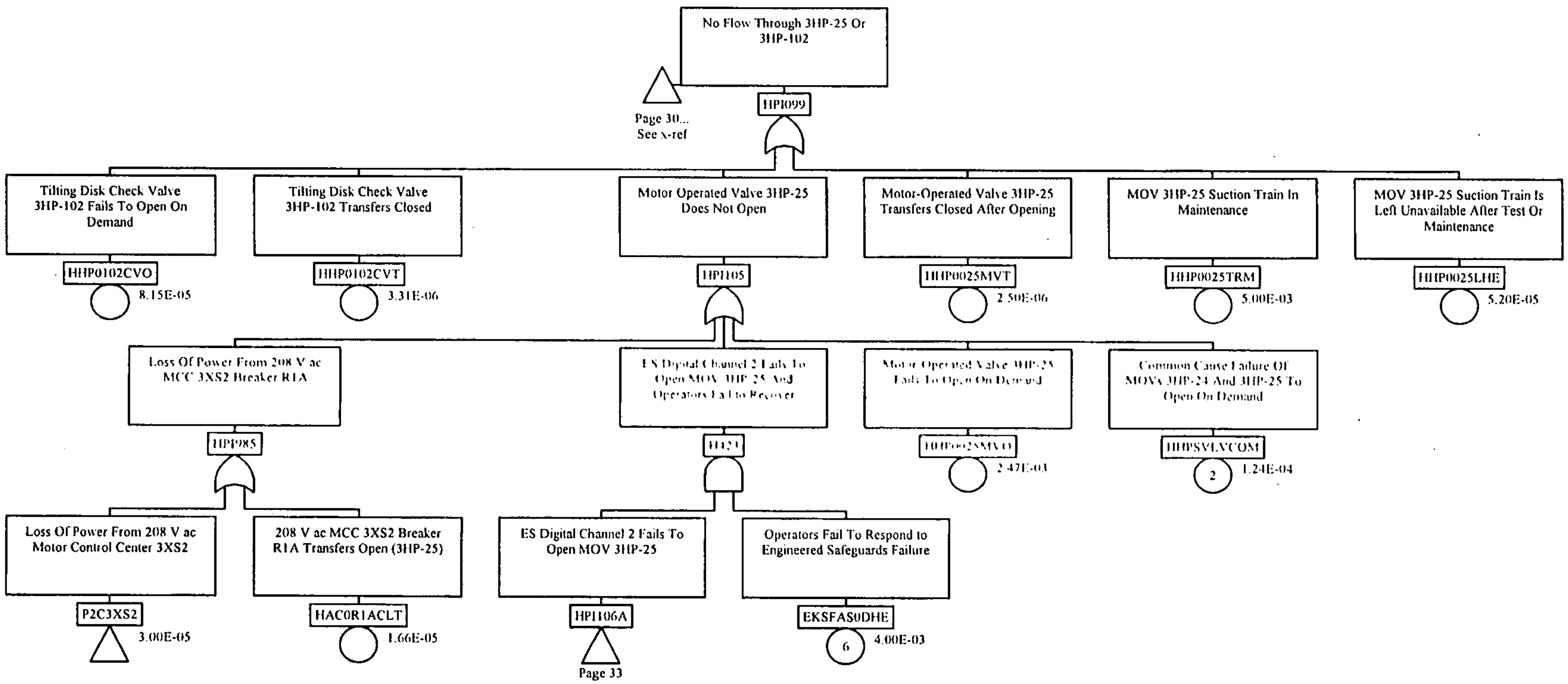
ES Digital Channel 1 Fails To Open MOV 3HP-24 And Operators Fail to Recover
H415
Page 26... See x-ref
ES Digital Channel 1 Fails To Open MOV 3HP-24
HPI082A
Operators Fail To Respond to Engineered Safeguards Failure
EKSFAS0DHE
6
4.00E-03
Enginered Safeguards Channel 1 Signal Fails
ESAS1
4
2.00E-06
Unit Control Module ES1B Fails
HES001BUCD
6.00E-08

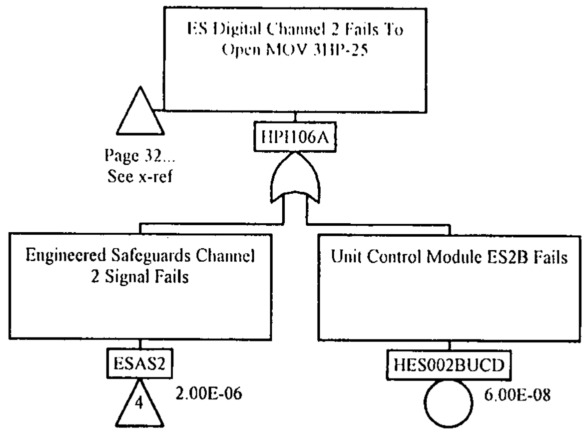

No Flow From BWST Header
L55
Page 30
Page 26...
See x-ref
BWST Fails To Supply Flow
Manual Valve 3LP-28 Transfers Closed
3LP-28 Left Closed Due to Human Error
L56
LLP0028VVT
9.00E-07
LLP0028LHE
2.60E-05
Vacuum-Breaker Valve 3LP-61 Transfers Closed
Borated Water Storage Tank Ruptures
LLP0061CVT
3.31E-06
LLP0BWTTKF
1.45E-05
Vacuum-Breaker Valve 3LP-61 Fails to Open
LLP0061CVO
8.15E-05


No Flow To HPI Train A From 3HP-98
HPI026C
Page 23... See x-ref
No Flow To HPI Train B From 3HP-99
Motor-Operated Valve 3HP-98 Transfers Closed
HPI092
Page 34... See x-ref
HHP0098MVT
5
2.50E-06
No Flow Through 3HP-99 Or 3HP-100
No Flow To HPI Train C From 3HP-102
HPI793
Page 31
Page 13... See x-ref
HPI098
No Flow Through 3HP-25 Or 3HP-102
No Flow From BWST Header
HPI099
Page 32
L55
Page 29

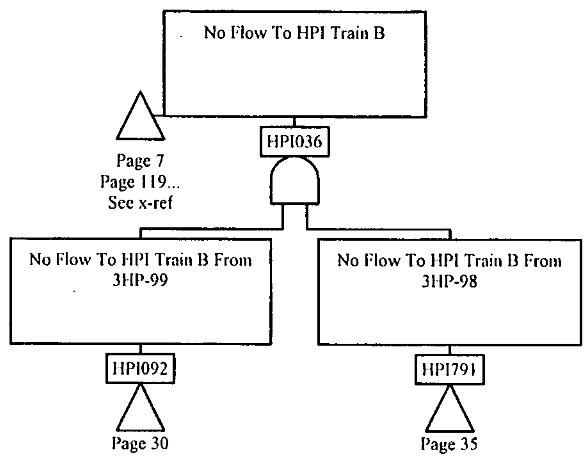


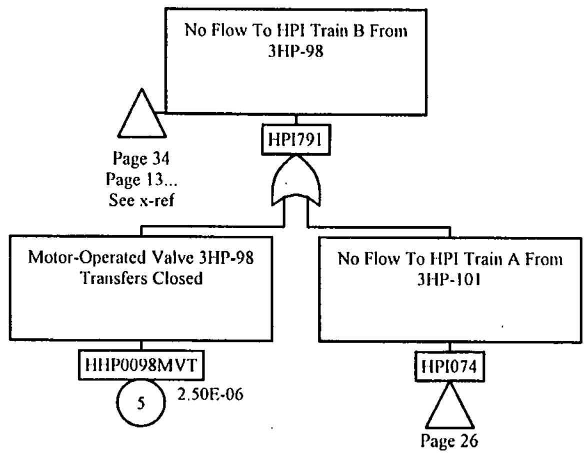
No Flow Through 3HP-99 Or 3HP-100
HPI793
Page 30
Page 13
Page 95
Page 92
HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance
HHP0SGOLHE
3.20E-03
Manual Valve 3HP-100 Transfers Closed
HHP0100VVT
4.14E-05
Manual Valve 3HP-99 Transfers Closed
HHP0099VVT
4.14E-05

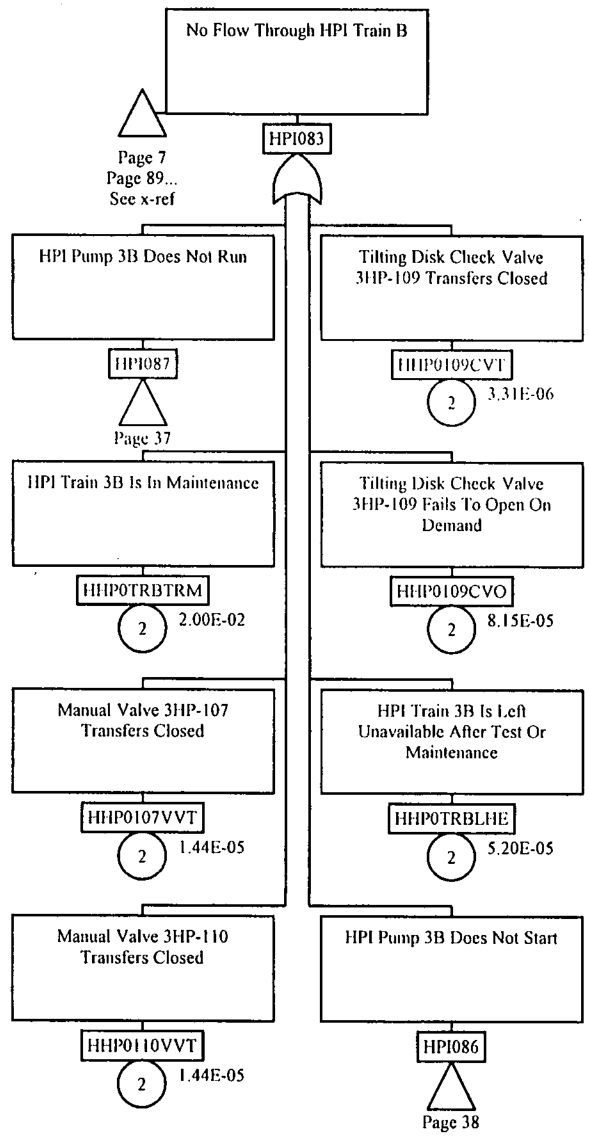

No Flow Through 3HP-25 Or 3HP-102
Page 30... See x-ref
HPI099
Tilting Disk Check Valve 3HP-102 Fails To Open On Demand
HHP0102CVO
8.15E-05
Tilting Disk Check Valve 3HP-102 Transfers Closed
HHP0102CVT
3.31E-06
Motor Operated Valve 3HP-25 Does Not Open
HPI105
Motor-Operated Valve 3HP-25 Transfers Closed After Opening
HHP0025MVT
2.50E-06
MOV 3HP-25 Suction Train In Maintenance
HHP0025TRM
5.00E-03
MOV 3HP-25 Suction Train Is Left Unavailable After Test Or Maintenance
HHP0025LHE
5.20E-05
Loss Of Power From 208 V ac MCC 3XS2 Breaker R1A
HPI985
ES Digital Channel 2 Fails To Open MOV 3HP-25 And Operators Fail to Recover
Motor Operated Valve 3HP-25 Fails To Open On Demand
2.47E-03
Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand
HHPSVLVCOM
2
1.24E-04
Loss Of Power From 208 V ac Motor Control Center 3XS2
P2C3XS2
3.00E-05
208 V ac MCC 3XS2 Breaker R1A Transfers Open (3HP-25)
HACOR1ACLT
1.66E-05
ES Digital Channel 2 Fails To Open MOV 3HP-25
HPI106A
Page 33
Operators Fail To Respond to Engineered Safeguards Failure
EKSFAS0DHE
6
4.00E-03

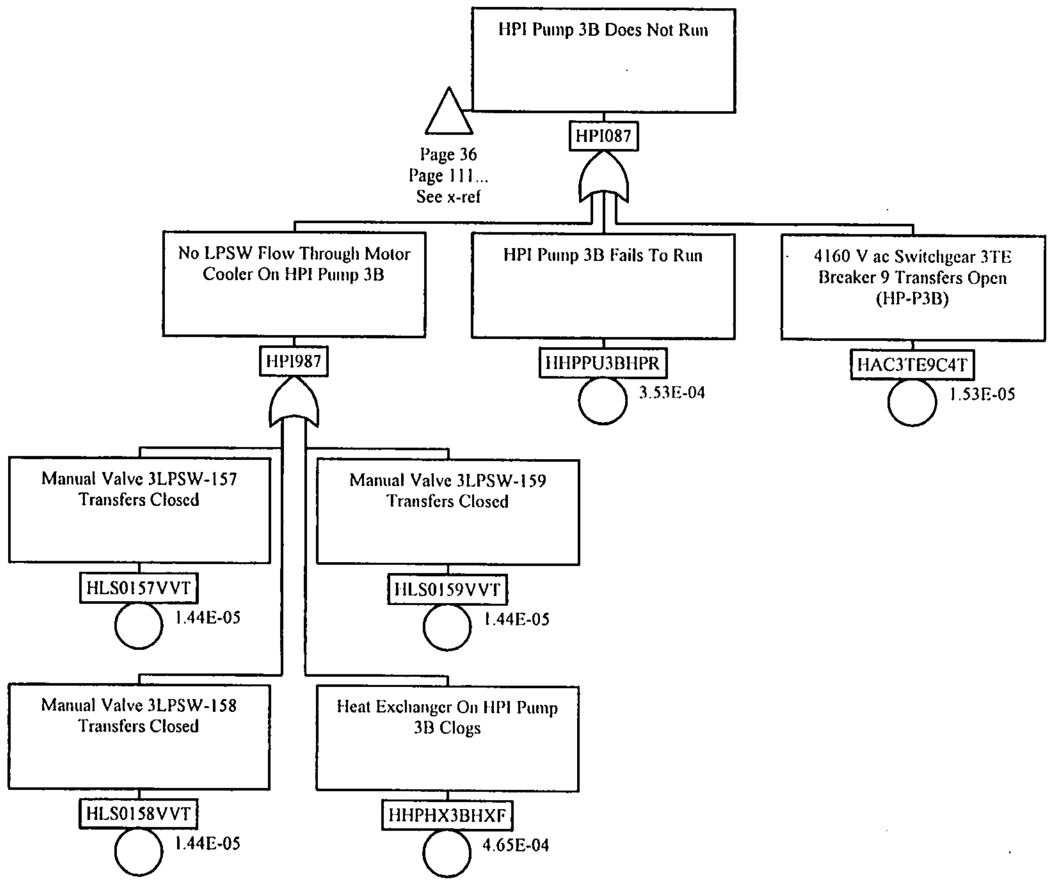


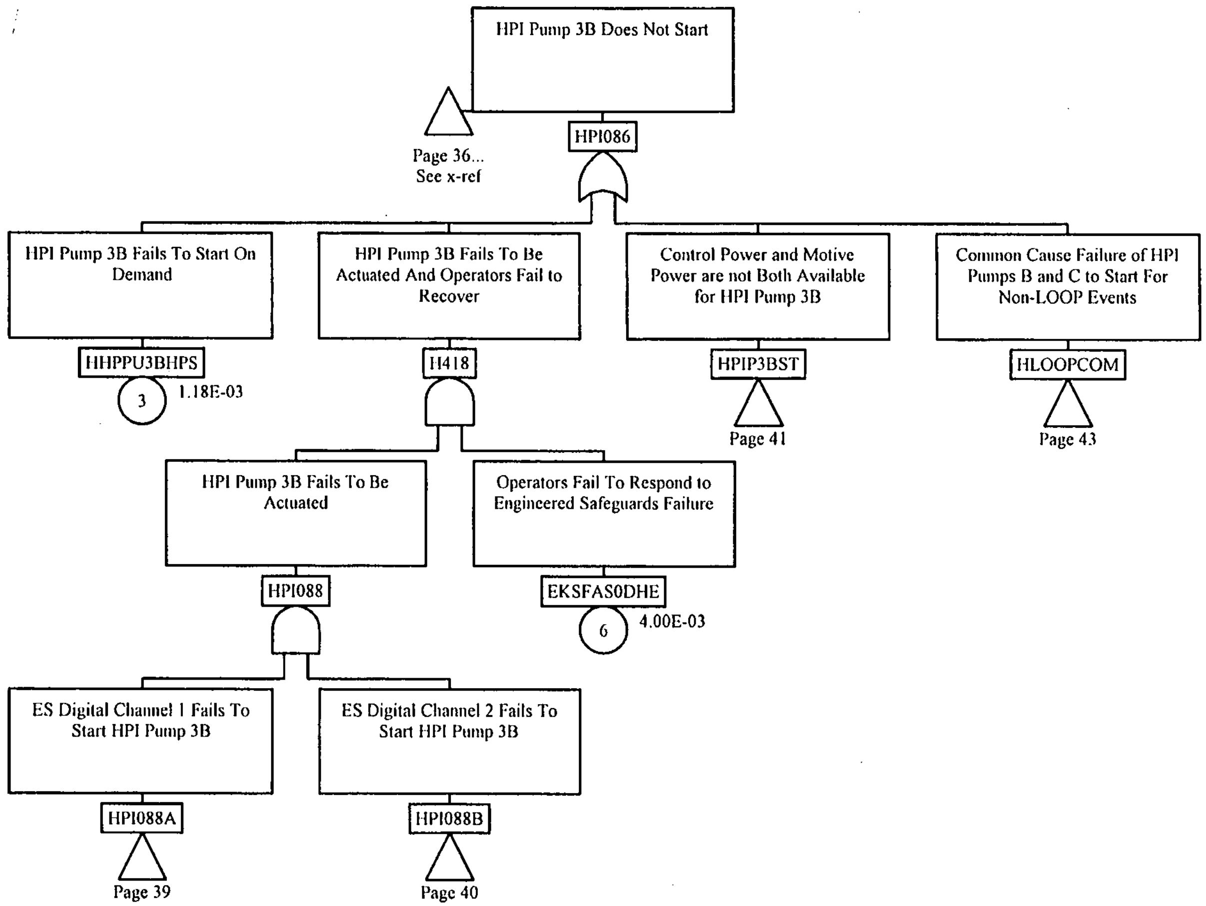
ES Digital Channel 2 Fails To Open MOV 3HP-25
HPI106A
Page 32...
See x-ref
Engineered Safeguards Channel 2 Signal Fails
ESAS2
4
2.00E-06
Unit Control Module ES2B Fails
HES002BUCD
6.00E-08


No Flow To HPI Train B
HPI036
Page 7
Page 119...
See x-ref
No Flow To HPI Train B From 3HP-99
No Flow To HPI Train B From 3HP-98
HPI092
HPI791
Page 30
Page 35

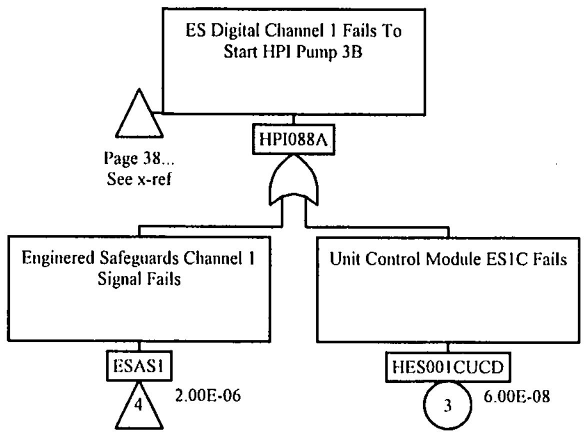

No Flow To HPI Train B From 3HP-98
HPI791
Page 34
Page 13...
See x-ref
Motor-Operated Valve 3HP-98 Transfers Closed
HHP0098MVT
5
2.50E-06
No Flow To HPI Train A From 3HP-101
HPI074
Page 26

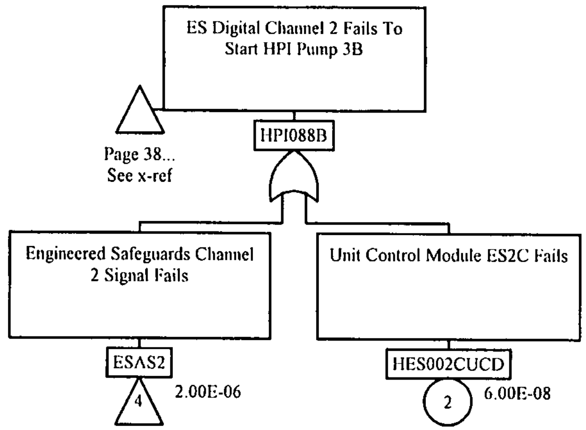

No Flow Through HPI Train B
HPI083
Page 7
Page 89...
See x-ref
HPI Pump 3B Does Not Run
HPI087
Page 37
Tilting Disk Check Valve 3HP-109 Transfers Closed
HHP0109CVT
2
3.31E-06
HPI Train 3B Is In Maintenance
HHP0TRBTRM
2
2.00E-02
Tilting Disk Check Valve 3HP-109 Fails To Open On Demand
HHP0109CVO
2
8.15E-05
Manual Valve 3HP-107 Transfers Closed
HHP0107VVT
2
1.44E-05
HPI Train 3B Is Left Unavailable After Test Or Maintenance
HHP0TRBLHE
2
5.20E-05
Manual Valve 3HP-110 Transfers Closed
HHP0110VVT
2
1.44E-05
HPI Pump 3B Does Not Start
HPI086
Page 38

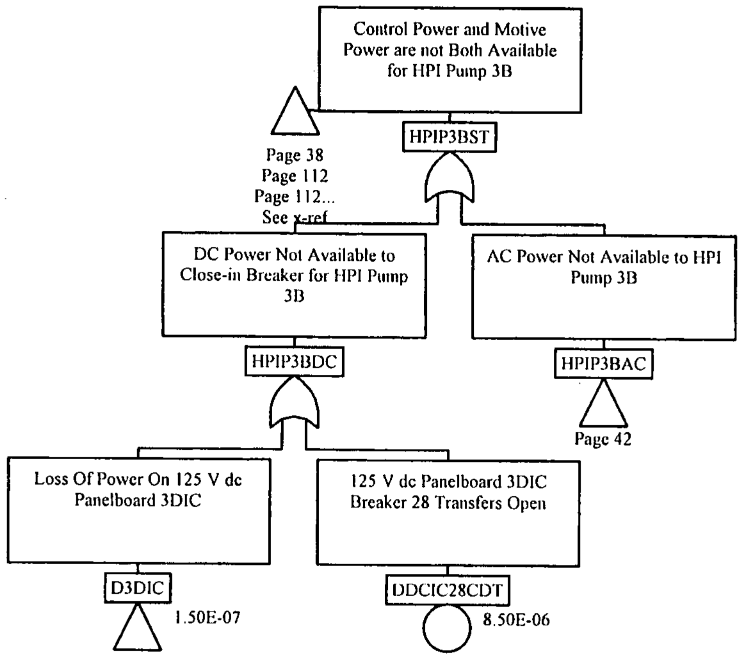

HPI Pump 3B Does Not Run
HPI087
Page 36
Page 111...
See x-ref
No LPSW Flow Through Motor Cooler On HPI Pump 3B
HPI Pump 3B Fails To Run
4160 V ac Switchgear 3TE Breaker 9 Transfers Open (HP-P3B)
HPI987
HHPPU3BHPR
3.53E-04
HAC3TE9C4T
1.53E-05
Manual Valve 3LPSW-157 Transfers Closed
Manual Valve 3LPSW-159 Transfers Closed
HLS0157VVT
1.44E-05
HLS0159VVT
1.44E-05
Manual Valve 3LPSW-158 Transfers Closed
Heat Exchanger On HPI Pump 3B Clogs
HLS0158VVT
1.44E-05
HHPHX3BHXF
4.65E-04

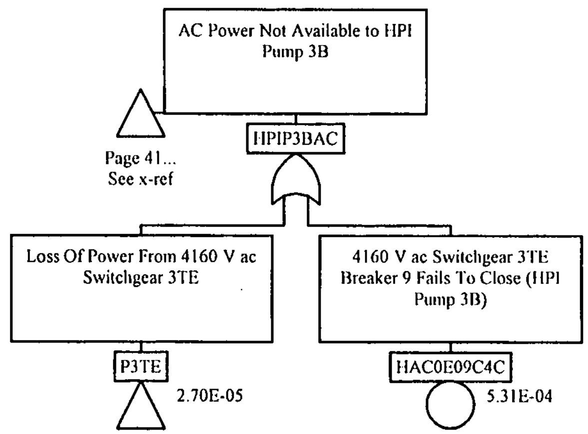


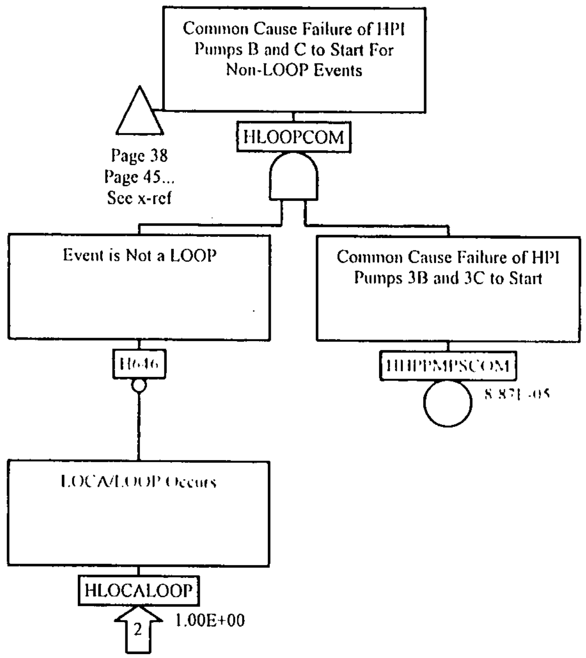
HPI Pump 3B Does Not Start
Page 36...
See x-ref
HPI086
HPI Pump 3B Fails To Start On Demand
HHPPU3BHPS
3
1.18E-03
HPI Pump 3B Fails To Be Actuated And Operators Fail to Recover
H418
Control Power and Motive Power are not Both Available for HPI Pump 3B
HPIP3BST
Page 41
Common Cause Failure of HPI Pumps B and C to Start For Non-LOOP Events
HLOOPCOM
Page 43
HPI Pump 3B Fails To Be Actuated
HPI088
Operators Fail To Respond to Engineered Safeguards Failure
EKSFAS0DHE
6
4.00E-03
ES Digital Channel 1 Fails To Start HPI Pump 3B
HPI088A
Page 39
ES Digital Channel 2 Fails To Start HPI Pump 3B
HPI088B
Page 40

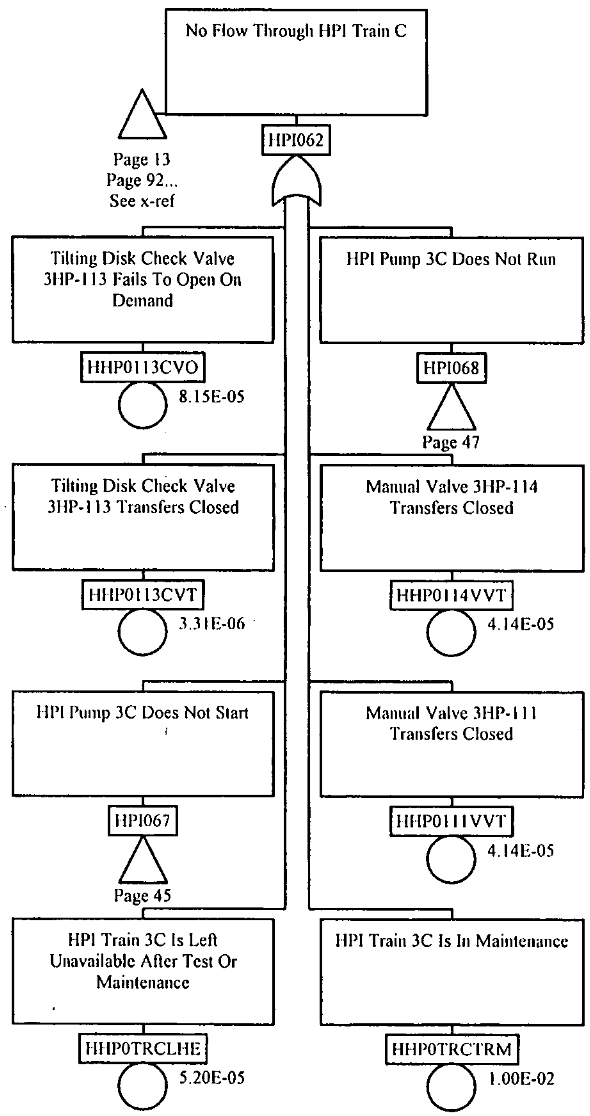

ES Digital Channel 1 Fails To Start HPI Pump 3B
HPI088A
Page 38...
See x-ref
Engineered Safeguards Channel 1 Signal Fails
ESAS1
4
2.00E-06
Unit Control Module ES1C Fails
HES001CUCD
3
6.00E-08

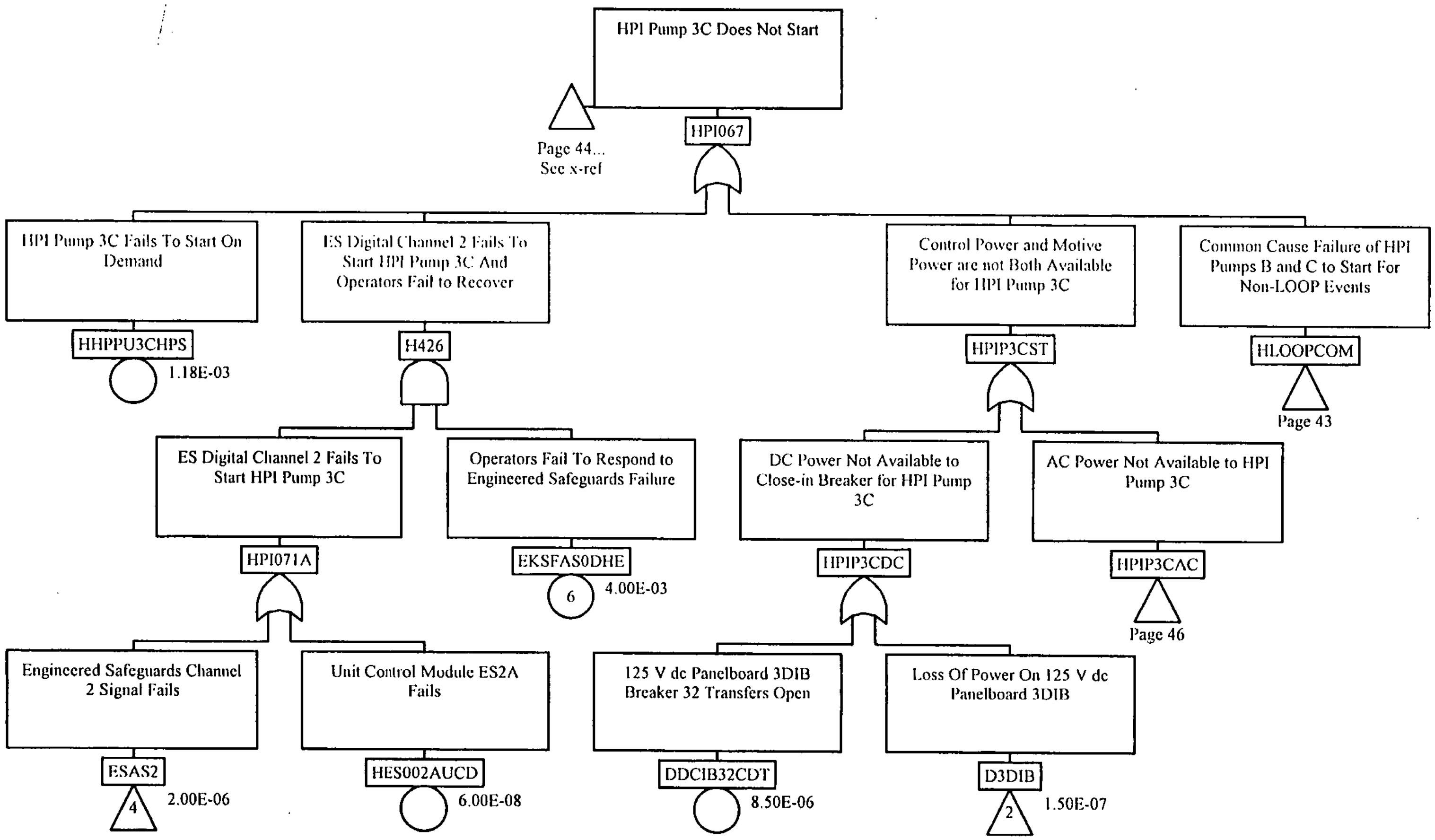

ES Digital Channel 2 Fails To Start HPI Pump 3B
HPI088B
Page 38...
See x-ref
Engineered Safeguards Channel 2 Signal Fails
ESAS2
4
2.00E-06
Unit Control Module ES2C Fails
HES002CUCD
2
6.00E-08

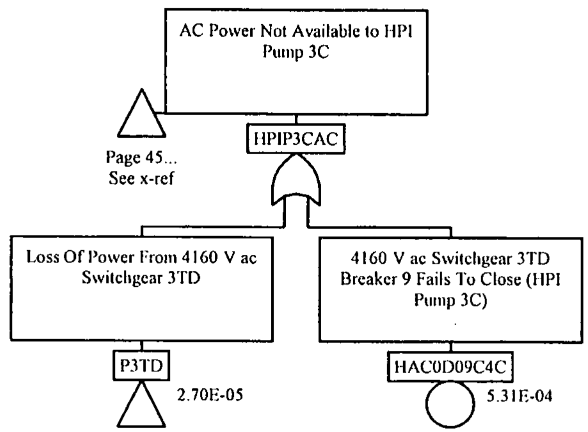

Control Power and Motive Power are not Both Available for HPI Pump 3B
HPIP3BST
Page 38
Page 112
Page 112...
See x-ref
DC Power Not Available to Close-in Breaker for HPI Pump 3B
HPIP3BDC
AC Power Not Available to HPI Pump 3B
HPIP3BAC
Page 42
Loss Of Power On 125 V dc Panelboard 3DIC
D3DIC
1.50E-07
125 V dc Panelboard 3DIC Breaker 28 Transfers Open
DDCIC28CDT
8.50E-06

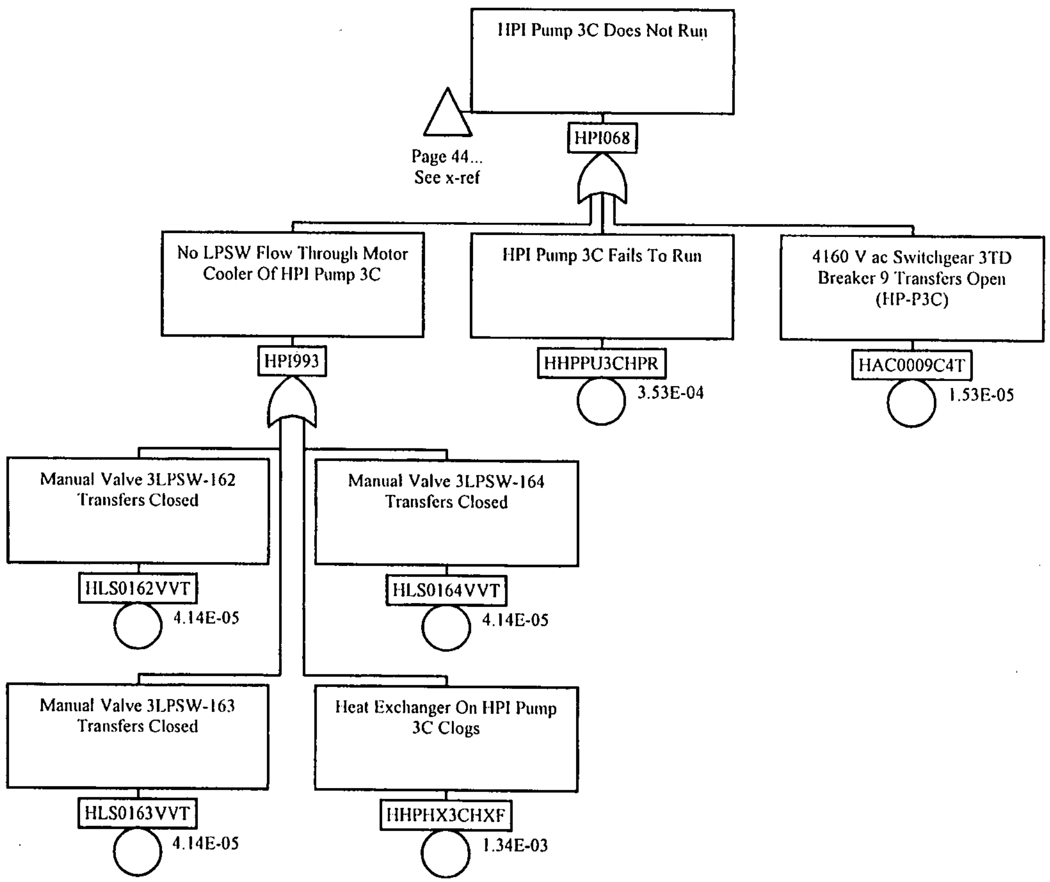

AC Power Not Available to HPI Pump 3B
HPIP3BAC
Page 41...
See x-ref
Loss Of Power From 4160 V ac Switchgear 3TE
P3TE
2.70E-05
4160 V ac Switchgear 3TE Breaker 9 Fails To Close (HPI Pump 3B)
HAC0E09C4C
5.31E-04


Common Cause Failure of HPI Pumps B and C to Start For Non-LOOP Events
HLOOPCOM
Page 38
Page 45...
See x-ref
Event is Not a LOOP
H646
LOCA/LOOP Occurs
HLOCALOOP
2
1.00E+00
Common Cause Failure of HPI Pumps 3B and 3C to Start
HHPPMPSCOM
8.87E-05

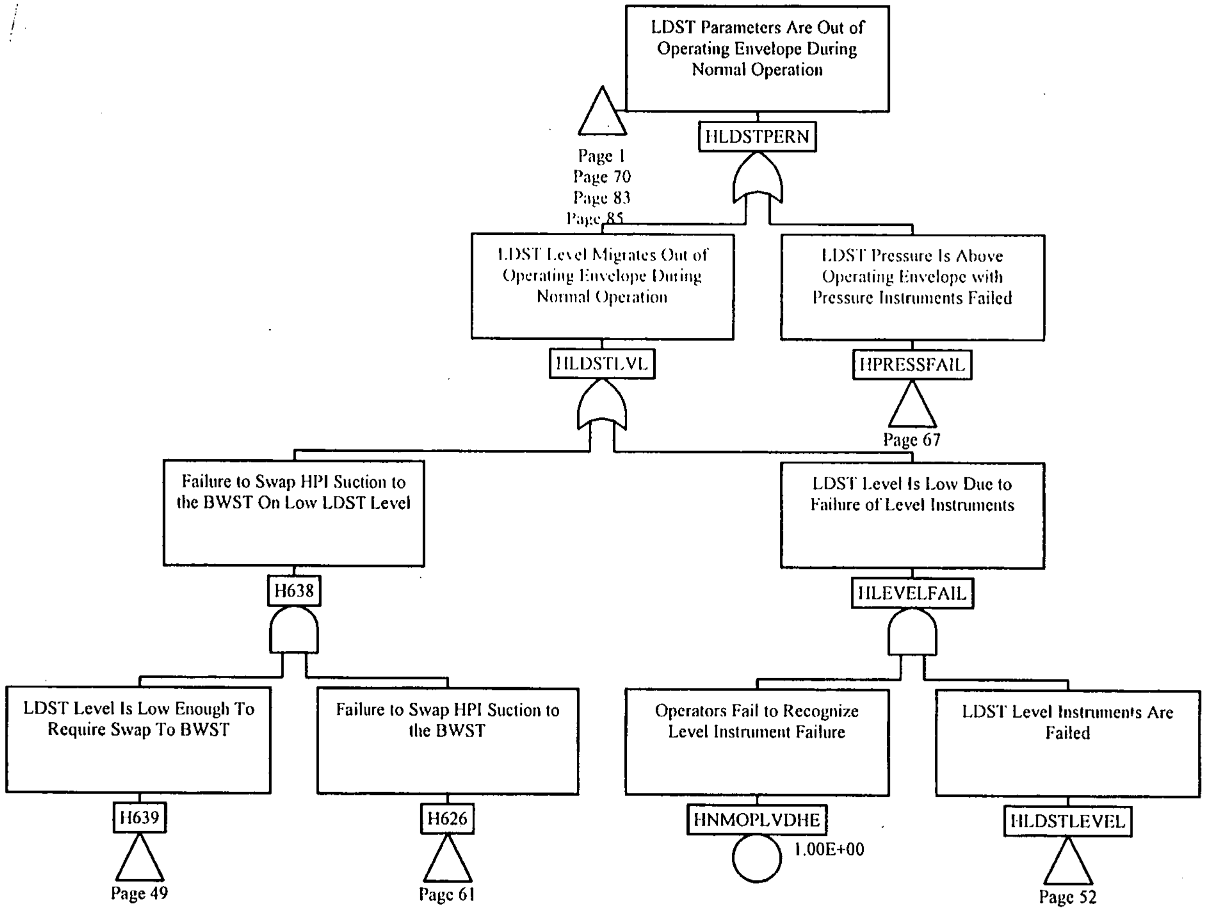

No Flow Through HPI Train C
HPI062
Page 13
Page 92...
See x-ref
Tilting Disk Check Valve 3HP-113 Fails To Open On Demand
HHP0113CVO
8.15E-05
HPI Pump 3C Does Not Run
HPI068
Page 47
Tilting Disk Check Valve 3HP-113 Transfers Closed
HHP0113CVT
3.31E-06
Manual Valve 3HP-114 Transfers Closed
HHP0114VVT
4.14E-05
HPI Pump 3C Does Not Start
HPI067
Page 45
Manual Valve 3HP-111 Transfers Closed
HHP0111VVT
4.14E-05
HPI Train 3C Is Left Unavailable After Test Or Maintenance
HHP0TRCLHE
5.20E-05
HPI Train 3C Is In Maintenance
HHP0TRCTRM
1.00E-02

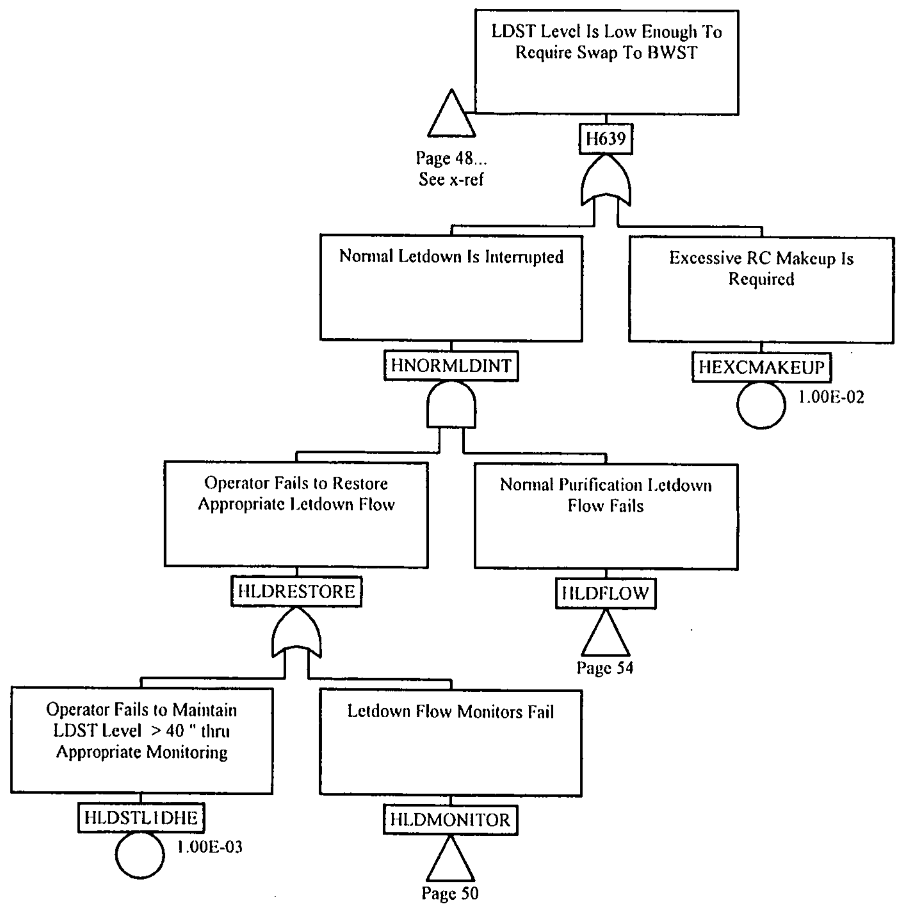

HPI Pump 3C Does Not Start
HPI067
Page 44...
See x-ref
HPI Pump 3C Fails To Start On Demand
HHPPU3CHPS
1.18E-03
ES Digital Channel 2 Fails To Start HPI Pump 3C And Operators Fail to Recover
H426
ES Digital Channel 2 Fails To Start HPI Pump 3C
HPI071A
Engineered Safeguards Channel 2 Signal Fails
ESAS2
4
2.00E-06
Unit Control Module ES2A Fails
HES002AUCD
6.00E-08
Operators Fail To Respond to Engineered Safeguards Failure
EKSFAS0DHE
6
4.00E-03
Control Power and Motive Power are not Both Available for HPI Pump 3C
HPIP3CST
DC Power Not Available to Close-in Breaker for HPI Pump 3C
HPIP3CDC
125 V dc Panelboard 3DIB Breaker 32 Transfers Open
DDCIB32CDT
8.50E-06
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB
2
1.50E-07
AC Power Not Available to HPI Pump 3C
HPIP3CAC
Page 46
Common Cause Failure of HPI Pumps B and C to Start For Non-LOOP Events
HLOOPCOM
Page 43

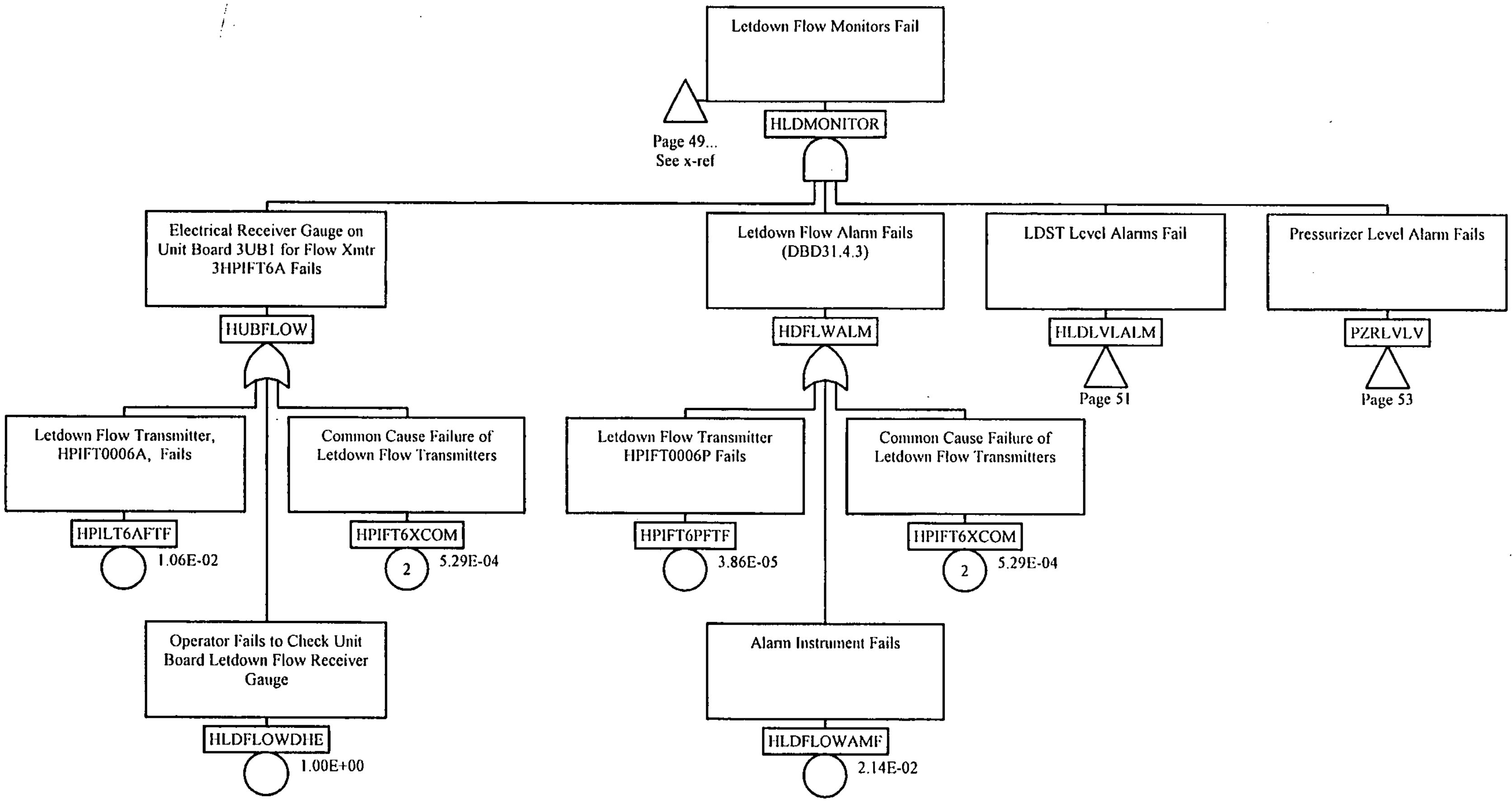

AC Power Not Available to HPI Pump 3C
HPIP3CAC
Page 45...
See x-ref
Loss Of Power From 4160 V ac Switchgear 3TD
P3TD
2.70E-05
4160 V ac Switchgear 3TD Breaker 9 Fails To Close (HPI Pump 3C)
HAC0D09C4C
5.31E-04



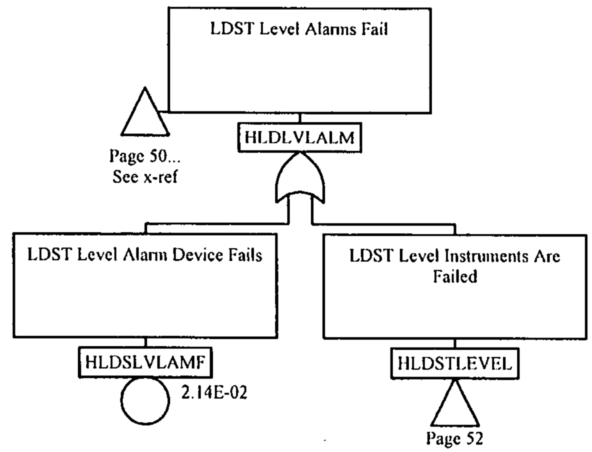
HPI Pump 3C Does Not Run
HPI068
Page 44...
See x-ref
No LPSW Flow Through Motor Cooler Of HPI Pump 3C
HPI993
HPI Pump 3C Fails To Run
HHPPU3CHPR
3.53E-04
4160 V ac Switchgear 3TD Breaker 9 Transfers Open (HP-P3C)
HAC0009C4T
1.53E-05
Manual Valve 3LPSW-162 Transfers Closed
HLS0162VVT
4.14E-05
Manual Valve 3LPSW-164 Transfers Closed
HLS0164VVT
4.14E-05
Manual Valve 3LPSW-163 Transfers Closed
HLS0163VVT
4.14E-05
Heat Exchanger On HPI Pump 3C Clogs
HHPHX3CHXF
1.34E-03

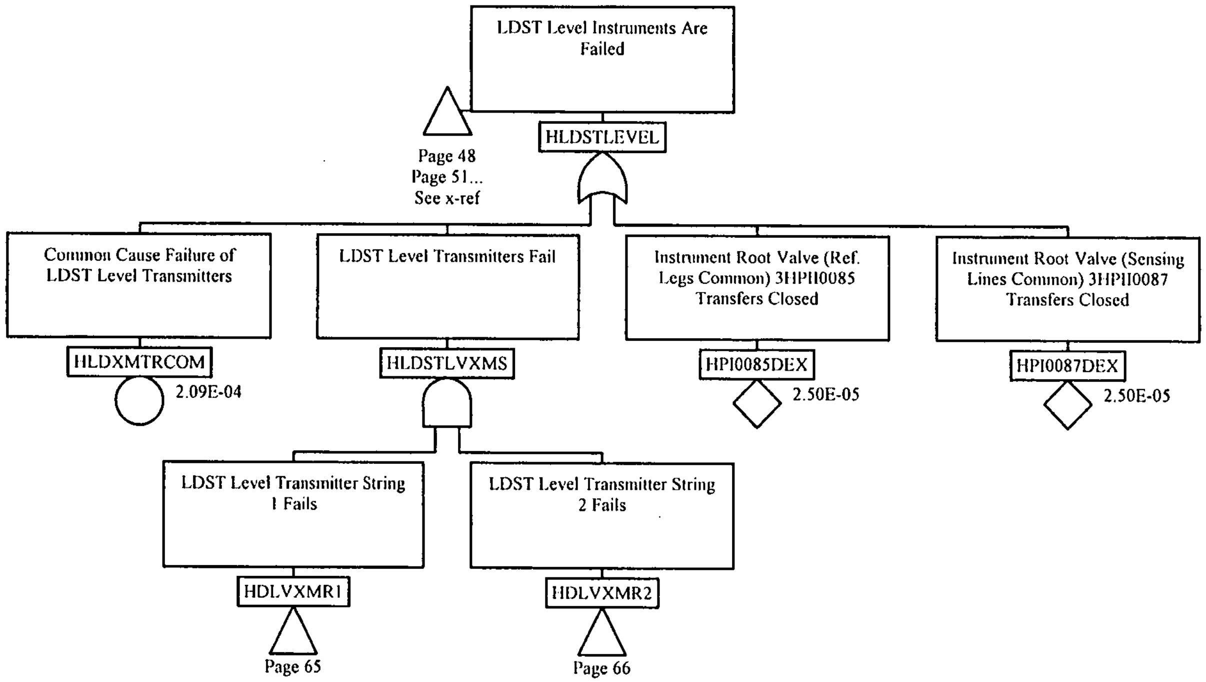

LDST Parameters Are Out of Operating Envelope During Normal Operation
HLDSTPERN
Page 1
Page 70
Page 83
Page 85
LDST Level Migrates Out of Operating Envelope During Normal Operation
HLDSTLVL
LDST Pressure Is Above Operating Envelope with Pressure Instruments Failed
HPRESSFAIL
Page 67
Failure to Swap HPI Suction to the BWST On Low LDST Level
H638
LDST Level Is Low Due to Failure of Level Instruments
HLEVELFAIL
LDST Level Is Low Enough To Require Swap To BWST
H639
Page 49
Failure to Swap HPI Suction to the BWST
H626
Page 61
Operators Fail to Recognize Level Instrument Failure
HNMOPLVDHE
1.00E+00
LDST Level Instruments Are Failed
HLDSTLEVEL
Page 52

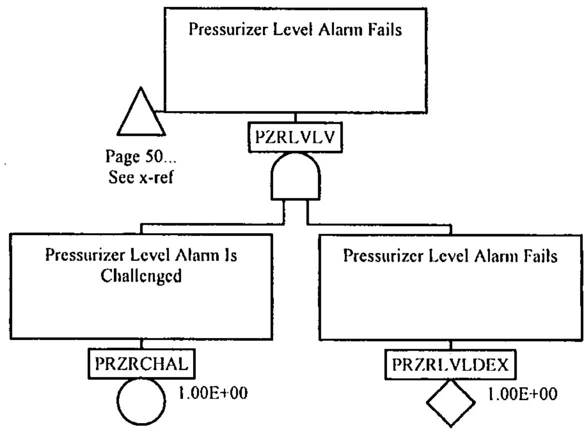

LDST Level Is Low Enough To Require Swap To BWST
H639
Page 48...
See x-ref
Normal Letdown Is Interrupted
HNORMLDINT
Excessive RC Makeup Is Required
HEXCMAKEUP
1.00E-02
Operator Fails to Restore Appropriate Letdown Flow
HLDRESTORE
Normal Purification Letdown Flow Fails
HLDFLOW
Page 54
Operator Fails to Maintain LDST Level > 40 " thru Appropriate Monitoring
HLDSTLIDHE
1.00E-03
Letdown Flow Monitors Fail
HLDMONITOR
Page 50

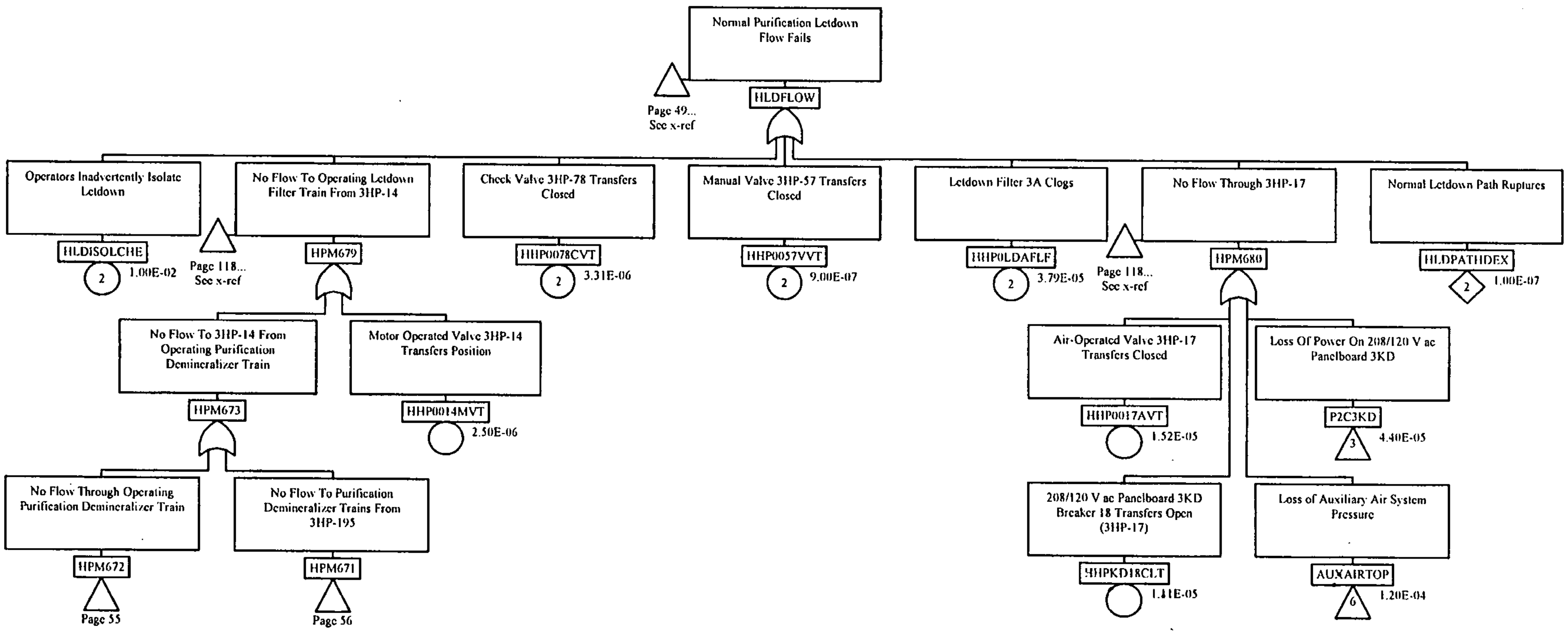


Letdown Flow Monitors Fail
HLDMONITOR
Page 49...
See x-ref
Electrical Receiver Gauge on Unit Board 3UB1 for Flow Xmtr 3HPIFT6A Fails
HUBFLOW
Letdown Flow Alarm Fails (DBD31.4.3)
HDFLWALM
LDST Level Alarms Fail
HLDLVLALM
Page 51
Pressurizer Level Alarm Fails
PZRLVLV
Page 53
Letdown Flow Transmitter, HPIFT0006A, Fails
HPILT6AFTF
1.06E-02
Common Cause Failure of Letdown Flow Transmitters
HPIFT6XCOM
2
5.29E-04
Letdown Flow Transmitter HPIFT0006P Fails
HPIFT6PFTF
3.86E-05
Common Cause Failure of Letdown Flow Transmitters
HPIFT6XCOM
2
5.29E-04
Operator Fails to Check Unit Board Letdown Flow Receiver Gauge
HLDFLOWDHE
1.00E+00
Alarm Instrument Fails
HLDFLOWAMF
2.14E-02

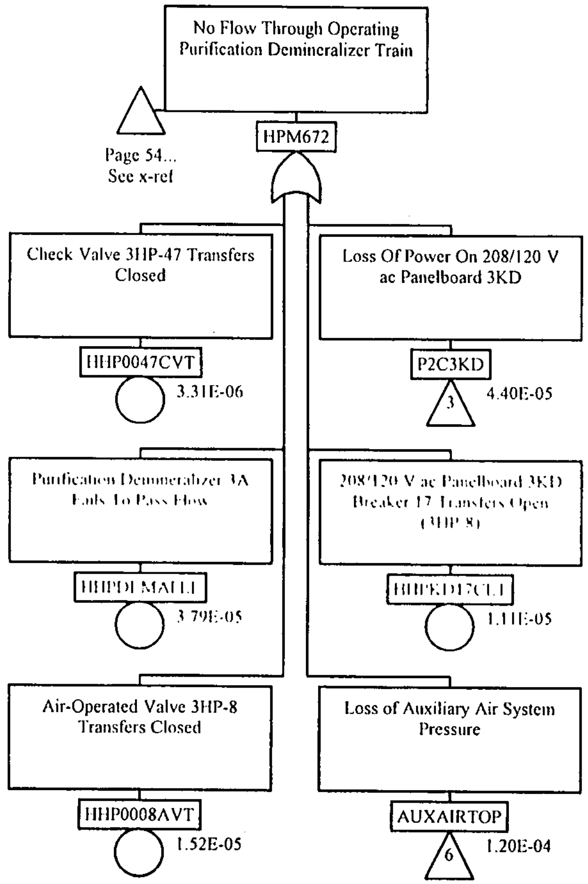

LDST Level Alarms Fail
HLDLVLALM
Page 50...
See x-ref
LDST Level Alarm Device Fails
HLDSLVLAMF
2.14E-02
LDST Level Instruments Are Failed
HLDSTLEVEL
Page 52

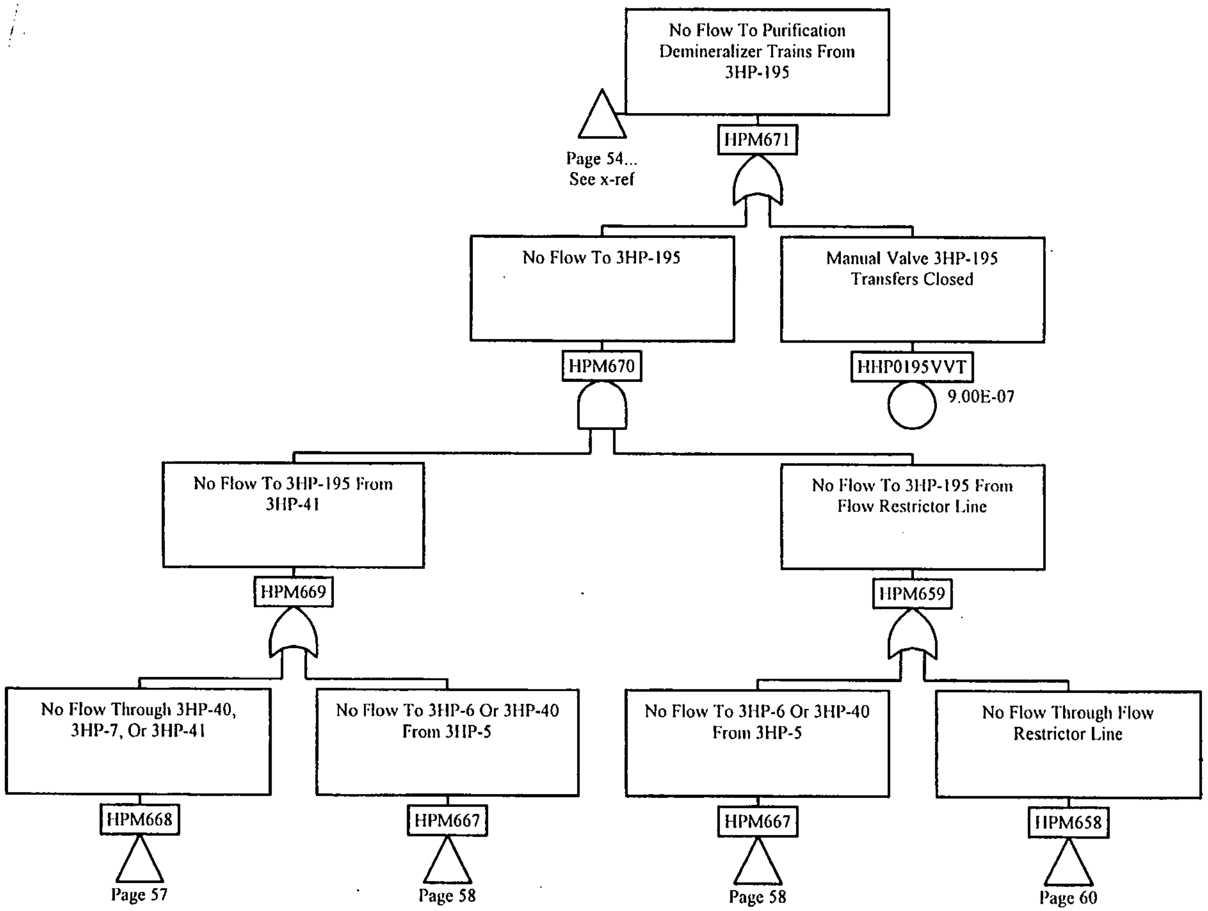

LDST Level Instruments Are Failed
HLDSTLEVEL
Page 48
Page 51...
See x-ref
Common Cause Failure of LDST Level Transmitters
HLDXMTRCOM
2.09E-04
LDST Level Transmitters Fail
HLDSTLVXMS
Instrument Root Valve (Ref. Legs Common) 3HPI0085 Transfers Closed
HPI0085DEX
2.50E-05
Instrument Root Valve (Sensing Lines Common) 3HPI0087 Transfers Closed
HPI0087DEX
2.50E-05
LDST Level Transmitter String 1 Fails
HDLVXMR1
Page 65
LDST Level Transmitter String 2 Fails
HDLVXMR2
Page 66

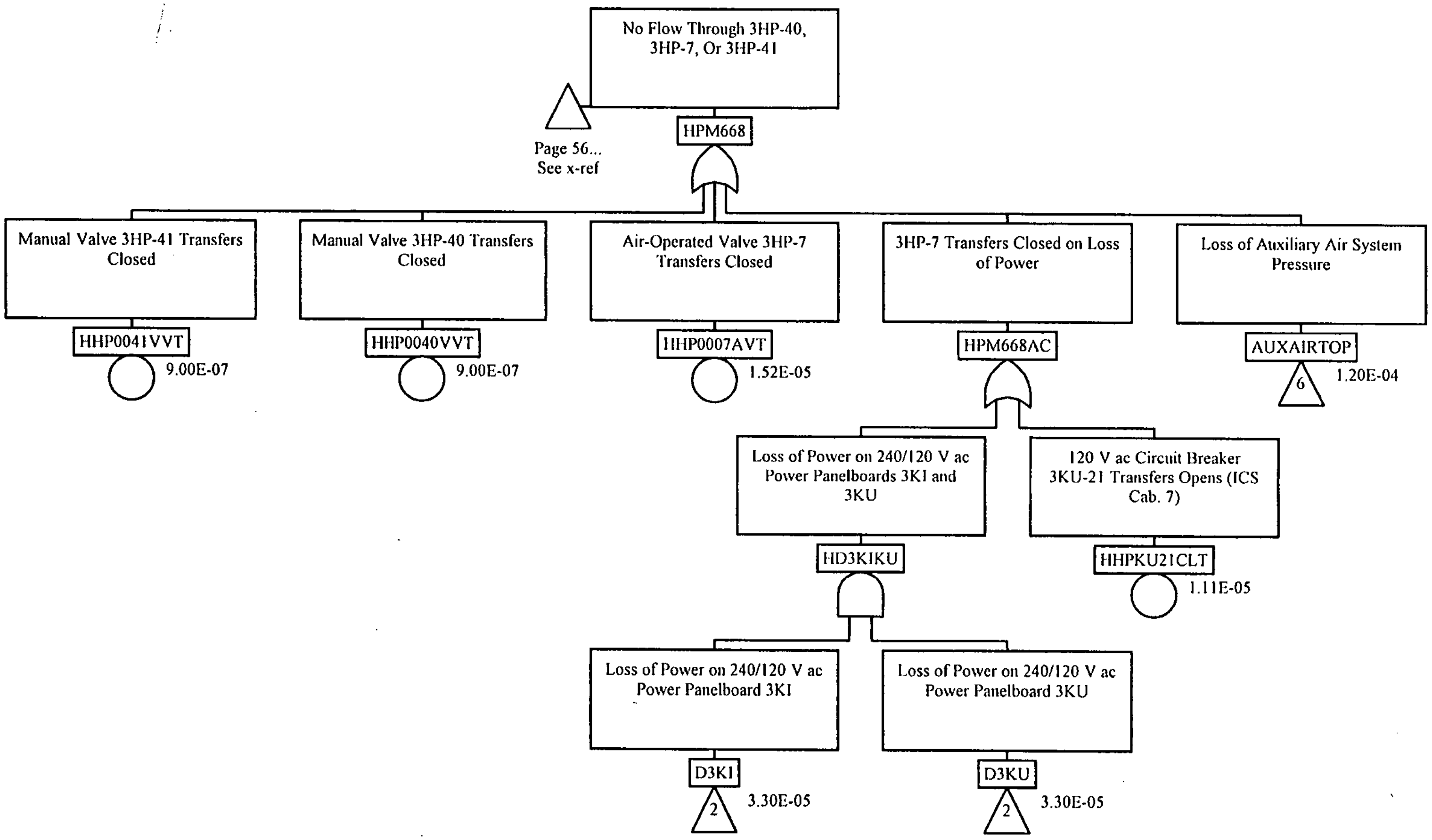

Pressurizer Level Alarm Fails
PZRLVLV
Page 50...
See x-ref
Pressurizer Level Alarm Is Challenged
PRZRCHAL
1.00E+00
Pressurizer Level Alarm Fails
PRZRLVLDEX
1.00E+00



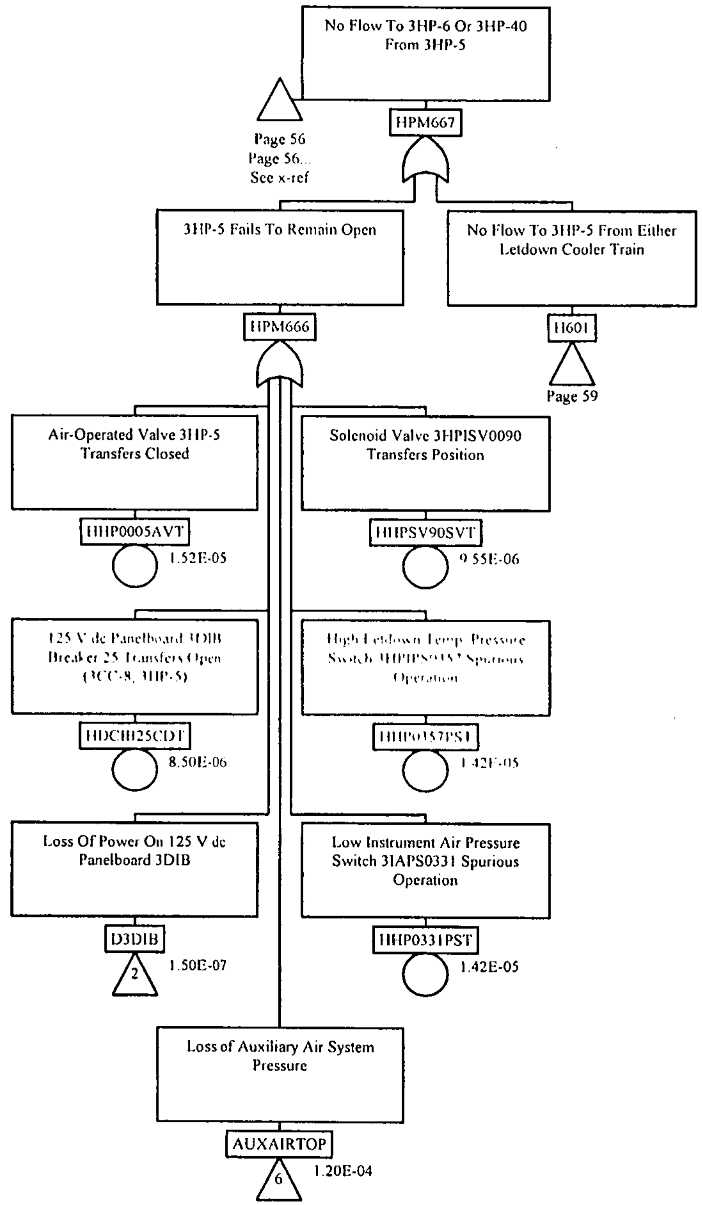
Normal Purification Letdown Flow Fails
HLDFLOW
Page 49... See x-ref
Operators Inadvertently Isolate Letdown
HLDISOLCHE
1.00E-02
Page 118... See x-ref
No Flow To Operating Letdown Filter Train From 3HP-14
HPM679
Check Valve 3HP-78 Transfers Closed
HHP0078CVT
3.31E-06
Manual Valve 3HP-57 Transfers Closed
HHP0057VVT
9.00E-07
Letdown Filter 3A Clogs
HHP0LDAFLF
3.79E-05
Page 118... See x-ref
No Flow Through 3HP-17
HPM680
Normal Letdown Path Ruptures
HLDPATHDEX
1.00E-07
No Flow To 3HP-14 From Operating Purification Demineralizer Train
HPM673
Motor Operated Valve 3HP-14 Transfers Position
HHP0014MVT
2.50E-06
No Flow Through Operating Purification Demineralizer Train
HPM672
Page 55
No Flow To Purification Demineralizer Trains From 3HP-195
HPM671
Page 56
Air-Operated Valve 3HP-17 Transfers Closed
HHP0017AVT
1.52E-05
Loss Of Power On 208/120 V ac Panelboard 3KD
P2C3KD
4.40E-05
208/120 V ac Panelboard 3KD Breaker 18 Transfers Open (3HP-17)
HHPKD18CLT
1.41E-05
Loss of Auxiliary Air System Pressure
AUXAIRTOP
1.20E-04

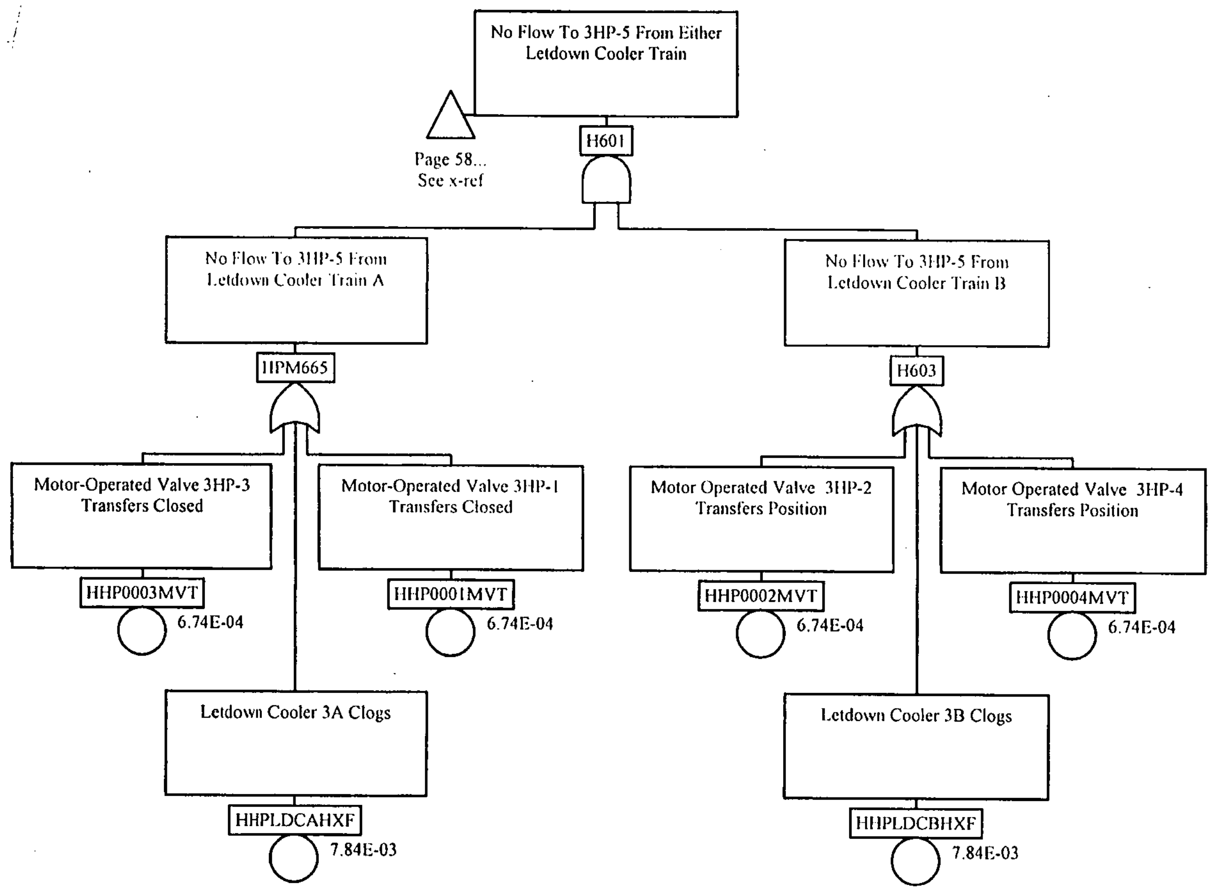

No Flow Through Operating Purification Demineralizer Train
HPM672
Page 54...
See x-ref
Check Valve 3HP-47 Transfers Closed
HHP0047CVT
3.31E-06
Loss Of Power On 208/120 V ac Panelboard 3KD
P2C3KD
3
4.40E-05
Purification Demineralizer 3A Fails To Pass Flow
3.79E-05
208/120 V ac Panelboard 3KD Breaker 17 Transfers Open (3HP-8)
1.11E-05
Air-Operated Valve 3HP-8 Transfers Closed
HHP0008AVT
1.52E-05
Loss of Auxiliary Air System Pressure
AUXAIRTOP
6
1.20E-04

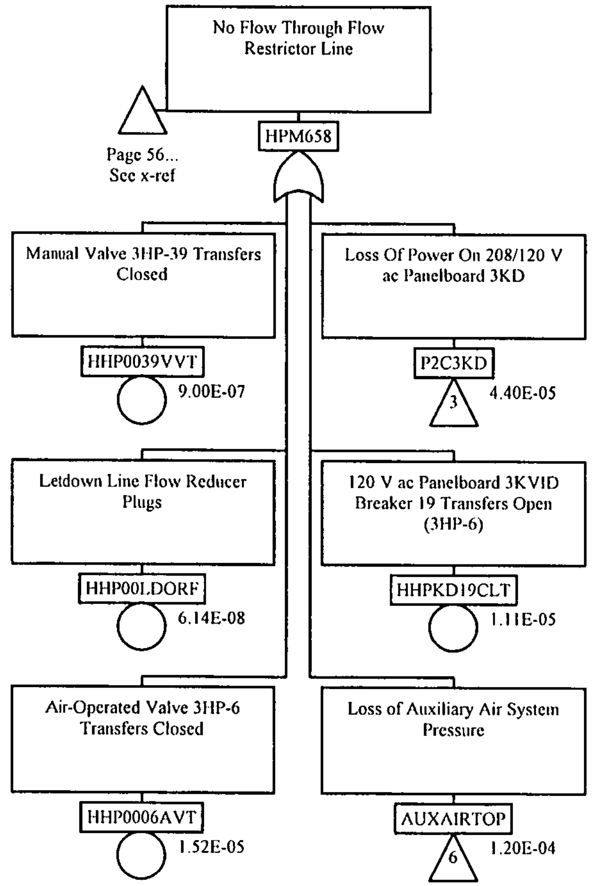

No Flow To Purification Demineralizer Trains From 3HP-195
HPM671
Page 54... See x-ref
No Flow To 3HP-195
HPM670
Manual Valve 3HP-195 Transfers Closed
HHP0195VVT
9.00E-07
No Flow To 3HP-195 From 3HP-41
HPM669
No Flow To 3HP-195 From Flow Restrictor Line
HPM659
No Flow Through 3HP-40, 3HP-7, Or 3HP-41
HPM668
Page 57
No Flow To 3HP-6 Or 3HP-40 From 3HP-5
HPM667
Page 58
No Flow To 3HP-6 Or 3HP-40 From 3HP-5
HPM667
Page 58
No Flow Through Flow Restrictor Line
HPM658
Page 60

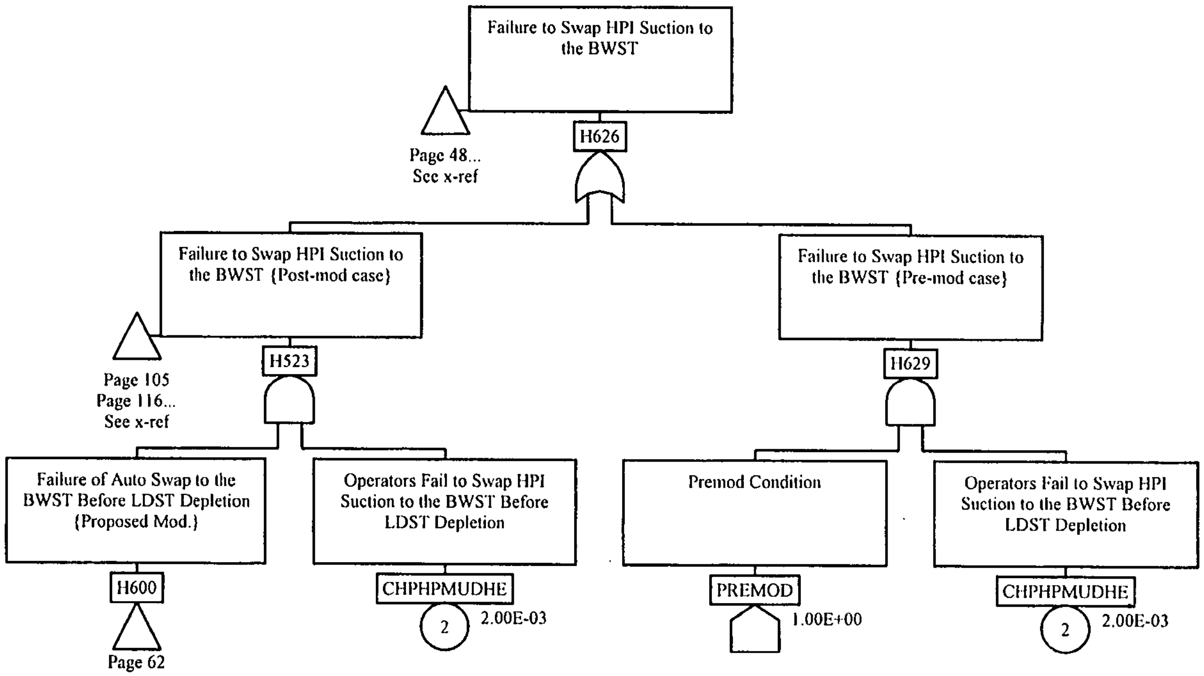


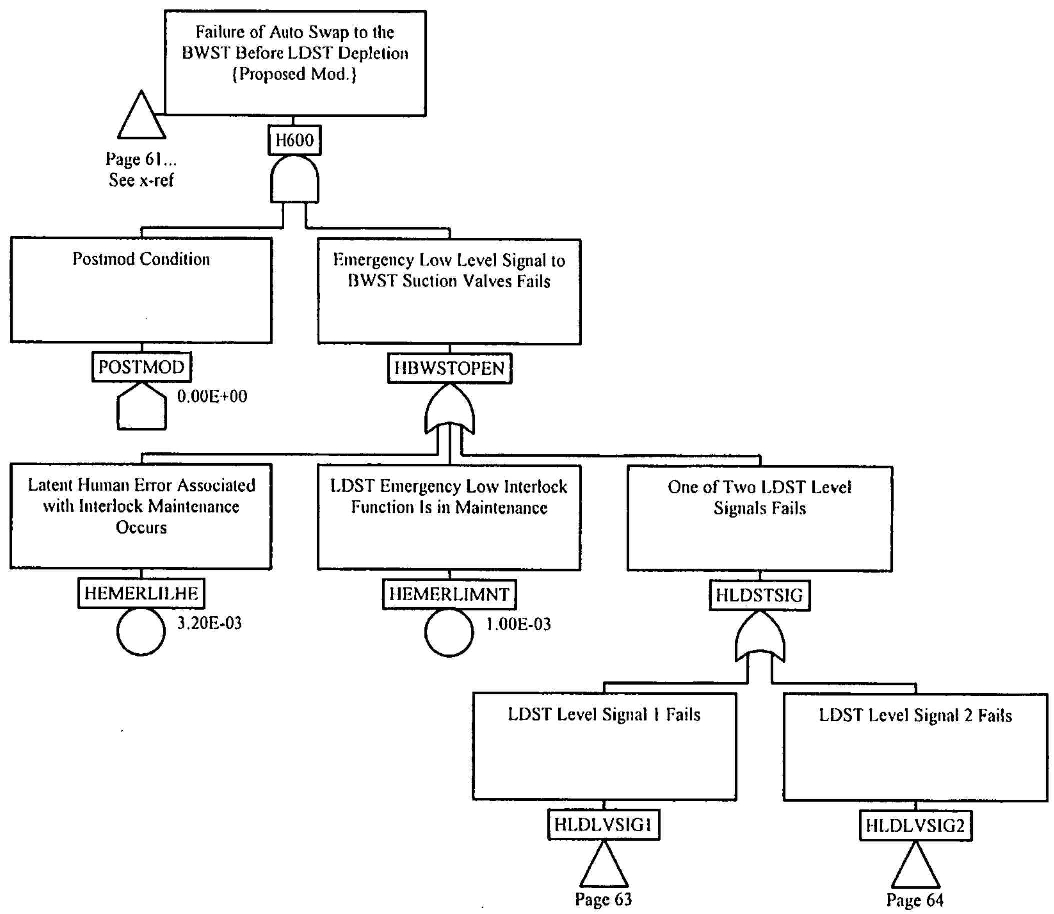
No Flow Through 3HP-40, 3HP-7, Or 3HP-41
HPM668
Page 56... See x-ref
Manual Valve 3HP-41 Transfers Closed
HHP0041VVT
9.00E-07
Manual Valve 3HP-40 Transfers Closed
HHP0040VVT
9.00E-07
Air-Operated Valve 3HP-7 Transfers Closed
HHP0007AVT
1.52E-05
3HP-7 Transfers Closed on Loss of Power
HPM668AC
Loss of Auxiliary Air System Pressure
AUXAIRTOP
6
1.20E-04
Loss of Power on 240/120 V ac Power Panelboards 3KI and 3KU
HD3KIKU
120 V ac Circuit Breaker 3KU-21 Transfers Opens (ICS Cab. 7)
HHPKU21CLT
1.11E-05
Loss of Power on 240/120 V ac Power Panelboard 3KI
D3KI
2
3.30E-05
Loss of Power on 240/120 V ac Power Panelboard 3KU
D3KU
2
3.30E-05

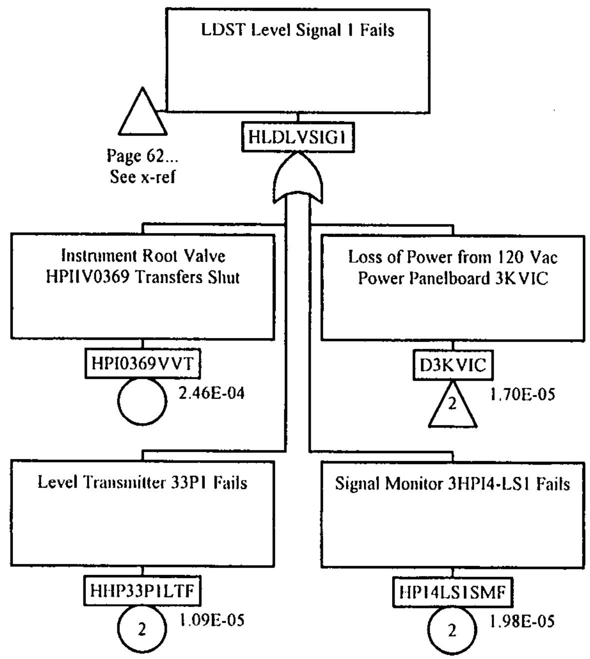

No Flow To 3HP-6 Or 3HP-40 From 3HP-5
HPM667
Page 56
Page 56...
See x-ref
3HP-5 Fails To Remain Open
HPM666
No Flow To 3HP-5 From Either Letdown Cooler Train
H601
Page 59
Air-Operated Valve 3HP-5 Transfers Closed
HHP0005AVT
1.52E-05
Solenoid Valve 3HPISV0090 Transfers Position
HHPSV90SVT
9.55E-06
125 V dc Panelboard 3DIB Breaker 25 Transfers Open (3CC-8, 3HP-5)
HDCIB25CDT
8.50E-06
High Letdown Temp Pressure
Spurious
Operation
HHP0157PST
1.42E-05
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB
2
1.50E-07
Low Instrument Air Pressure Switch 3IAPS0331 Spurious Operation
HHP0331PST
1.42E-05
Loss of Auxiliary Air System Pressure
AUXAIRTOP
6
1.20E-04

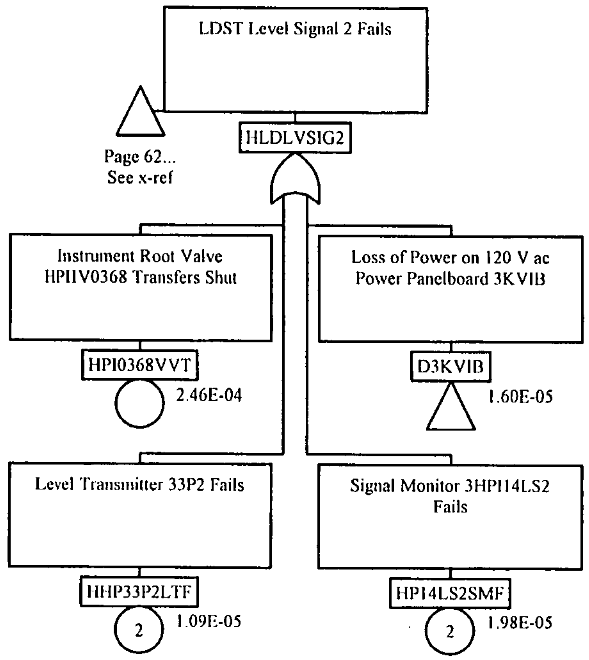

No Flow To 3HP-5 From Either Letdown Cooler Train
H601
Page 58...
See x-ref
No Flow To 3HP-5 From Letdown Cooler Train A
HPM665
No Flow To 3HP-5 From Letdown Cooler Train B
H603
Motor-Operated Valve 3HP-3 Transfers Closed
HHP0003MVT
6.74E-04
Motor-Operated Valve 3HP-1 Transfers Closed
HHP0001MVT
6.74E-04
Motor Operated Valve 3HP-2 Transfers Position
HHP0002MVT
6.74E-04
Motor Operated Valve 3HP-4 Transfers Position
HHP0004MVT
6.74E-04
Letdown Cooler 3A Clogs
HHPLDCAHXF
7.84E-03
Letdown Cooler 3B Clogs
HHPLDCBHXF
7.84E-03

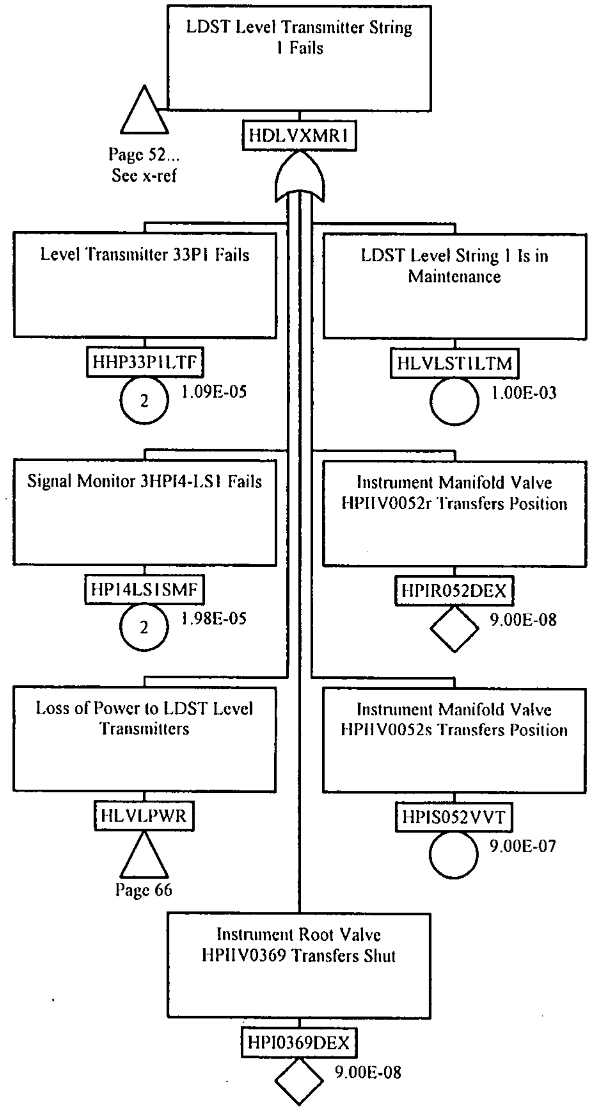

No Flow Through Flow Restrictor Line
HPM658
Page 56... See x-ref
Manual Valve 3HP-39 Transfers Closed
HHP0039VVT
9.00E-07
Loss Of Power On 208/120 V ac Panelboard 3KD
P2C3KD
3
4.40E-05
Letdown Line Flow Reducer Plugs
HHP00LDORF
6.14E-08
120 V ac Panelboard 3KVID Breaker 19 Transfers Open (3HP-6)
HHPKD19CLT
1.11E-05
Air-Operated Valve 3HP-6 Transfers Closed
HHP0006AVT
1.52E-05
Loss of Auxiliary Air System Pressure
AUXAIRTOP
6
1.20E-04

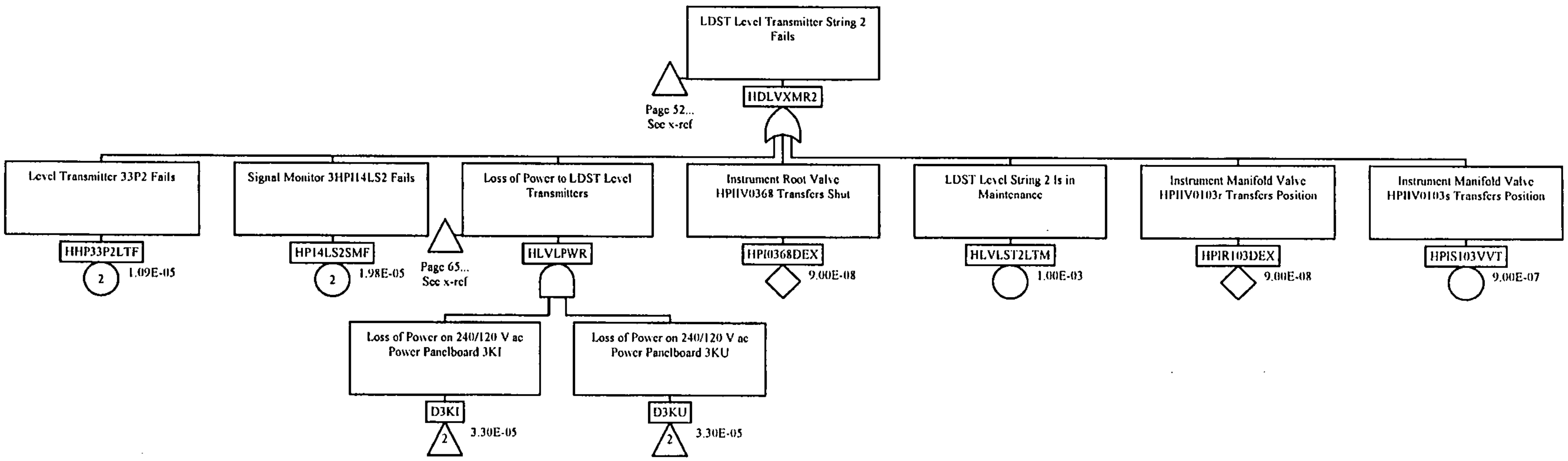

Failure to Swap HPI Suction to the BWST
H626
Page 48...
See x-ref
Failure to Swap HPI Suction to the BWST {Post-mod case}
H523
Page 105
Page 116...
See x-ref
Failure to Swap HPI Suction to the BWST {Pre-mod case}
H629
Failure of Auto Swap to the BWST Before LDST Depletion {Proposed Mod.}
H600
Page 62
Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion
CHPHPMUDHE
2
2.00E-03
Premod Condition
PREMOD
1.00E+00
Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion
CHPHPMUDHE
2
2.00E-03

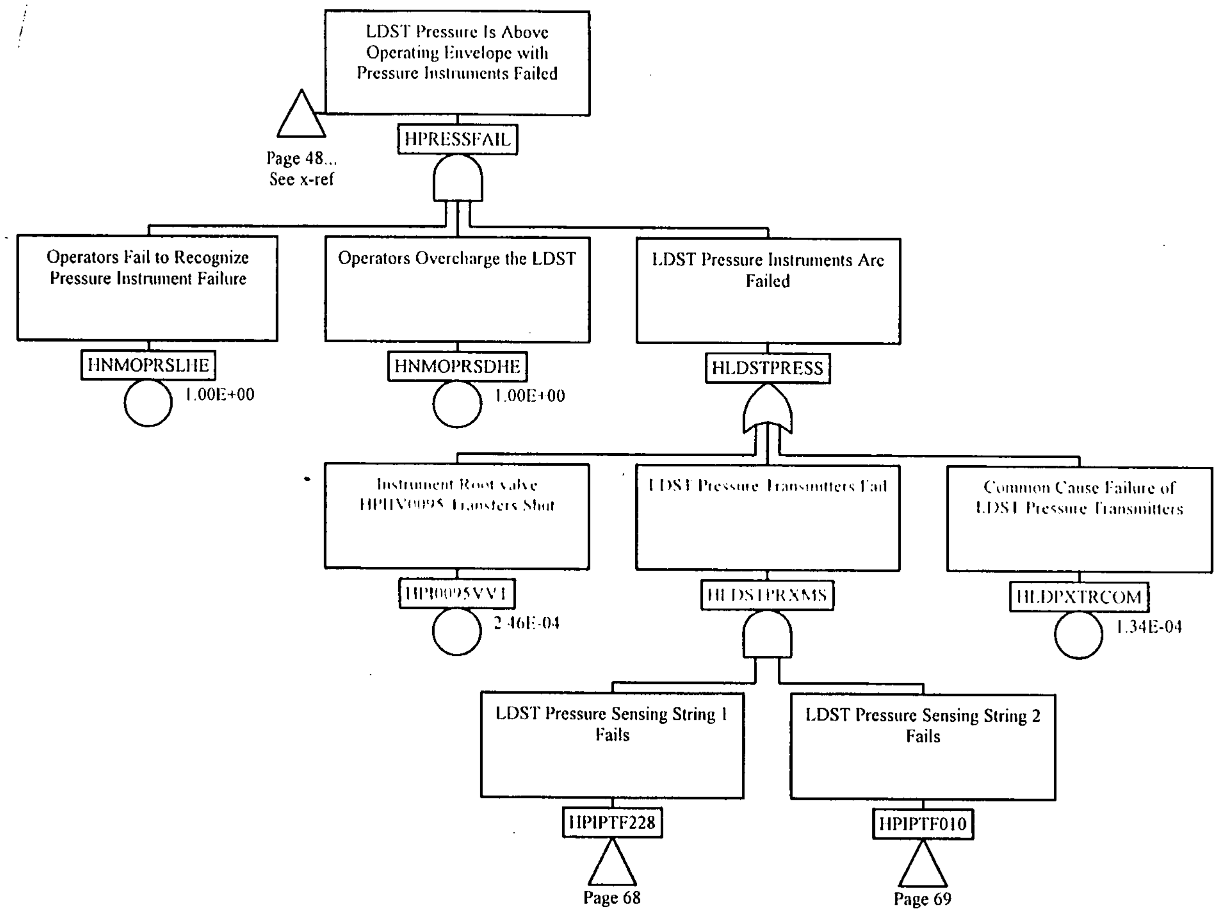

Failure of Auto Swap to the BWST Before LDST Depletion {Proposed Mod.}
Page 61... See x-ref
H600
Postmod Condition
POSTMOD
0.00E+00
Emergency Low Level Signal to BWST Suction Valves Fails
HBWSTOPEN
Latent Human Error Associated with Interlock Maintenance Occurs
HEMERLILHE
3.20E-03
LDST Emergency Low Interlock Function Is in Maintenance
HEMERLIMNT
1.00E-03
One of Two LDST Level Signals Fails
HLDSTSIG
LDST Level Signal 1 Fails
HLDLVSIG1
Page 63
LDST Level Signal 2 Fails
HLDLVSIG2
Page 64


LDST Level Signal 1 Fails
HLDLVSIG1
Page 62...
See x-ref
Instrument Root Valve
HPIIV0369 Transfers Shut
HPI0369VVT
2.46E-04
Loss of Power from 120 Vac
Power Panelboard 3KVIC
D3KVIC
2
1.70E-05
Level Transmitter 33P1 Fails
HHP33P1LTF
2
1.09E-05
Signal Monitor 3HPI4-LS1 Fails
HPI4LS1SMF
2
1.98E-05

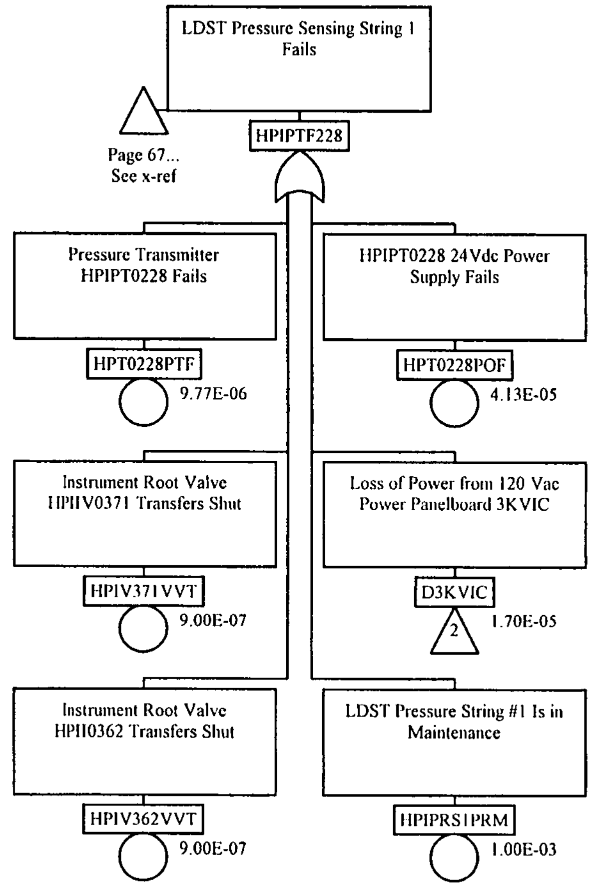

LDST Level Signal 2 Fails
HLDLVSIG2
Page 62...
See x-ref
Instrument Root Valve
HPIIV0368 Transfers Shut
HPI0368VVT
2.46E-04
Loss of Power on 120 V ac
Power Panelboard 3KVIB
D3KVIB
1.60E-05
Level Transmitter 33P2 Fails
HHP33P2LTF
2
1.09E-05
Signal Monitor 3HPI14LS2
Fails
HP14LS2SMF
2
1.98E-05

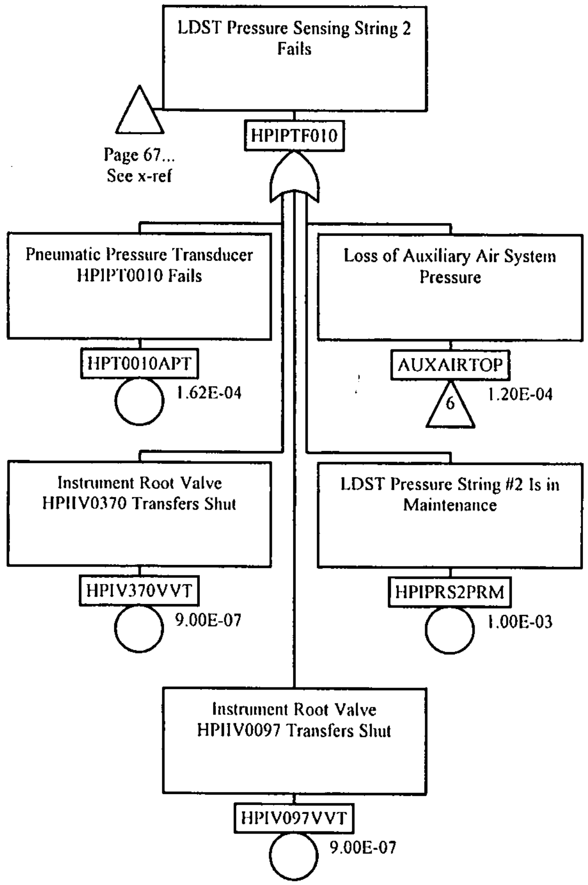

LDST Level Transmitter String 1 Fails
HDLVXMR1
Page 52...
See x-ref
Level Transmitter 33P1 Fails
HHP33P1LTF
2
1.09E-05
LDST Level String 1 Is in Maintenance
HLVLST1LTM
1.00E-03
Signal Monitor 3HPI4-LS1 Fails
HPI4LS1SMF
2
1.98E-05
Instrument Manifold Valve HPIIV0052r Transfers Position
HPIR052DEX
9.00E-08
Loss of Power to LDST Level Transmitters
HLVLPWR
Page 66
Instrument Manifold Valve HPIIV0052s Transfers Position
HPIS052VVT
9.00E-07
Instrument Root Valve HPIIV0369 Transfers Shut
HPI0369DEX
9.00E-08

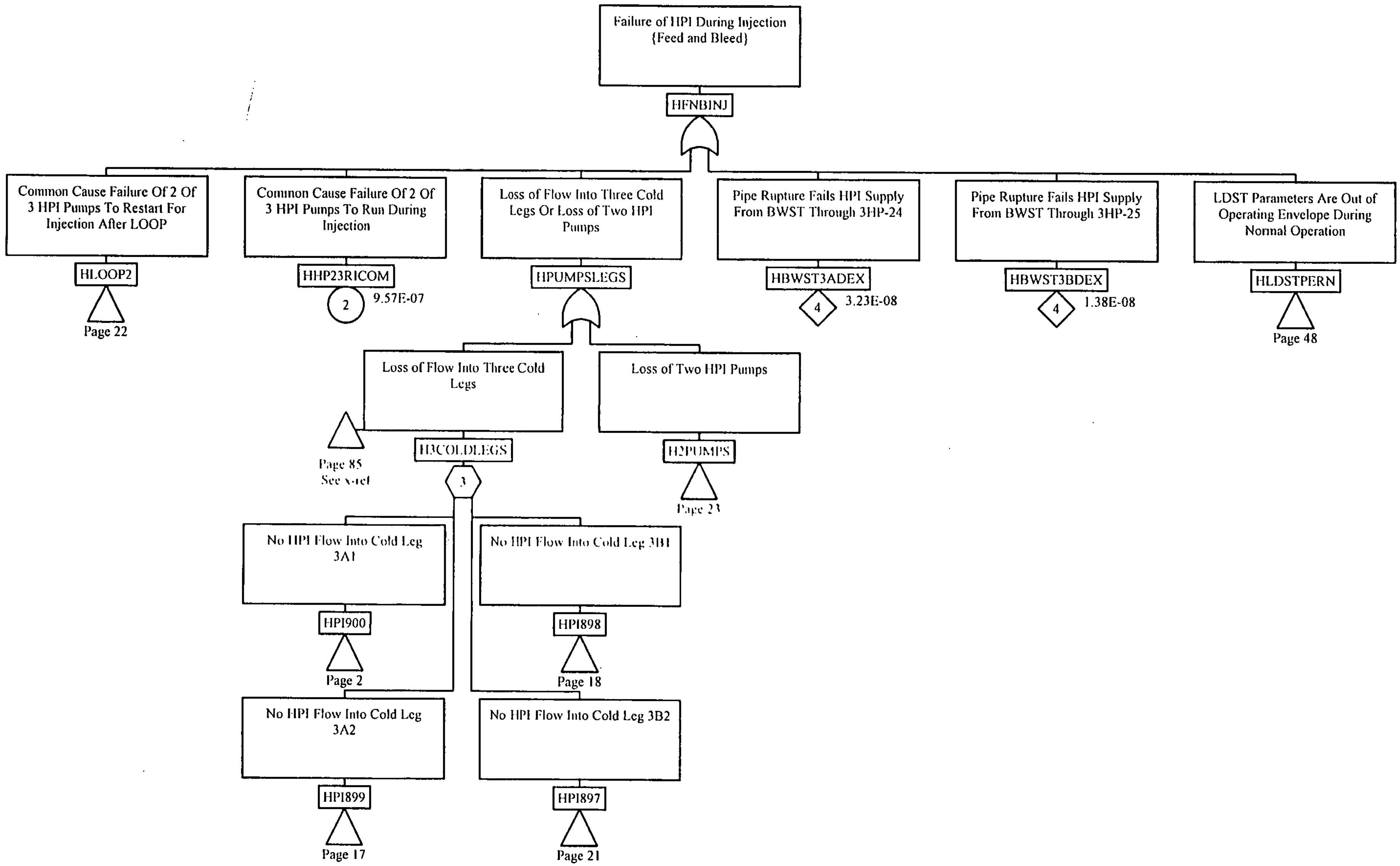

LDST Level Transmitter String 2 Fails
HDLVXMR2
Page 52...
See x-ref
Level Transmitter 33P2 Fails
HHP33P2LTF
2
1.09E-05
Signal Monitor 3HPI14LS2 Fails
HPI4LS2SMF
2
1.98E-05
Page 65...
See x-ref
Loss of Power to LDST Level Transmitters
HLVLPWR
Instrument Root Valve HPIIV0368 Transfers Shut
HPI0368DEX
9.00E-08
LDST Level String 2 Is in Maintenance
HLVLST2LTM
1.00E-03
Instrument Manifold Valve HPIIV0103r Transfers Position
HPIR103DEX
9.00E-08
Instrument Manifold Valve HPIIV0103s Transfers Position
HPIS103VVT
9.00E-07
Loss of Power on 240/120 V ac Power Panelboard 3KI
D3KI
2
3.30E-05
Loss of Power on 240/120 V ac Power Panelboard 3KU
D3KU
2
3.30E-05

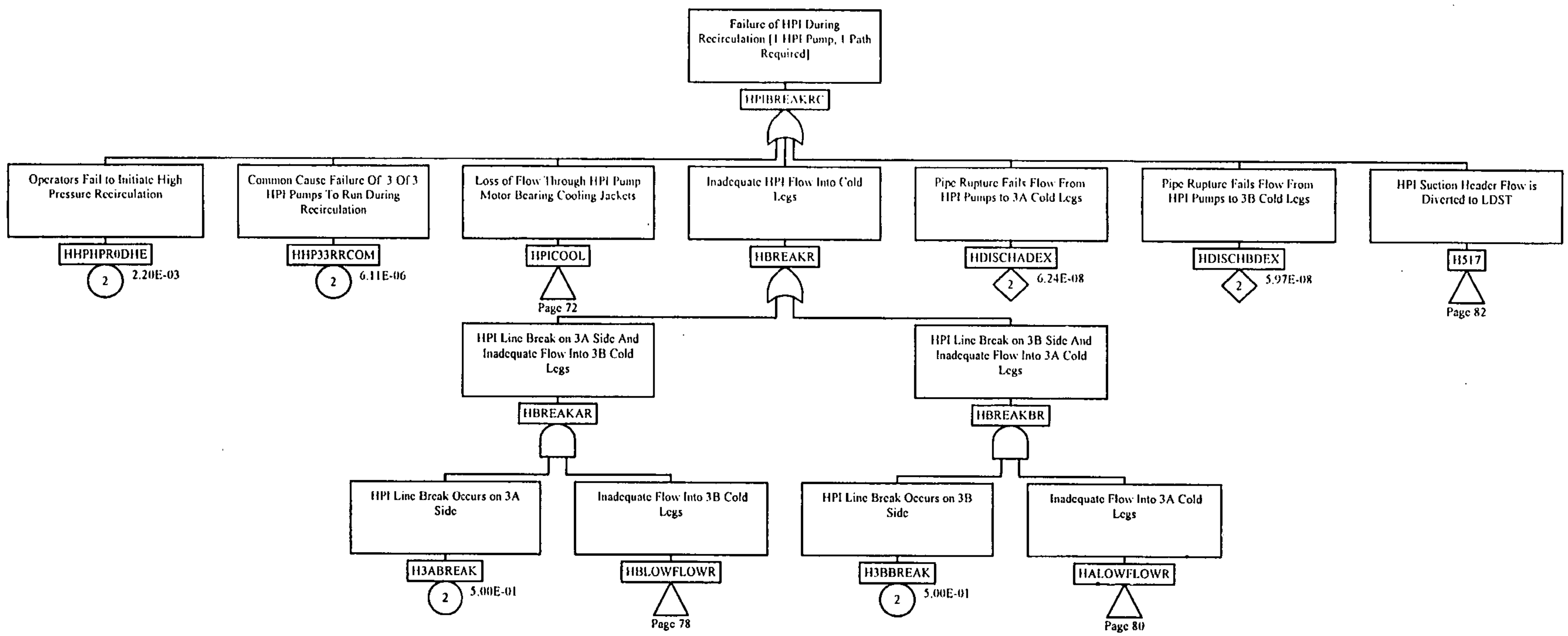


LDST Pressure Is Above Operating Envelope with Pressure Instruments Failed
HPRESSFAIL
Page 48... See x-ref
Operators Fail to Recognize Pressure Instrument Failure
HNMOPRSLHE
1.00E+00
Operators Overcharge the LDST
HNMOPRSDHE
1.00E+00
LDST Pressure Instruments Are Failed
HLDSTPRESS
Instrument Root Valve HPHV0095 Transfers Shut
HPI0095VV1
2.46E-04
LDST Pressure Transmitters Fail
HLDSTPRXMS
Common Cause Failure of LDST Pressure Transmitters
HLDPXTRCOM
1.34E-04
LDST Pressure Sensing String 1 Fails
HPIPTF228
Page 68
LDST Pressure Sensing String 2 Fails
HPIPTF010
Page 69

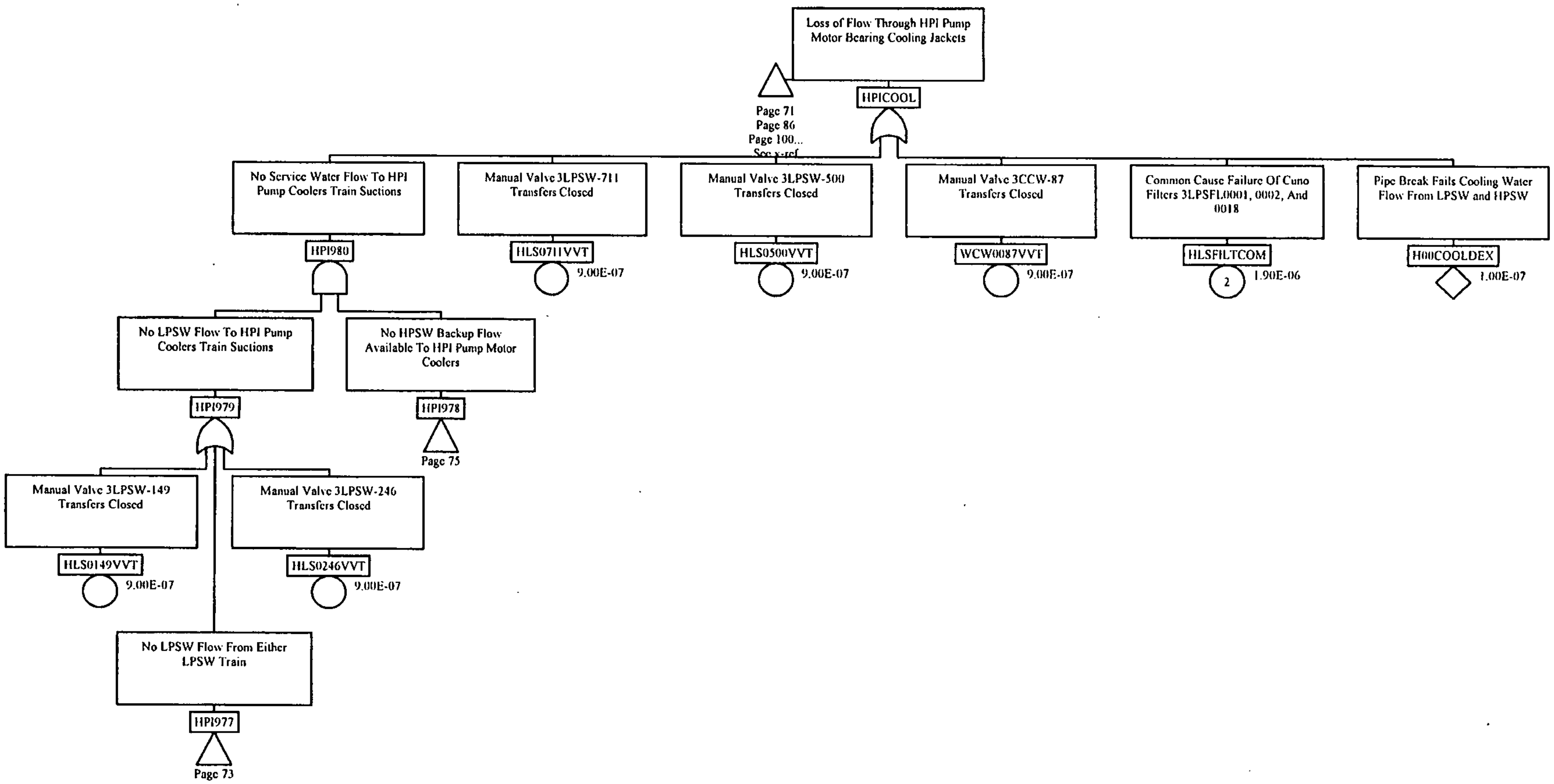

LDST Pressure Sensing String 1 Fails
HPIPTF228
Page 67... See x-ref
Pressure Transmitter HPIPT0228 Fails
HPT0228PTF
9.77E-06
HPIPT0228 24Vdc Power Supply Fails
HPT0228POF
4.13E-05
Instrument Root Valve HPIIV0371 Transfers Shut
HPIV371VVT
9.00E-07
Loss of Power from 120 Vac Power Panelboard 3KVIC
D3KVIC
2
1.70E-05
Instrument Root Valve HPII0362 Transfers Shut
HPIV362VVT
9.00E-07
LDST Pressure String #1 Is in Maintenance
HPIPRS1PRM
1.00E-03


LDST Pressure Sensing String 2 Fails
HPIPTF010
Page 67...
See x-ref
Pneumatic Pressure Transducer HPIPT0010 Fails
HPT0010APT
1.62E-04
Loss of Auxiliary Air System Pressure
AUXAIRTOP
6
1.20E-04
Instrument Root Valve HPIIV0370 Transfers Shut
HPIV370VVT
9.00E-07
LDST Pressure String #2 Is in Maintenance
HPIPRS2PRM
1.00E-03
Instrument Root Valve HPIIV0097 Transfers Shut
HPIV097VVT
9.00E-07

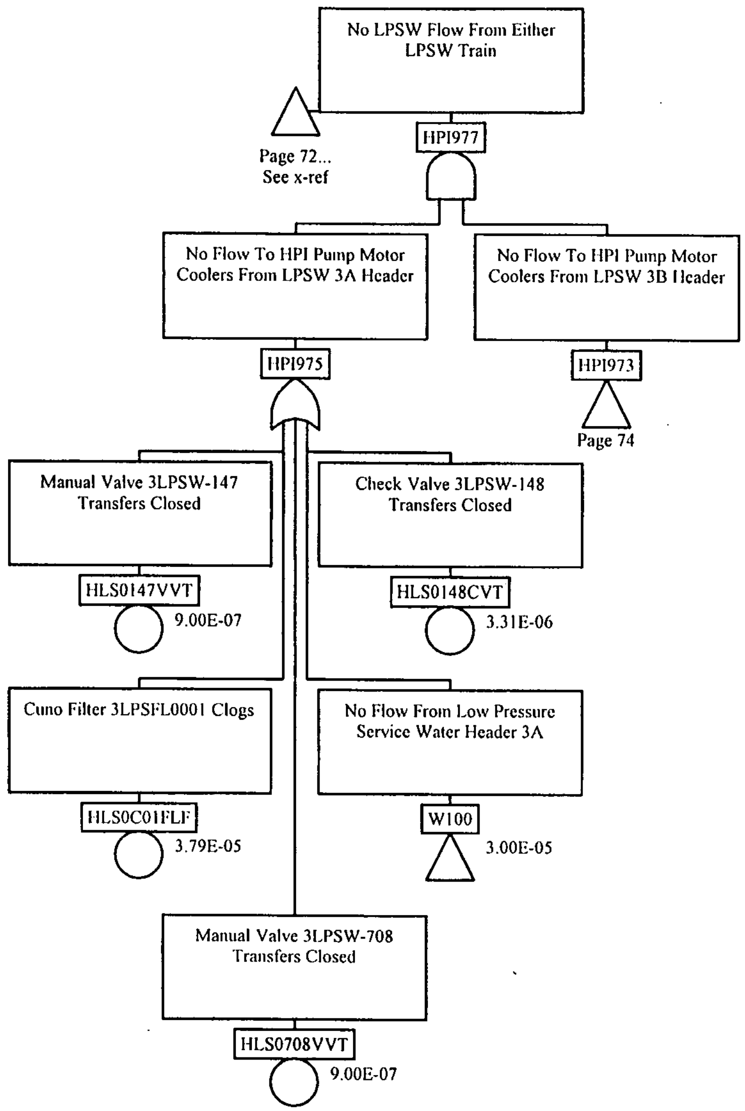

Failure of HPI During Injection (Feed and Bleed)
HFNBINJ
Common Cause Failure Of 2 Of 3 HPI Pumps To Restart For Injection After LOOP
HLOOP2
Page 22
Common Cause Failure Of 2 Of 3 HPI Pumps To Run During Injection
HHP23RICOM
2
9.57E-07
Loss of Flow Into Three Cold Legs Or Loss of Two HPI Pumps
HPUMPSLEGS
Pipe Rupture Fails HPI Supply From BWST Through 3HP-24
HBWST3ADEX
4
3.23E-08
Pipe Rupture Fails HPI Supply From BWST Through 3HP-25
HBWST3BDEX
4
1.38E-08
LDST Parameters Are Out of Operating Envelope During Normal Operation
HLDSTPERN
Page 48
Loss of Flow Into Three Cold Legs
H3COLDLEGS
3
Page 85
See x-ref
Loss of Two HPI Pumps
H2PUMPS
Page 23
No HPI Flow Into Cold Leg 3A1
HPI900
Page 2
No HPI Flow Into Cold Leg 3B1
HPI898
Page 18
No HPI Flow Into Cold Leg 3A2
HPI899
Page 17
No HPI Flow Into Cold Leg 3B2
HPI897
Page 21

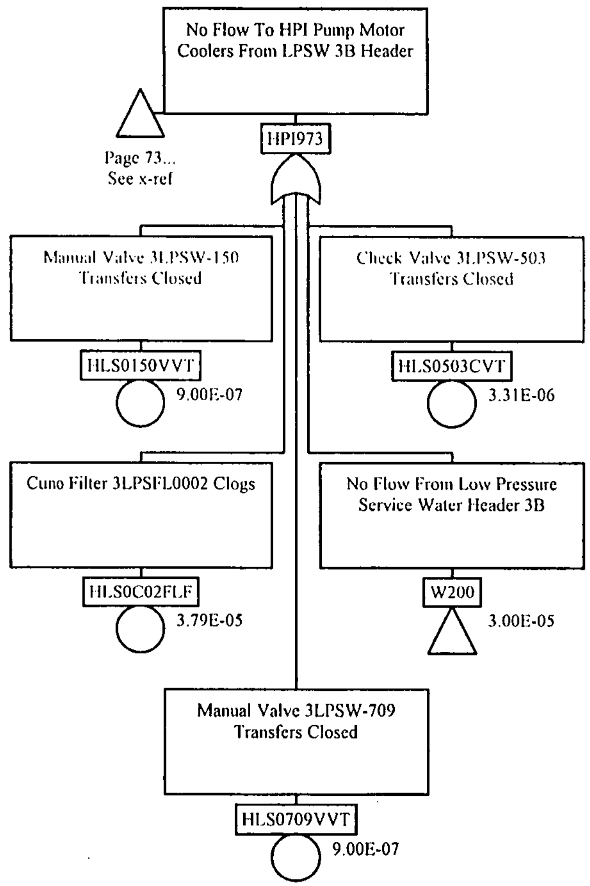


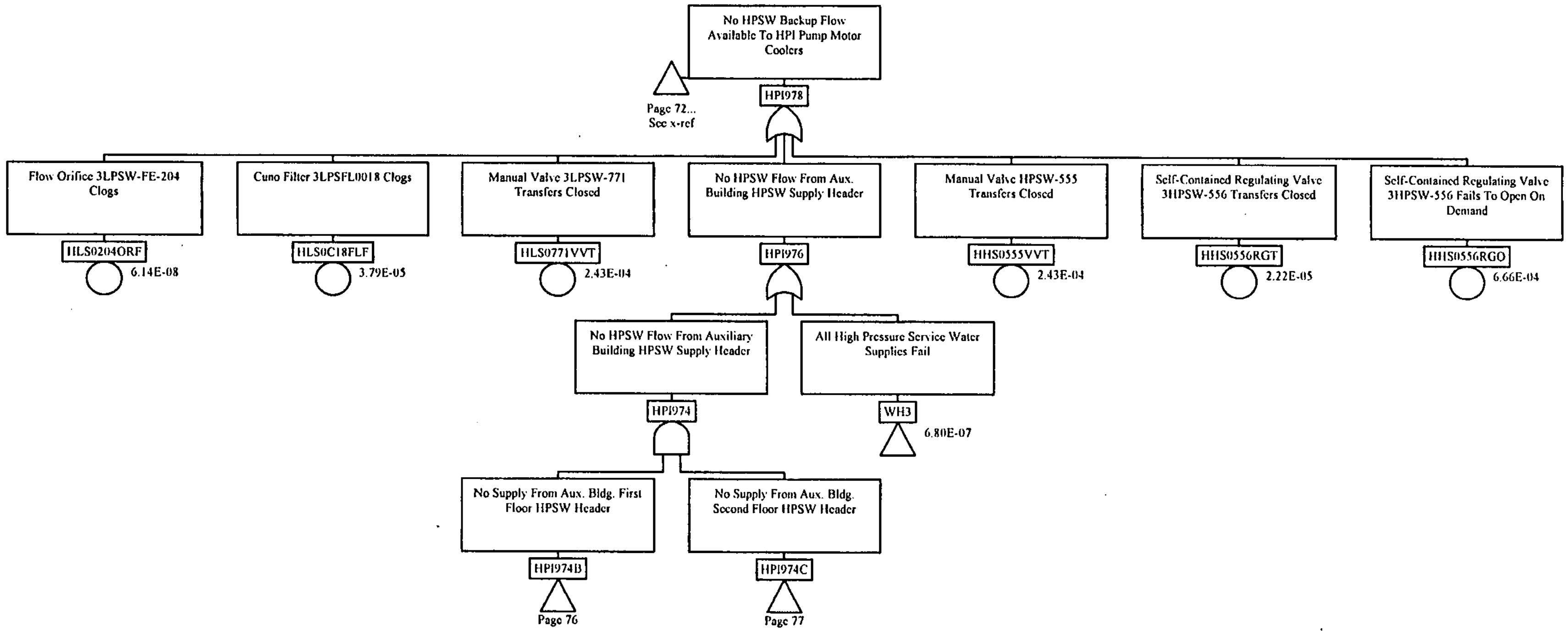
Failure of HPI During Recirculation [1 HPI Pump, 1 Path Required]
HPIBREAKRC
Operators Fail to Initiate High Pressure Recirculation
HHPHPR0DHE
2
2.20E-03
Common Cause Failure Of 3 Of 3 HPI Pumps To Run During Recirculation
HHP33RRCOM
2
6.11E-06
Loss of Flow Through HPI Pump Motor Bearing Cooling Jackets
HPICOOL
Page 72
Inadequate HPI Flow Into Cold Legs
HBREAKR
Pipe Rupture Fails Flow From HPI Pumps to 3A Cold Legs
HDISCHADEX
2
6.24E-08
Pipe Rupture Fails Flow From HPI Pumps to 3B Cold Legs
HDISCHBDEX
2
5.97E-08
HPI Suction Header Flow is Diverted to LDST
H517
Page 82
HPI Line Break on 3A Side And Inadequate Flow Into 3B Cold Legs
HBREAKAR
HPI Line Break on 3B Side And Inadequate Flow Into 3A Cold Legs
HBREAKBR
HPI Line Break Occurs on 3A Side
H3ABREAK
2
5.00E-01
Inadequate Flow Into 3B Cold Legs
HBLOWFLOWR
Page 78
HPI Line Break Occurs on 3B Side
H3BBREAK
2
5.00E-01
Inadequate Flow Into 3A Cold Legs
HALOWFLOWR
Page 80

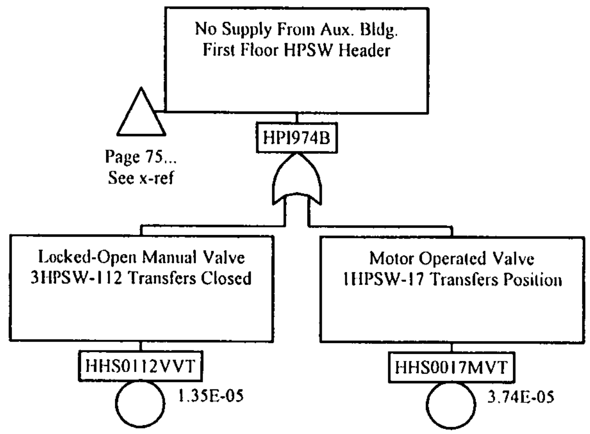


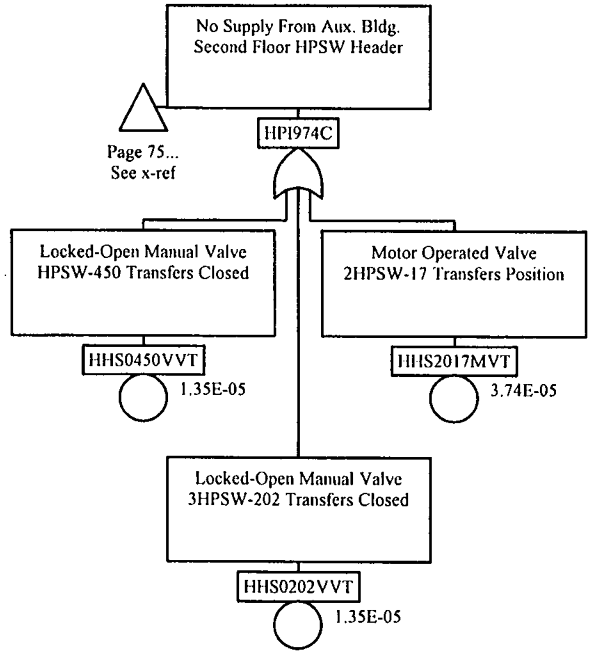
Loss of Flow Through HPI Pump Motor Bearing Cooling Jackets
HPICOOL
Page 71
Page 86
Page 100...
No Service Water Flow To HPI Pump Coolers Train Suctions
HPI980
Manual Valve 3LPSW-711 Transfers Closed
HLS0711VVT
9.00E-07
Manual Valve 3LPSW-500 Transfers Closed
HLS0500VVT
9.00E-07
Manual Valve 3CCW-87 Transfers Closed
WCW0087VVT
9.00E-07
Common Cause Failure Of Cuno Filters 3LPSFL0001, 0002, And 0018
HLSFILTCOM
2
1.90E-06
Pipe Break Fails Cooling Water Flow From LPSW and HPSW
H00COOLDEX
1.00E-07
No LPSW Flow To HPI Pump Coolers Train Suctions
HPI979
No HPSW Backup Flow Available To HPI Pump Motor Coolers
HPI978
Page 75
Manual Valve 3LPSW-149 Transfers Closed
HLS0149VVT
9.00E-07
Manual Valve 3LPSW-246 Transfers Closed
HLS0246VVT
9.00E-07
No LPSW Flow From Either LPSW Train
HPI977
Page 73


No LPSW Flow From Either LPSW Train
HPI977
Page 72... See x-ref
No Flow To HPI Pump Motor Coolers From LPSW 3A Header
No Flow To HPI Pump Motor Coolers From LPSW 3B Header
HPI975
HPI973
Page 74
Manual Valve 3LPSW-147 Transfers Closed
HLS0147VVT
9.00E-07
Check Valve 3LPSW-148 Transfers Closed
HLS0148CVT
3.31E-06
Cuno Filter 3LPSFL0001 Clogs
HLS0C01FLF
3.79E-05
No Flow From Low Pressure Service Water Header 3A
W100
3.00E-05
Manual Valve 3LPSW-708 Transfers Closed
HLS0708VVT
9.00E-07

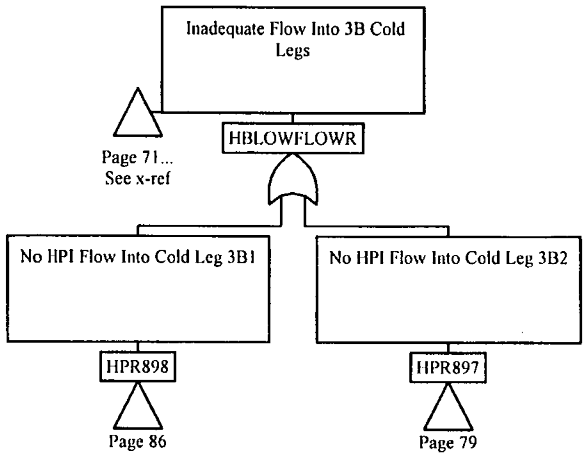

No Flow To HPI Pump Motor Coolers From LPSW 3B Header
HPI973
Page 73... See x-ref
Manual Valve 3LPSW-150 Transfers Closed
HLS0150VVT
9.00E-07
Check Valve 3LPSW-503 Transfers Closed
HLS0503CVT
3.31E-06
Cuno Filter 3LPSFL0002 Clogs
HLS0C02FLF
3.79E-05
No Flow From Low Pressure Service Water Header 3B
W200
3.00E-05
Manual Valve 3LPSW-709 Transfers Closed
HLS0709VVT
9.00E-07

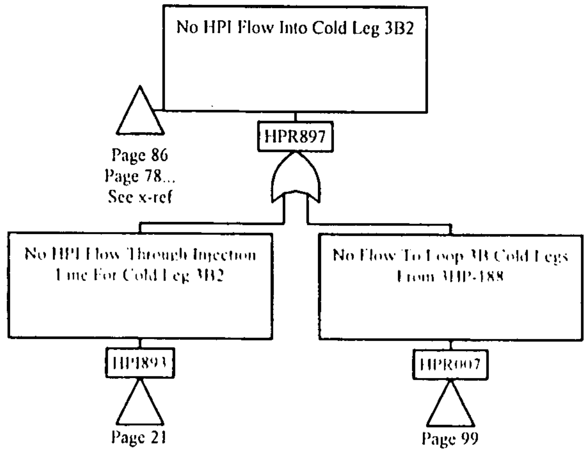

No HPSW Backup Flow Available To HPI Pump Motor Coolers
HPI978
Page 72... See x-ref
Flow Orifice 3LPSW-FE-204 Clogs
HLS0204ORF
6.14E-08
Cuno Filter 3LPSFL0018 Clogs
HLS0C18FLF
3.79E-05
Manual Valve 3LPSW-771 Transfers Closed
HLS0771VVT
2.43E-04
No HPSW Flow From Aux. Building HPSW Supply Header
HPI976
Manual Valve HPSW-555 Transfers Closed
HHS0555VVT
2.43E-04
Self-Contained Regulating Valve 3HPSW-556 Transfers Closed
HHS0556RGT
2.22E-05
Self-Contained Regulating Valve 3HPSW-556 Fails To Open On Demand
HHS0556RGO
6.66E-04
No HPSW Flow From Auxiliary Building HPSW Supply Header
HPI974
All High Pressure Service Water Supplies Fail
WH3
6.80E-07
No Supply From Aux. Bldg. First Floor HPSW Header
HPI974B
Page 76
No Supply From Aux. Bldg. Second Floor HPSW Header
HPI974C
Page 77


No Supply From Aux. Bldg. First Floor HPSW Header
HPI974B
Page 75...
See x-ref
Locked-Open Manual Valve 3HPSW-112 Transfers Closed
HHS0112VVT
1.35E-05
Motor Operated Valve 1HPSW-17 Transfers Position
HHS0017MVT
3.74E-05

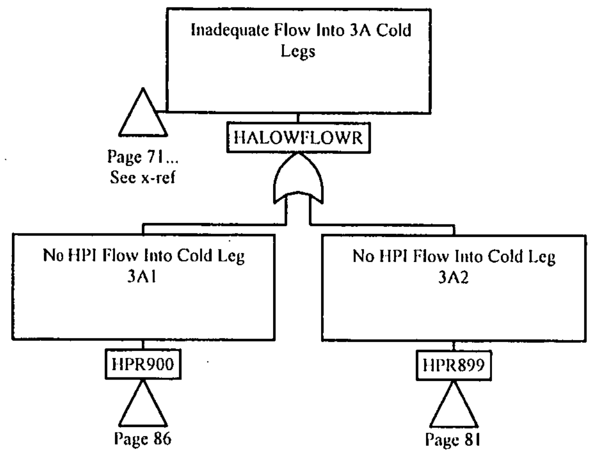


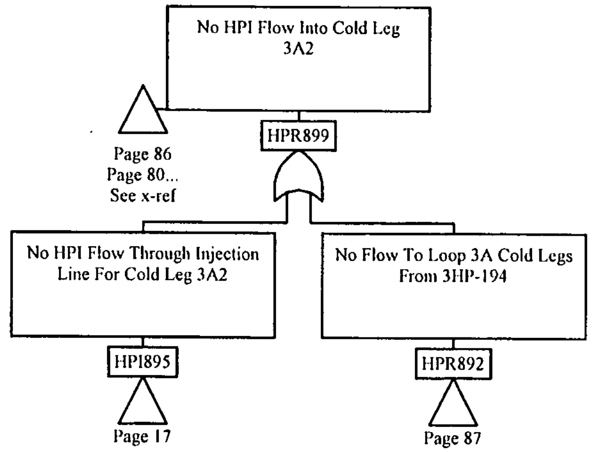
No Supply From Aux. Bldg. Second Floor HPSW Header
HPI974C
Page 75...
See x-ref
Locked-Open Manual Valve HPSW-450 Transfers Closed
HHS0450VVT
1.35E-05
Motor Operated Valve 2HPSW-17 Transfers Position
HHS2017MVT
3.74E-05
Locked-Open Manual Valve 3HPSW-202 Transfers Closed
HHS0202VVT
1.35E-05


Inadequate Flow Into 3B Cold Legs
HBLOWFLOWR
Page 71...
See x-ref
No HPI Flow Into Cold Leg 3B1
No HPI Flow Into Cold Leg 3B2
HPR898
HPR897
Page 86
Page 79

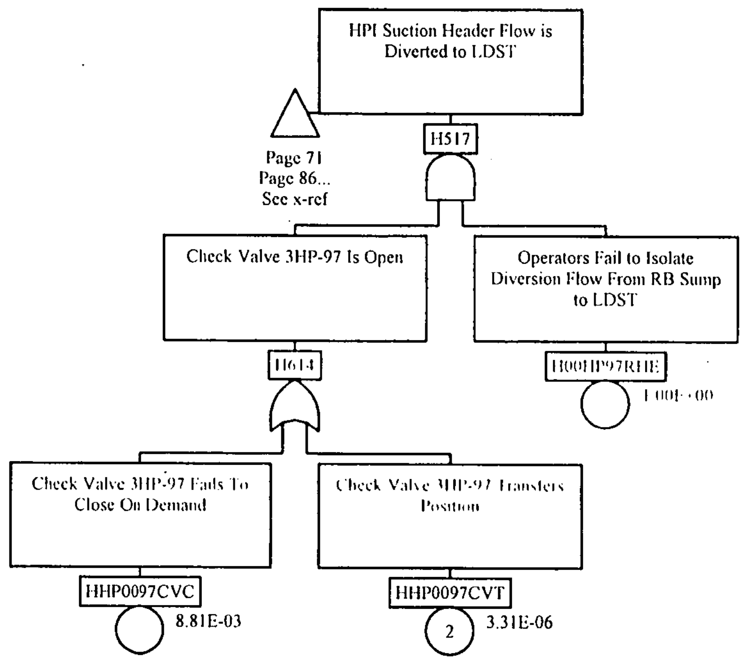


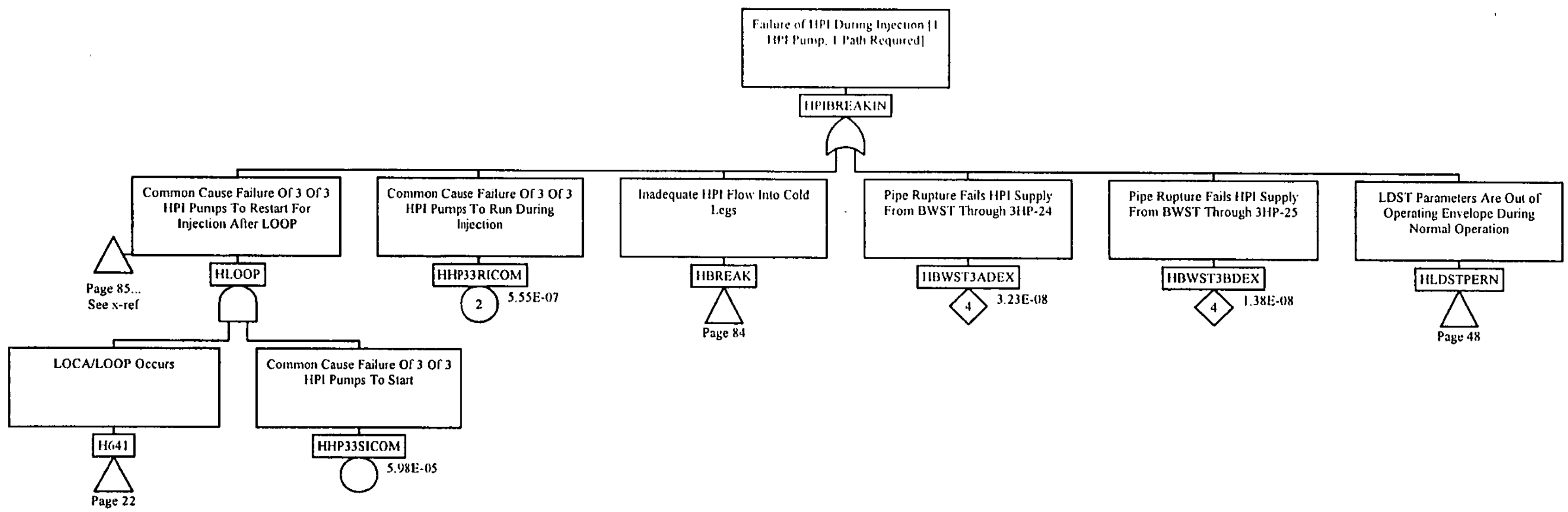
No HPI Flow Into Cold Leg 3B2
HPR897
Page 86
Page 78...
See x-ref
No HPI Flow Through Injection Line For Cold Leg 3B2
HPI893
Page 21
No Flow To Loop 3B Cold Legs From 3HP-188
HPR007
Page 99


Inadequate Flow Into 3A Cold Legs
HALOWFLOWR
Page 71...
See x-ref
No HPI Flow Into Cold Leg 3A1
No HPI Flow Into Cold Leg 3A2
HPR900
HPR899
Page 86
Page 81

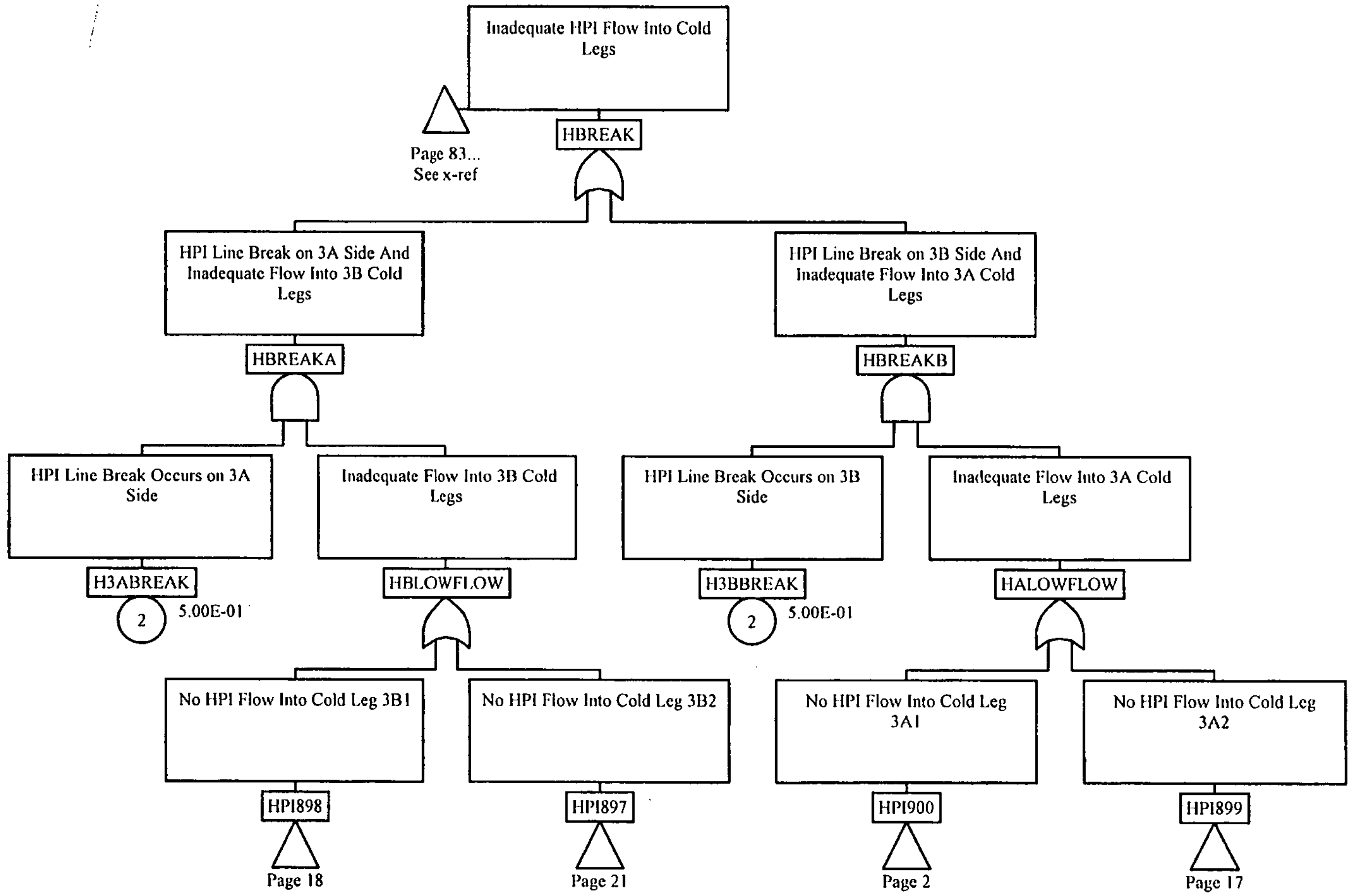


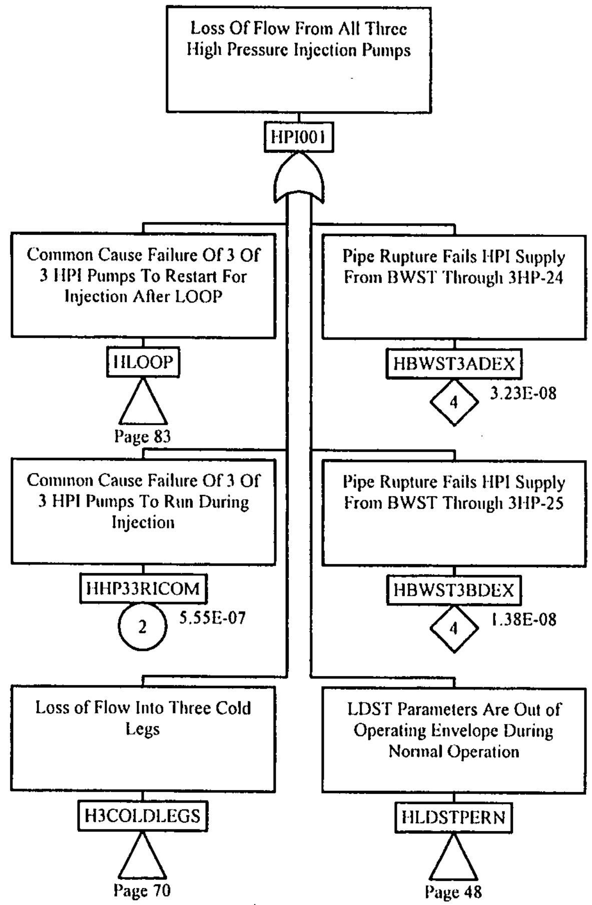
No HPI Flow Into Cold Leg 3A2
HPR899
Page 86
Page 80...
See x-ref
No HPI Flow Through Injection Line For Cold Leg 3A2
HPI895
Page 17
No Flow To Loop 3A Cold Legs From 3HP-194
HPR892
Page 87

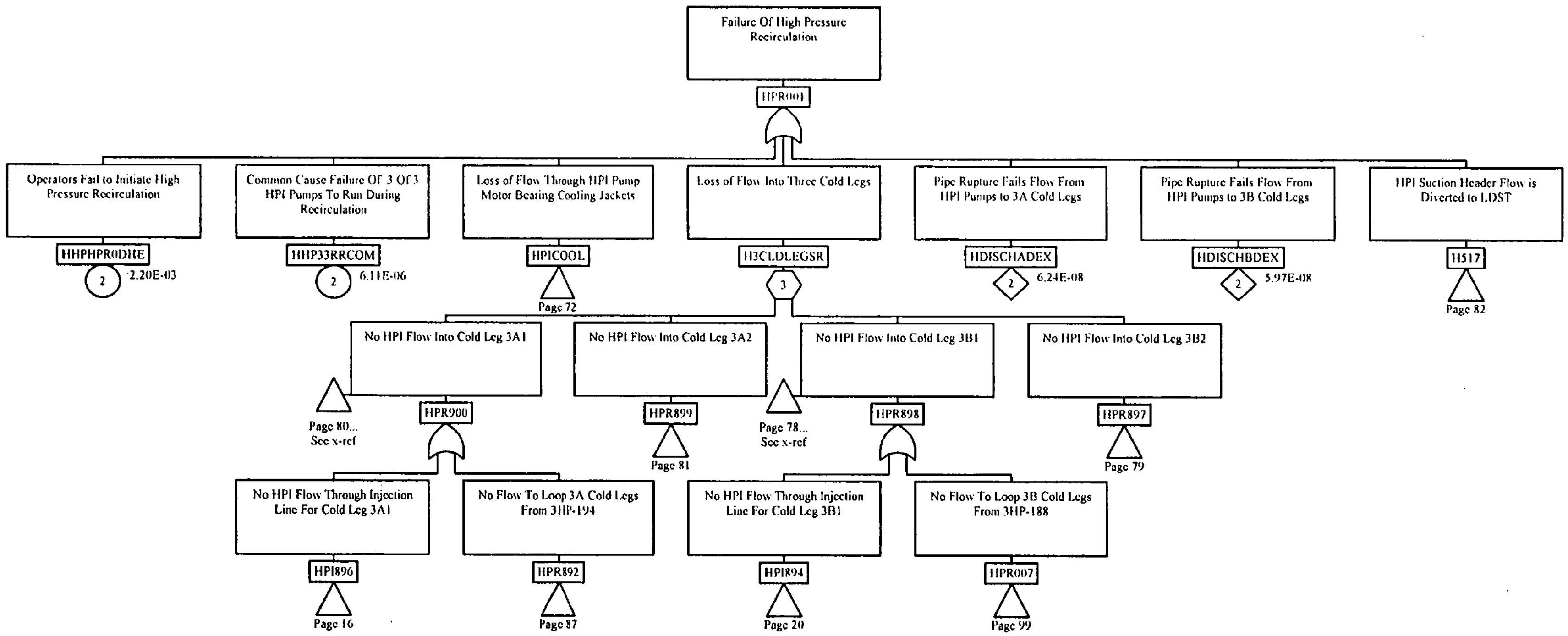

HPI Suction Header Flow is Diverted to LDST
H517
Page 71
Page 86...
See x-ref
Check Valve 3HP-97 Is Open
Operators Fail to Isolate Diversion Flow From RB Sump to LDST
H614
H00HP97RHE
1.00E+00
Check Valve 3HP-97 Fails To Close On Demand
Check Valve 3HP-97 Transfers Position
HHP0097CVC
8.81E-03
HHP0097CVT
2
3.31E-06



Failure of HPI During Injection [1 HPI Pump, 1 Path Required]
HPIBREAKIN
Common Cause Failure Of 3 Of 3 HPI Pumps To Restart For Injection After LOOP
HLOOP
Page 85... See x-ref
LOCA/LOOP Occurs
H641
Page 22
Common Cause Failure Of 3 Of 3 HPI Pumps To Start
HHP33SICOM
5.98E-05
Common Cause Failure Of 3 Of 3 HPI Pumps To Run During Injection
HHP33RICOM
2
5.55E-07
Inadequate HPI Flow Into Cold Legs
HBREAK
Page 84
Pipe Rupture Fails HPI Supply From BWST Through 3HP-24
HBWST3ADEX
4
3.23E-08
Pipe Rupture Fails HPI Supply From BWST Through 3HP-25
HBWST3BDEX
4
1.38E-08
LDST Parameters Are Out of Operating Envelope During Normal Operation
HLDSTPERN
Page 48


Inadequate HPI Flow Into Cold Legs
HBREAK
Page 83... See x-ref
HPI Line Break on 3A Side And Inadequate Flow Into 3B Cold Legs
HBREAKA
HPI Line Break on 3B Side And Inadequate Flow Into 3A Cold Legs
HBREAKB
HPI Line Break Occurs on 3A Side
H3ABREAK
2
5.00E-01
Inadequate Flow Into 3B Cold Legs
HBLOWFLOW
HPI Line Break Occurs on 3B Side
H3BBREAK
2
5.00E-01
Inadequate Flow Into 3A Cold Legs
HALOWFLOW
No HPI Flow Into Cold Leg 3B1
HPI898
Page 18
No HPI Flow Into Cold Leg 3B2
HPI897
Page 21
No HPI Flow Into Cold Leg 3A1
HPI900
Page 2
No HPI Flow Into Cold Leg 3A2
HPI899
Page 17


Loss Of Flow From All Three High Pressure Injection Pumps
HPI001
Common Cause Failure Of 3 Of 3 HPI Pumps To Restart For Injection After LOOP
HLOOP
Page 83
Pipe Rupture Fails HPI Supply From BWST Through 3HP-24
HBWST3ADEX
4
3.23E-08
Common Cause Failure Of 3 Of 3 HPI Pumps To Run During Injection
HHP33RICOM
2
5.55E-07
Pipe Rupture Fails HPI Supply From BWST Through 3HP-25
HBWST3BDEX
4
1.38E-08
Loss of Flow Into Three Cold Legs
H3COLDLEGS
Page 70
LDST Parameters Are Out of Operating Envelope During Normal Operation
HLDSTPERN
Page 48



Failure Of High Pressure Recirculation
HPR001
Operators Fail to Initiate High Pressure Recirculation
HHPHPR0DHE
2
2.20E-03
Common Cause Failure Of 3 Of 3 HPI Pumps To Run During Recirculation
HHP33RRCOM
2
6.11E-06
Loss of Flow Through HPI Pump Motor Bearing Cooling Jackets
HPICOOL
Page 72
Loss of Flow Into Three Cold Legs
H3CLDLEGSR
3
Pipe Rupture Fails Flow From HPI Pumps to 3A Cold Legs
HDISCHADEX
2
6.24E-08
Pipe Rupture Fails Flow From HPI Pumps to 3B Cold Legs
HDISCHBDEX
2
5.97E-08
HPI Suction Header Flow is Diverted to LDST
H517
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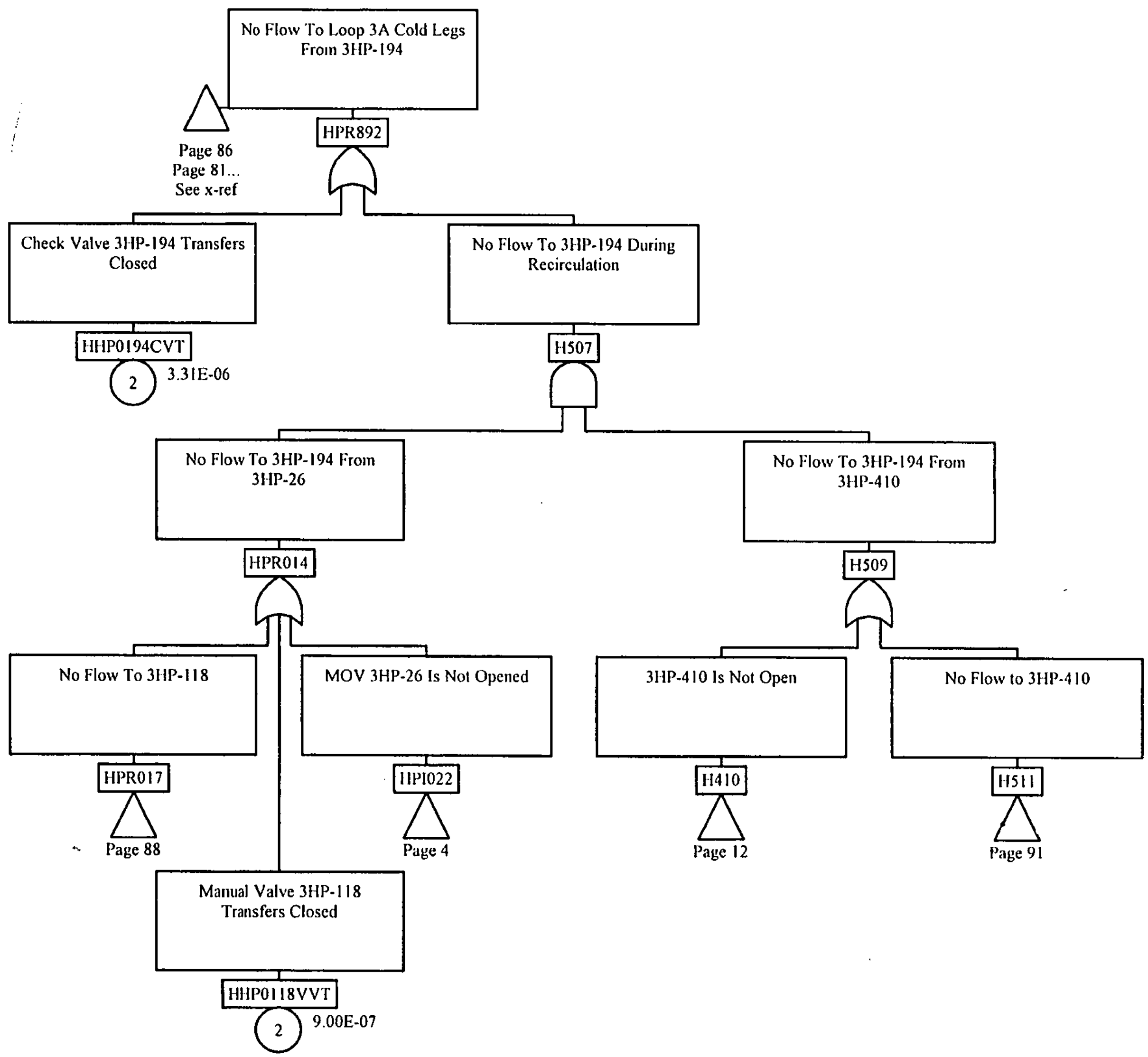
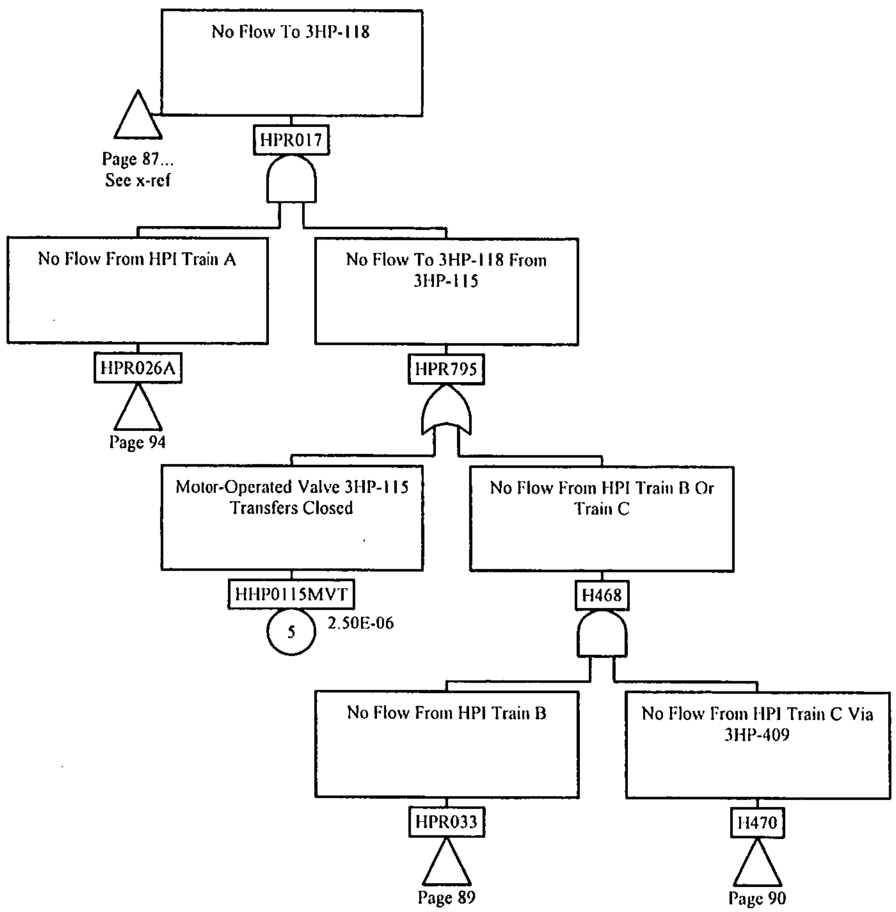
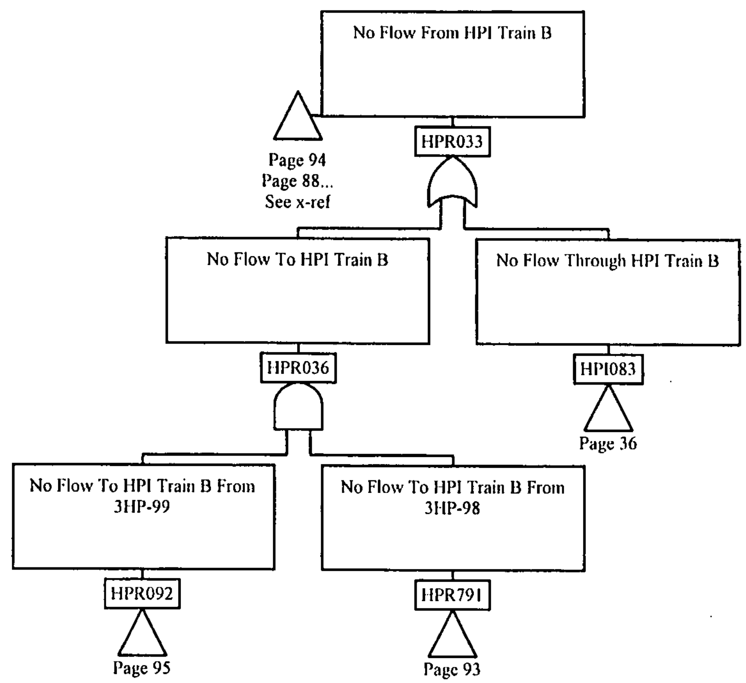
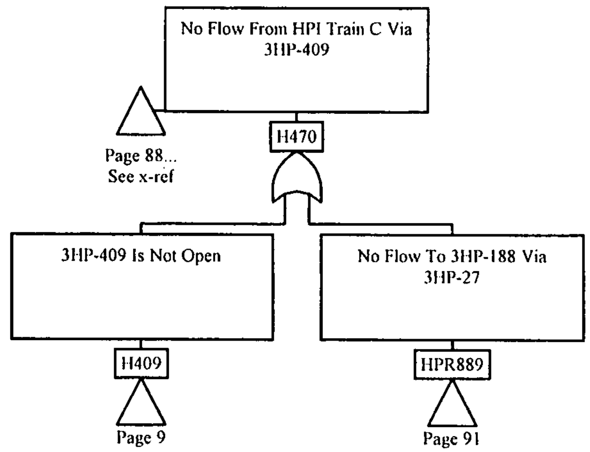
No HPI Flow Into Cold Leg 3A1
Page 80... See x-ref
HPR900
No HPI Flow Into Cold Leg 3A2
HPR899
Page 81
Page 78... See x-ref
No HPI Flow Into Cold Leg 3B1
HPR898
No HPI Flow Into Cold Leg 3B2
HPR897
Page 79
No HPI Flow Through Injection Line For Cold Leg 3A1
HPI896
Page 16
No Flow To Loop 3A Cold Legs From 3HP-194
HPR892
Page 87
No HPI Flow Through Injection Line For Cold Leg 3B1
HPI894
Page 20
No Flow To Loop 3B Cold Legs From 3HP-188
HPR007
Page 99

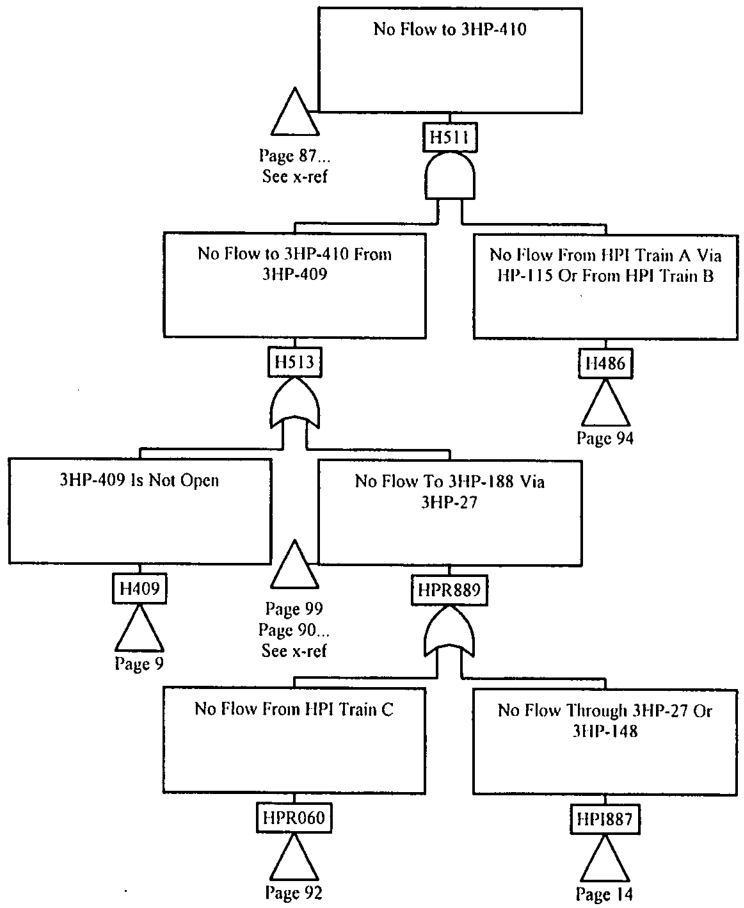

No Flow To Loop 3A Cold Legs From 3HP-194
HPR892
Page 86
Page 81...
See x-ref
Check Valve 3HP-194 Transfers Closed
HHP0194CVT
2
3.31E-06
No Flow To 3HP-194 During Recirculation
H507
No Flow To 3HP-194 From 3HP-26
HPR014
No Flow To 3HP-194 From 3HP-410
H509
No Flow To 3HP-118
HPR017
Page 88
MOV 3HP-26 Is Not Opened
HPI022
Page 4
3HP-410 Is Not Open
H410
Page 12
No Flow to 3HP-410
H511
Page 91
Manual Valve 3HP-118 Transfers Closed
HHP0118VVT
2
9.00E-07

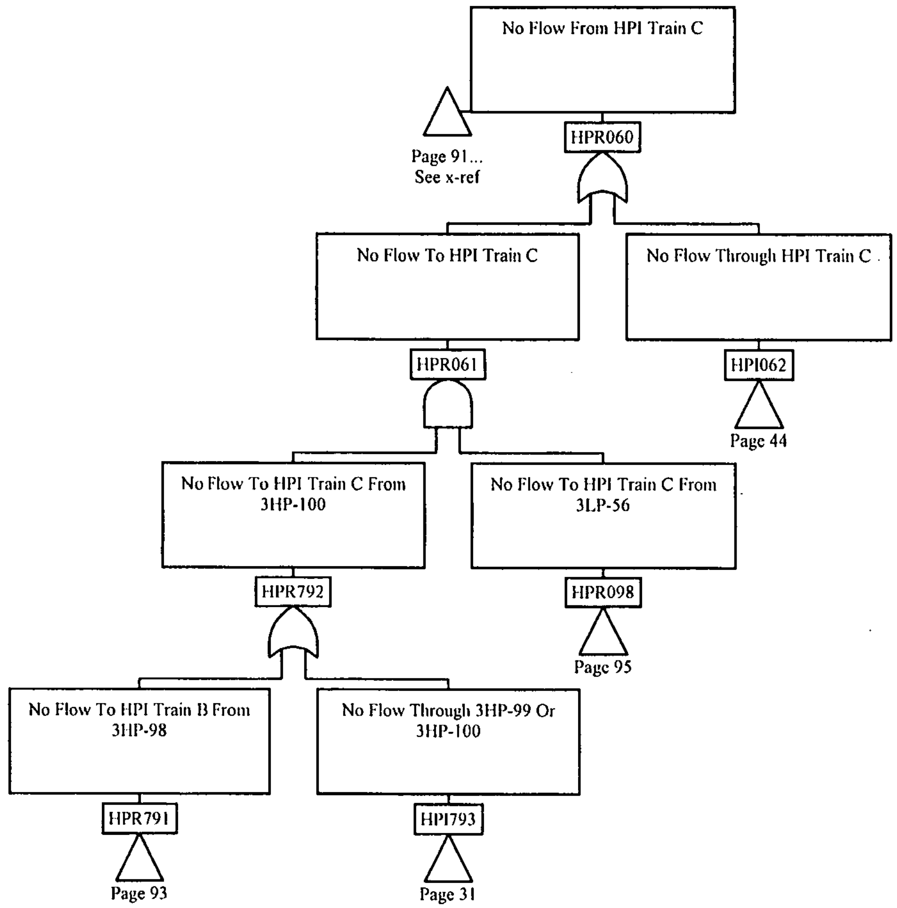


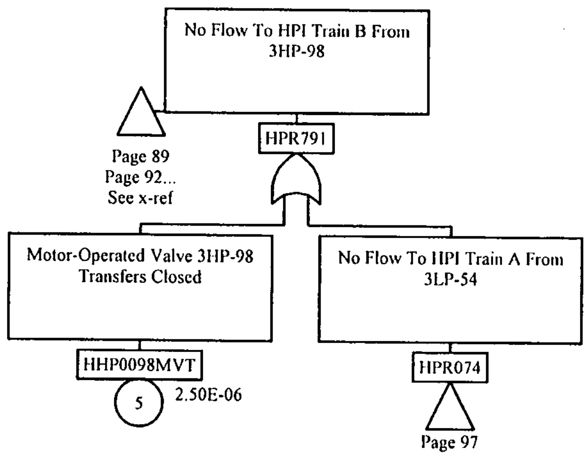
No Flow To 3HP-118
Page 87...
See x-ref
HPR017
No Flow From HPI Train A
HPR026A
Page 94
No Flow To 3HP-118 From 3HP-115
HPR795
Motor-Operated Valve 3HP-115 Transfers Closed
HHP0115MVT
5
2.50E-06
No Flow From HPI Train B Or Train C
H468
No Flow From HPI Train B
HPR033
Page 89
No Flow From HPI Train C Via 3HP-409
H470
Page 90

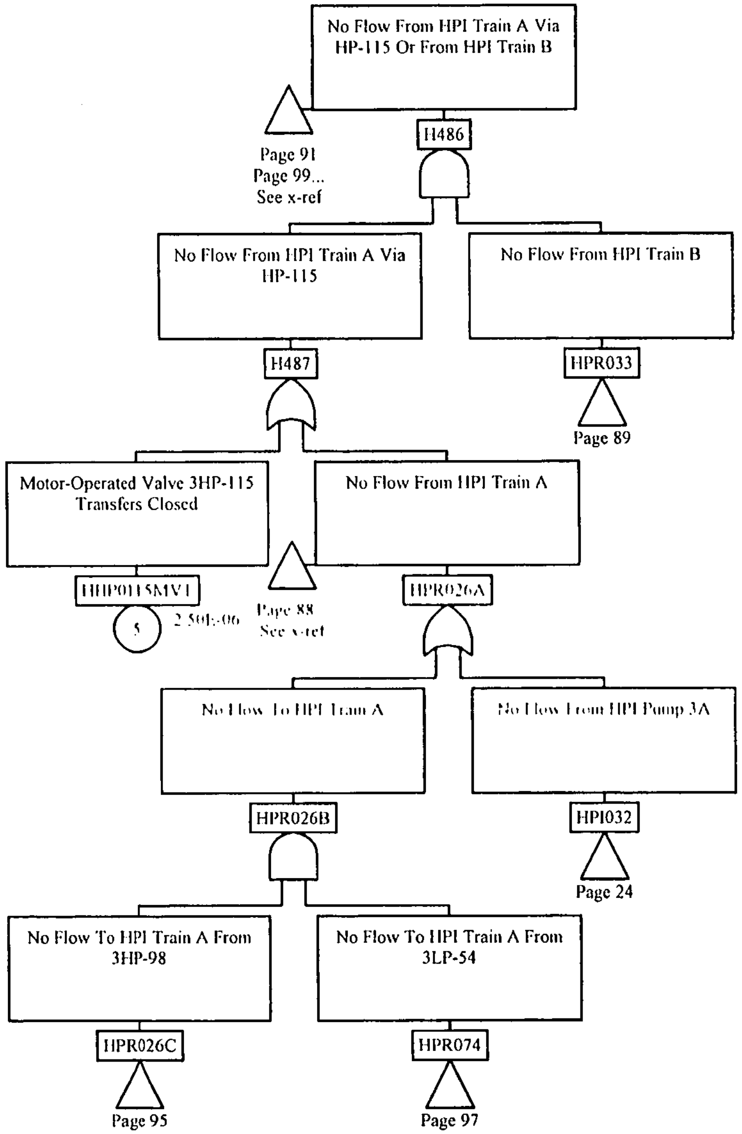

No Flow From HPI Train B
Page 94
Page 88...
See x-ref
HPR033
No Flow To HPI Train B
No Flow Through HPI Train B
HPR036
HPI083
Page 36
No Flow To HPI Train B From 3HP-99
No Flow To HPI Train B From 3HP-98
HPR092
HPR791
Page 95
Page 93


No Flow From HPI Train C Via 3HP-409
H470
Page 88...
See x-ref
3HP-409 Is Not Open
H409
Page 9
No Flow To 3HP-188 Via 3HP-27
HPR889
Page 91


No Flow to 3HP-410
Page 87...
See x-ref
H511
No Flow to 3HP-410 From 3HP-409
No Flow From HPI Train A Via HP-115 Or From HPI Train B
H513
H486
Page 94
3HP-409 Is Not Open
No Flow To 3HP-188 Via 3HP-27
H409
Page 9
Page 99
Page 90...
See x-ref
HPR889
No Flow From HPI Train C
No Flow Through 3HP-27 Or 3HP-148
HPR060
HPI887
Page 92
Page 14


No Flow From HPI Train C
Page 91...
See x-ref
HPR060
No Flow To HPI Train C
No Flow Through HPI Train C
HPR061
HPI062
Page 44
No Flow To HPI Train C From 3HP-100
No Flow To HPI Train C From 3LP-56
HPR792
HPR098
Page 95
No Flow To HPI Train B From 3HP-98
No Flow Through 3HP-99 Or 3HP-100
HPR791
HPI793
Page 93
Page 31


No Flow To HPI Train B From 3HP-98
Page 89
Page 92...
See x-ref
HPR791
Motor-Operated Valve 3HP-98 Transfers Closed
HHP0098MVT
5
2.50E-06
No Flow To HPI Train A From 3LP-54
HPR074
Page 97


No Flow From HPI Train A Via HP-115 Or From HPI Train B
H486
Page 91
Page 99...
See x-ref
No Flow From HPI Train A Via HP-115
No Flow From HPI Train B
H487
HPR033
Page 89
Motor-Operated Valve 3HP-115 Transfers Closed
No Flow From HPI Train A
HHP0115MVT
5
2.50E-06
Page 88
See x-ref
HPR026A
No Flow To HPI Train A
No Flow From HPI Pump 3A
HPR026B
HPI032
Page 24
No Flow To HPI Train A From 3HP-98
No Flow To HPI Train A From 3LP-54
HPR026C
HPR074
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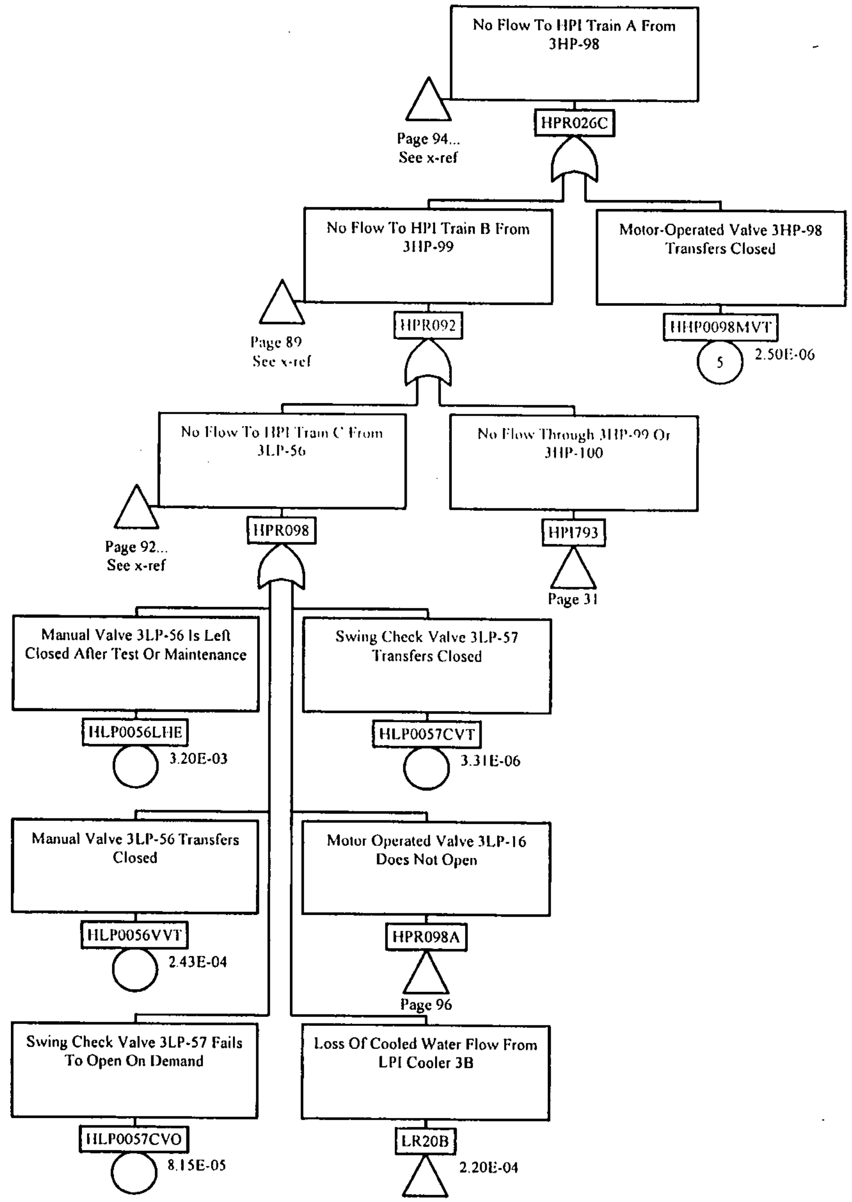
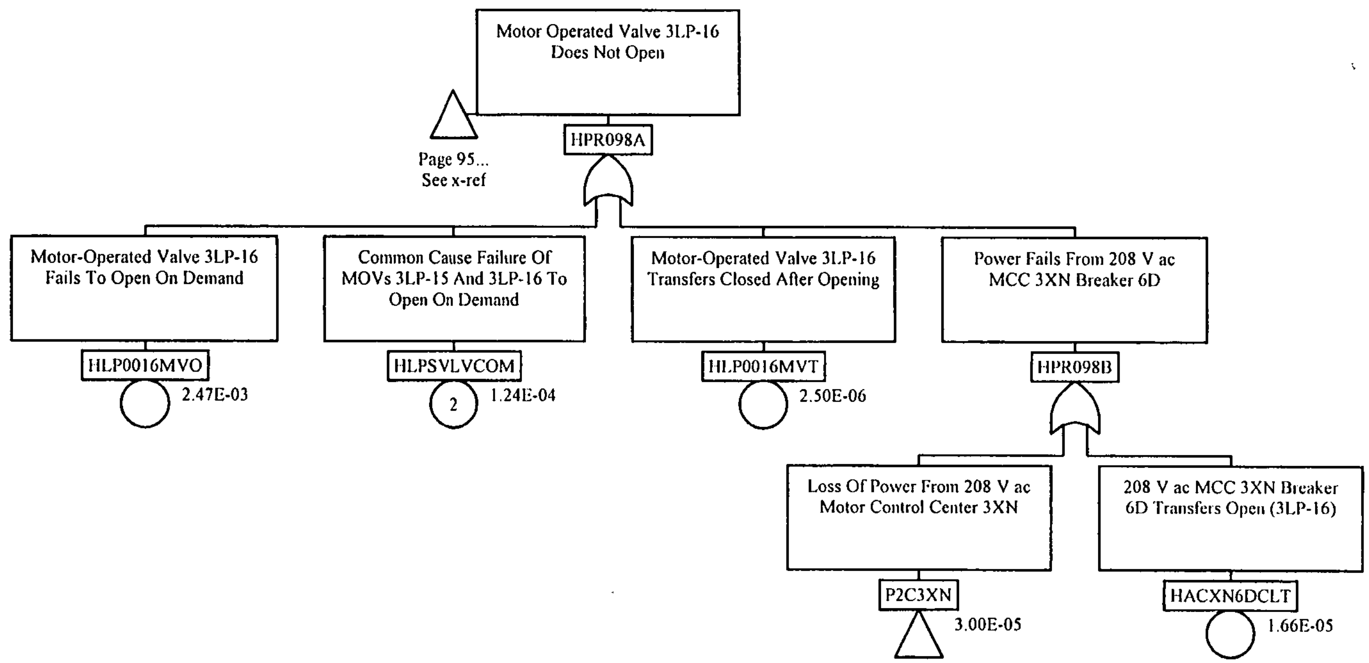
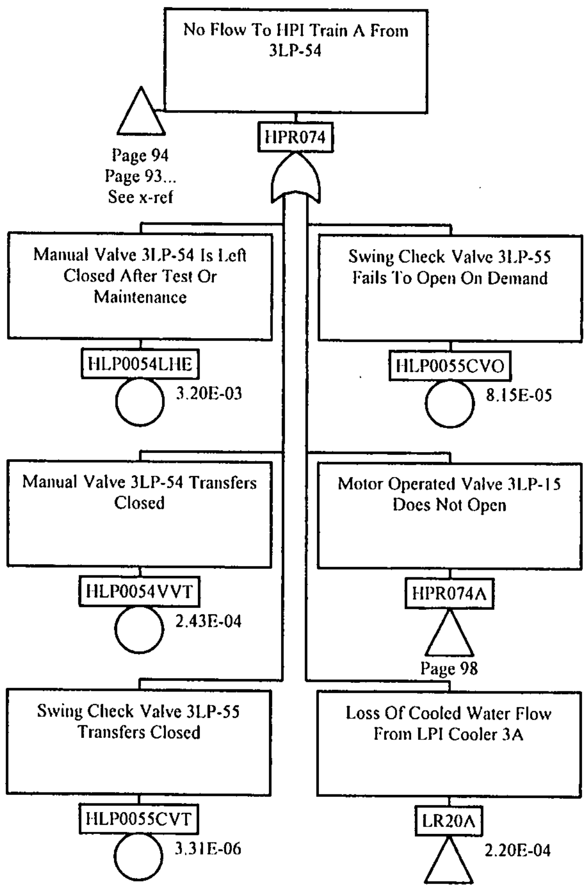
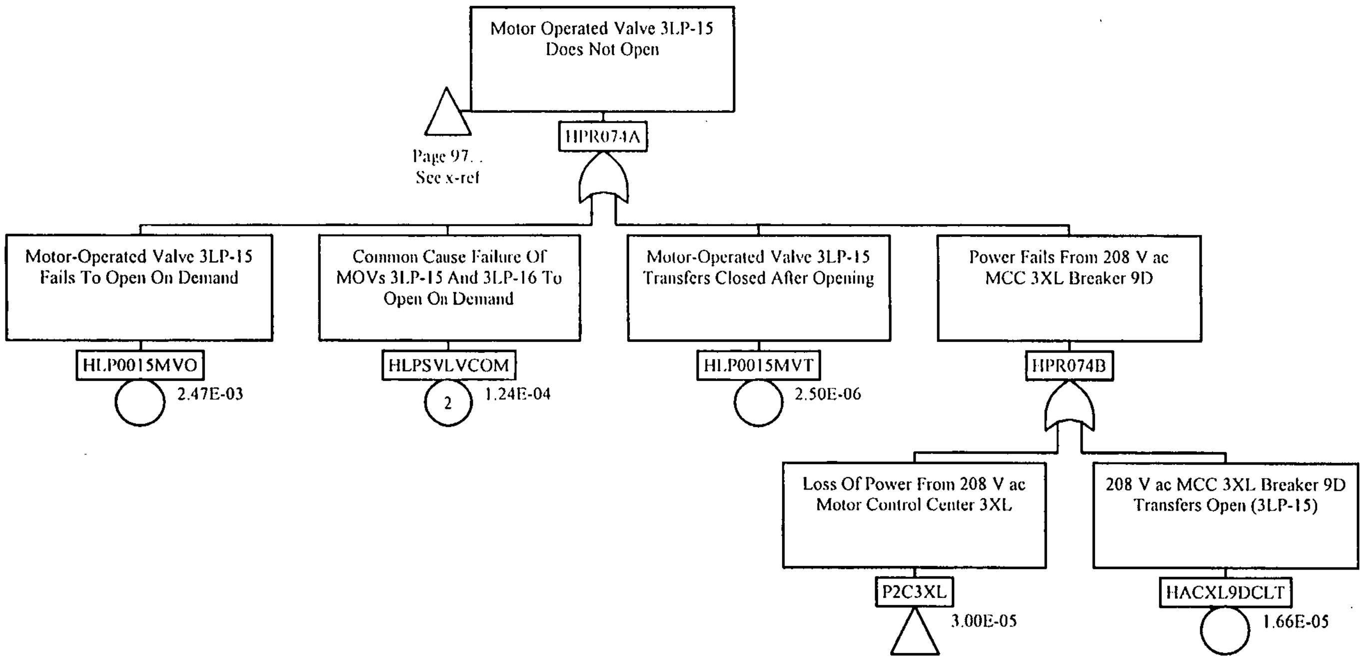
Page 97

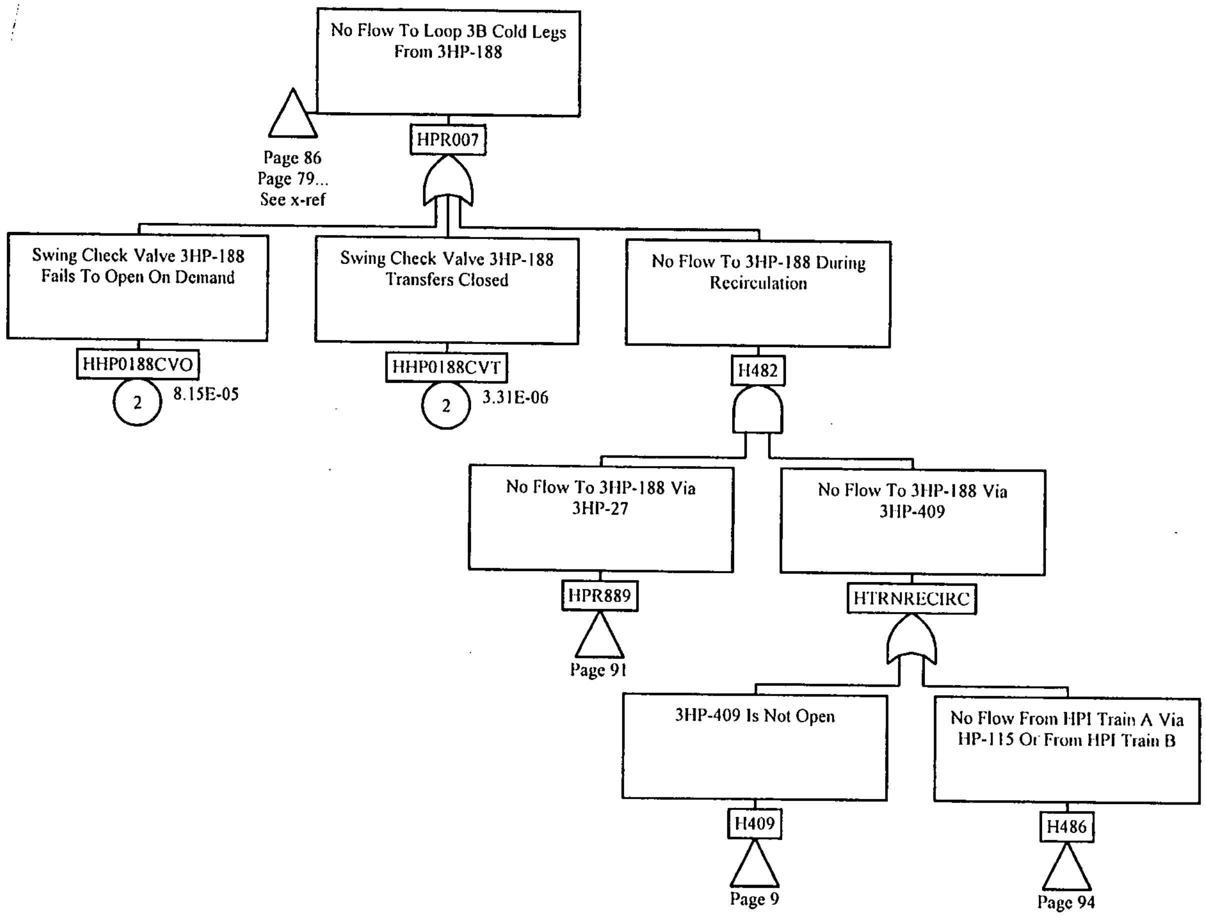

No Flow To HPI Train A From 3HP-98
Page 94... See x-ref
HPR026C
No Flow To HPI Train B From 3HP-99
Motor-Operated Valve 3HP-98 Transfers Closed
Page 89 See x-ref
HPR092
HHP0098MVT
5
2.50E-06
No Flow To HPI Train C From 3LP-56
No Flow Through 3HP-99 Or 3HP-100
Page 92... See x-ref
HPR098
HPI793
Page 31
Manual Valve 3LP-56 Is Left Closed After Test Or Maintenance
Swing Check Valve 3LP-57 Transfers Closed
HLP0056LHE
3.20E-03
HLP0057CVT
3.31E-06
Manual Valve 3LP-56 Transfers Closed
Motor Operated Valve 3LP-16 Does Not Open
HLP0056VVT
2.43E-04
HPR098A
Page 96
Swing Check Valve 3LP-57 Fails To Open On Demand
Loss Of Cooled Water Flow From LPI Cooler 3B
HLP0057CVO
8.15E-05
LR20B
2.20E-04


Motor Operated Valve 3LP-16 Does Not Open
Page 95... See x-ref
HPR098A
Motor-Operated Valve 3LP-16 Fails To Open On Demand
HLP0016MVO
2.47E-03
Common Cause Failure Of MOVs 3LP-15 And 3LP-16 To Open On Demand
HLPSVLVCOM
2
1.24E-04
Motor-Operated Valve 3LP-16 Transfers Closed After Opening
HLP0016MVT
2.50E-06
Power Fails From 208 V ac MCC 3XN Breaker 6D
HPR098B
Loss Of Power From 208 V ac Motor Control Center 3XN
P2C3XN
3.00E-05
208 V ac MCC 3XN Breaker 6D Transfers Open (3LP-16)
HACXN6DCLT
1.66E-05

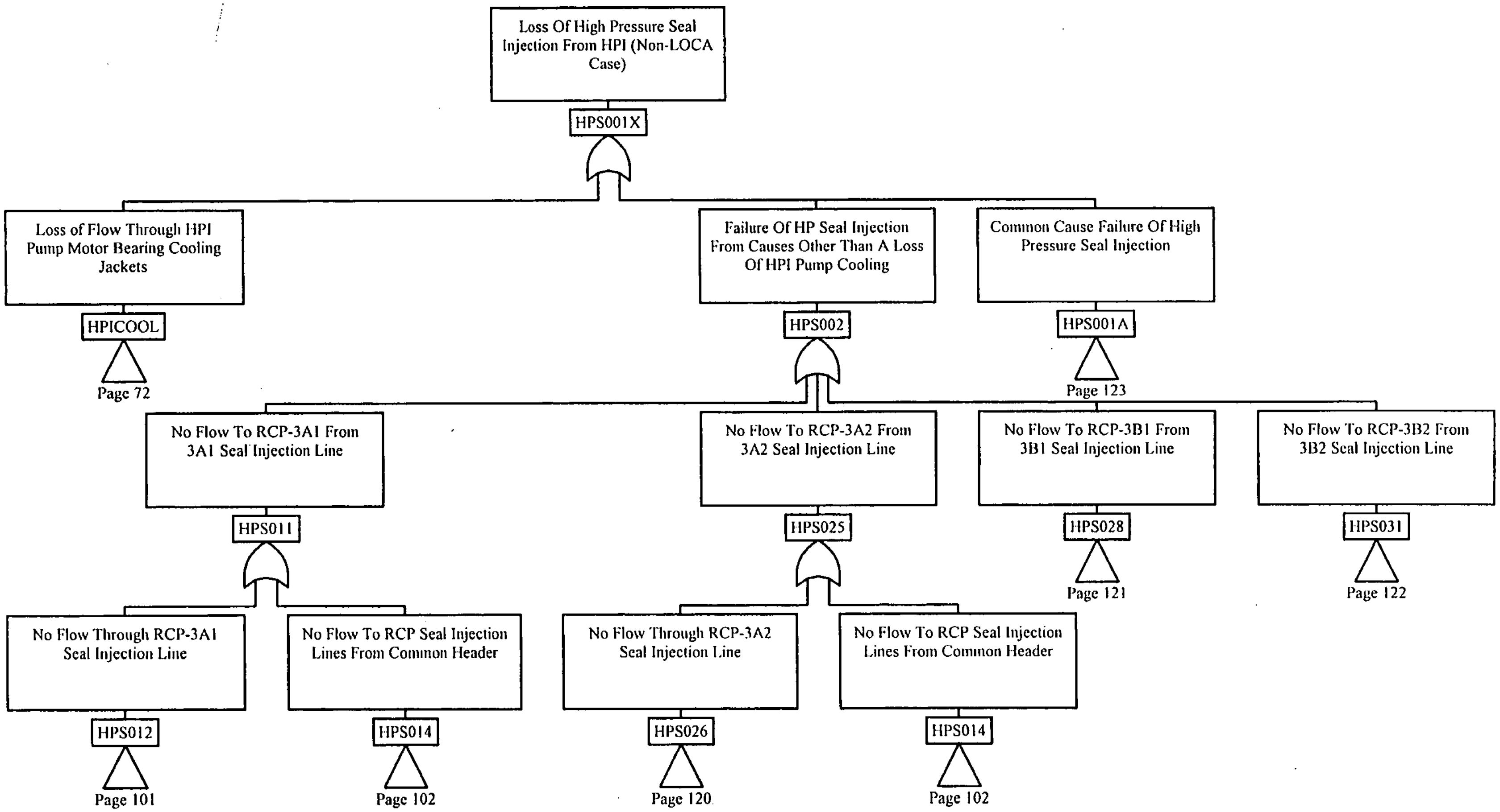

No Flow To HPI Train A From 3LP-54
HPR074
Page 94
Page 93...
See x-ref
Manual Valve 3LP-54 Is Left Closed After Test Or Maintenance
HLP0054LHE
3.20E-03
Swing Check Valve 3LP-55 Fails To Open On Demand
HLP0055CVO
8.15E-05
Manual Valve 3LP-54 Transfers Closed
HLP0054VVT
2.43E-04
Motor Operated Valve 3LP-15 Does Not Open
HPR074A
Page 98
Swing Check Valve 3LP-55 Transfers Closed
HLP0055CVT
3.31E-06
Loss Of Cooled Water Flow From LPI Cooler 3A
LR20A
2.20E-04

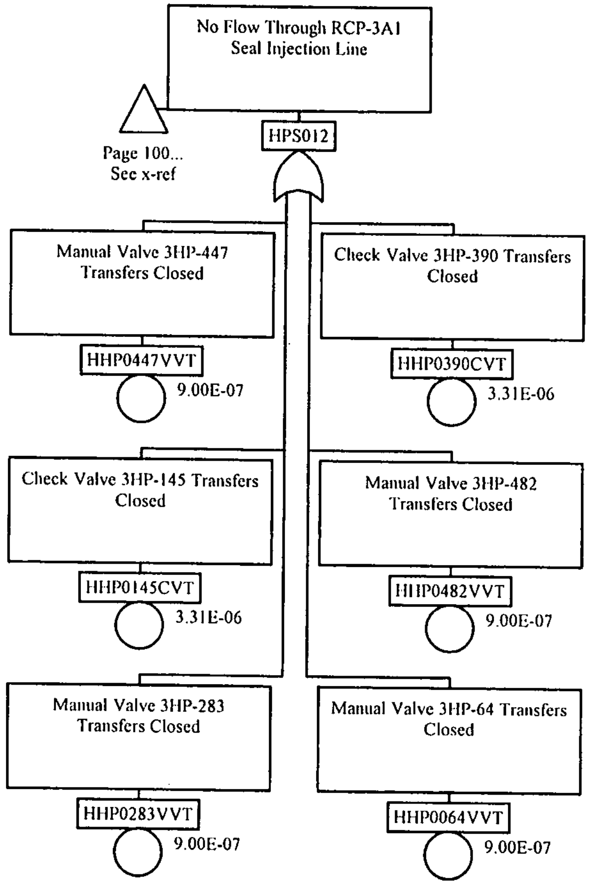


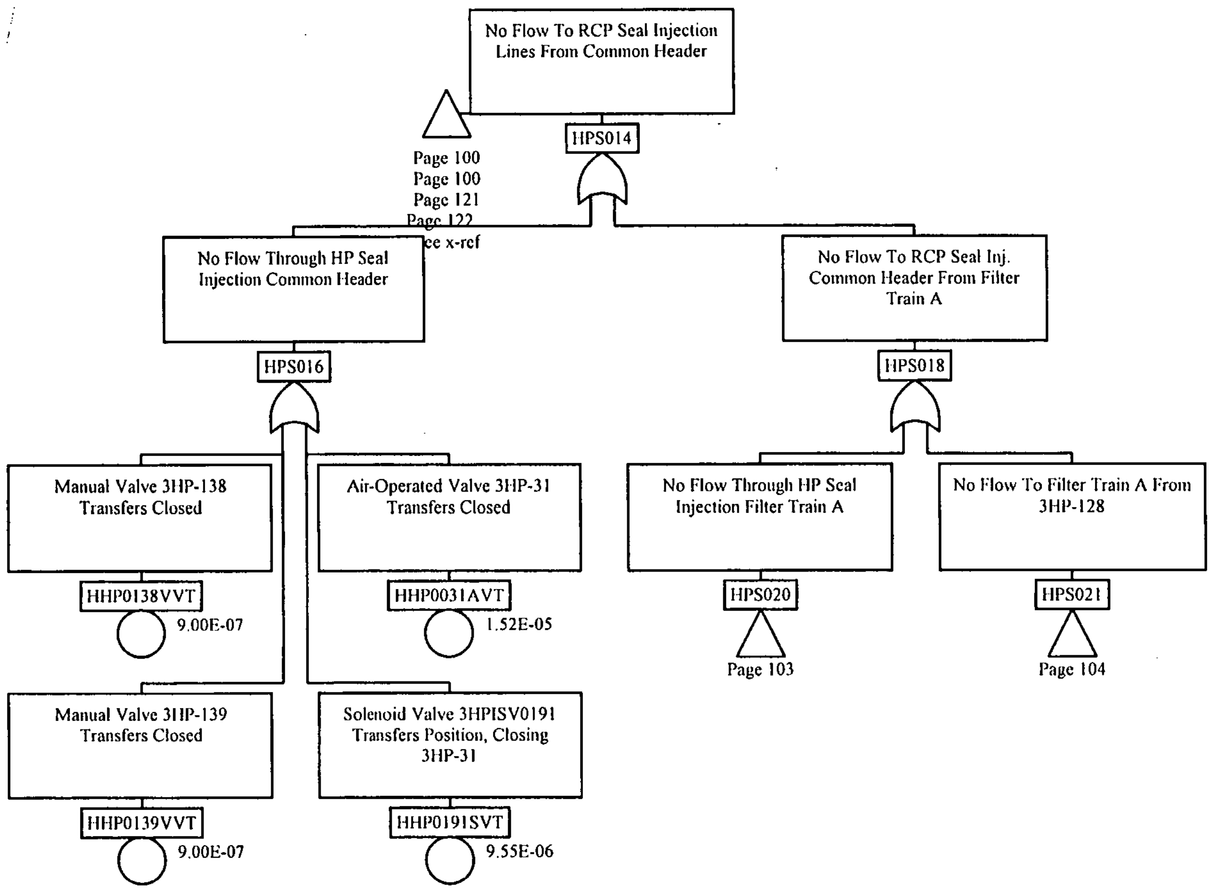
Motor Operated Valve 3LP-15 Does Not Open
Page 97
See x-ref
HPR074A
Motor-Operated Valve 3LP-15 Fails To Open On Demand
HLP0015MVO
2.47E-03
Common Cause Failure Of MOVs 3LP-15 And 3LP-16 To Open On Demand
HLPSVLVCOM
2
1.24E-04
Motor-Operated Valve 3LP-15 Transfers Closed After Opening
HLP0015MVT
2.50E-06
Power Fails From 208 V ac MCC 3XL Breaker 9D
HPR074B
Loss Of Power From 208 V ac Motor Control Center 3XL
P2C3XL
3.00E-05
208 V ac MCC 3XL Breaker 9D Transfers Open (3LP-15)
HACXL9DCLT
1.66E-05

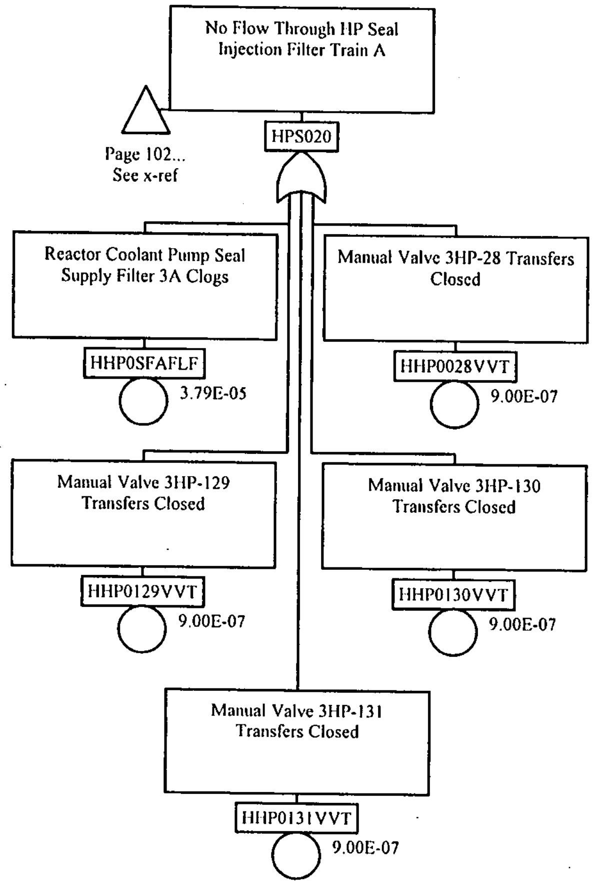


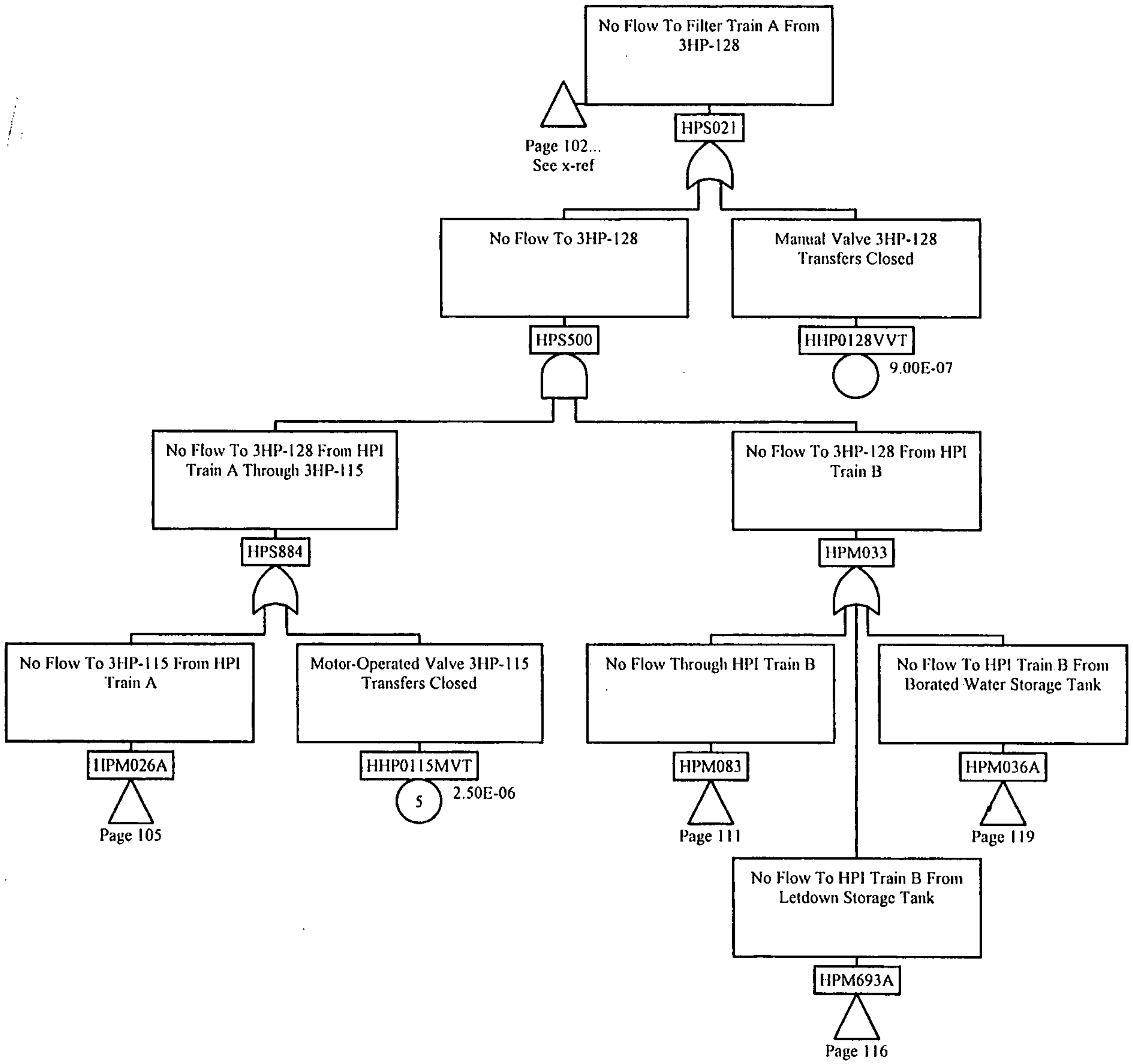
No Flow To Loop 3B Cold Legs From 3HP-188
HPR007
Page 86
Page 79...
See x-ref
Swing Check Valve 3HP-188 Fails To Open On Demand
HHP0188CVO
2
8.15E-05
Swing Check Valve 3HP-188 Transfers Closed
HHP0188CVT
2
3.31E-06
No Flow To 3HP-188 During Recirculation
H482
No Flow To 3HP-188 Via 3HP-27
HPR889
Page 91
No Flow To 3HP-188 Via 3HP-409
HTRNRECIRC
3HP-409 Is Not Open
H409
Page 9
No Flow From HPI Train A Via HP-115 Or From HPI Train B
H486
Page 94


Loss Of High Pressure Seal Injection From HPI (Non-LOCA Case)
HPS001X
Loss of Flow Through HPI Pump Motor Bearing Cooling Jackets
HPICOOL
Page 72
Failure Of HP Seal Injection From Causes Other Than A Loss Of HPI Pump Cooling
HPS002
Common Cause Failure Of High Pressure Seal Injection
HPS001A
Page 123
No Flow To RCP-3A1 From 3A1 Seal Injection Line
HPS011
No Flow To RCP-3A2 From 3A2 Seal Injection Line
HPS025
No Flow To RCP-3B1 From 3B1 Seal Injection Line
HPS028
Page 121
No Flow To RCP-3B2 From 3B2 Seal Injection Line
HPS031
Page 122
No Flow Through RCP-3A1 Seal Injection Line
HPS012
Page 101
No Flow To RCP Seal Injection Lines From Common Header
HPS014
Page 102
No Flow Through RCP-3A2 Seal Injection Line
HPS026
Page 120
No Flow To RCP Seal Injection Lines From Common Header
HPS014
Page 102

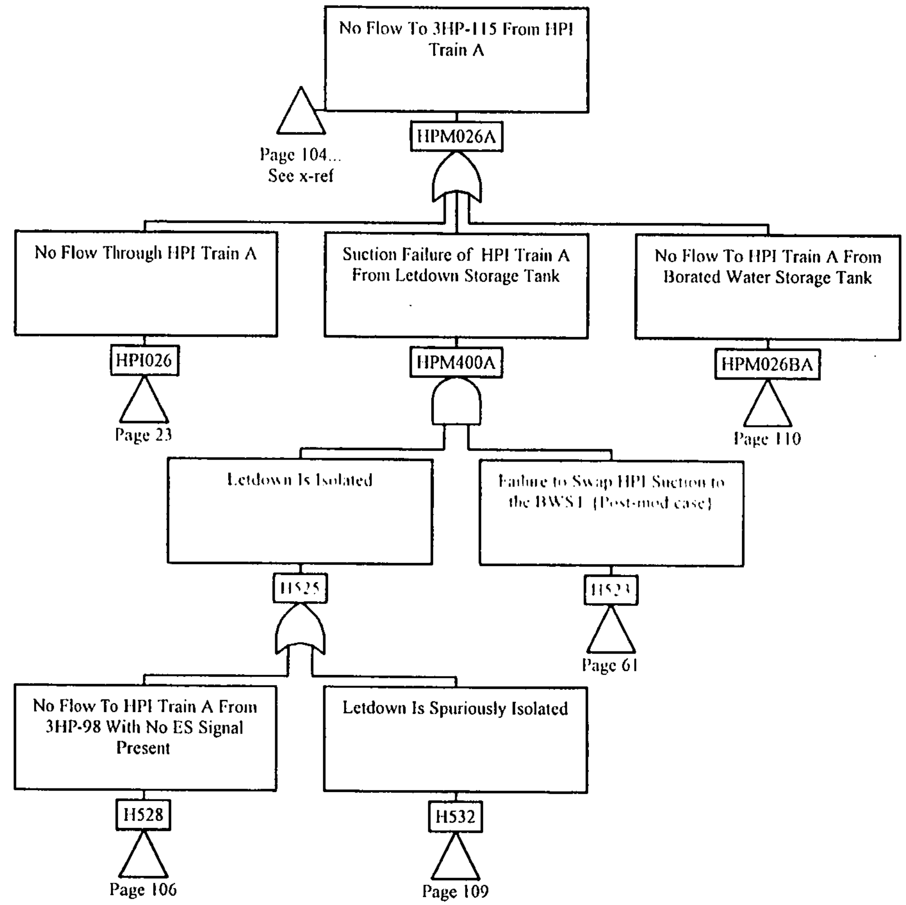

No Flow Through RCP-3A1 Seal Injection Line
HPS012
Page 100...
See x-ref
Manual Valve 3HP-447 Transfers Closed
HHP0447VVT
9.00E-07
Check Valve 3HP-390 Transfers Closed
HHP0390CVT
3.31E-06
Check Valve 3HP-145 Transfers Closed
HHP0145CVT
3.31E-06
Manual Valve 3HP-482 Transfers Closed
HHP0482VVT
9.00E-07
Manual Valve 3HP-283 Transfers Closed
HHP0283VVT
9.00E-07
Manual Valve 3HP-64 Transfers Closed
HHP0064VVT
9.00E-07

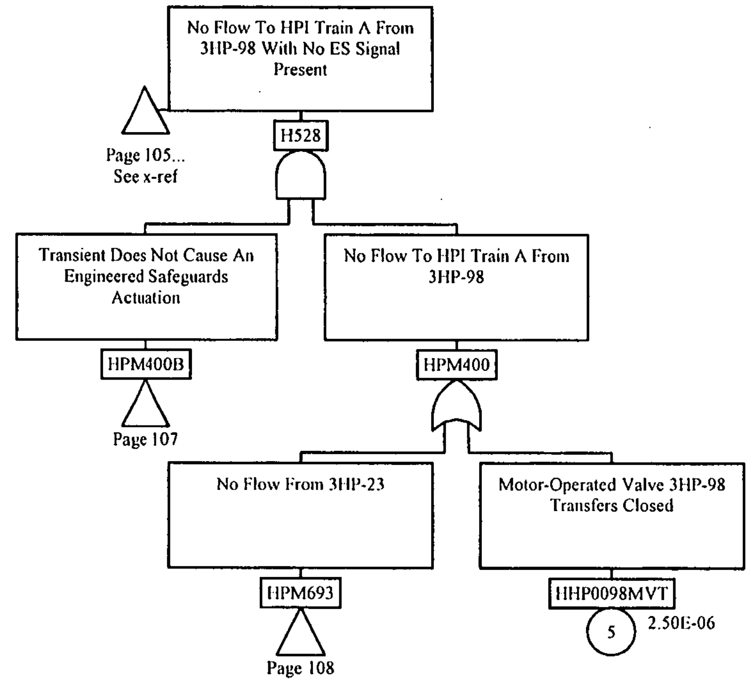

No Flow To RCP Seal Injection Lines From Common Header
HPS014
Page 100
Page 100
Page 121
Page 122
ee x-ref
No Flow Through HP Seal Injection Common Header
HPS016
No Flow To RCP Seal Inj. Common Header From Filter Train A
HPS018
Manual Valve 3HP-138 Transfers Closed
HHP0138VVT
9.00E-07
Air-Operated Valve 3HP-31 Transfers Closed
HHP0031AVT
1.52E-05
No Flow Through HP Seal Injection Filter Train A
HPS020
Page 103
No Flow To Filter Train A From 3HP-128
HPS021
Page 104
Manual Valve 3HP-139 Transfers Closed
HHP0139VVT
9.00E-07
Solenoid Valve 3HPISV0191 Transfers Position, Closing 3HP-31
HHP0191SVT
9.55E-06

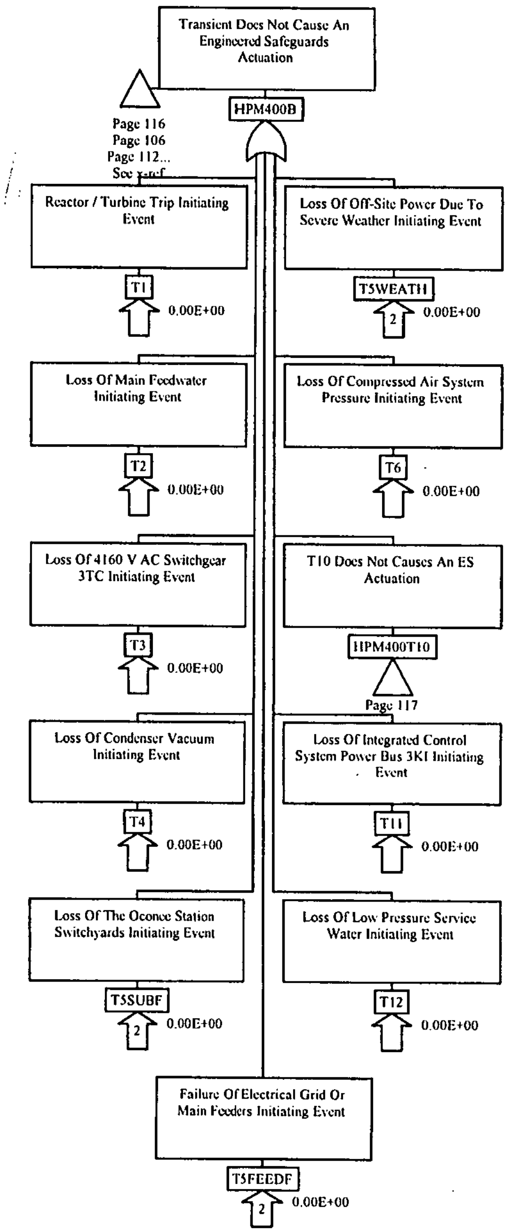

No Flow Through HP Seal Injection Filter Train A
HPS020
Page 102...
See x-ref
Reactor Coolant Pump Seal Supply Filter 3A Clogs
HHP0SFAFLF
3.79E-05
Manual Valve 3HP-28 Transfers Closed
HHP0028VVT
9.00E-07
Manual Valve 3HP-129 Transfers Closed
HHP0129VVT
9.00E-07
Manual Valve 3HP-130 Transfers Closed
HHP0130VVT
9.00E-07
Manual Valve 3HP-131 Transfers Closed
HHP0131VVT
9.00E-07



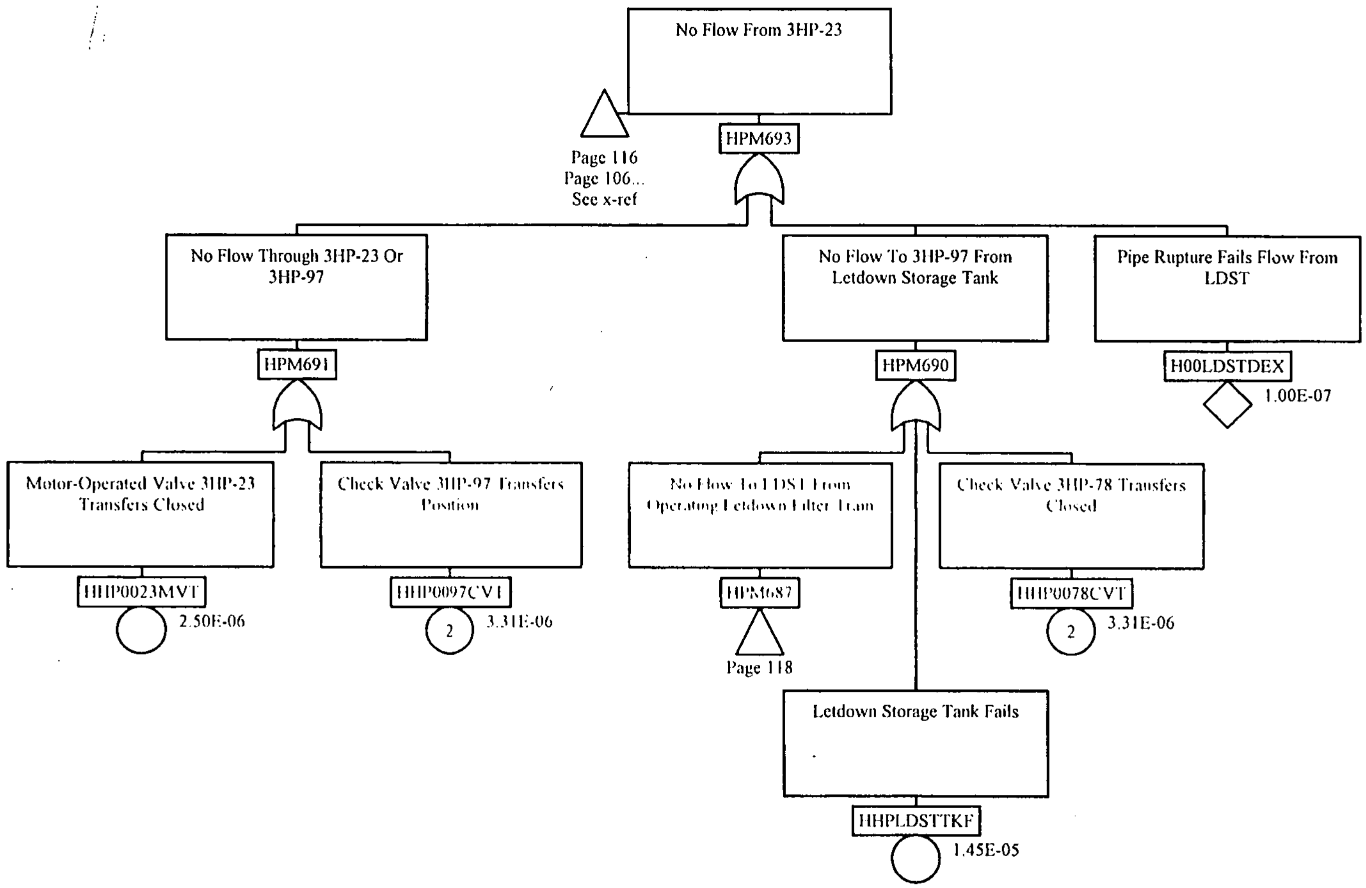
No Flow To Filter Train A From 3HP-128
Page 102... See x-ref
HPS021
No Flow To 3HP-128
Manual Valve 3HP-128 Transfers Closed
HPS500
HHP0128VVT
9.00E-07
No Flow To 3HP-128 From HPI Train A Through 3HP-115
No Flow To 3HP-128 From HPI Train B
HPS884
HPM033
No Flow To 3HP-115 From HPI Train A
Motor-Operated Valve 3HP-115 Transfers Closed
No Flow Through HPI Train B
No Flow To HPI Train B From Borated Water Storage Tank
HPM026A
HHP0115MVT
5
2.50E-06
HPM083
HPM036A
Page 105
Page 111
Page 119
No Flow To HPI Train B From Letdown Storage Tank
HPM693A
Page 116

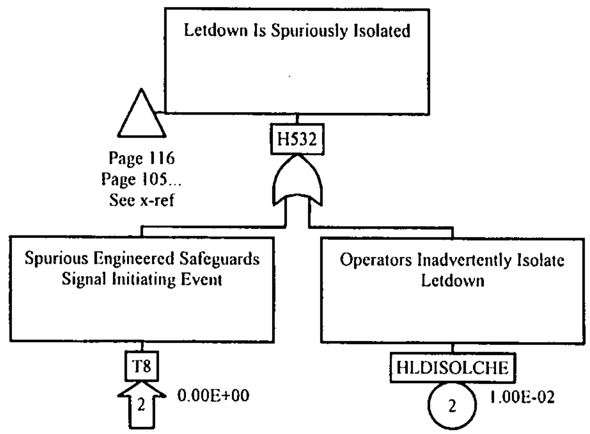

No Flow To 3HP-115 From HPI Train A
HPM026A
Page 104...
See x-ref
No Flow Through HPI Train A
HPI026
Page 23
Suction Failure of HPI Train A From Letdown Storage Tank
HPM400A
No Flow To HPI Train A From Borated Water Storage Tank
HPM026BA
Page 110
Letdown Is Isolated
H525
Failure to Swap HPI Suction to the BWST (Post-mod case)
H523
Page 61
No Flow To HPI Train A From 3HP-98 With No ES Signal Present
H528
Page 106
Letdown Is Spuriously Isolated
H532
Page 109

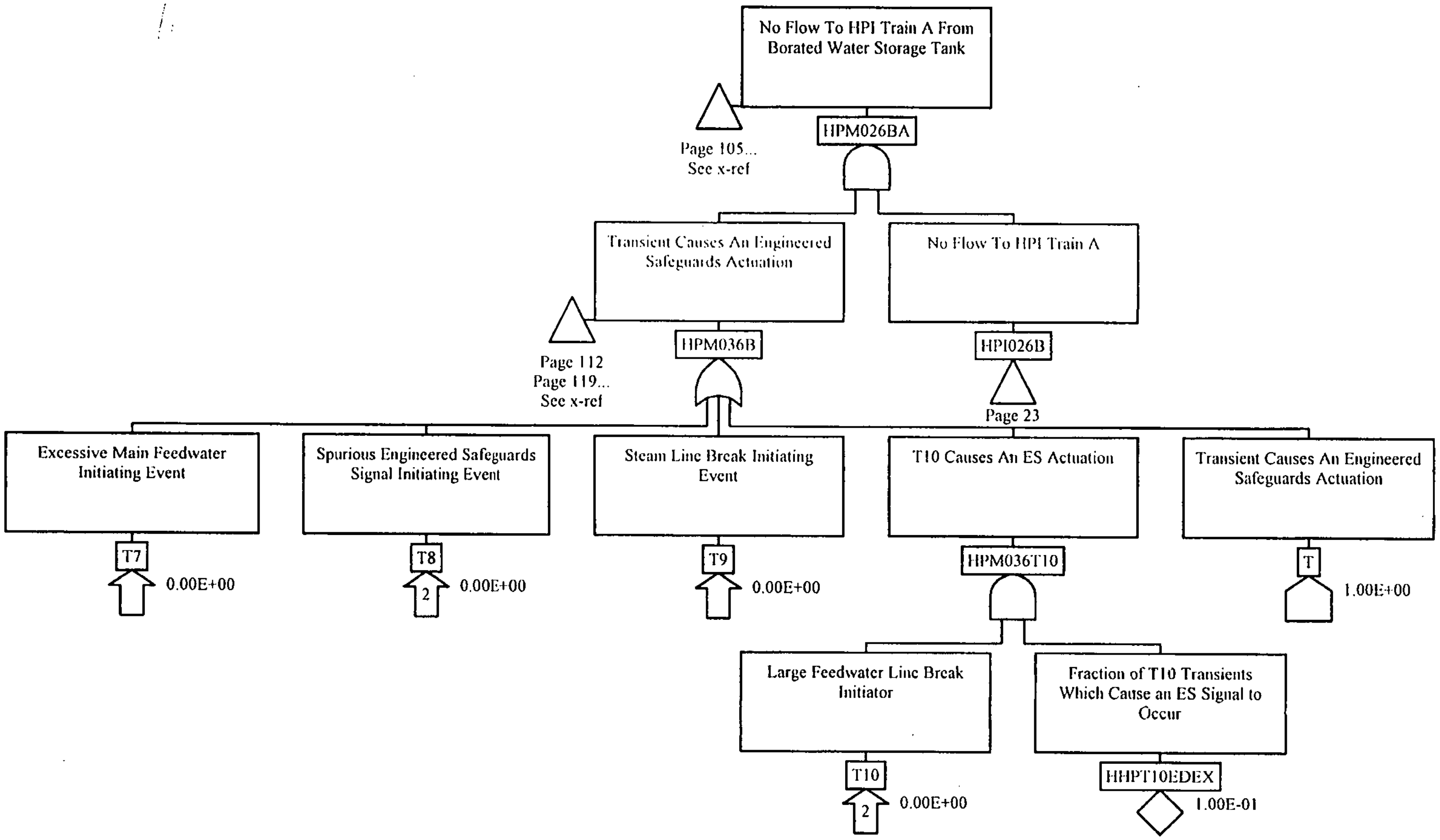

No Flow To HPI Train A From 3HP-98 With No ES Signal Present
Page 105... See x-ref
H528
Transient Does Not Cause An Engineered Safeguards Actuation
No Flow To HPI Train A From 3HP-98
HPM400B
Page 107
HPM400
No Flow From 3HP-23
Motor-Operated Valve 3HP-98 Transfers Closed
HPM693
Page 108
HHP0098MVT
5
2.50E-06

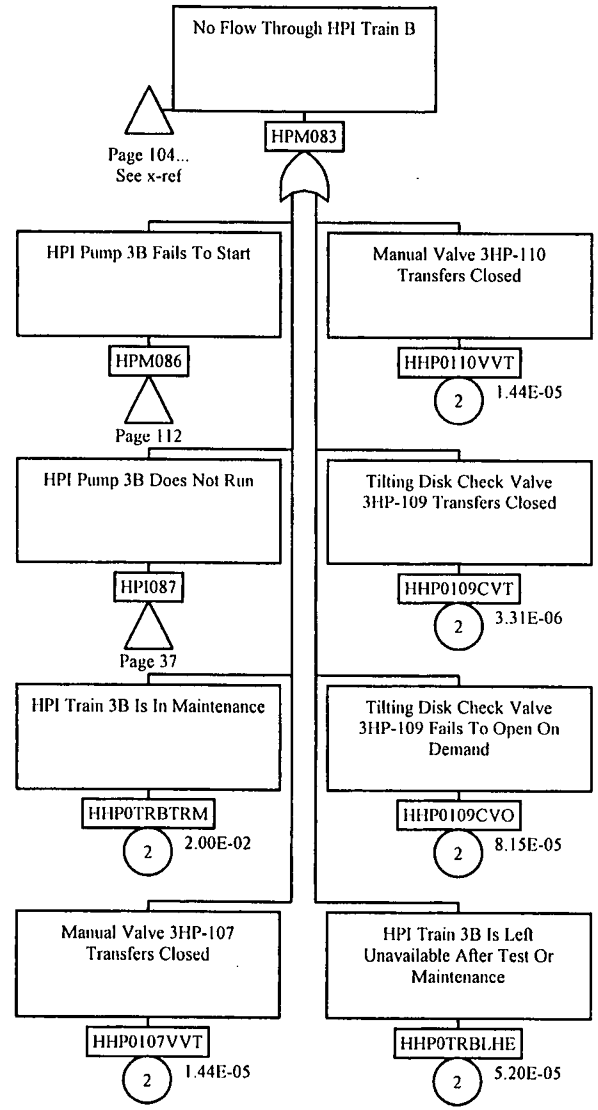


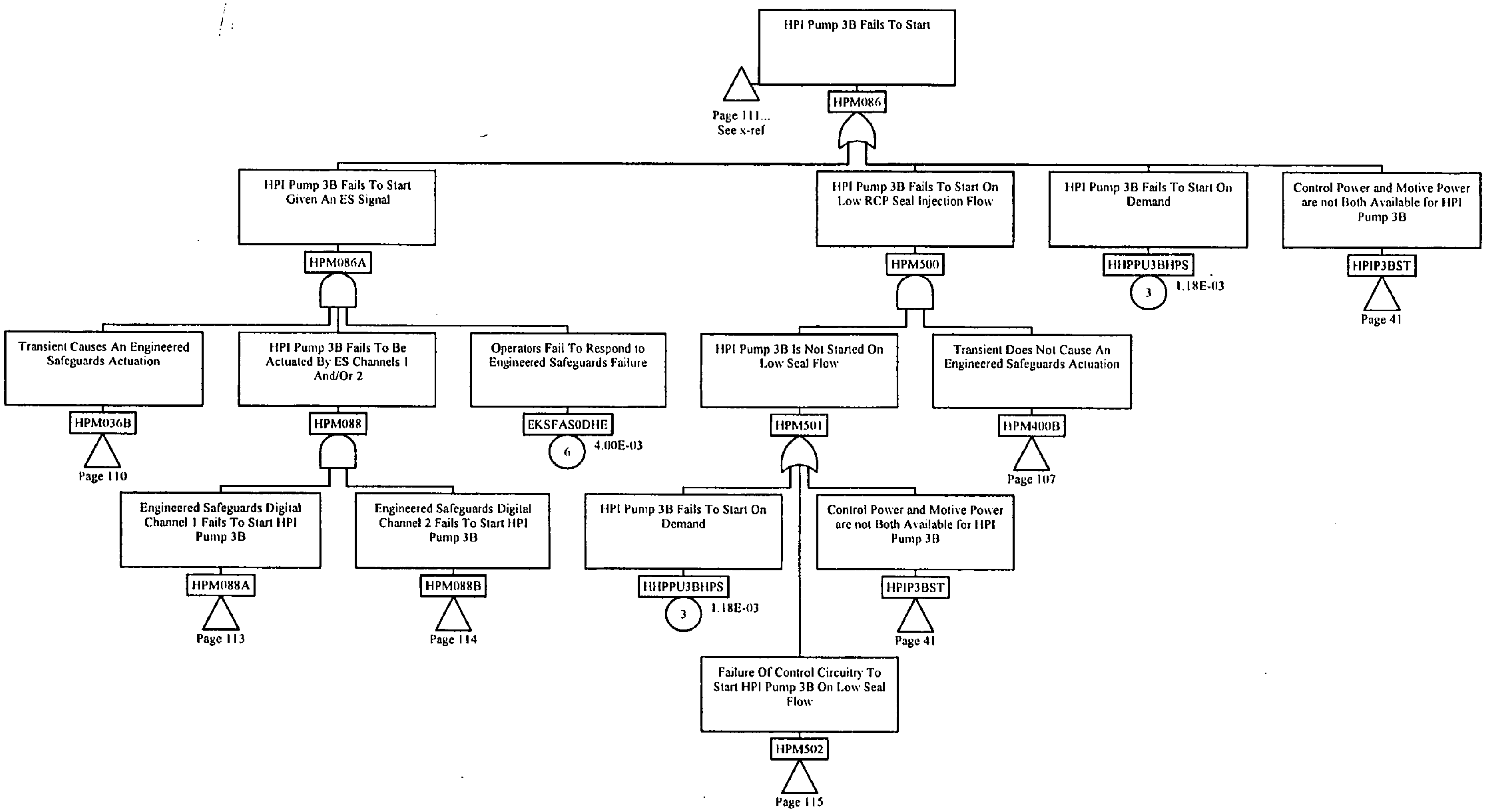
Transient Does Not Cause An Engineered Safeguards Actuation
HPM400B
Page 116
Page 106
Page 112...
See x-ref
Reactor / Turbine Trip Initiating Event
T1
0.00E+00
Loss Of Off-Site Power Due To Severe Weather Initiating Event
T5WEATH
2
0.00E+00
Loss Of Main Feedwater Initiating Event
T2
0.00E+00
Loss Of Compressed Air System Pressure Initiating Event
T6
0.00E+00
Loss Of 4160 V AC Switchgear 3TC Initiating Event
T3
0.00E+00
T10 Does Not Causes An ES Actuation
HPM400T10
Page 117
Loss Of Condenser Vacuum Initiating Event
T4
0.00E+00
Loss Of Integrated Control System Power Bus 3KI Initiating Event
T11
0.00E+00
Loss Of The Oconee Station Switchyards Initiating Event
T5SUBF
2
0.00E+00
Loss Of Low Pressure Service Water Initiating Event
T12
0.00E+00
Failure Of Electrical Grid Or Main Feeders Initiating Event
T5FEEDF
2
0.00E+00

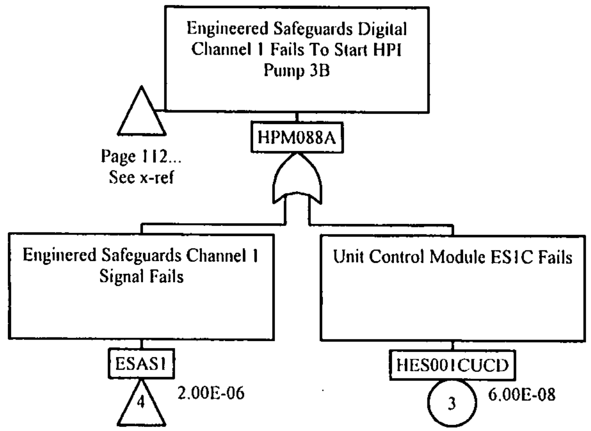

No Flow From 3HP-23
HPM693
Page 116
Page 106...
See x-ref
No Flow Through 3HP-23 Or 3HP-97
HPM691
No Flow To 3HP-97 From Letdown Storage Tank
HPM690
Pipe Rupture Fails Flow From LDST
H00LDSTDEX
1.00E-07
Motor-Operated Valve 3HP-23 Transfers Closed
HHP0023MVT
2.50E-06
Check Valve 3HP-97 Transfers Position
HHP0097CVT
2
3.31E-06
No Flow To LDST From Operating Letdown Filter Train
HPM687
Page 118
Check Valve 3HP-78 Transfers Closed
HHP0078CVT
2
3.31E-06
Letdown Storage Tank Fails
HHPLDSTTKF
1.45E-05

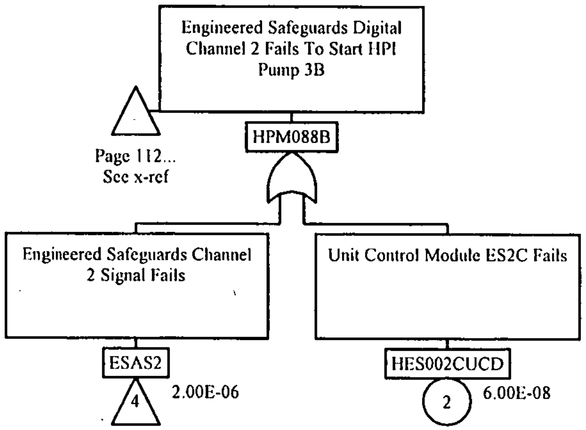

Letdown Is Spuriously Isolated
H532
Page 116
Page 105...
See x-ref
Spurious Engineered Safeguards Signal Initiating Event
T8
2
0.00E+00
Operators Inadvertently Isolate Letdown
HLDISOLCHE
2
1.00E-02

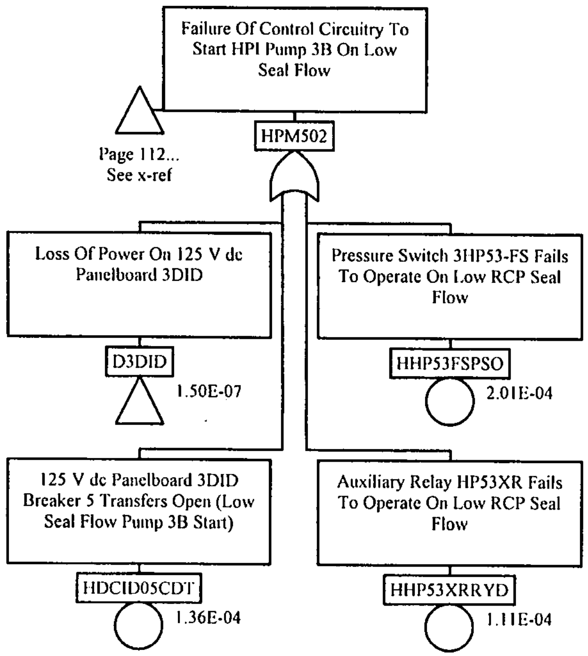

No Flow To HPI Train A From Borated Water Storage Tank
Page 105... See x-ref
HPM026BA
Transient Causes An Engineered Safeguards Actuation
No Flow To HPI Train A
Page 112 Page 119... See x-ref
HPM036B
HPI026B
Page 23
Excessive Main Feedwater Initiating Event
Spurious Engineered Safeguards Signal Initiating Event
Steam Line Break Initiating Event
T10 Causes An ES Actuation
Transient Causes An Engineered Safeguards Actuation
T7
0.00E+00
T8
2
0.00E+00
T9
0.00E+00
HPM036T10
T
1.00E+00
Large Feedwater Line Break Initiator
Fraction of T10 Transients Which Cause an ES Signal to Occur
T10
2
0.00E+00
HHPT10EDEX
1.00E-01


No Flow Through HPI Train B
HPM083
Page 104...
See x-ref
HPI Pump 3B Fails To Start
HPM086
Page 112
Manual Valve 3HP-110 Transfers Closed
HHP0110VVT
2
1.44E-05
HPI Pump 3B Does Not Run
HPI087
Page 37
Tilting Disk Check Valve 3HP-109 Transfers Closed
HHP0109CVT
2
3.31E-06
HPI Train 3B Is In Maintenance
HHP0TRBTRM
2
2.00E-02
Tilting Disk Check Valve 3HP-109 Fails To Open On Demand
HHP0109CVO
2
8.15E-05
Manual Valve 3HP-107 Transfers Closed
HHP0107VVT
2
1.44E-05
HPI Train 3B Is Left Unavailable After Test Or Maintenance
HHP0TRBLHE
2
5.20E-05

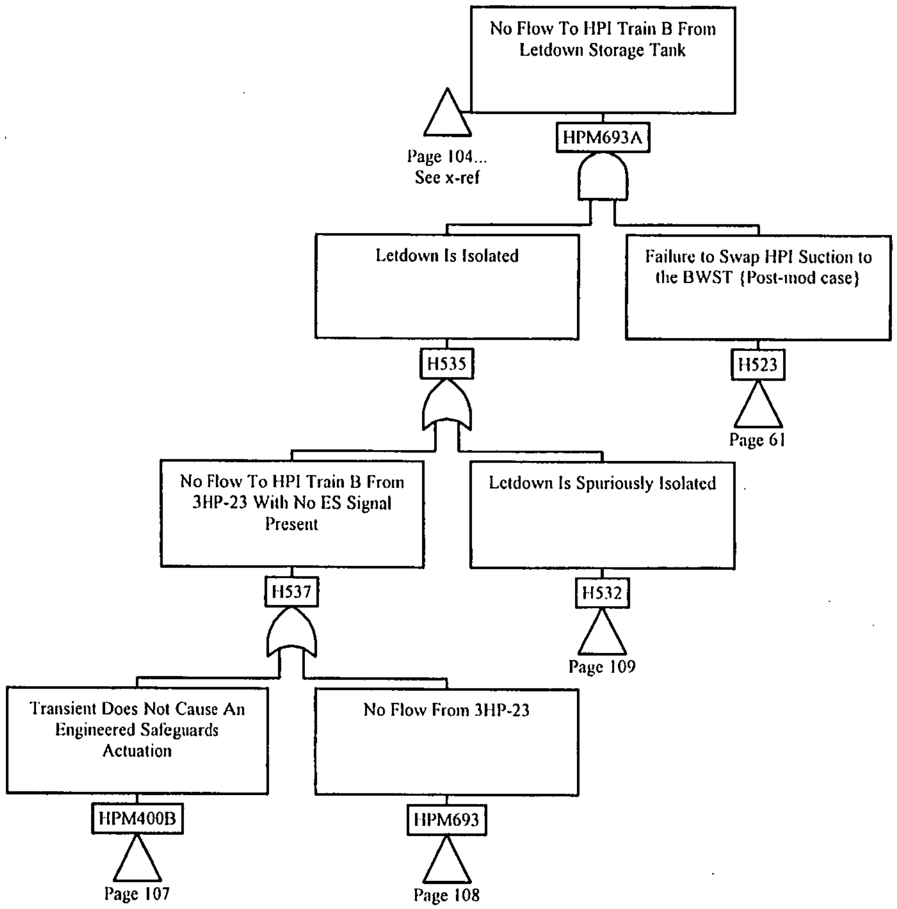

HPI Pump 3B Fails To Start
Page 111... See x-ref
HPM086
HPI Pump 3B Fails To Start Given An ES Signal
HPM086A
HPI Pump 3B Fails To Start On Low RCP Seal Injection Flow
HPM500
HPI Pump 3B Fails To Start On Demand
HHPPU3BHPS
3
1.18E-03
Control Power and Motive Power are not Both Available for HPI Pump 3B
HPIP3BST
Page 41
Transient Causes An Engineered Safeguards Actuation
HPM036B
Page 110
HPI Pump 3B Fails To Be Actuated By ES Channels 1 And/Or 2
HPM088
Operators Fail To Respond to Engineered Safeguards Failure
EKSFAS0DHE
6
4.00E-03
HPI Pump 3B Is Not Started On Low Seal Flow
HPM501
Transient Does Not Cause An Engineered Safeguards Actuation
HPM400B
Page 107
Engineered Safeguards Digital Channel 1 Fails To Start HPI Pump 3B
HPM088A
Page 113
Engineered Safeguards Digital Channel 2 Fails To Start HPI Pump 3B
HPM088B
Page 114
HPI Pump 3B Fails To Start On Demand
HHPPU3BHPS
3
1.18E-03
Control Power and Motive Power are not Both Available for HPI Pump 3B
HPIP3BST
Page 41
Failure Of Control Circuitry To Start HPI Pump 3B On Low Seal Flow
HPM502
Page 115

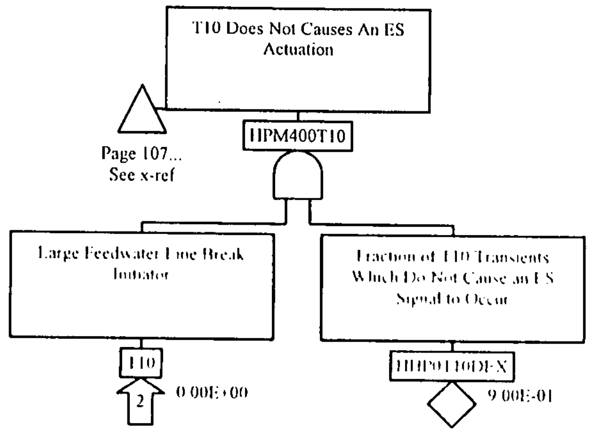

Engineered Safeguards Digital Channel 1 Fails To Start HPI Pump 3B
HPM088A
Page 112...
See x-ref
Engineered Safeguards Channel 1 Signal Fails
ESAS1
4
2.00E-06
Unit Control Module ES1C Fails
HES001CUCD
3
6.00E-08


Engineered Safeguards Digital Channel 2 Fails To Start HPI Pump 3B
HPM088B
Page 112...
See x-ref
Engineered Safeguards Channel 2 Signal Fails
ESAS2
4
2.00E-06
Unit Control Module ES2C Fails
HES002CUCD
2
6.00E-08

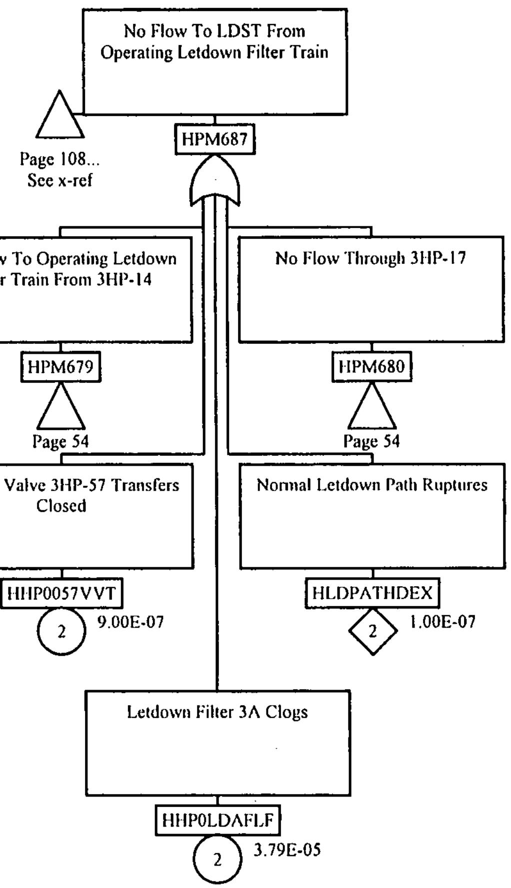


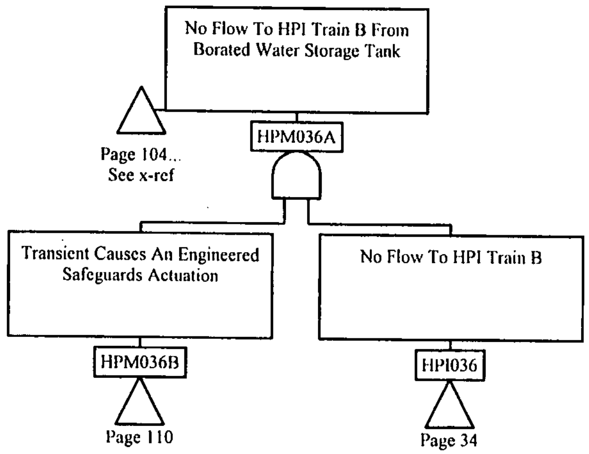
Failure Of Control Circuitry To Start HPI Pump 3B On Low Seal Flow
HPM502
Page 112...
See x-ref
Loss Of Power On 125 V dc Panelboard 3DID
D3DID
1.50E-07
Pressure Switch 3HP53-FS Fails To Operate On Low RCP Seal Flow
HHP53FSPSO
2.01E-04
125 V dc Panelboard 3DID Breaker 5 Transfers Open (Low Seal Flow Pump 3B Start)
HDCID05CDT
1.36E-04
Auxiliary Relay HP53XR Fails To Operate On Low RCP Seal Flow
HHP53XRRYD
1.11E-04


No Flow To HPI Train B From Letdown Storage Tank
HPM693A
Page 104... See x-ref
Letdown Is Isolated
H535
Failure to Swap HPI Suction to the BWST {Post-mod case}
H523
Page 61
No Flow To HPI Train B From 3HP-23 With No ES Signal Present
H537
Letdown Is Spuriously Isolated
H532
Page 109
Transient Does Not Cause An Engineered Safeguards Actuation
HPM400B
Page 107
No Flow From 3HP-23
HPM693
Page 108

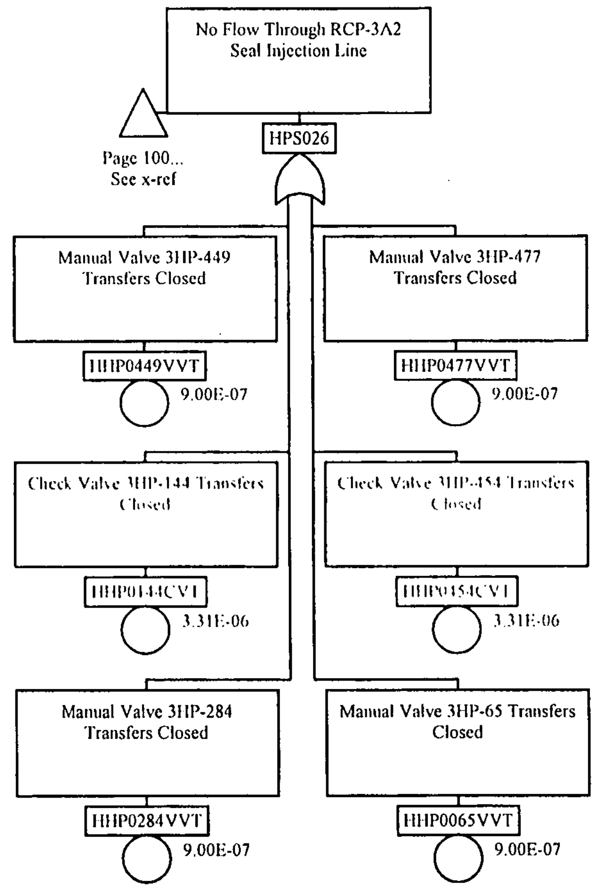


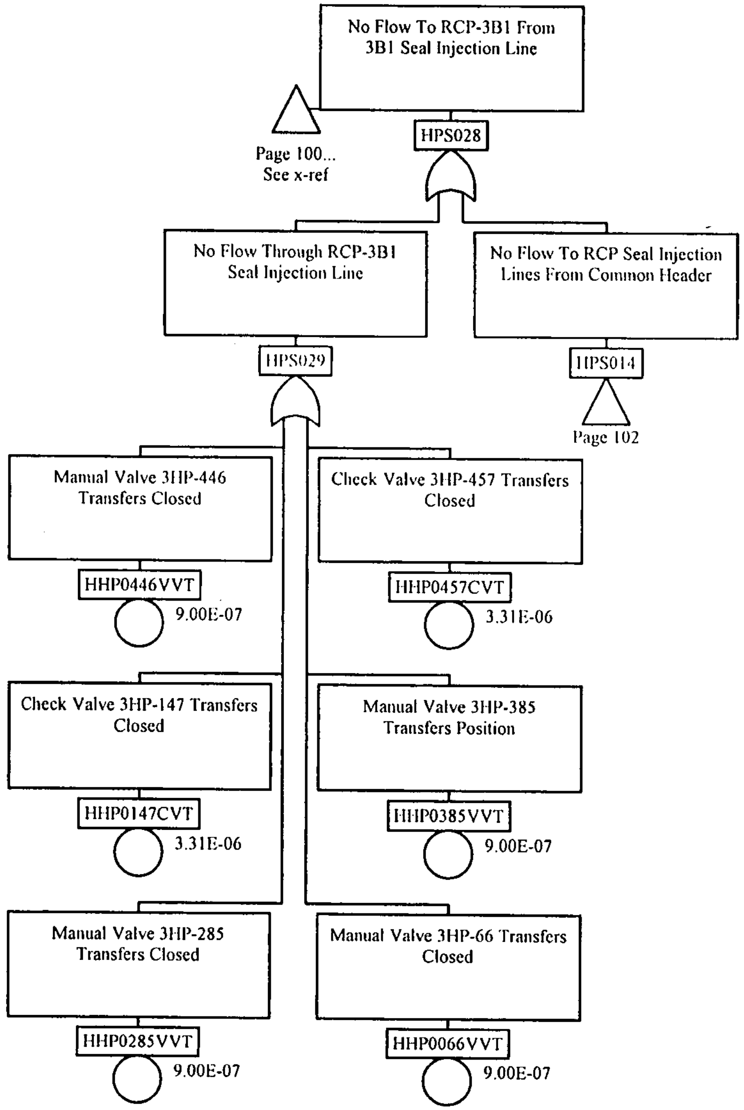
T10 Does Not Causes An ES Actuation
HPM400T10
Page 107...
See x-ref
Large Feedwater Line Break Initiator
Fraction of T10 Transients Which Do Not Cause an ES Signal to Occur
T10
2
0.00E+00
9.00E-01

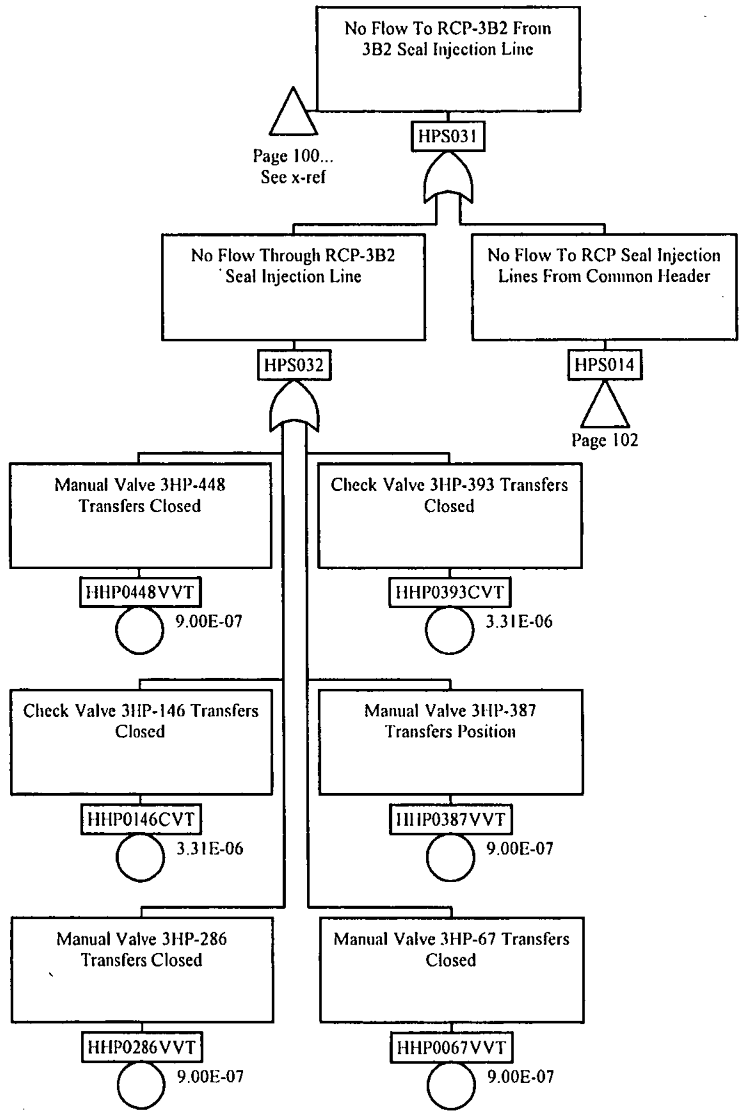

No Flow To LDST From Operating Letdown Filter Train
Page 108... See x-ref
HPM687
No Flow To Operating Letdown Filter Train From 3HP-14
HPM679
Page 54
No Flow Through 3HP-17
HPM680
Page 54
Manual Valve 3HP-57 Transfers Closed
HHP0057VVT
2
9.00E-07
Normal Letdown Path Ruptures
HLDPATHDEX
2
1.00E-07
Letdown Filter 3A Clogs
HHP0LDAFLF
2
3.79E-05

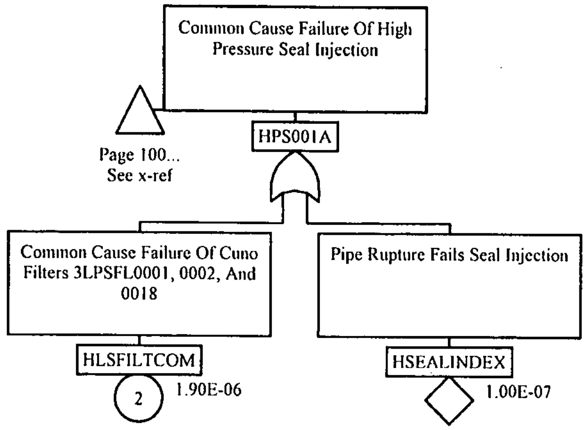


No Flow To HPI Train B From Borated Water Storage Tank
Page 104...
See x-ref
HPM036A
Transient Causes An Engineered Safeguards Actuation
No Flow To HPI Train B
HPM036B
HPI036
Page 110
Page 34


No Flow Through RCP-3A2 Seal Injection Line
HPS026
Page 100... See x-ref
Manual Valve 3HP-449 Transfers Closed
HHP0449VVT
9.00E-07
Manual Valve 3HP-477 Transfers Closed
HHP0477VVT
9.00E-07
Check Valve 3HP-144 Transfers Closed
HHP0144CVT
3.31E-06
Check Valve 3HP-454 Transfers Closed
HHP0454CVT
3.31E-06
Manual Valve 3HP-284 Transfers Closed
HHP0284VVT
9.00E-07
Manual Valve 3HP-65 Transfers Closed
HHP0065VVT
9.00E-07


No Flow To RCP-3B1 From 3B1 Seal Injection Line
HPS028
Page 100... See x-ref
No Flow Through RCP-3B1 Seal Injection Line
HPS029
No Flow To RCP Seal Injection Lines From Common Header
HPS014
Page 102
Manual Valve 3HP-446 Transfers Closed
HHP0446VVT
9.00E-07
Check Valve 3HP-457 Transfers Closed
HHP0457CVT
3.31E-06
Check Valve 3HP-147 Transfers Closed
HHP0147CVT
3.31E-06
Manual Valve 3HP-385 Transfers Position
HHP0385VVT
9.00E-07
Manual Valve 3HP-285 Transfers Closed
HHP0285VVT
9.00E-07
Manual Valve 3HP-66 Transfers Closed
HHP0066VVT
9.00E-07


No Flow To RCP-3B2 From 3B2 Seal Injection Line
Page 100... See x-ref
HPS031
No Flow Through RCP-3B2 Seal Injection Line
No Flow To RCP Seal Injection Lines From Common Header
HPS032
HPS014
Page 102
Manual Valve 3HP-448 Transfers Closed
HHP0448VVT
9.00E-07
Check Valve 3HP-393 Transfers Closed
HHP0393CVT
3.31E-06
Check Valve 3HP-146 Transfers Closed
HHP0146CVT
3.31E-06
Manual Valve 3HP-387 Transfers Position
HHP0387VVT
9.00E-07
Manual Valve 3HP-286 Transfers Closed
HHP0286VVT
9.00E-07
Manual Valve 3HP-67 Transfers Closed
HHP0067VVT
9.00E-07



Common Cause Failure Of High Pressure Seal Injection
Page 100... See x-ref
HPS001A
Common Cause Failure Of Cuno Filters 3LPSFL0001, 0002, And 0018
Pipe Rupture Fails Seal Injection
HLSFILTCOM
2
1.90E-06
HSEALINDEX
1.00E-07

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AUXAIRTOP	54	7	H3COLDLEGS	85	1	H601	58	3
AUXAIRTOP	55	2	H409	8	1	H601	59	3
AUXAIRTOP	57	5	H409	9	2	H603	59	4
AUXAIRTOP	58	2	H409	11	1	H614	82	2
AUXAIRTOP	60	2	H409	19	1	H626	48	2
AUXAIRTOP	69	2	H409	90	1	H626	61	3
CHPHPMUDHE	61	2	H409	91	1	H629	61	4
CHPHPMUDHE	61	4	H409	99	3	H638	48	2
D3DIB	45	4	H410	11	1	H639	48	1
D3DIB	58	1	H410	12	2	H639	49	3
D3DIC	41	1	H410	87	3	H641	22	2
D3DID	115	1	H412	4	4	H641	83	1
D3KI	57	3	H415	26	3	H646	43	1
D3KI	66	3	H415	28	2	HAC0008C4T	24	4
D3KU	57	4	H418	38	2	HAC0009C4T	47	4
D3KU	66	4	H423	32	4	HAC0D09C4C	46	2
D3KVIB	64	2	H426	45	2	HAC0E09C4C	42	2
D3KVIC	63	2	H468	88	3	HAC0R1ACLT	32	2
D3KVIC	68	2	H470	88	3	HAC0R1DCLT	27	2
DDCIB32CDT	45	3	H470	90	2	HAC0R2ACLT	4	2
DDCIC28CDT	41	2	H472	18	3	HAC3TE9C4T	37	4
EKSFAS0DHE	4	4	H482	99	3	HACXL9DCLT	98	5
EKSFAS0DHE	28	3	H486	91	3	HACXN6DCLT	96	5
EKSFAS0DHE	32	4	H486	94	2	HALOWFLOW	84	4
EKSFAS0DHE	38	3	H486	99	4	HALOWFLOWR	71	6
EKSFAS0DHE	45	3	H487	94	2	HALOWFLOWR	80	2
EKSFAS0DHE	112	3	H491	2	2	HBLOWFLOW	84	2
ESAS1	5	1	H493	2	3	HBLOWFLOWR	71	4
ESAS1	28	1	H493	11	2	HBLOWFLOWR	78	2
ESAS1	39	1	H498	11	3	HBREAK	83	4
ESAS1	113	1	H499	11	2	HBREAK	84	3
ESAS2	33	1	H507	87	3	HBREAKA	84	2
ESAS2	40	1	H509	87	4	HBREAKAR	71	3
ESAS2	45	1	H511	87	4	HBREAKB	84	4
ESAS2	114	1	H511	91	2	HBREAKBR	71	5
H005	11	4	H513	91	2	HBREAKR	71	4
H005	19	2	H517	71	7	HBWST3ADEX	1	6
H006	11	3	H517	82	2	HBWST3ADEX	70	4
H006	15	2	H517	86	7	HBWST3ADEX	83	5
H00COOLDEX	72	7	H523	61	2	HBWST3ADEX	85	2
H00HP97RHE	82	3	H523	105	3	HBWST3BDEX	1	7
H00LDSTDEX	108	5	H523	116	3	HBWST3BDEX	70	5
H1COLDLEG	1	2	H525	105	2	HBWST3BDEX	83	6
H2PUMPS	1	5	H528	105	1	HBWST3BDEX	85	2
H2PUMPS	23	4	H528	106	2	HBWSTOPEN	62	2
H2PUMPS	70	4	H532	105	2	HCH15BREAK	1	1
H3ABREAK	71	3	H532	109	2	HCH15INJ	1	5
H3ABREAK	84	1	H532	116	3	HD3KIKU	57	4
H3BBREAK	71	5	H535	116	2	HDCIB25CDT	58	1
H3BBREAK	84	3	H537	116	2	HDCID05CDT	115	1
H3CLDLEGSR	86	4	H600	61	1	HDFLWALM	50	4
H3COLDLEGS	70	3	H600	62	2	HDISCHADEX	71	5

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HDISCHADEX	86	5	HHP0066VVT	121	2	HHP0147CVT	121	1
HDISCHBDEX	71	6	HHP0067VVT	122	2	HHP0148VVT	14	2
HDISCHBDEX	86	6	HHP0078CVT	54	3	HHP0152VVT	21	3
HDLVXMR1	52	2	HHP0078CVT	108	4	HHP0153VVT	20	2
HDLVXMR1	65	2	HHP0097CVC	82	1	HHP0188CVO	18	1
HDLVXMR2	52	3	HHP0097CVT	82	2	HHP0188CVO	99	1
HDLVXMR2	66	4	HHP0097CVT	108	2	HHP0188CVT	18	2
HEMERLILHE	62	1	HHP0098MVT	30	3	HHP0188CVT	99	2
HEMERLIMNT	62	2	HHP0098MVT	35	1	HHP0191SVT	102	2
HES001BUCD	28	2	HHP0098MVT	93	1	HHP0194CVT	2	1
HES001CUCD	5	2	HHP0098MVT	95	3	HHP0194CVT	87	1
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HES001CUCD	113	2	HHP0099VVT	31	2	HHP0283VVT	101	1
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HES002BUCD	33	2	HHP0100VVT	31	2	HHP0285VVT	121	1
HES002CUCD	40	2	HHP0101CVO	26	1	HHP0286VVT	122	1
HES002CUCD	114	2	HHP0101CVT	26	2	HHP0331PST	58	2
HEXCMAKEUP	49	3	HHP0102CVO	32	1	HHP0357PST	58	2
HFLOW	1	2	HHP0102CVT	32	2	HHP0385VVT	121	2
HFNBINJ	70	4	HHP0103VVT	25	2	HHP0387VVT	122	2
HHP0001MVT	59	2	HHP0105CVT	25	2	HHP0390CVT	101	2
HHP0002MVT	59	3	HHP0106VVT	25	1	HHP0393CVT	122	2
HHP0003MVT	59	1	HHP0107VVT	36	1	HHP03A1ORF	16	2
HHP0004MVT	59	4	HHP0107VVT	111	1	HHP03A2ORF	17	2
HHP0005AVT	58	1	HHP0109CVO	36	2	HHP03B1ORF	20	1
HHP0006AVT	60	1	HHP0109CVO	111	2	HHP03B2ORF	21	2
HHP0007AVT	57	3	HHP0109CVT	36	2	HHP0409DHE	9	1
HHP0008AVT	55	1	HHP0109CVT	111	2	HHP0409DHE	12	1
HHP0014MVT	54	3	HHP0110VVT	36	1	HHP0409MVO	9	2
HHP0017AVT	54	6	HHP0110VVT	111	2	HHP0409MVT	9	2
HHP0023MVT	108	1	HHP0111VVT	44	2	HHP0410MVO	12	2
HHP0024LHE	26	5	HHP0113CVO	44	1	HHP0410MVT	12	2
HHP0024MVO	26	4	HHP0113CVT	44	1	HHP0446VVT	121	1
HHP0024MVT	26	4	HHP0114VVT	44	2	HHP0447VVT	101	1
HHP0024TRM	26	6	HHP0115MVT	6	3	HHP0448VVT	122	1
HHP0025LHE	32	7	HHP0115MVT	15	1	HHP0449VVT	120	1
HHP0025MVO	32	5	HHP0115MVT	88	2	HHP0454CVT	120	2
HHP0025MVT	32	5	HHP0115MVT	94	1	HHP0457CVT	121	2
HHP0025TRM	32	6	HHP0115MVT	104	2	HHP0477VVT	120	2
HHP0026MVO	4	5	HHP0118VVT	3	2	HHP0482VVT	101	2
HHP0026MVT	4	6	HHP0118VVT	87	2	HHP0486CVT	17	2
HHP0027MVT	14	1	HHP0126VVT	17	3	HHP0487CVT	16	2
HHP0028VVT	103	2	HHP0127VVT	16	1	HHP0488CVO	20	1
HHP0031AVT	102	2	HHP0128VVT	104	4	HHP0488CVT	20	2
HHP0039VVT	60	1	HHP0129VVT	103	1	HHP0489CVO	21	2
HHP0040VVT	57	2	HHP0130VVT	103	2	HHP0489CVT	21	3
HHP0041VVT	57	1	HHP0131VVT	103	2	HHP0LDAFLF	54	5
HHP0047CVT	55	1	HHP0138VVT	102	1	HHP0LDAFLF	118	2
HHP0057VVT	54	4	HHP0139VVT	102	1	HHP0SFAFLF	103	1
HHP0057VVT	118	1	HHP0144CVT	120	1	HHP0SGOLHE	31	1
HHP0064VVT	101	2	HHP0145CVT	101	1	HHP0T10DEX	117	2
HHP0065VVT	120	2	HHP0146CVT	122	1	HHP0TRBLHE	36	2

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HHP0TRBLHE	111	2	HLDFLOW	49	3	HLP0055CVT	97	1
HHP0TRBTRM	36	1	HLDFLOW	54	4	HLP0056LHE	95	1
HHP0TRBTRM	111	1	HLDFLOWAMF	50	4	HLP0056VVT	95	1
HHP0TRCLHE	44	1	HLDFLOWDHE	50	2	HLP0057CVO	95	1
HHP0TRCTRM	44	2	HLDISOLCHE	54	1	HLP0057CVT	95	2
HHP23RICOM	1	4	HLDISOLCHE	109	2	HLPSVLVCOM	96	2
HHP23RICOM	70	2	HLDLVLALM	50	5	HLPSVLVCOM	98	2
HHP23SICOM	22	3	HLDLVLALM	51	2	HLS0147VVT	73	1
HHP33P1LTF	63	1	HLDLVSIG1	62	3	HLS0148CVT	73	2
HHP33P1LTF	65	1	HLDLVSIG1	63	2	HLS0149VVT	72	1
HHP33P2LTF	64	1	HLDLVSIG2	62	4	HLS0150VVT	74	1
HHP33P2LTF	66	1	HLDLVSIG2	64	2	HLS0152VVT	24	1
HHP33RICOM	83	3	HLDMONITOR	49	2	HLS0153VVT	24	1
HHP33RICOM	85	1	HLDMONITOR	50	4	HLS0154VVT	24	2
HHP33RRCOM	71	2	HLDPATHDEX	54	7	HLS0157VVT	37	1
HHP33RRCOM	86	2	HLDPATHDEX	118	2	HLS0158VVT	37	1
HHP33SICOM	83	2	HLDPXTRCOM	67	4	HLS0159VVT	37	2
HHP53FSPSO	115	2	HLDRESTORE	49	2	HLS0162VVT	47	1
HHP53XRRYD	115	2	HLDSLVLAMF	51	1	HLS0163VVT	47	1
HHPDEMAFLF	55	1	HLDSTL1DHE	49	1	HLS0164VVT	47	2
HHPHPR0DHE	71	1	HLDSTLEVEL	48	4	HLS0204ORF	75	1
HHPHPR0DHE	86	1	HLDSTLEVEL	51	2	HLS0246VVT	72	2
HHPHX3AHXF	24	2	HLDSTLEVEL	52	3	HLS0500VVT	72	4
HHPHX3BHXF	37	2	HLDSTLVL	48	3	HLS0503CVT	74	2
HHPHX3CHXF	47	2	HLDSTLVXMS	52	2	HLS0708VVT	73	2
HHPKD17CLT	55	2	HLDSTPERN	1	8	HLS0709VVT	74	2
HHPKD18CLT	54	6	HLDSTPERN	48	3	HLS0711VVT	72	3
HHPKD19CLT	60	2	HLDSTPERN	70	6	HLS0771VVT	75	3
HHPKU21CLT	57	5	HLDSTPERN	83	7	HLS0C01FLF	73	1
HHPLDCAHXF	59	2	HLDSTPERN	85	2	HLS0C02FLF	74	1
HHPLDCBHXF	59	4	HLDSTPRESS	67	3	HLS0C18FLF	75	2
HHPLDSTTKF	108	4	HLDSTPRXMS	67	3	HLSFILTCOM	72	6
HHPPMPSCOM	43	2	HLDSTSIG	62	3	HLSFILTCOM	123	1
HHPPU3AHPR	24	3	HLDXMTRCOM	52	1	HLVLPWR	65	1
HHPPU3BHPR	37	3	HLEVELFAIL	48	4	HLVLPWR	66	3
HHPPU3BHPS	38	1	HLOCALOOP	22	1	HLVLST1LTM	65	2
HHPPU3BHPS	112	4	HLOCALOOP	43	1	HLVLST2LTM	66	5
HHPPU3BHPS	112	6	HLOOP	83	2	HNMOPLVDHE	48	3
HHPPU3CHPR	47	3	HLOOP	85	1	HNMOPRSDHE	67	2
HHPPU3CHPS	45	1	HLOOP2	1	3	HNMOPRSLHE	67	1
HHPSV90SVT	58	2	HLOOP2	22	2	HNORMLDINT	49	2
HHPSVLVCOM	26	4	HLOOP2	70	1	HP14LS1SMF	63	2
HHPSVLVCOM	32	6	HLOOPCOM	38	4	HP14LS1SMF	65	1
HHPT10EDEX	110	5	HLOOPCOM	43	2	HP14LS2SMF	64	2
HHS0017MVT	76	2	HLOOPCOM	45	5	HP14LS2SMF	66	2
HHS0112VVT	76	1	HLP0015MVO	98	1	HPI001	85	2
HHS0202VVT	77	2	HLP0015MVT	98	3	HPI004	23	2
HHS0450VVT	77	1	HLP0016MVO	96	1	HPI004	25	2
HHS0555VVT	75	5	HLP0016MVT	96	3	HPI007	18	2
HHS0556RGO	75	7	HLP0054LHE	97	1	HPI007	21	1
HHS0556RGT	75	6	HLP0054VVT	97	1	HPI0085DEX	52	3
HHS2017MVT	77	2	HLP0055CVO	97	2	HPI0087DEX	52	4

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HPI0095VVT	67	2	HPI083	36	2	HPI897	70	3
HPI014	2	2	HPI083	89	3	HPI897	84	3
HPI014	3	2	HPI086	36	2	HPI898	1	3
HPI017	3	2	HPI086	38	3	HPI898	18	3
HPI017	6	2	HPI087	36	1	HPI898	70	3
HPI022	3	1	HPI087	37	3	HPI898	84	2
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HPI022	87	2	HPI088	38	2	HPI899	17	2
HPI023A	4	3	HPI088A	38	1	HPI899	70	2
HPI023A	5	2	HPI088A	39	2	HPI899	84	5
HPI026	23	2	HPI088B	38	2	HPI900	1	2
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HPI026A	6	1	HPI092	30	2	HPI900	70	2
HPI026A	15	2	HPI092	34	1	HPI900	84	4
HPI026A	23	3	HPI098	13	3	HPI973	73	3
HPI026B	23	4	HPI098	30	2	HPI973	74	2
HPI026B	110	4	HPI099	30	2	HPI974	75	4
HPI026C	23	4	HPI099	32	4	HPI974B	75	3
HPI026C	30	2	HPI105	32	4	HPI974B	76	2
HPI032	23	1	HPI106A	32	3	HPI974C	75	4
HPI032	24	3	HPI106A	33	2	HPI974C	77	2
HPI032	94	3	HPI791	13	2	HPI975	73	2
HPI033	6	1	HPI791	34	2	HPI976	75	4
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HPI033	11	4	HPI792	13	2	HPI977	73	2
HPI033	23	4	HPI793	13	1	HPI978	72	3
HPI036	7	1	HPI793	30	1	HPI978	75	4
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HPI060	10	1	HPI887	91	3	HPI991	24	2
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HPI060	23	5	HPI889	10	2	HPI997	24	4
HPI061	13	2	HPI889	11	2	HPI999	4	2
HPI062	13	3	HPI889	18	4	HPIBREAKIN	83	4
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HPI067	44	1	HPI893	21	2	HPICOOL	72	5
HPI067	45	3	HPI893	79	1	HPICOOL	86	3
HPI068	44	2	HPI894	18	3	HPICOOL	100	1
HPI068	47	3	HPI894	20	2	HPIFT6PFTF	50	3
HPI071A	45	2	HPI894	86	4	HPIFT6XCOM	50	2
HPI074	23	3	HPI895	17	2	HPIFT6XCOM	50	4
HPI074	26	4	HPI895	81	1	HPILT6AFTF	50	1
HPI074	35	2	HPI896	2	3	HPIP3BAC	41	3
HPI075	26	4	HPI896	16	2	HPIP3BAC	42	2
HPI080	26	3	HPI896	86	2	HPIP3BDC	41	2
HPI082A	28	2	HPI897	1	3	HPIP3BST	38	3
HPI083	7	2	HPI897	21	2	HPIP3BST	41	2

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HPIP3BST	112	5	HPM502	115	2	HPR074	94	2
HPIP3BST	112	7	HPM658	56	4	HPR074	97	2
HPIP3CAC	45	5	HPM658	60	2	HPR074A	97	2
HPIP3CAC	46	2	HPM659	56	4	HPR074A	98	3
HPIP3CDC	45	4	HPM665	59	2	HPR074B	98	4
HPIP3CST	45	4	HPM666	58	2	HPR092	89	1
HPIPRS1PRM	68	2	HPM667	56	2	HPR092	95	2
HPIPRS2PRM	69	2	HPM667	56	3	HPR098	92	3
HPIPTF010	67	4	HPM667	58	2	HPR098	95	2
HPIPTF010	69	2	HPM668	56	1	HPR098A	95	2
HPIPTF228	67	3	HPM668	57	3	HPR098A	96	3
HPIPTF228	68	2	HPM668AC	57	4	HPR098B	96	4
HPIR052DEX	65	2	HPM669	56	2	HPR791	89	2
HPIR103DEX	66	6	HPM670	56	3	HPR791	92	1
HPIS052VVT	65	2	HPM671	54	2	HPR791	93	2
HPIS103VVT	66	7	HPM671	56	3	HPR792	92	2
HPIV097VVT	69	2	HPM672	54	1	HPR795	88	2
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HPIV370VVT	69	1	HPM673	54	2	HPR889	91	2
HPIV371VVT	68	1	HPM679	54	2	HPR889	99	3
HPM026A	104	1	HPM679	118	1	HPR892	81	2
HPM026A	105	2	HPM680	54	6	HPR892	86	3
HPM026BA	105	3	HPM680	118	2	HPR892	87	2
HPM026BA	110	4	HPM687	108	3	HPR897	78	2
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HPM036A	104	4	HPM690	108	4	HPR897	86	6
HPM036A	119	2	HPM691	108	2	HPR898	78	1
HPM036B	110	3	HPM693	106	2	HPR898	86	5
HPM036B	112	1	HPM693	108	3	HPR899	80	2
HPM036B	119	1	HPM693	116	2	HPR899	81	2
HPM036T10	110	4	HPM693A	104	4	HPR899	86	4
HPM083	104	3	HPM693A	116	3	HPR900	80	1
HPM083	111	2	HPR001	86	4	HPR900	86	3
HPM086	111	1	HPR007	79	2	HPRESSFAIL	48	4
HPM086	112	4	HPR007	86	5	HPRESSFAIL	67	2
HPM086A	112	2	HPR007	99	2	HPS001A	100	5
HPM088	112	2	HPR014	87	2	HPS001A	123	2
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HPM088A	113	2	HPR017	88	2	HPS002	100	4
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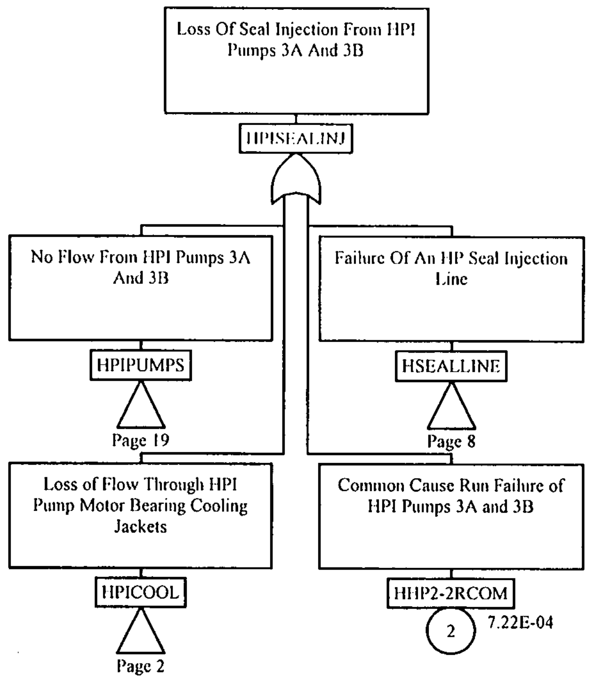
HPM088B	114	2	HPR026A	94	2	HPS012	100	1
HPM400	106	2	HPR026B	94	2	HPS012	101	2
HPM400A	105	2	HPR026C	94	1	HPS014	100	2
HPM400B	106	1	HPR026C	95	3	HPS014	100	4
HPM400B	107	2	HPR033	88	2	HPS014	102	3
HPM400B	112	5	HPR033	89	2	HPS014	121	3
HPM400B	116	1	HPR033	94	3	HPS014	122	3
HPM400T10	107	2	HPR036	89	2	HPS016	102	2
HPM400T10	117	2	HPR060	91	2	HPS018	102	4
HPM500	112	5	HPR060	92	3	HPS020	102	3
HPM501	112	4	HPR061	92	2	HPS020	103	2
HPM502	112	4	HPR074	93	2	HPS021	102	4

APPENDIX B2

HPI SYSTEM
RC MAKE-UP AND RCP SEAL INJECTION
FAULT TREE


Loss Of Seal Injection From HPI Pumps 3A And 3B
HPISEALINJ
No Flow From HPI Pumps 3A And 3B
HPIPUMPS
Page 19
Failure Of An HP Seal Injection Line
HSEALLINE
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Loss of Flow Through HPI Pump Motor Bearing Cooling Jackets
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Page 2
Common Cause Run Failure of HPI Pumps 3A and 3B
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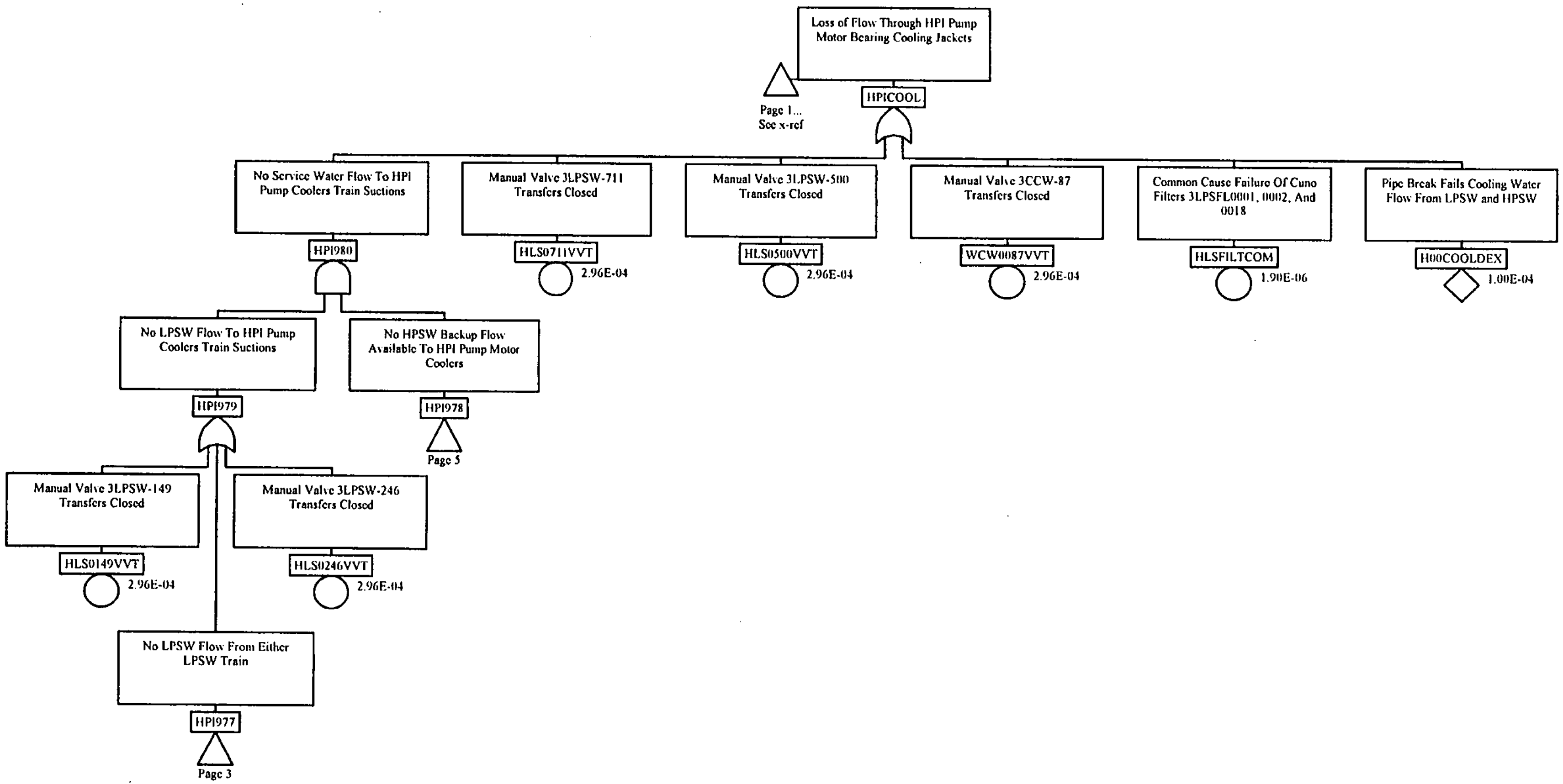
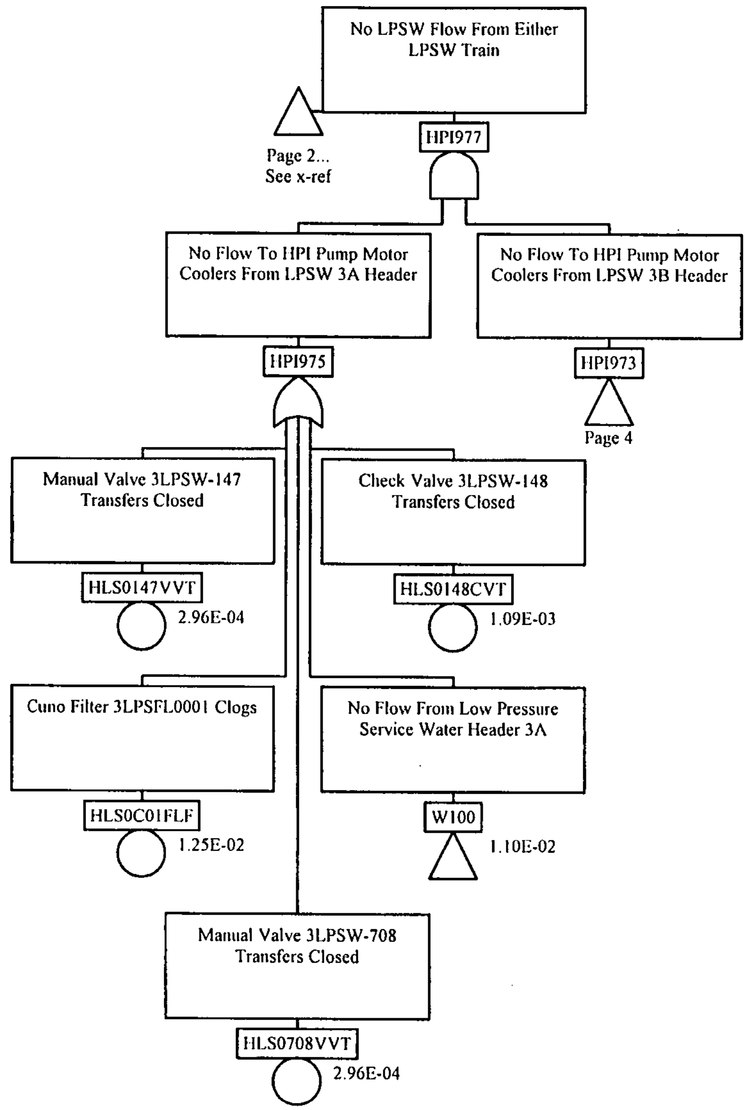
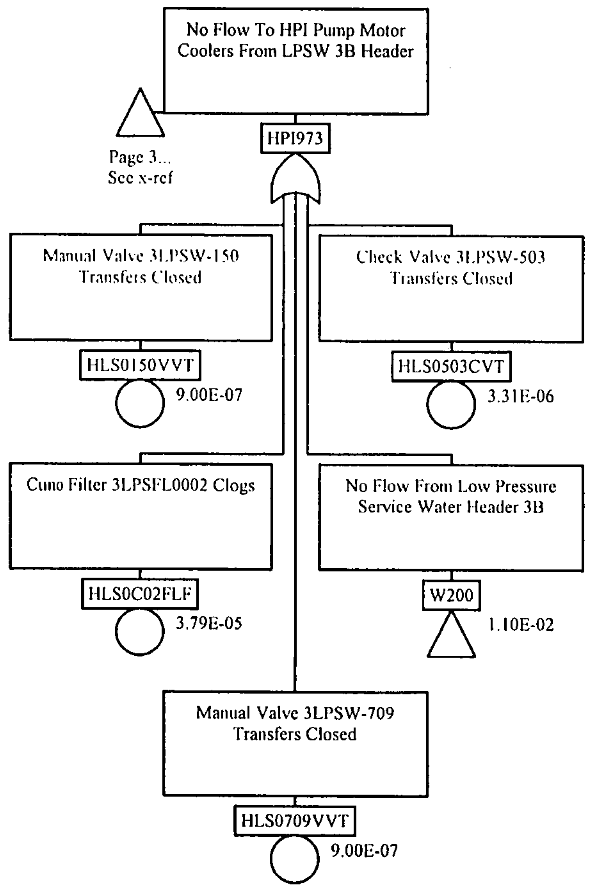
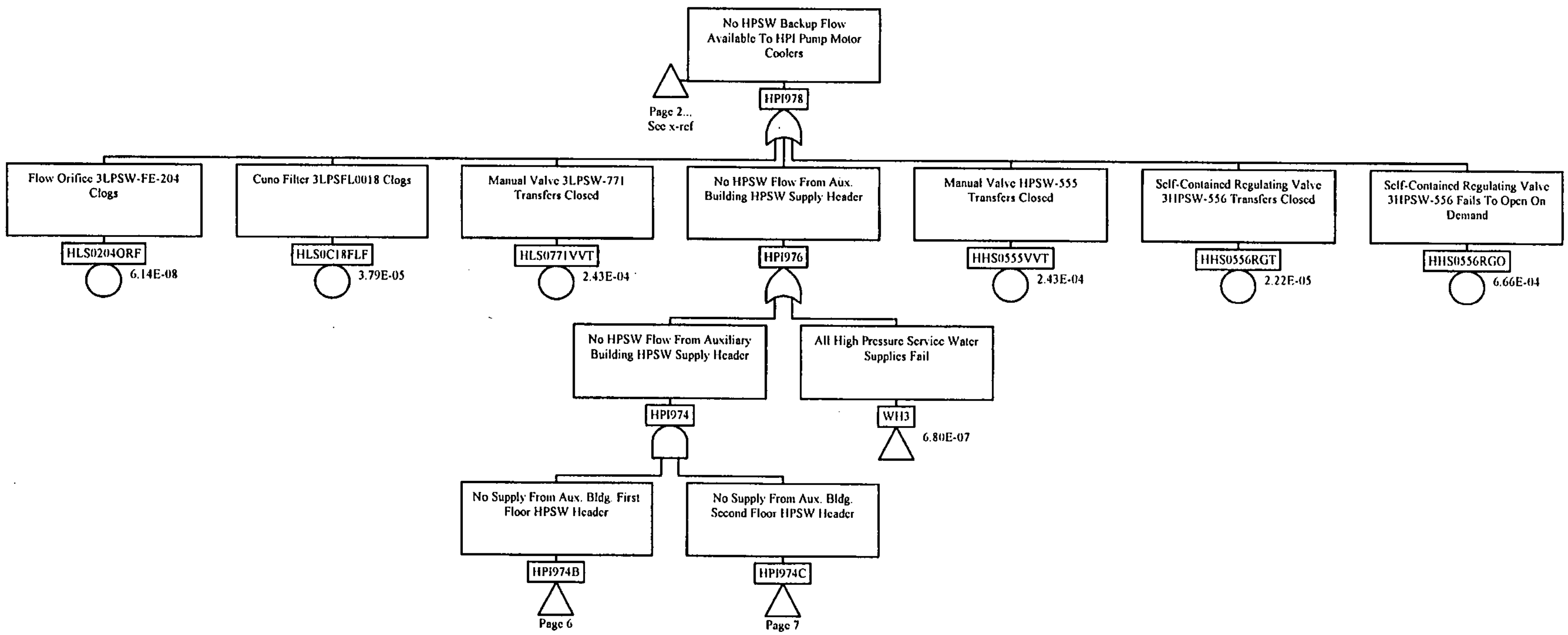
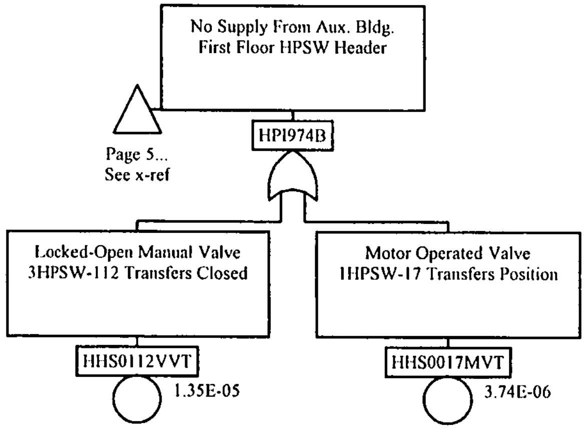
2
7.22E-04

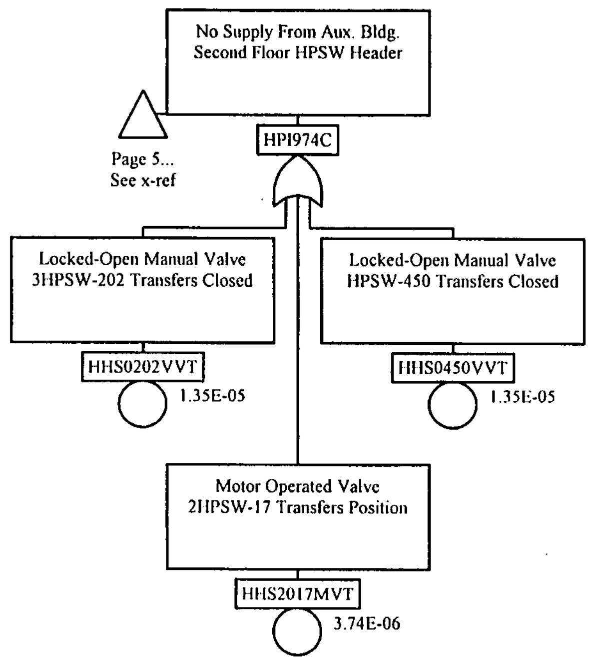

Loss of Flow Through HPI Pump Motor Bearing Cooling Jackets
HPICOOL
Page 1... See x-ref
No Service Water Flow To HPI Pump Coolers Train Suctions
HPI980
Manual Valve 3LPSW-711 Transfers Closed
HLS0711VVT
2.96E-04
Manual Valve 3LPSW-500 Transfers Closed
HLS0500VVT
2.96E-04
Manual Valve 3CCW-87 Transfers Closed
WCW0087VVT
2.96E-04
Common Cause Failure Of Cuno Filters 3LPSFL0001, 0002, And 0018
HLSFILTCOM
1.90E-06
Pipe Break Fails Cooling Water Flow From LPSW and HPSW
H00COOLDEX
1.00E-04
No LPSW Flow To HPI Pump Coolers Train Suctions
HPI979
No HPSW Backup Flow Available To HPI Pump Motor Coolers
HPI978
Page 5
Manual Valve 3LPSW-149 Transfers Closed
HLS0149VVT
2.96E-04
Manual Valve 3LPSW-246 Transfers Closed
HLS0246VVT
2.96E-04
No LPSW Flow From Either LPSW Train
HPI977
Page 3

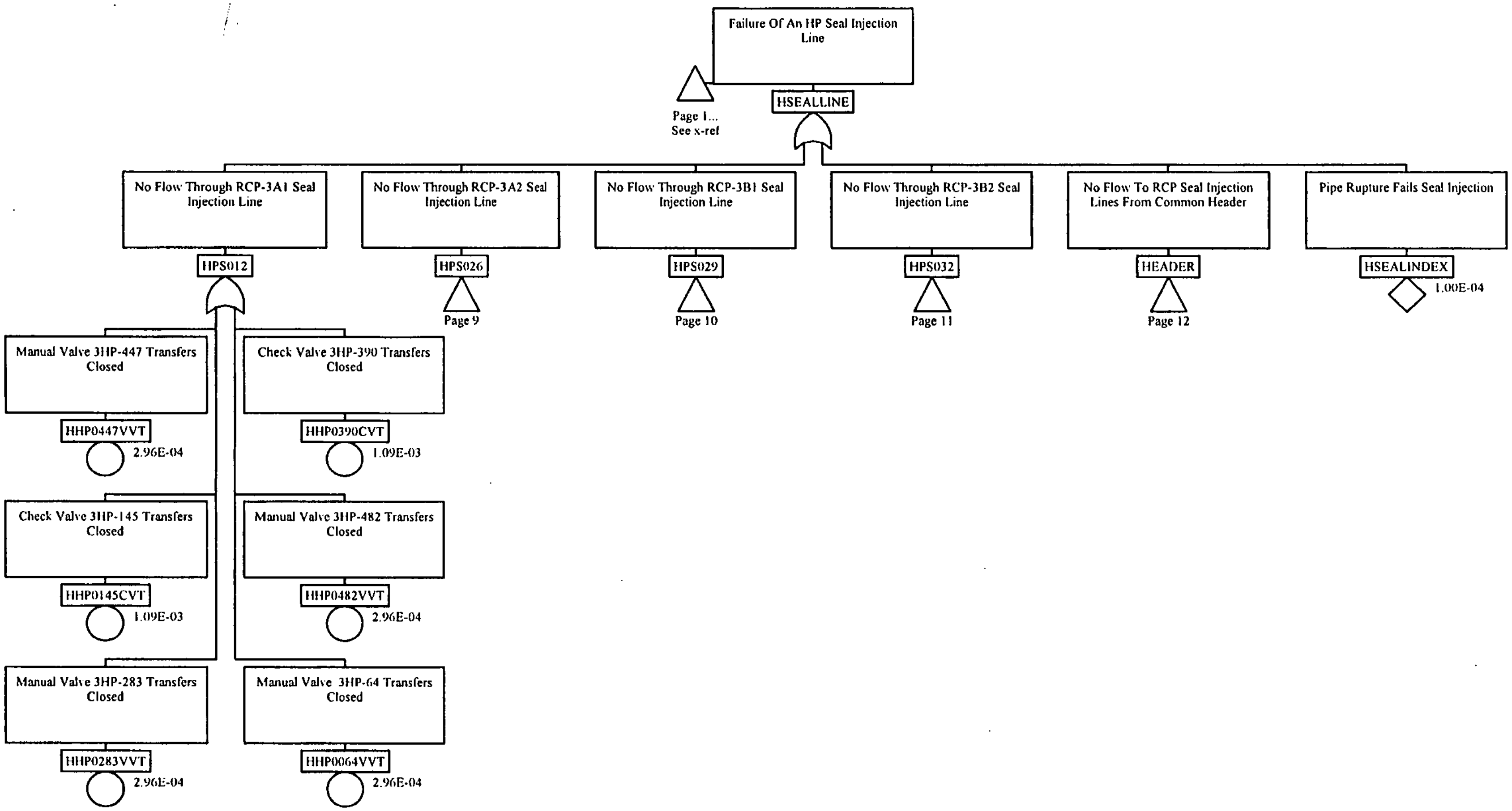

No LPSW Flow From Either LPSW Train
Page 2...
See x-ref
HPI977
No Flow To HPI Pump Motor Coolers From LPSW 3A Header
No Flow To HPI Pump Motor Coolers From LPSW 3B Header
HPI975
HPI973
Page 4
Manual Valve 3LPSW-147 Transfers Closed
Check Valve 3LPSW-148 Transfers Closed
HLS0147VVT
2.96E-04
HLS0148CVT
1.09E-03
Cuno Filter 3LPSFL0001 Clogs
No Flow From Low Pressure Service Water Header 3A
HLSC01FLF
1.25E-02
W100
1.10E-02
Manual Valve 3LPSW-708 Transfers Closed
HLS0708VVT
2.96E-04

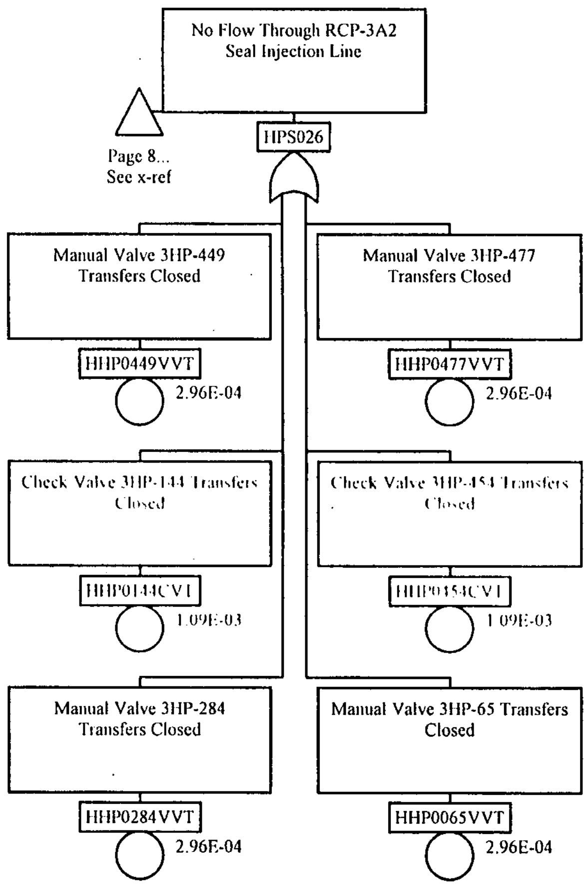

No Flow To HPI Pump Motor Coolers From LPSW 3B Header
HPI973
Page 3...
See x-ref
Manual Valve 3LPSW-150 Transfers Closed
HLS0150VVT
9.00E-07
Check Valve 3LPSW-503 Transfers Closed
HLS0503CVT
3.31E-06
Cuno Filter 3LPSFL0002 Clogs
HLS0C02FLF
3.79E-05
No Flow From Low Pressure Service Water Header 3B
W200
1.10E-02
Manual Valve 3LPSW-709 Transfers Closed
HLS0709VVT
9.00E-07

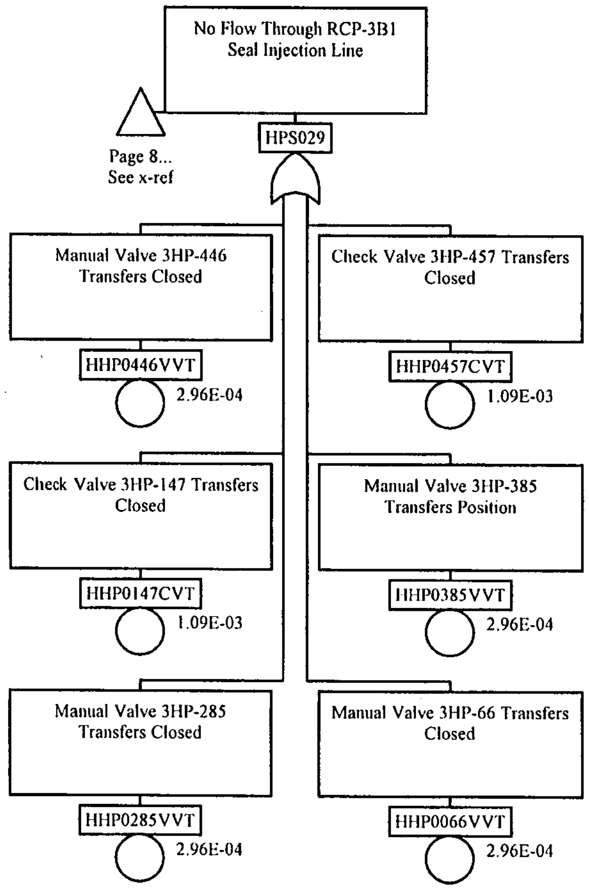

No HPSW Backup Flow Available To HPI Pump Motor Coolers
HPI978
Page 2... See x-ref
Flow Orifice 3LPSW-FE-204 Clogs
HLS0204ORF
6.14E-08
Cuno Filter 3LPSFL0018 Clogs
HLS0C18FLF
3.79E-05
Manual Valve 3LPSW-771 Transfers Closed
HLS0771VVT
2.43E-04
No HPSW Flow From Aux. Building HPSW Supply Header
HPI976
Manual Valve HPSW-555 Transfers Closed
HHS0555VVT
2.43E-04
Self-Contained Regulating Valve 3HPSW-556 Transfers Closed
HHS0556RGT
2.22E-05
Self-Contained Regulating Valve 3HPSW-556 Fails To Open On Demand
HHS0556RGO
6.66E-04
No HPSW Flow From Auxiliary Building HPSW Supply Header
HPI974
All High Pressure Service Water Supplies Fail
WH3
6.80E-07
No Supply From Aux. Bldg. First Floor HPSW Header
HPI974B
Page 6
No Supply From Aux. Bldg. Second Floor HPSW Header
HPI974C
Page 7

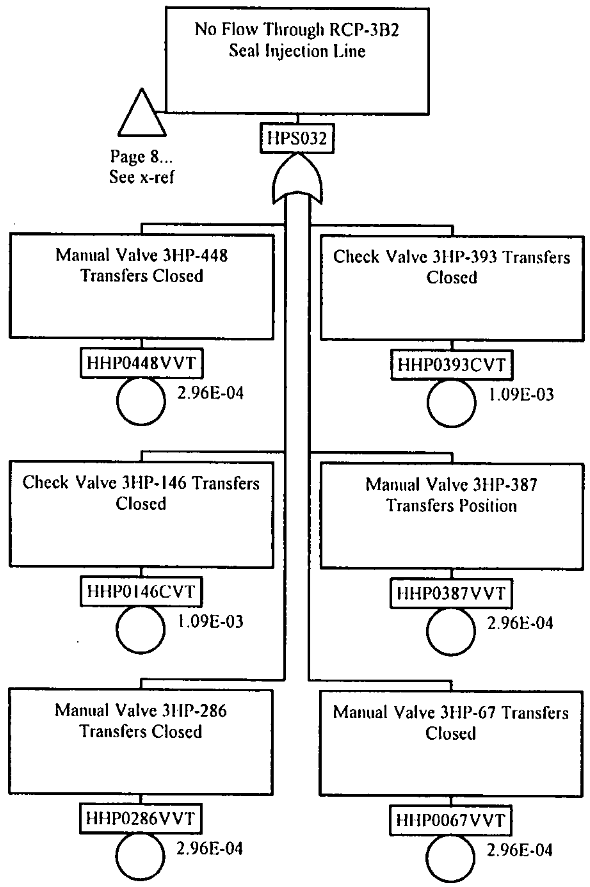

No Supply From Aux. Bldg. First Floor HPSW Header
HPI974B
Page 5...
See x-ref
Locked-Open Manual Valve 3HPSW-112 Transfers Closed
HHS0112VVT
1.35E-05
Motor Operated Valve 1HPSW-17 Transfers Position
HHS0017MVT
3.74E-06

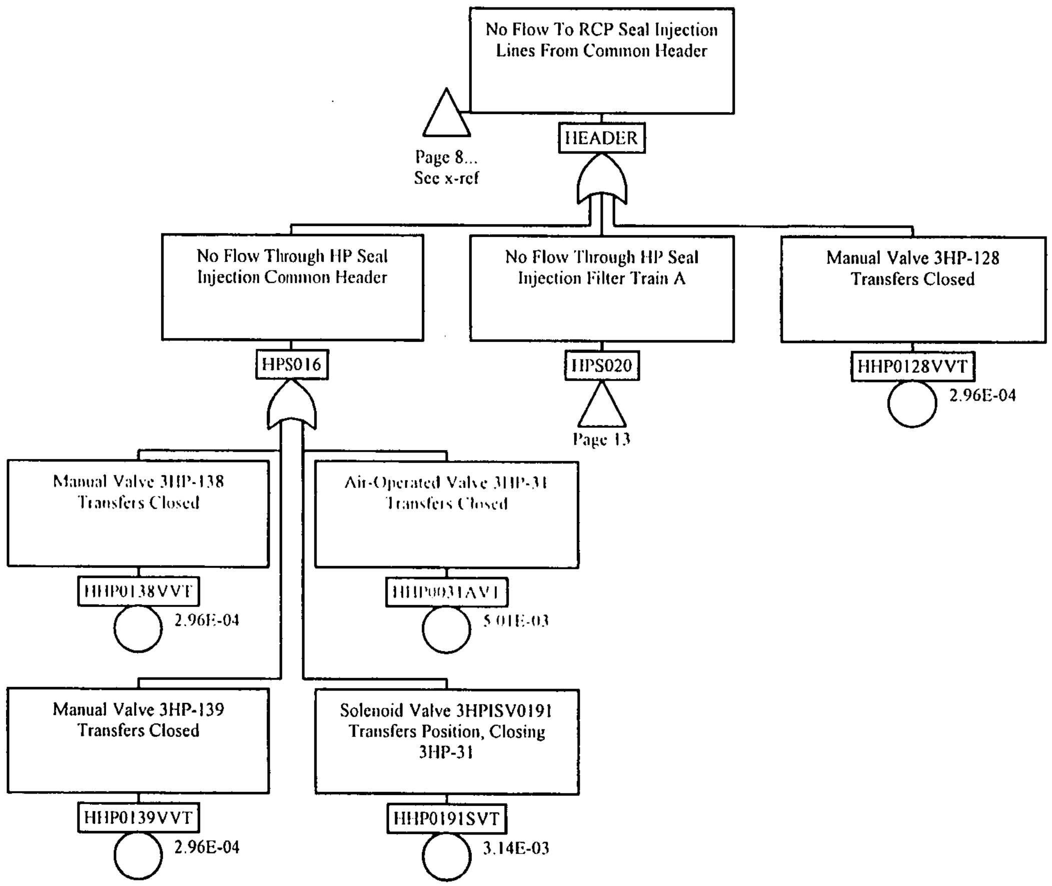

No Supply From Aux. Bldg. Second Floor HPSW Header
HPI974C
Page 5...
See x-ref
Locked-Open Manual Valve 3HPSW-202 Transfers Closed
HHS0202VVT
1.35E-05
Locked-Open Manual Valve HPSW-450 Transfers Closed
HHS0450VVT
1.35E-05
Motor Operated Valve 2HPSW-17 Transfers Position
HHS2017MVT
3.74E-06

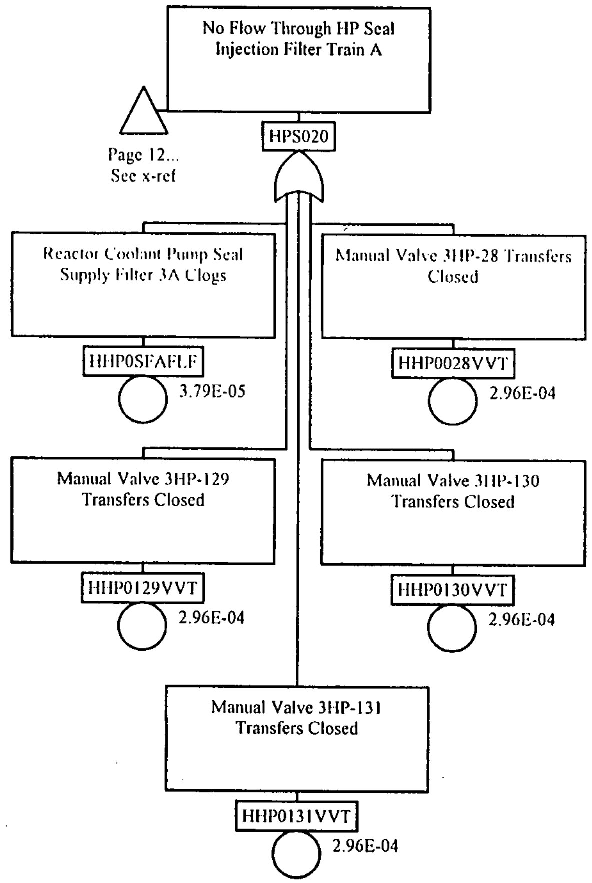

Failure Of An HP Seal Injection Line
HSEALLINE
Page 1...
See x-ref
No Flow Through RCP-3A1 Seal Injection Line
HPS012
No Flow Through RCP-3A2 Seal Injection Line
HPS026
Page 9
No Flow Through RCP-3B1 Seal Injection Line
HPS029
Page 10
No Flow Through RCP-3B2 Seal Injection Line
HPS032
Page 11
No Flow To RCP Seal Injection Lines From Common Header
HEADER
Page 12
Pipe Rupture Fails Seal Injection
HSEALINDEX
1.00E-04
Manual Valve 3HP-447 Transfers Closed
HHP0447VVT
2.96E-04
Check Valve 3HP-390 Transfers Closed
HHP0390CVT
1.09E-03
Check Valve 3HP-145 Transfers Closed
HHP0145CVT
1.09E-03
Manual Valve 3HP-482 Transfers Closed
HHP0482VVT
2.96E-04
Manual Valve 3HP-283 Transfers Closed
HHP0283VVT
2.96E-04
Manual Valve 3HP-64 Transfers Closed
HHP0064VVT
2.96E-04

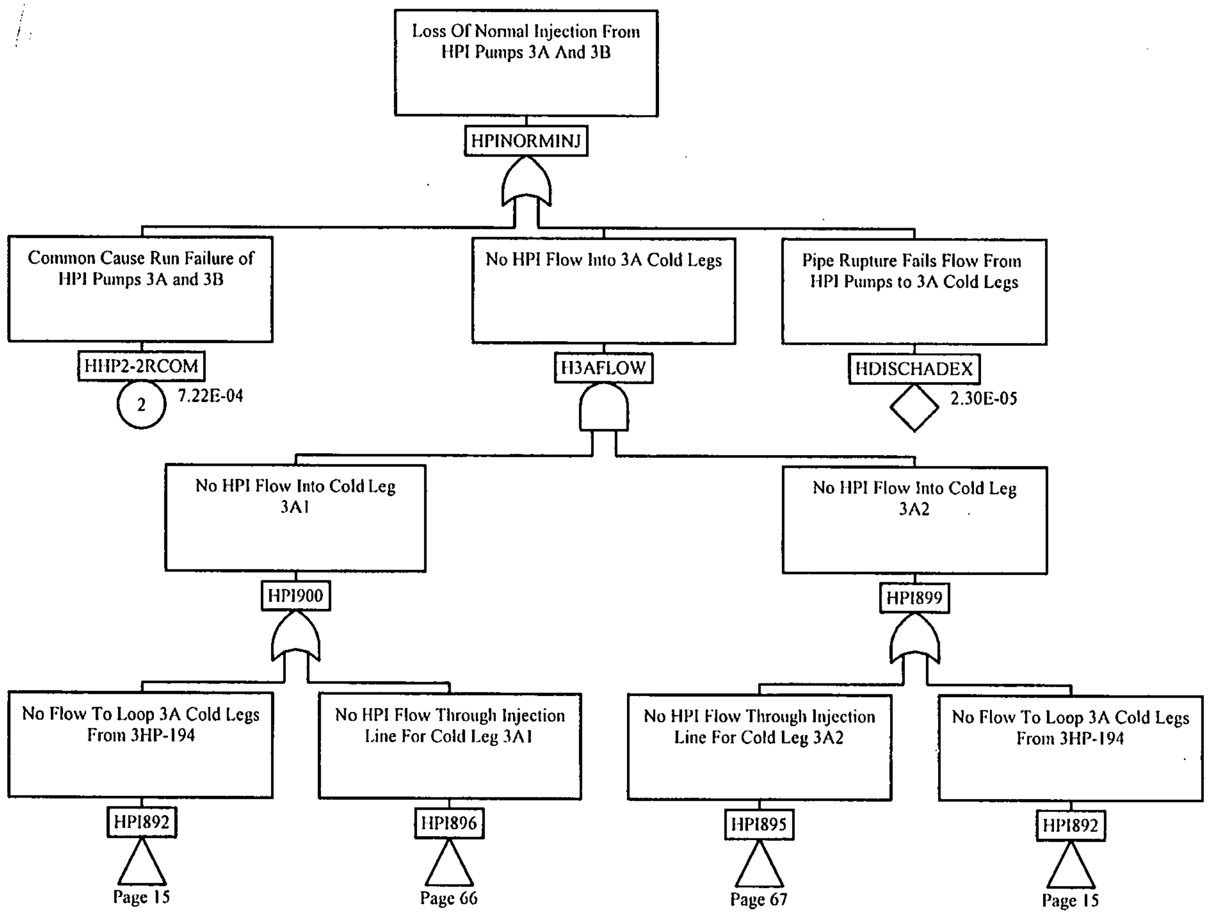

No Flow Through RCP-3A2 Seal Injection Line
HPS026
Page 8...
See x-ref
Manual Valve 3HP-449 Transfers Closed
HHP0449VVT
2.96E-04
Manual Valve 3HP-477 Transfers Closed
HHP0477VVT
2.96E-04
Check Valve 3HP-144 Transfers Closed
HHP0144CVT
1.09E-03
Check Valve 3HP-454 Transfers Closed
HHP0454CVT
1.09E-03
Manual Valve 3HP-284 Transfers Closed
HHP0284VVT
2.96E-04
Manual Valve 3HP-65 Transfers Closed
HHP0065VVT
2.96E-04

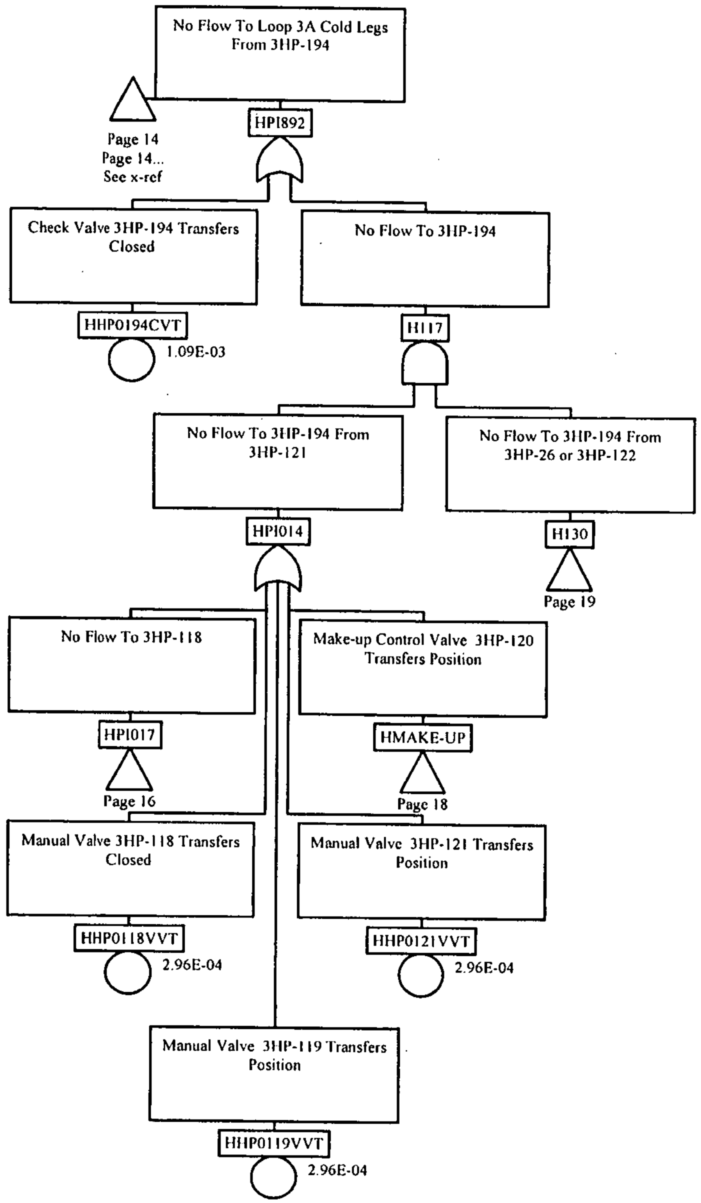

No Flow Through RCP-3B1 Seal Injection Line
HPS029
Page 8... See x-ref
Manual Valve 3HP-446 Transfers Closed
HHP0446VVT
2.96E-04
Check Valve 3HP-457 Transfers Closed
HHP0457CVT
1.09E-03
Check Valve 3HP-147 Transfers Closed
HHP0147CVT
1.09E-03
Manual Valve 3HP-385 Transfers Position
HHP0385VVT
2.96E-04
Manual Valve 3HP-285 Transfers Closed
HHP0285VVT
2.96E-04
Manual Valve 3HP-66 Transfers Closed
HHP0066VVT
2.96E-04

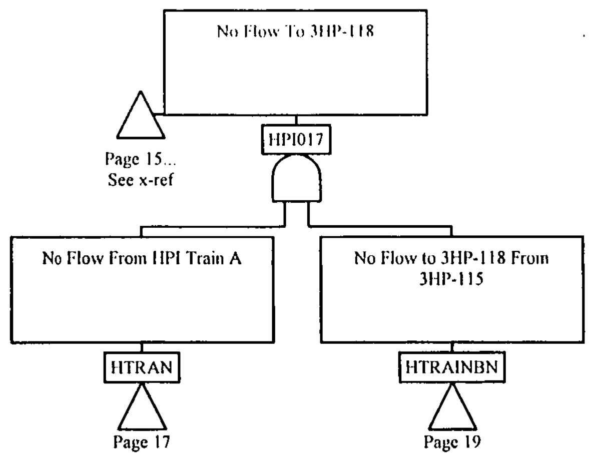

No Flow Through RCP-3B2 Seal Injection Line
HPS032
Page 8... See x-ref
Manual Valve 3HP-448 Transfers Closed
HHP0448VVT
2.96E-04
Check Valve 3HP-393 Transfers Closed
HHP0393CVT
1.09E-03
Check Valve 3HP-146 Transfers Closed
HHP0146CVT
1.09E-03
Manual Valve 3HP-387 Transfers Position
HHP0387VVT
2.96E-04
Manual Valve 3HP-286 Transfers Closed
HHP0286VVT
2.96E-04
Manual Valve 3HP-67 Transfers Closed
HHP0067VVT
2.96E-04


No Flow To RCP Seal Injection Lines From Common Header
HEADER
Page 8...
See x-ref
No Flow Through HP Seal Injection Common Header
HPS016
No Flow Through HP Seal Injection Filter Train A
HPS020
Page 13
Manual Valve 3HP-128 Transfers Closed
HHP0128VVT
2.96E-04
Manual Valve 3HP-138 Transfers Closed
HHP0138VVT
2.96E-04
Air-Operated Valve 3HP-31 Transfers Closed
HHP0031AVT
5.01E-03
Manual Valve 3HP-139 Transfers Closed
HHP0139VVT
2.96E-04
Solenoid Valve 3HPISV0191 Transfers Position, Closing 3HP-31
HHP0191SVT
3.14E-03

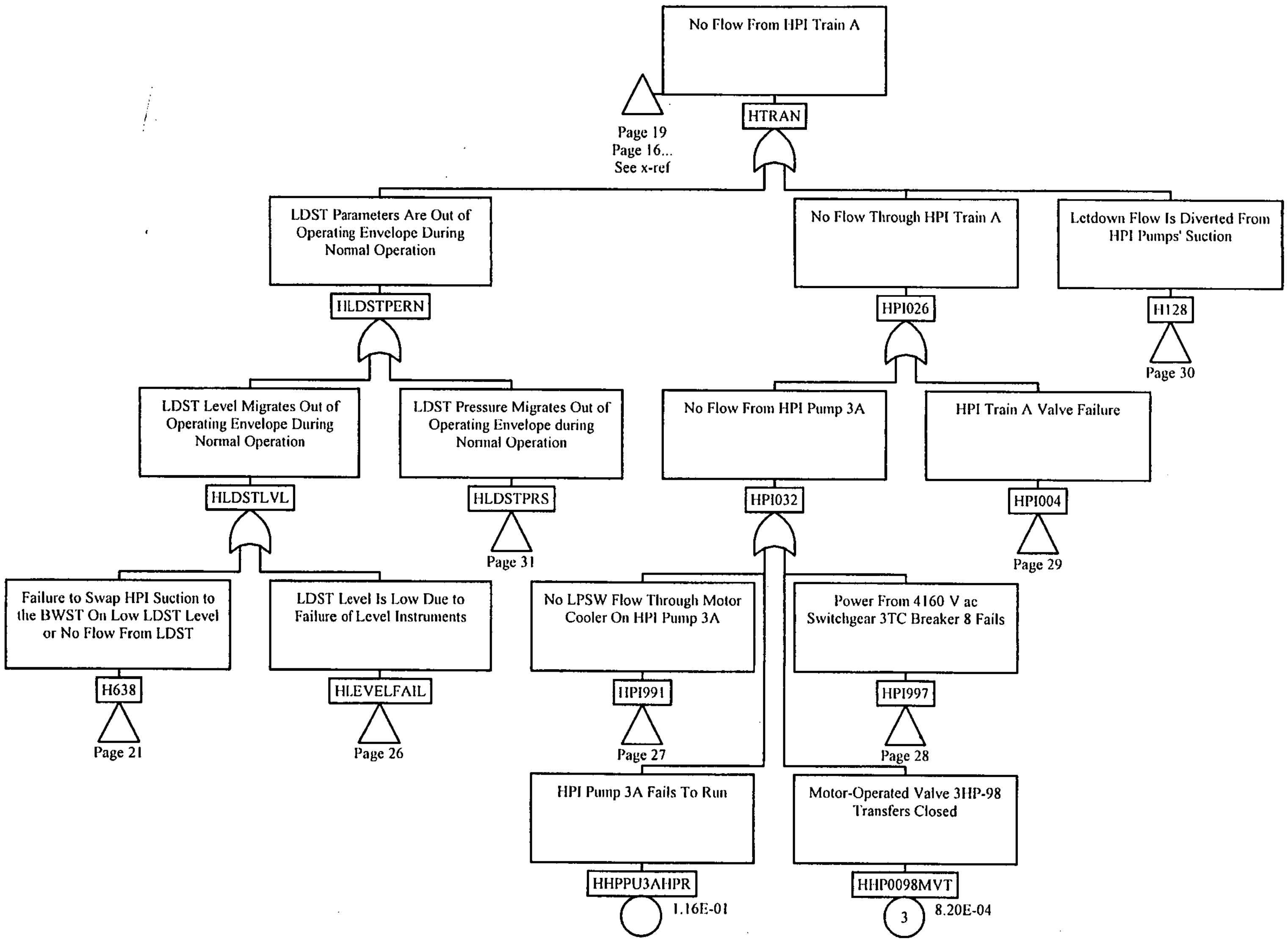

No Flow Through HP Seal Injection Filter Train A
HPS020
Page 12... See x-ref
Reactor Coolant Pump Seal Supply Filter 3A Clogs
HHP0SFAFLF
3.79E-05
Manual Valve 3HP-28 Transfers Closed
HHP0028VVT
2.96E-04
Manual Valve 3HP-129 Transfers Closed
HHP0129VVT
2.96E-04
Manual Valve 3HP-130 Transfers Closed
HHP0130VVT
2.96E-04
Manual Valve 3HP-131 Transfers Closed
HHP0131VVT
2.96E-04

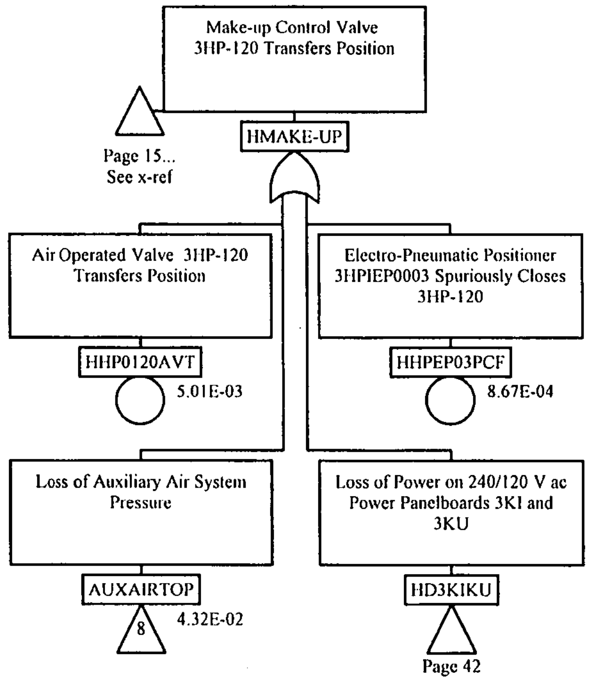

Loss Of Normal Injection From HPI Pumps 3A And 3B
HPINORMINJ
Common Cause Run Failure of HPI Pumps 3A and 3B
HHP2-2RCOM
2
7.22E-04
No HPI Flow Into 3A Cold Legs
H3AFLOW
Pipe Rupture Fails Flow From HPI Pumps to 3A Cold Legs
HDISCHADEX
2.30E-05
No HPI Flow Into Cold Leg 3A1
HPI900
No HPI Flow Into Cold Leg 3A2
HPI899
No Flow To Loop 3A Cold Legs From 3HP-194
HPI892
Page 15
No HPI Flow Through Injection Line For Cold Leg 3A1
HPI896
Page 66
No HPI Flow Through Injection Line For Cold Leg 3A2
HPI895
Page 67
No Flow To Loop 3A Cold Legs From 3HP-194
HPI892
Page 15

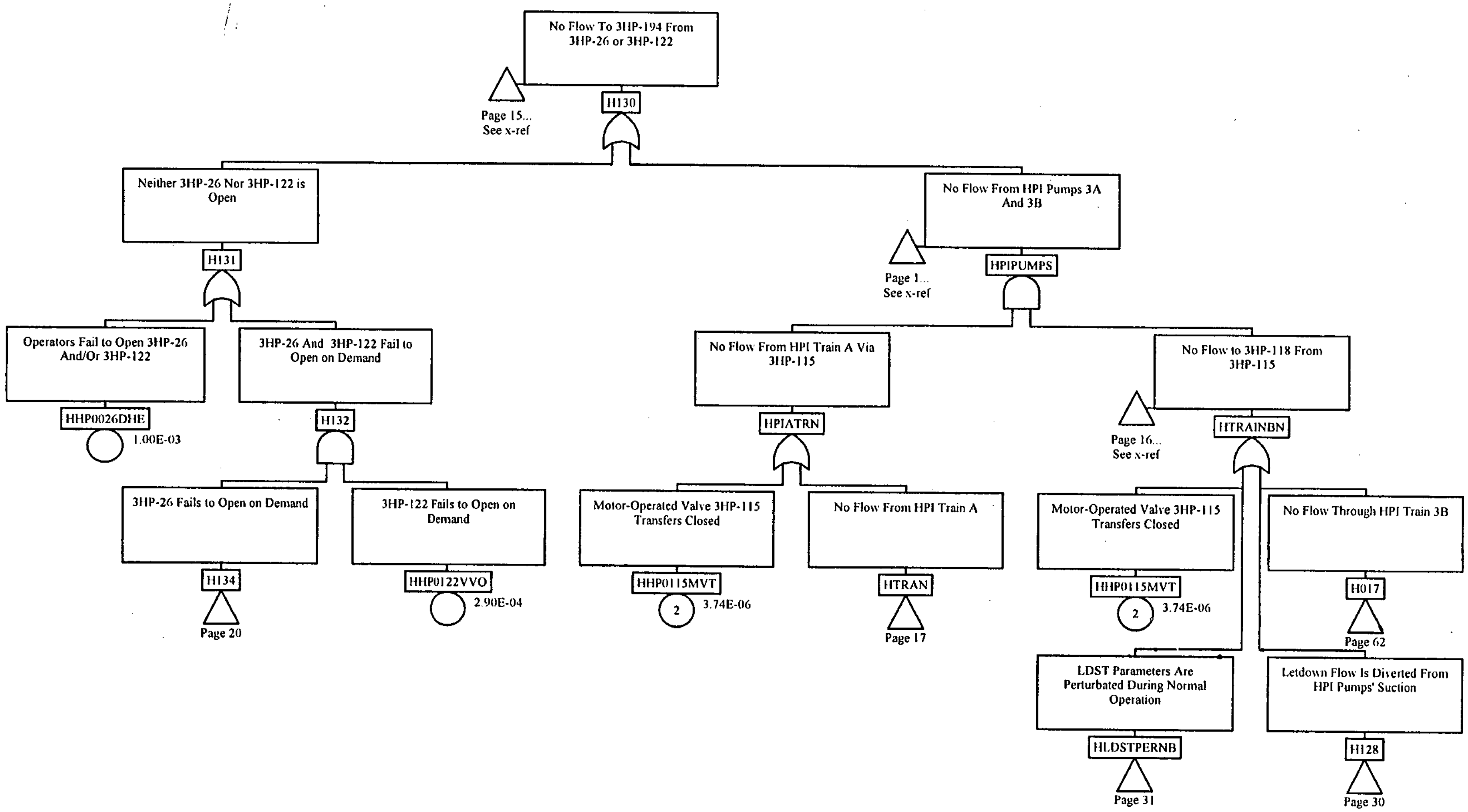

No Flow To Loop 3A Cold Legs From 3HP-194
Page 14
Page 14...
See x-ref
HPI892
Check Valve 3HP-194 Transfers Closed
HHP0194CVT
1.09E-03
No Flow To 3HP-194
H117
No Flow To 3HP-194 From 3HP-121
No Flow To 3HP-194 From 3HP-26 or 3HP-122
HPI014
H130
Page 19
No Flow To 3HP-118
HPI017
Page 16
Make-up Control Valve 3HP-120 Transfers Position
HMAKE-UP
Page 18
Manual Valve 3HP-118 Transfers Closed
HHP0118VVT
2.96E-04
Manual Valve 3HP-121 Transfers Position
HHP0121VVT
2.96E-04
Manual Valve 3HP-119 Transfers Position
HHP0119VVT
2.96E-04

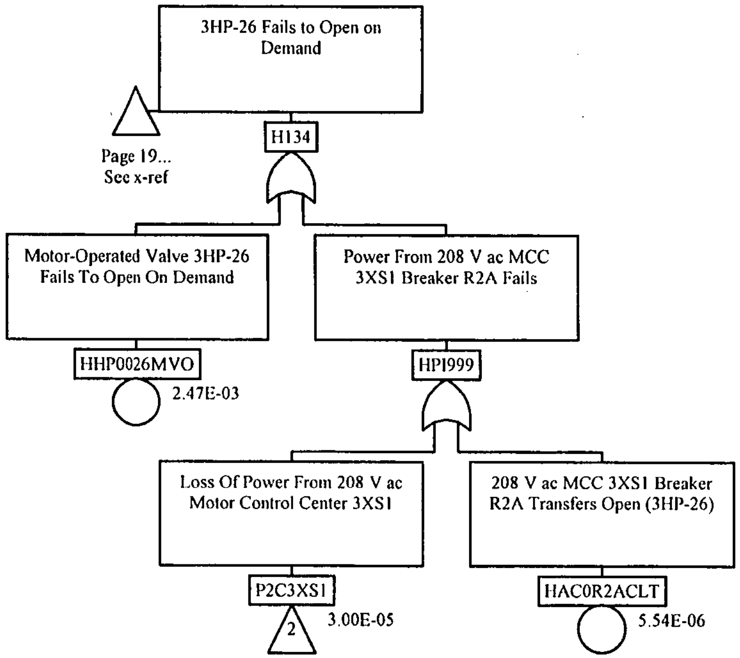


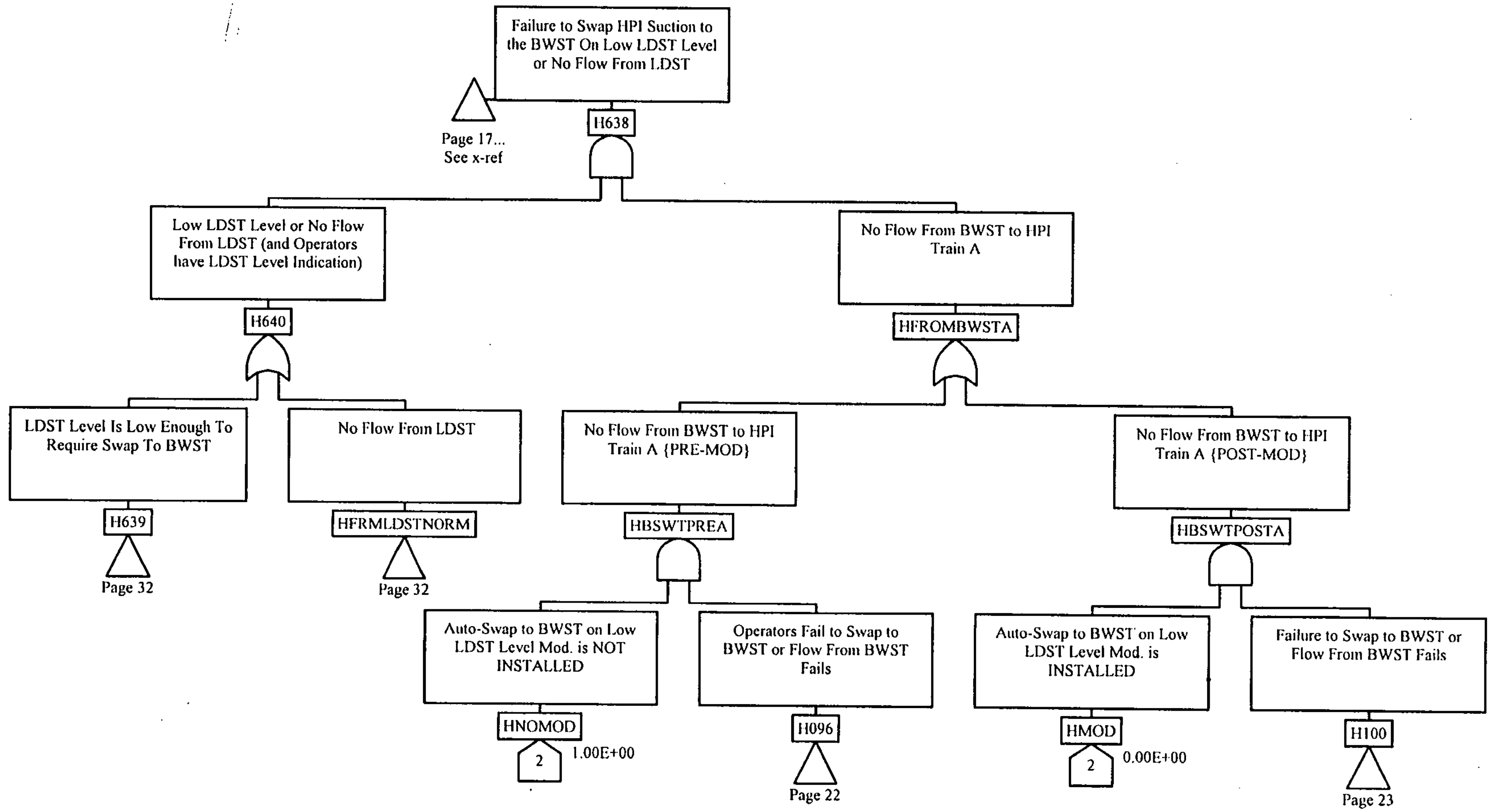
No Flow To 3HP-118
HPI017
Page 15...
See x-ref
No Flow From HPI Train A
No Flow to 3HP-118 From 3HP-115
HTRAN
HTRAINBN
Page 17
Page 19

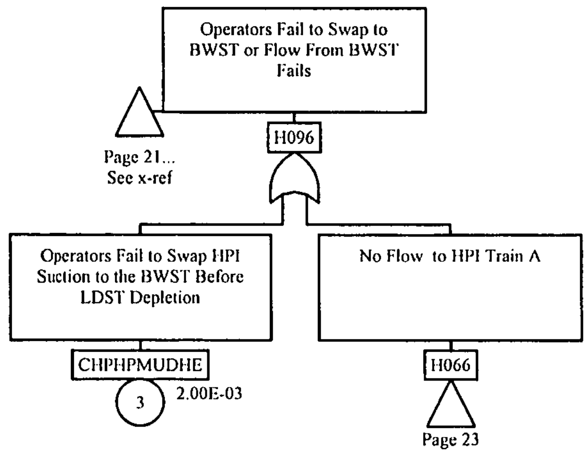

No Flow From HPI Train A
HTRAN
Page 19
Page 16...
See x-ref
LDST Parameters Are Out of Operating Envelope During Normal Operation
HLDSTPERN
No Flow Through HPI Train A
HPI026
Letdown Flow Is Diverted From HPI Pumps' Suction
H128
Page 30
LDST Level Migrates Out of Operating Envelope During Normal Operation
HLDSTLVL
LDST Pressure Migrates Out of Operating Envelope during Normal Operation
HLDSTPRS
Page 31
No Flow From HPI Pump 3A
HPI032
HPI Train A Valve Failure
HPI004
Page 29
Failure to Swap HPI Suction to the BWST On Low LDST Level or No Flow From LDST
H638
Page 21
LDST Level Is Low Due to Failure of Level Instruments
HLEVELFAIL
Page 26
No LPSW Flow Through Motor Cooler On HPI Pump 3A
HPI991
Page 27
Power From 4160 V ac Switchgear 3TC Breaker 8 Fails
HPI997
Page 28
HPI Pump 3A Fails To Run
HHPPU3AHPR
1.16E-01
Motor-Operated Valve 3HP-98 Transfers Closed
HHP0098MVT
3
8.20E-04

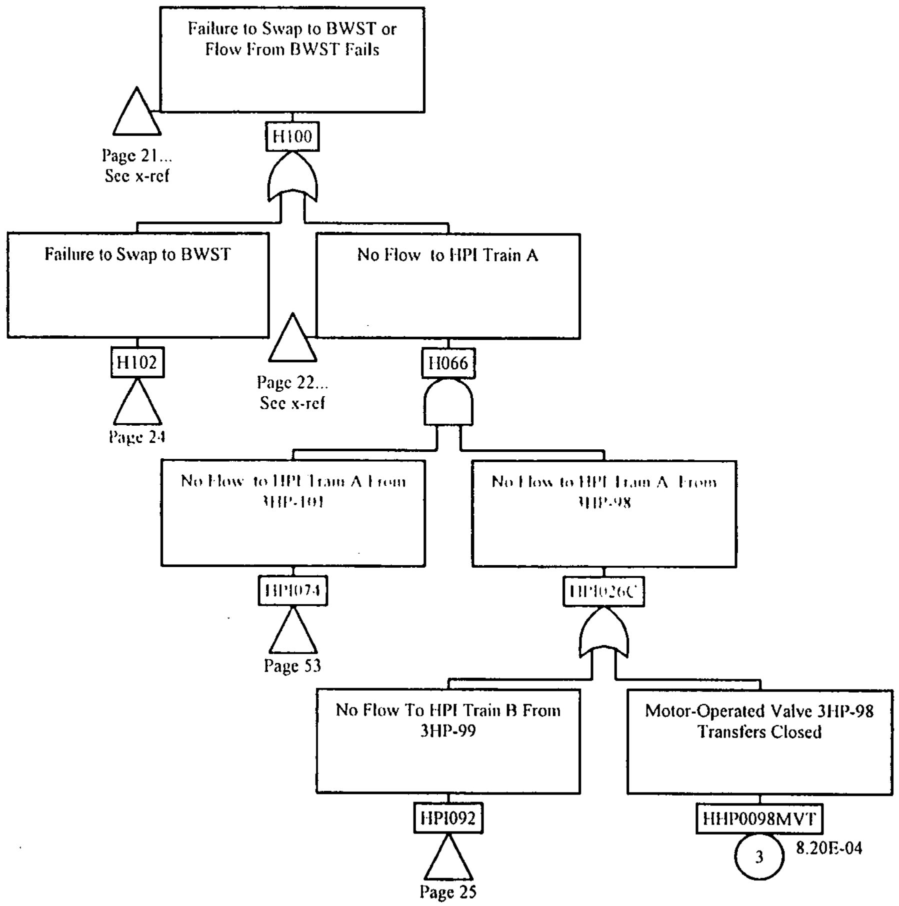

Make-up Control Valve 3HP-120 Transfers Position
Page 15... See x-ref
HMAKE-UP
Air Operated Valve 3HP-120 Transfers Position
HHP0120AVT
5.01E-03
Electro-Pneumatic Positioner 3HPIEP0003 Spuriously Closes 3HP-120
HHPEP03PCF
8.67E-04
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
4.32E-02
Loss of Power on 240/120 V ac Power Panelboards 3KI and 3KU
HD3KIKU
Page 42

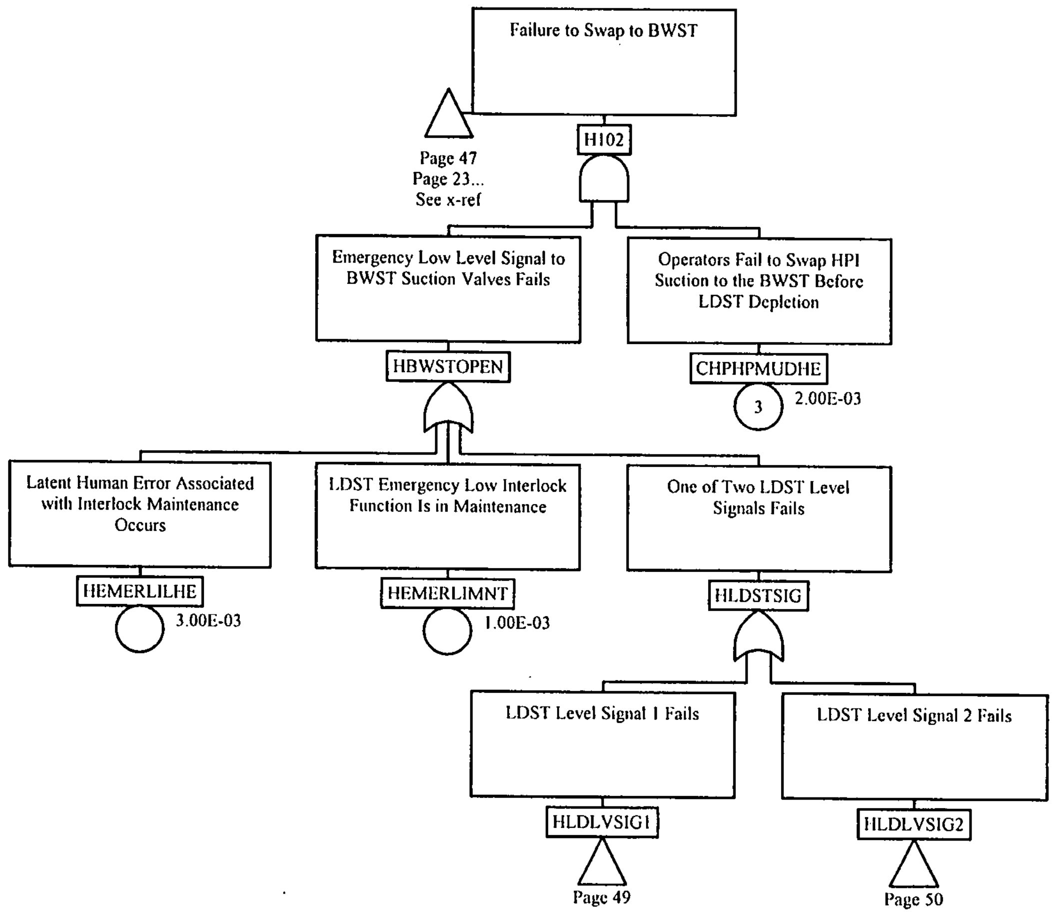

No Flow To 3HP-194 From 3HP-26 or 3HP-122
H130
Page 15... See x-ref
Neither 3HP-26 Nor 3HP-122 is Open
H131
No Flow From HPI Pumps 3A And 3B
HPIPUMPS
Page 1... See x-ref
Operators Fail to Open 3HP-26 And/Or 3HP-122
HHP0026DHE
1.00E-03
3HP-26 And 3HP-122 Fail to Open on Demand
H132
3HP-26 Fails to Open on Demand
H134
Page 20
3HP-122 Fails to Open on Demand
HHP0122VVO
2.90E-04
No Flow From HPI Train A Via 3HP-115
HPIATRN
Motor-Operated Valve 3HP-115 Transfers Closed
HHP0115MVT
2
3.74E-06
No Flow From HPI Train A
HTRAN
Page 17
No Flow to 3HP-118 From 3HP-115
HTRAINBN
Page 16... See x-ref
Motor-Operated Valve 3HP-115 Transfers Closed
HHP0115MVT
2
3.74E-06
No Flow Through HPI Train 3B
H017
Page 62
LDST Parameters Are Perturbated During Normal Operation
HLDSTPERNB
Page 31
Letdown Flow Is Diverted From HPI Pumps' Suction
H128
Page 30

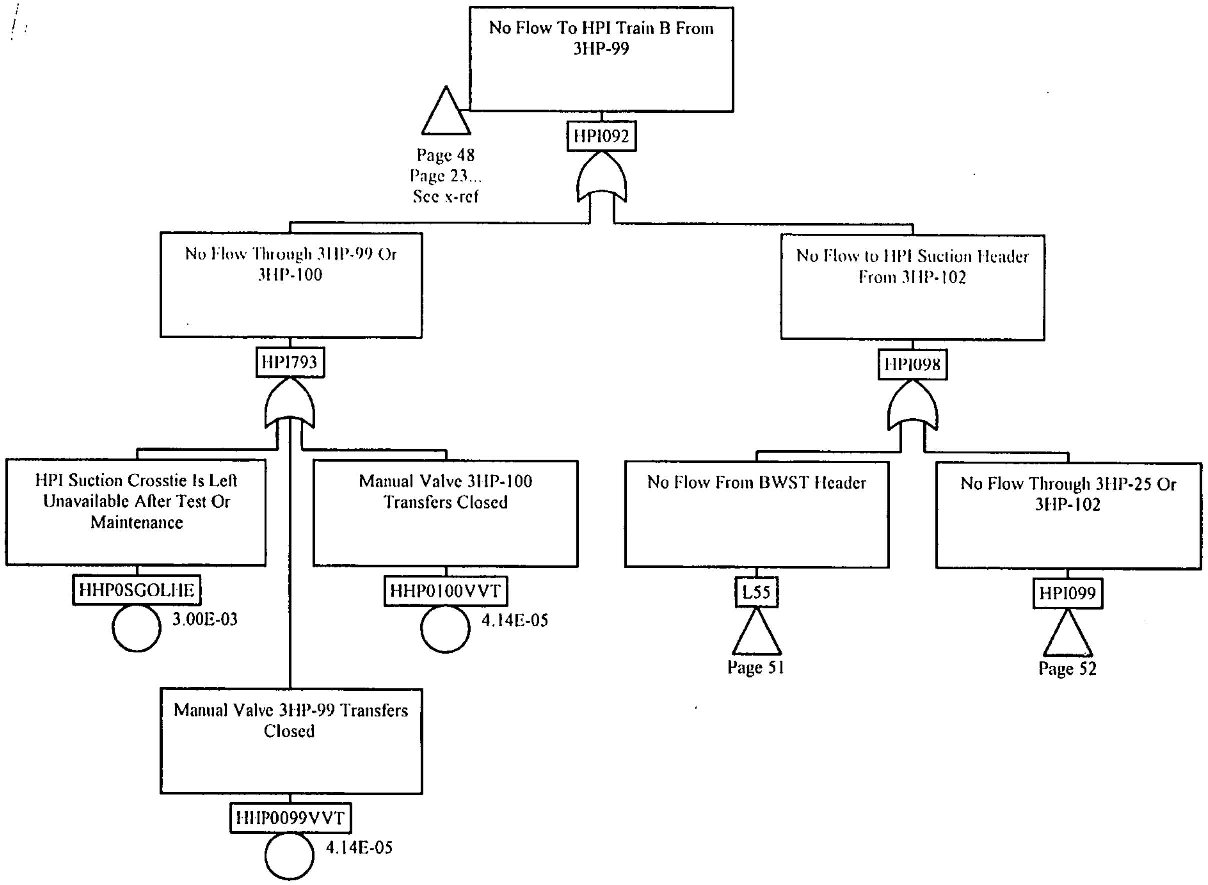

3HP-26 Fails to Open on Demand
Page 19...
See x-ref
H134
Motor-Operated Valve 3HP-26 Fails To Open On Demand
HHP0026MVO
2.47E-03
Power From 208 V ac MCC 3XS1 Breaker R2A Fails
HPI999
Loss Of Power From 208 V ac Motor Control Center 3XS1
P2C3XS1
2
3.00E-05
208 V ac MCC 3XS1 Breaker R2A Transfers Open (3HP-26)
HAC0R2ACLT
5.54E-06

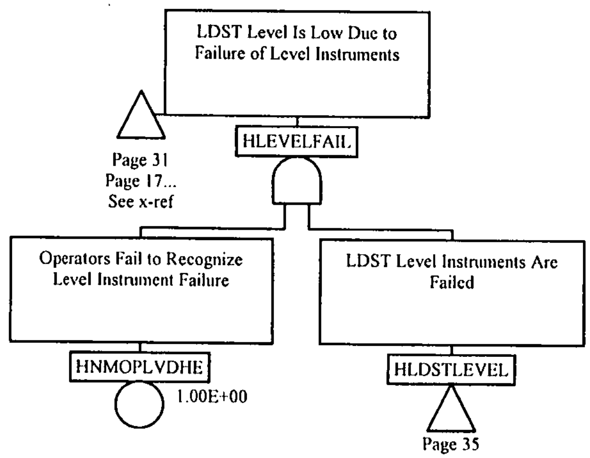

Failure to Swap HPI Suction to the BWST On Low LDST Level or No Flow From LDST
H638
Page 17... See x-ref
Low LDST Level or No Flow From LDST (and Operators have LDST Level Indication)
H640
No Flow From BWST to HPI Train A
HFROMBWSTA
LDST Level Is Low Enough To Require Swap To BWST
H639
Page 32
No Flow From LDST
HFRMLDSTNORM
Page 32
No Flow From BWST to HPI Train A {PRE-MOD}
HBSWTPREA
No Flow From BWST to HPI Train A {POST-MOD}
HBSWTPOSTA
Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED
HNOMOD
2
1.00E+00
Operators Fail to Swap to BWST or Flow From BWST Fails
H096
Page 22
Auto-Swap to BWST on Low LDST Level Mod. is INSTALLED
HMOD
2
0.00E+00
Failure to Swap to BWST or Flow From BWST Fails
H100
Page 23


Operators Fail to Swap to BWST or Flow From BWST Fails
Page 21...
See x-ref
H096
Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion
CHPHPMUDHE
3
2.00E-03
No Flow to HPI Train A
H066
Page 23

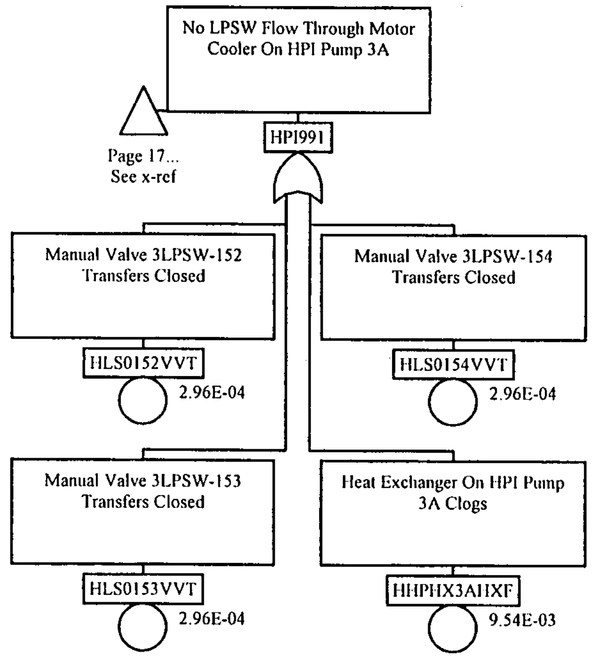

Failure to Swap to BWST or Flow From BWST Fails
H100
Page 21... See x-ref
Failure to Swap to BWST
H102
Page 24
Page 22... See x-ref
No Flow to HPI Train A
H066
No Flow to HPI Train A From 3HP-101
HPI074
Page 53
No Flow to HPI Train A From 3HP-98
HPI026C
No Flow To HPI Train B From 3HP-99
HPI092
Page 25
Motor-Operated Valve 3HP-98 Transfers Closed
HHP0098MVT
3
8.20E-04


Failure to Swap to BWST
H102
Page 47
Page 23...
See x-ref
Emergency Low Level Signal to BWST Suction Valves Fails
HBWSTOPEN
Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion
CHPHPMUDHE
3
2.00E-03
Latent Human Error Associated with Interlock Maintenance Occurs
HEMERLILHE
3.00E-03
LDST Emergency Low Interlock Function Is in Maintenance
HEMERLIMNT
1.00E-03
One of Two LDST Level Signals Fails
HLDSTSIG
LDST Level Signal 1 Fails
HLDLVSIG1
Page 49
LDST Level Signal 2 Fails
HLDLVSIG2
Page 50

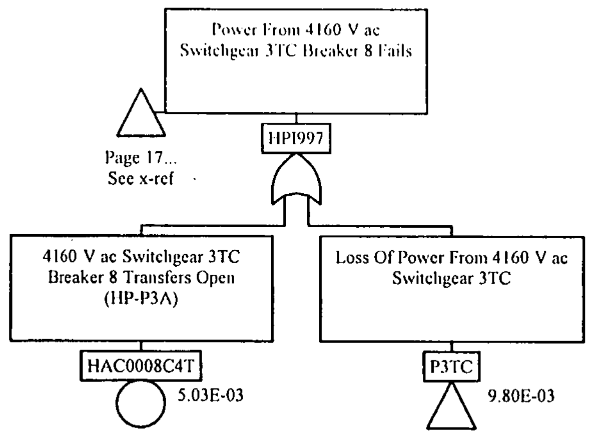

No Flow To HPI Train B From 3HP-99
HPI092
Page 48
Page 23...
See x-ref
No Flow Through 3HP-99 Or 3HP-100
HPI793
No Flow to HPI Suction Header From 3HP-102
HPI098
HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance
HHP0SGOLHE
3.00E-03
Manual Valve 3HP-100 Transfers Closed
HHP0100VVT
4.14E-05
No Flow From BWST Header
L55
Page 51
No Flow Through 3HP-25 Or 3HP-102
HPI099
Page 52
Manual Valve 3HP-99 Transfers Closed
HHP0099VVT
4.14E-05

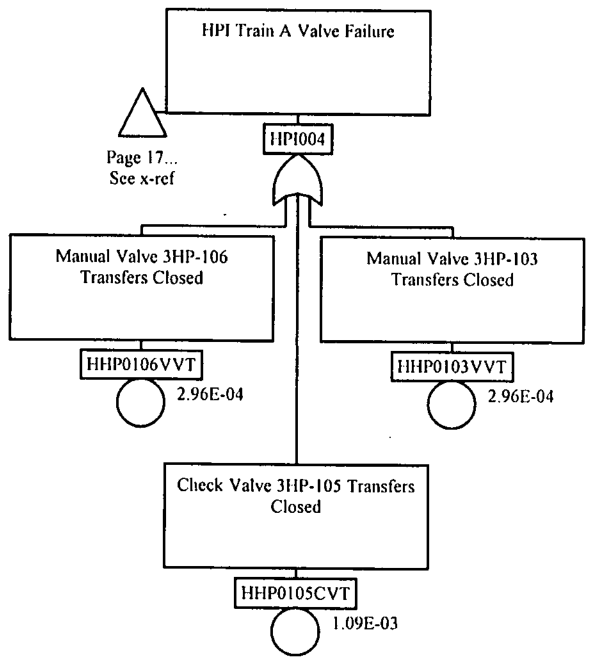


LDST Level Is Low Due to Failure of Level Instruments
HLEVELFAIL
Page 31
Page 17...
See x-ref
Operators Fail to Recognize Level Instrument Failure
HNMOPLVDHE
1.00E+00
LDST Level Instruments Are Failed
HLDSTLEVEL
Page 35

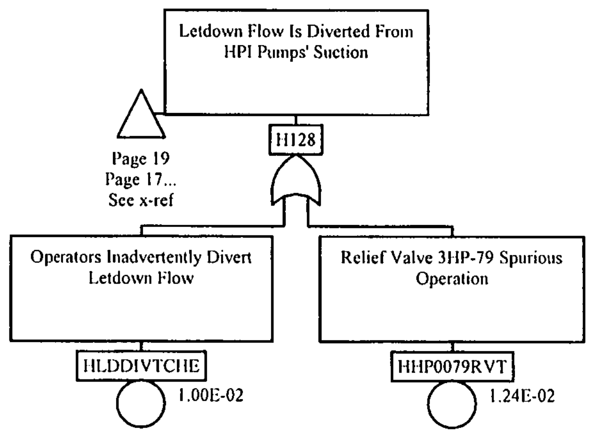


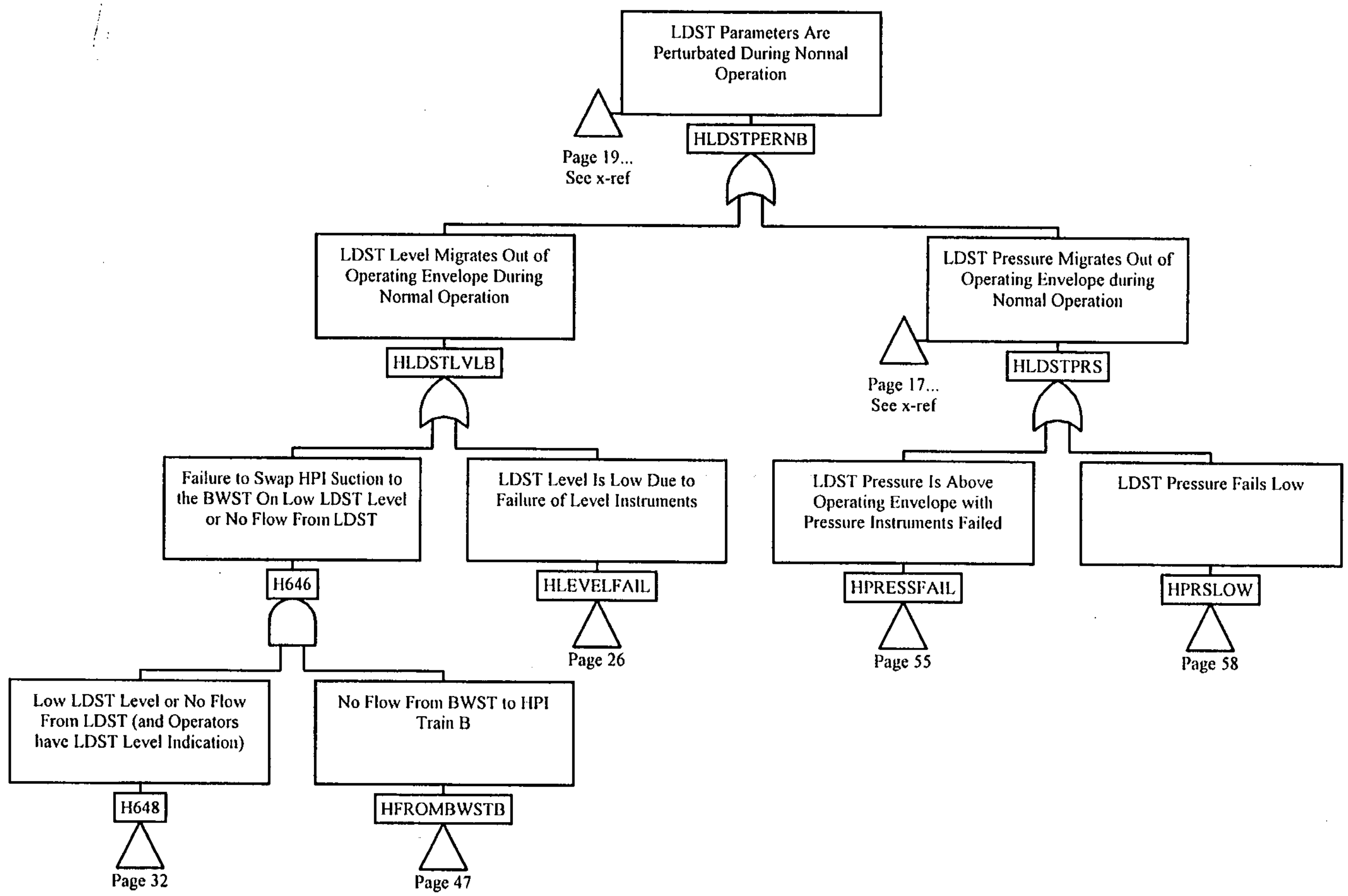
No LPSW Flow Through Motor Cooler On HPI Pump 3A
HPI991
Page 17... See x-ref
Manual Valve 3LPSW-152 Transfers Closed
HLS0152VVT
2.96E-04
Manual Valve 3LPSW-154 Transfers Closed
HLS0154VVT
2.96E-04
Manual Valve 3LPSW-153 Transfers Closed
HLS0153VVT
2.96E-04
Heat Exchanger On HPI Pump 3A Clogs
HHPHX3AHXF
9.54E-03

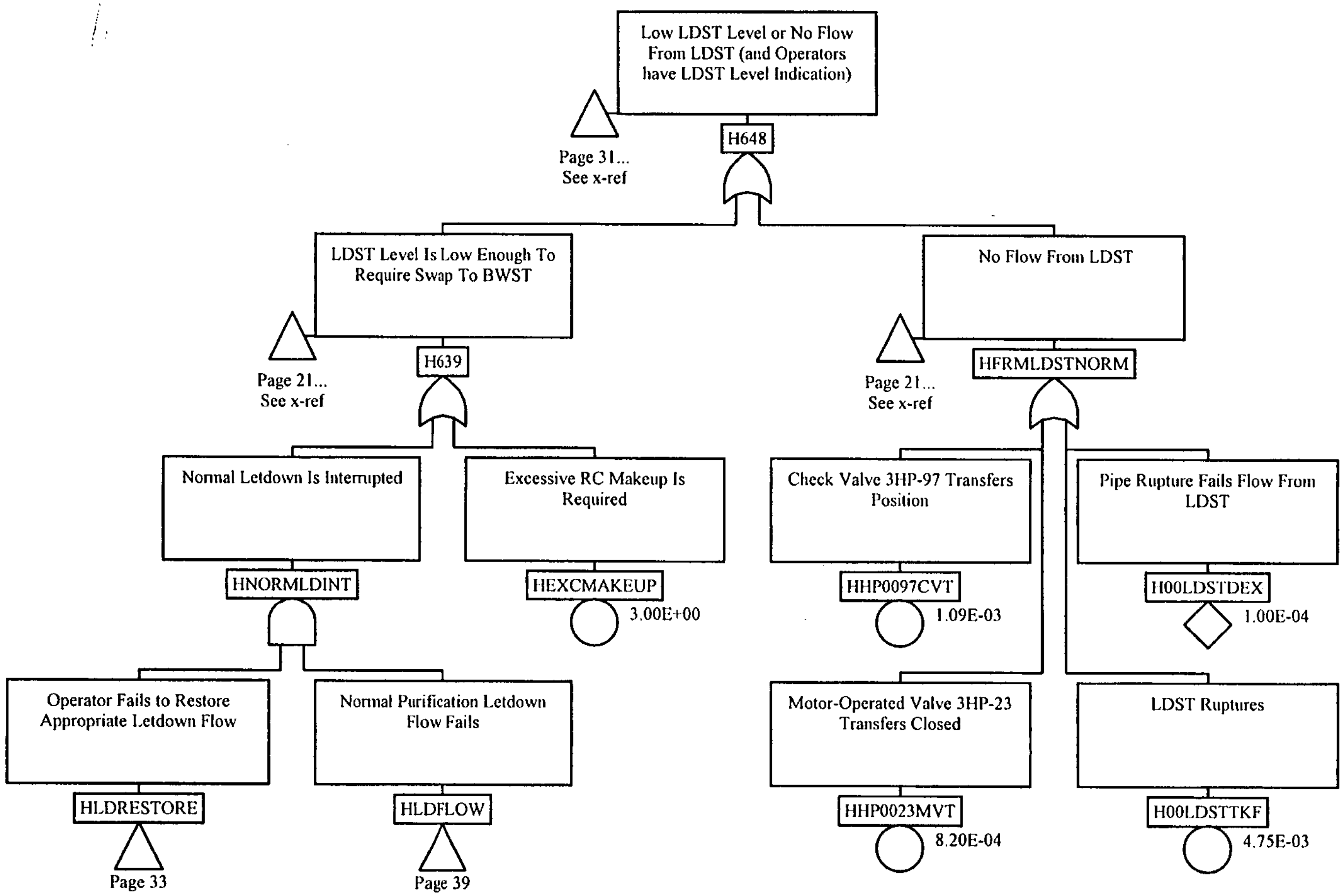

Power From 4160 V ac Switchgear 3TC Breaker 8 Fails
Page 17...
See x-ref
HPI997
4160 V ac Switchgear 3TC Breaker 8 Transfers Open (HP-P3A)
Loss Of Power From 4160 V ac Switchgear 3TC
HAC0008C4T
5.03E-03
P3TC
9.80E-03

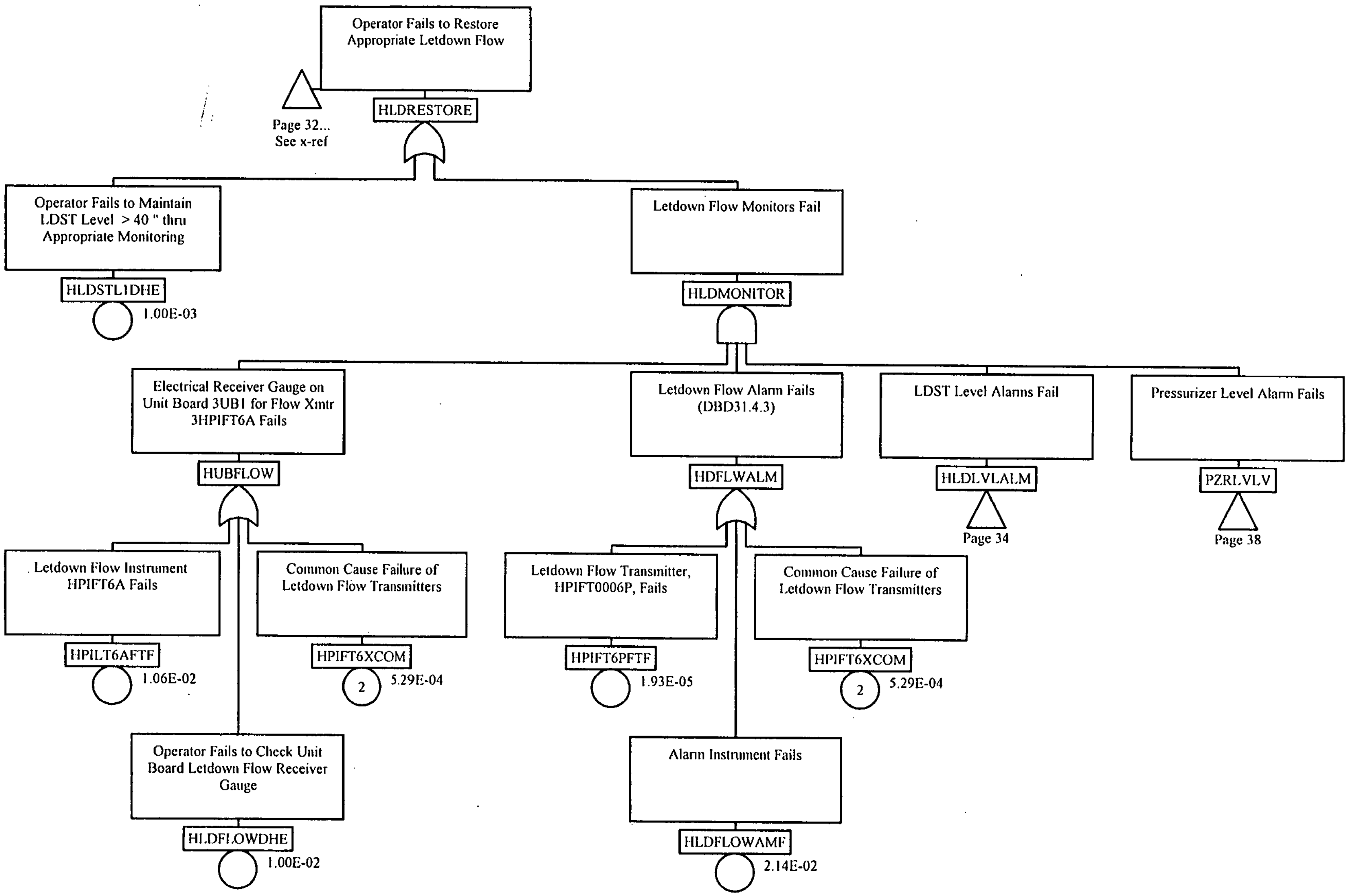


HPI Train A Valve Failure
HPI004
Page 17...
See x-ref
Manual Valve 3HP-106 Transfers Closed
HHP0106VVT
2.96E-04
Manual Valve 3HP-103 Transfers Closed
HHP0103VVT
2.96E-04
Check Valve 3HP-105 Transfers Closed
HHP0105CVT
1.09E-03

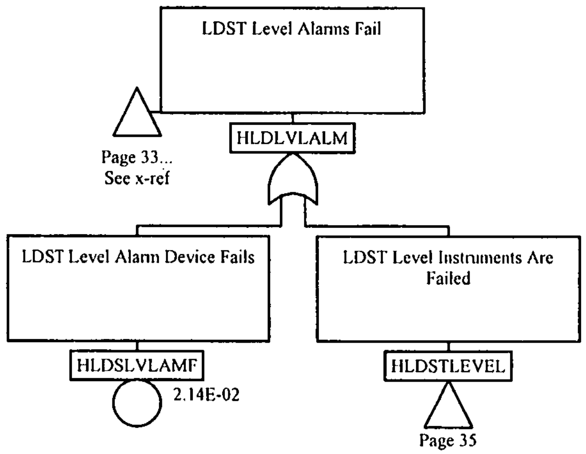

Letdown Flow Is Diverted From HPI Pumps' Suction
H128
Page 19
Page 17...
See x-ref
Operators Inadvertently Divert Letdown Flow
HLDDIVTCHE
1.00E-02
Relief Valve 3HP-79 Spurious Operation
HHP0079RVT
1.24E-02

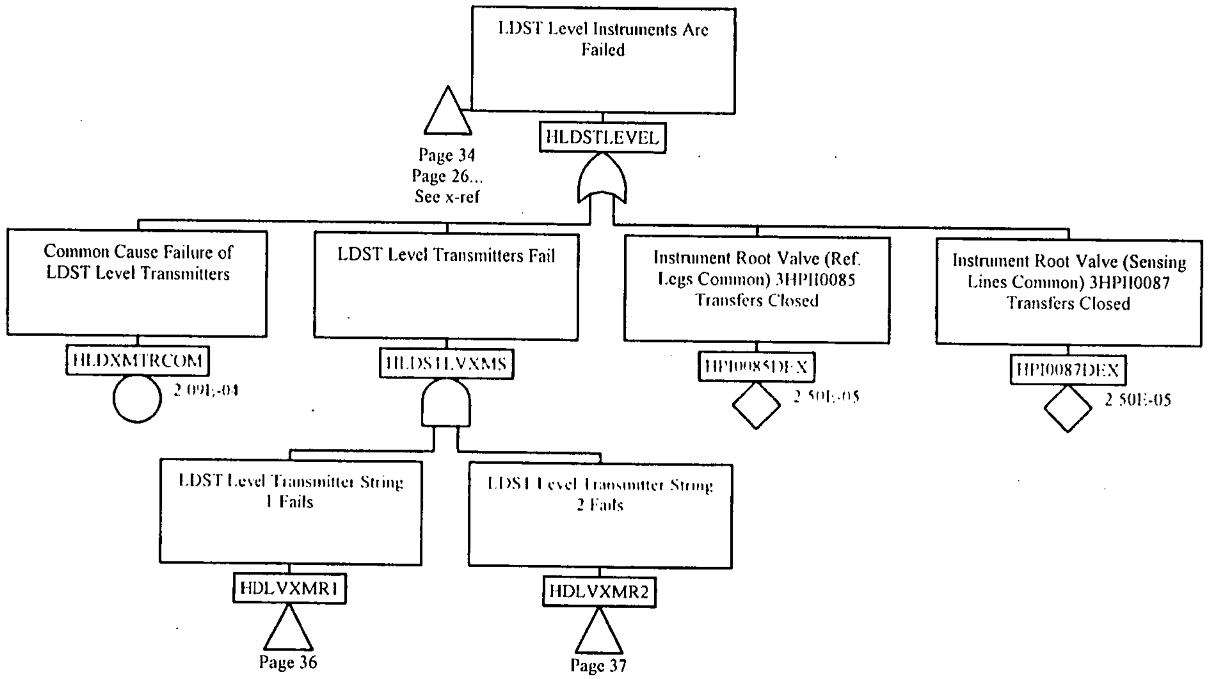

LDST Parameters Are Perturbated During Normal Operation
HLDSTPERNB
Page 19... See x-ref
LDST Level Migrates Out of Operating Envelope During Normal Operation
HLDSTLVLB
LDST Pressure Migrates Out of Operating Envelope during Normal Operation
HLDSTPRS
Page 17... See x-ref
Failure to Swap HPI Suction to the BWST On Low LDST Level or No Flow From LDST
H646
LDST Level Is Low Due to Failure of Level Instruments
HLEVELFAIL
Page 26
LDST Pressure Is Above Operating Envelope with Pressure Instruments Failed
HPRESSFAIL
Page 55
LDST Pressure Fails Low
HPRSLOW
Page 58
Low LDST Level or No Flow From LDST (and Operators have LDST Level Indication)
H648
Page 32
No Flow From BWST to HPI Train B
HFROMBWSTB
Page 47

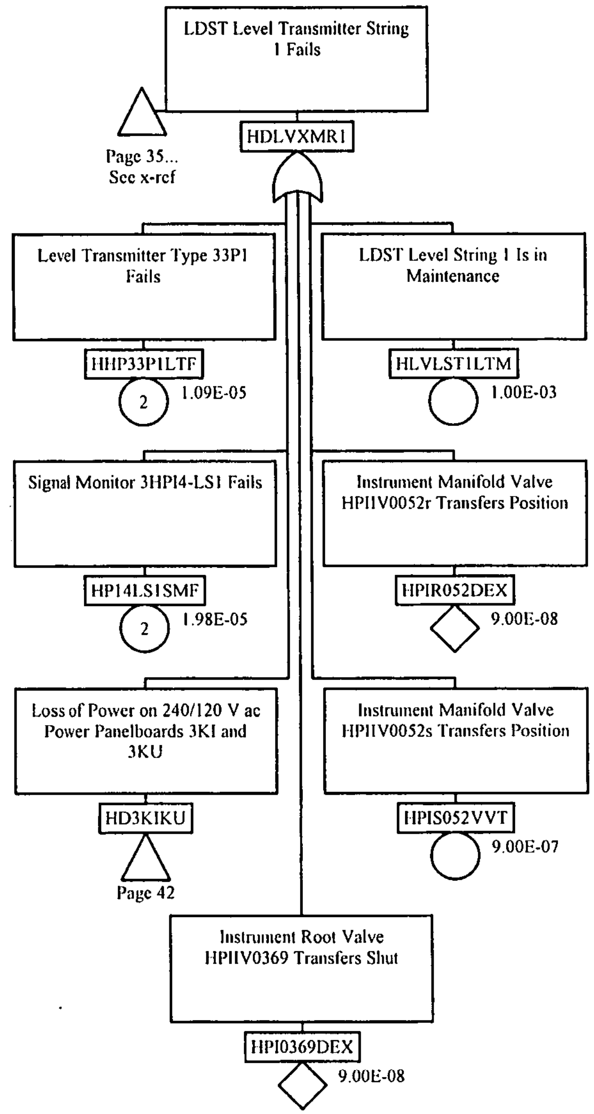

Low LDST Level or No Flow From LDST (and Operators have LDST Level Indication)
H648
Page 31...
See x-ref
LDST Level Is Low Enough To Require Swap To BWST
H639
Page 21...
See x-ref
No Flow From LDST
HFRMLDSTNORM
Page 21...
See x-ref
Normal Letdown Is Interrupted
HNORMLDINT
Excessive RC Makeup Is Required
HEXCMAKEUP
3.00E+00
Check Valve 3HP-97 Transfers Position
HHP0097CVT
1.09E-03
Pipe Rupture Fails Flow From LDST
H00LDSTDEX
1.00E-04
Operator Fails to Restore Appropriate Letdown Flow
HLDRESTORE
Page 33
Normal Purification Letdown Flow Fails
HLDFLOW
Page 39
Motor-Operated Valve 3HP-23 Transfers Closed
HHP0023MVT
8.20E-04
LDST Ruptures
H00LDSTTKF
4.75E-03

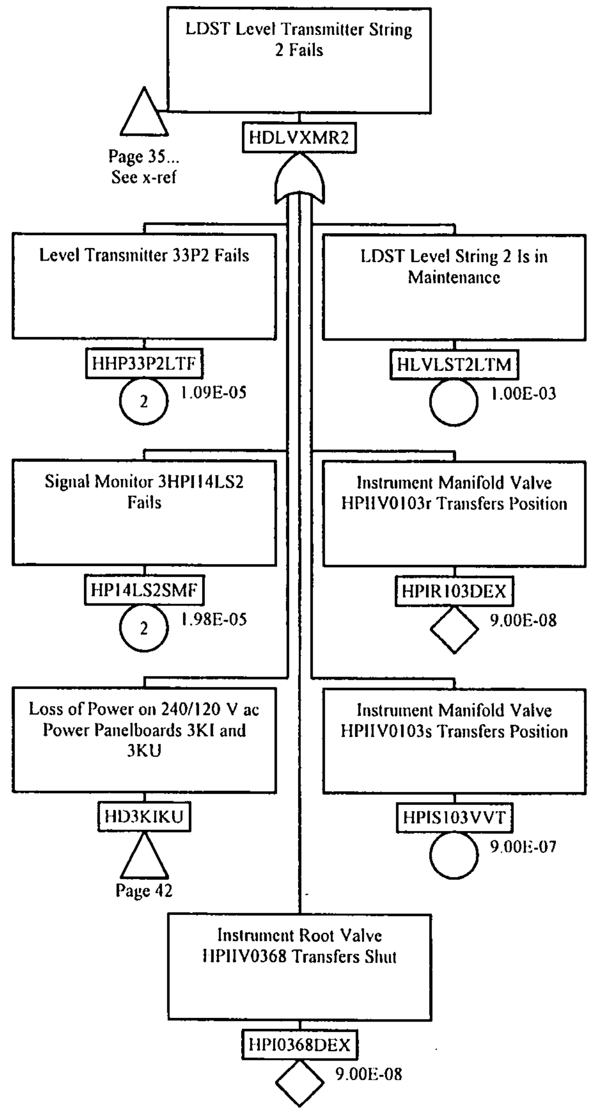


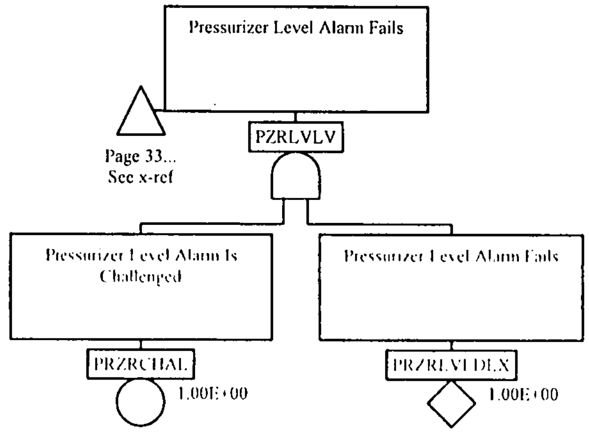
Operator Fails to Restore Appropriate Letdown Flow
HLDRESTORE
Page 32...
See x-ref
Operator Fails to Maintain LDST Level > 40 " thru Appropriate Monitoring
HLDSTL1DHE
1.00E-03
Letdown Flow Monitors Fail
HLDMONITOR
Electrical Receiver Gauge on Unit Board 3UB1 for Flow Xmtr 3HPIFT6A Fails
HUBFLOW
Letdown Flow Alarm Fails (DBD31.4.3)
HDFLWALM
LDST Level Alarms Fail
HLDLVLALM
Page 34
Pressurizer Level Alarm Fails
PZRLVLV
Page 38
Letdown Flow Instrument HPIFT6A Fails
HPILT6AFTF
1.06E-02
Common Cause Failure of Letdown Flow Transmitters
HPIFT6XCOM
2
5.29E-04
Letdown Flow Transmitter, HPIFT0006P, Fails
HPIFT6PFTF
1.93E-05
Common Cause Failure of Letdown Flow Transmitters
HPIFT6XCOM
2
5.29E-04
Operator Fails to Check Unit Board Letdown Flow Receiver Gauge
HLDFLOWDHE
1.00E-02
Alarm Instrument Fails
HLDFLOWAMF
2.14E-02

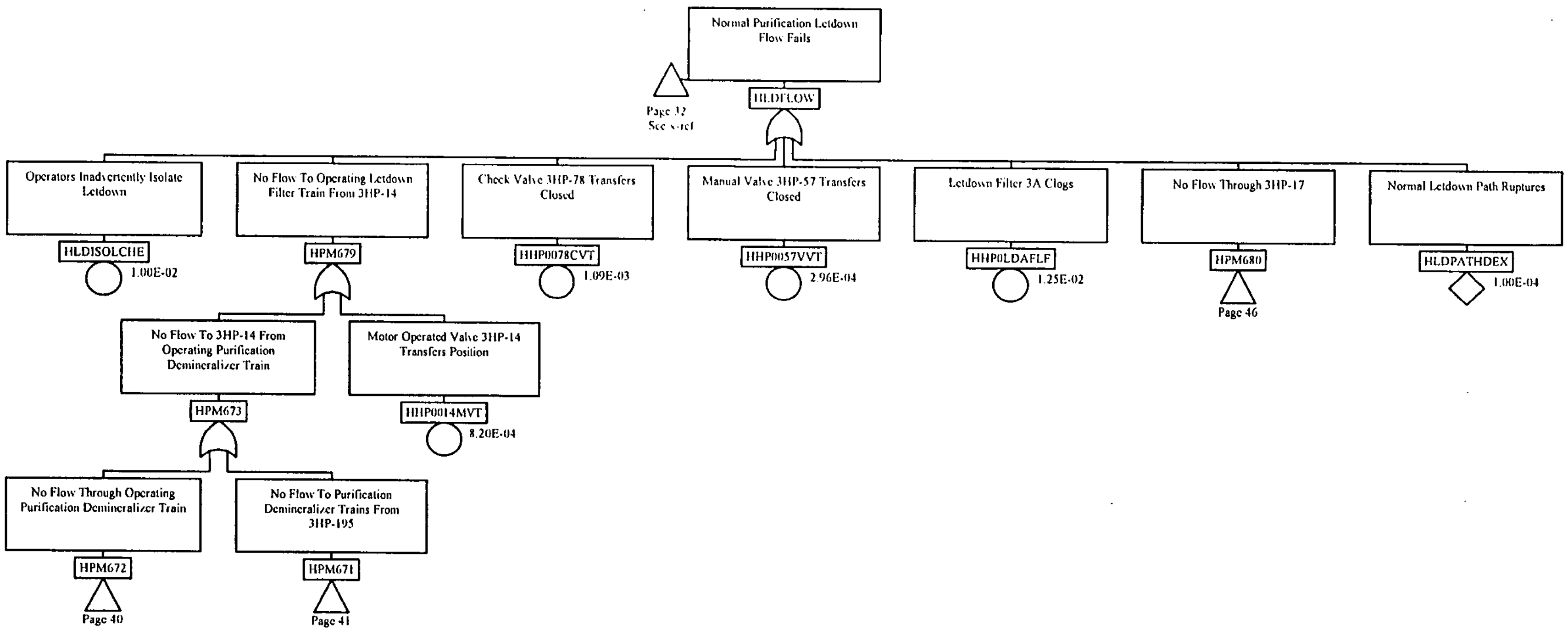

LDST Level Alarms Fail
HLDLVLALM
Page 33...
See x-ref
LDST Level Alarm Device Fails
HLDSLVLAMF
2.14E-02
LDST Level Instruments Are Failed
HLDSTLEVEL
Page 35

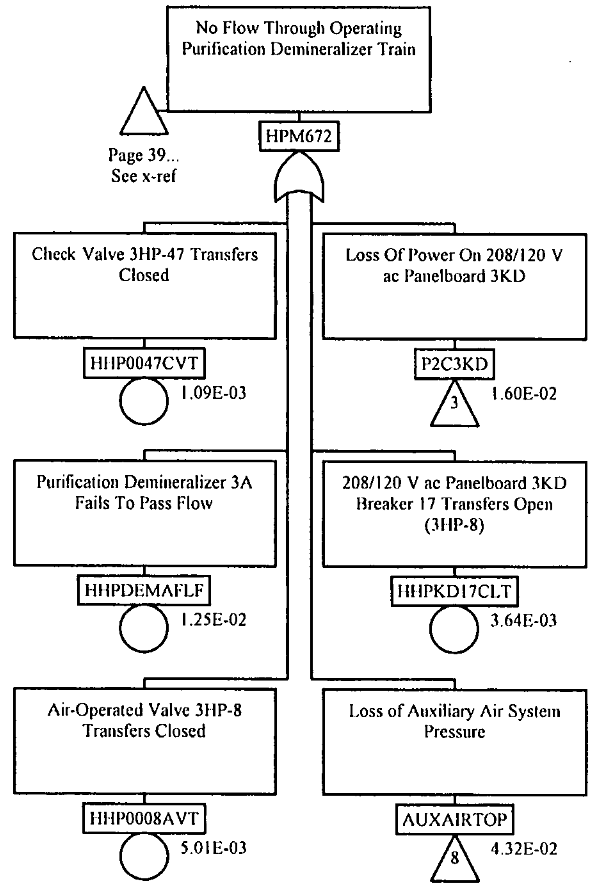

LDST Level Instruments Are Failed
HLDSTLEVEL
Page 34
Page 26...
See x-ref
Common Cause Failure of LDST Level Transmitters
HLDXMTRCOM
2.09E-04
LDST Level Transmitters Fail
HLDSTLVXMS
Instrument Root Valve (Ref. Legs Common) 3HPI0085 Transfers Closed
HPI0085DEX
2.50E-05
Instrument Root Valve (Sensing Lines Common) 3HPI0087 Transfers Closed
HPI0087DEX
2.50E-05
LDST Level Transmitter String 1 Fails
HDLVXMR1
Page 36
LDST Level Transmitter String 2 Fails
HDLVXMR2
Page 37

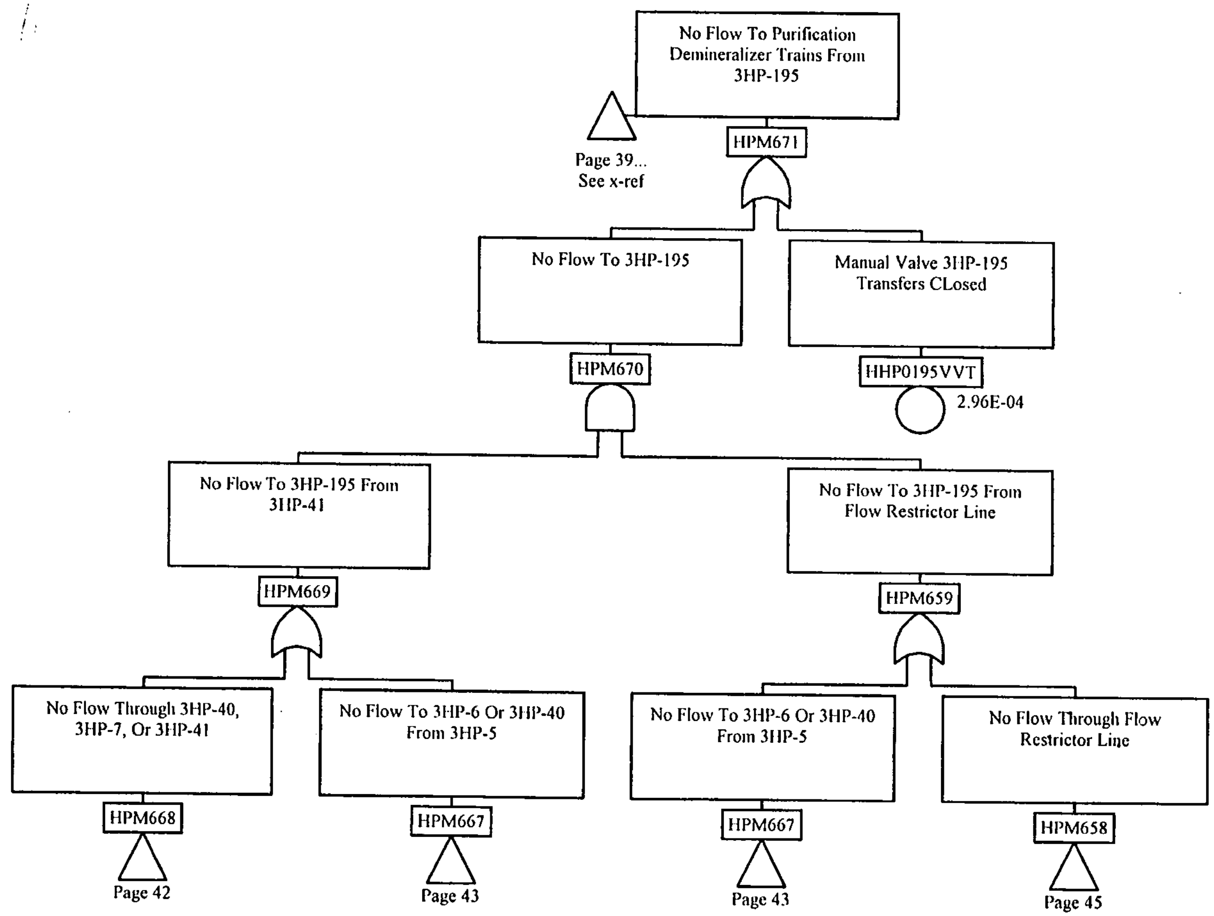

LDST Level Transmitter String 1 Fails
HDLVXMR1
Page 35... See x-ref
Level Transmitter Type 33P1 Fails
HHP33P1LTF
2
1.09E-05
LDST Level String 1 Is in Maintenance
HLVLST1LTM
1.00E-03
Signal Monitor 3HPI4-LS1 Fails
HP14LS1SMF
2
1.98E-05
Instrument Manifold Valve HPIIV0052r Transfers Position
HPIR052DEX
9.00E-08
Loss of Power on 240/120 V ac Power Panelboards 3KI and 3KU
HD3KIKU
Page 42
Instrument Manifold Valve HPIIV0052s Transfers Position
HPIS052VVT
9.00E-07
Instrument Root Valve HPIIV0369 Transfers Shut
HPI0369DEX
9.00E-08


LDST Level Transmitter String 2 Fails
HDLVXMR2
Page 35...
See x-ref
Level Transmitter 33P2 Fails
HHP33P2LTF
2
1.09E-05
LDST Level String 2 Is in Maintenance
HLVLST2LTM
1.00E-03
Signal Monitor 3HPI14LS2 Fails
HP14LS2SMF
2
1.98E-05
Instrument Manifold Valve HPIIV0103r Transfers Position
HPIR103DEX
9.00E-08
Loss of Power on 240/120 V ac Power Panelboards 3KI and 3KU
HD3KIKU
Page 42
Instrument Manifold Valve HPIIV0103s Transfers Position
HPIS103VVT
9.00E-07
Instrument Root Valve HPIIV0368 Transfers Shut
HPI0368DEX
9.00E-08

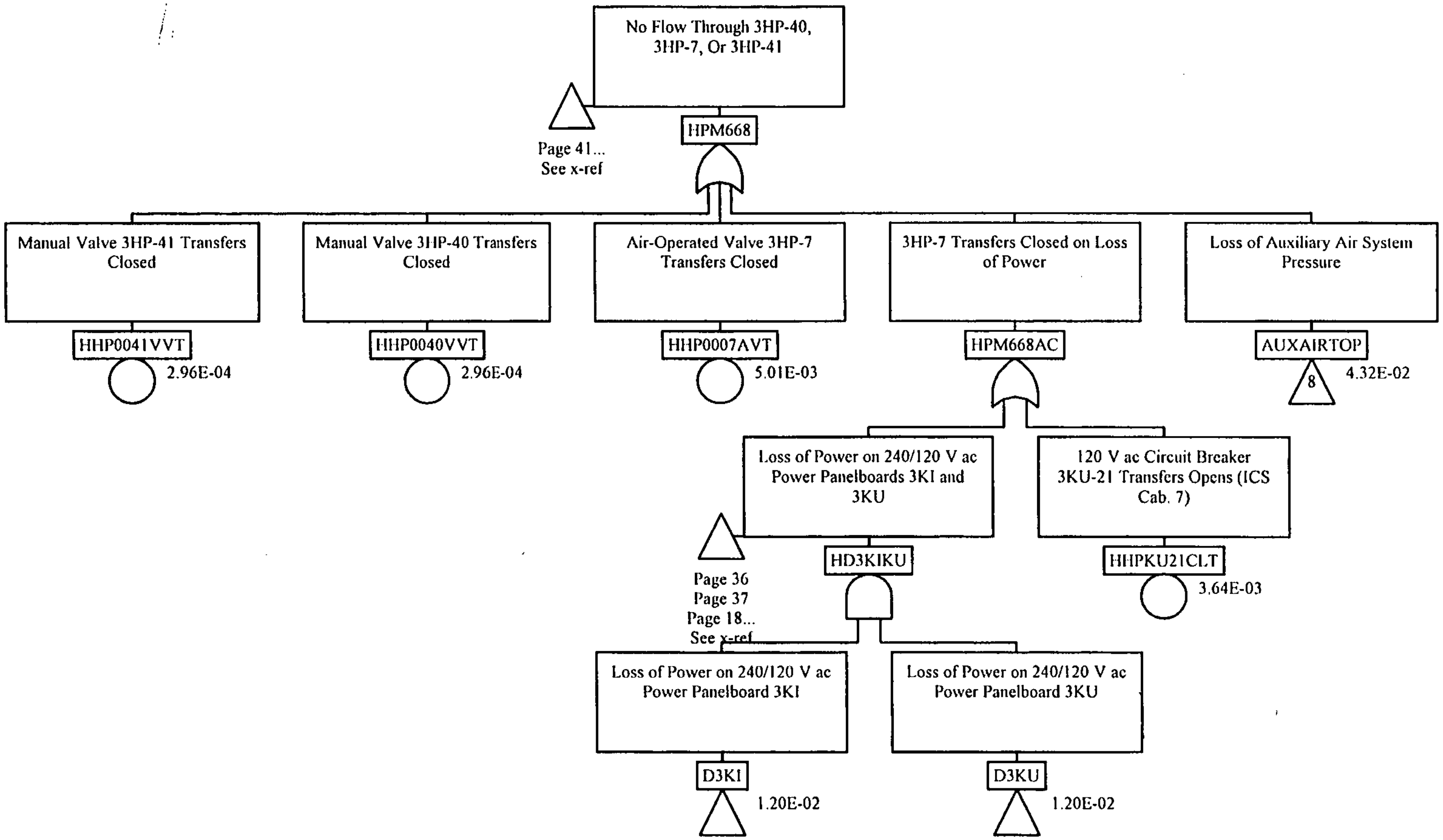

Pressurizer Level Alarm Fails
Page 33...
See x-ref
PZRLVLV
Pressurizer Level Alarm Is Challenged
Pressurizer Level Alarm Fails
PRZRCHAL
1.00E+00
PRZRLVLDLX
1.00E+00

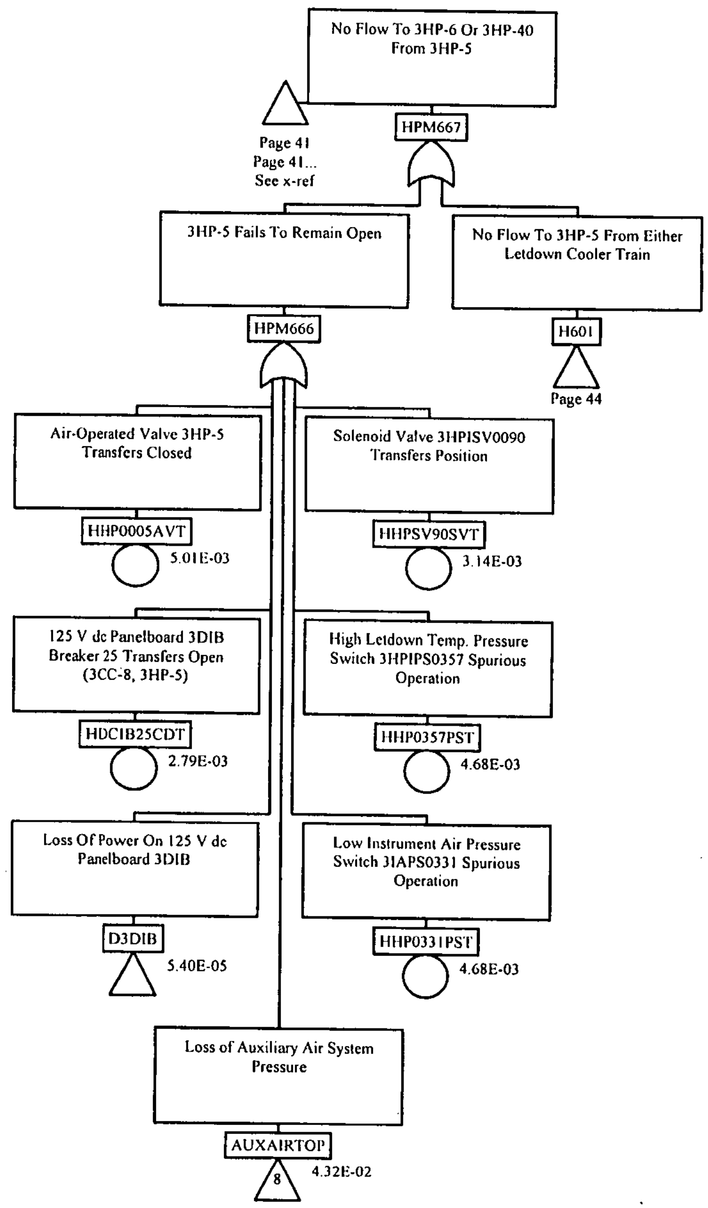

Normal Purification Letdown Flow Fails
HLDFLOW
Page 32
See x-ref
Operators Inadvertently Isolate Letdown
HLDISOLCHE
1.00E-02
No Flow To Operating Letdown Filter Train From 3HP-14
HPM679
Check Valve 3HP-78 Transfers Closed
HHP0078CVT
1.09E-03
Manual Valve 3HP-57 Transfers Closed
HHP0057VVT
2.96E-04
Letdown Filter 3A Clogs
HHP0LDAFLF
1.25E-02
No Flow Through 3HP-17
HPM680
Page 46
Normal Letdown Path Ruptures
HLDPATHDEX
1.00E-04
No Flow To 3HP-14 From Operating Purification Demineralizer Train
HPM673
Motor Operated Valve 3HP-14 Transfers Position
HHP0014MVT
8.20E-04
No Flow Through Operating Purification Demineralizer Train
HPM672
Page 40
No Flow To Purification Demineralizer Trains From 3HP-195
HPM671
Page 41

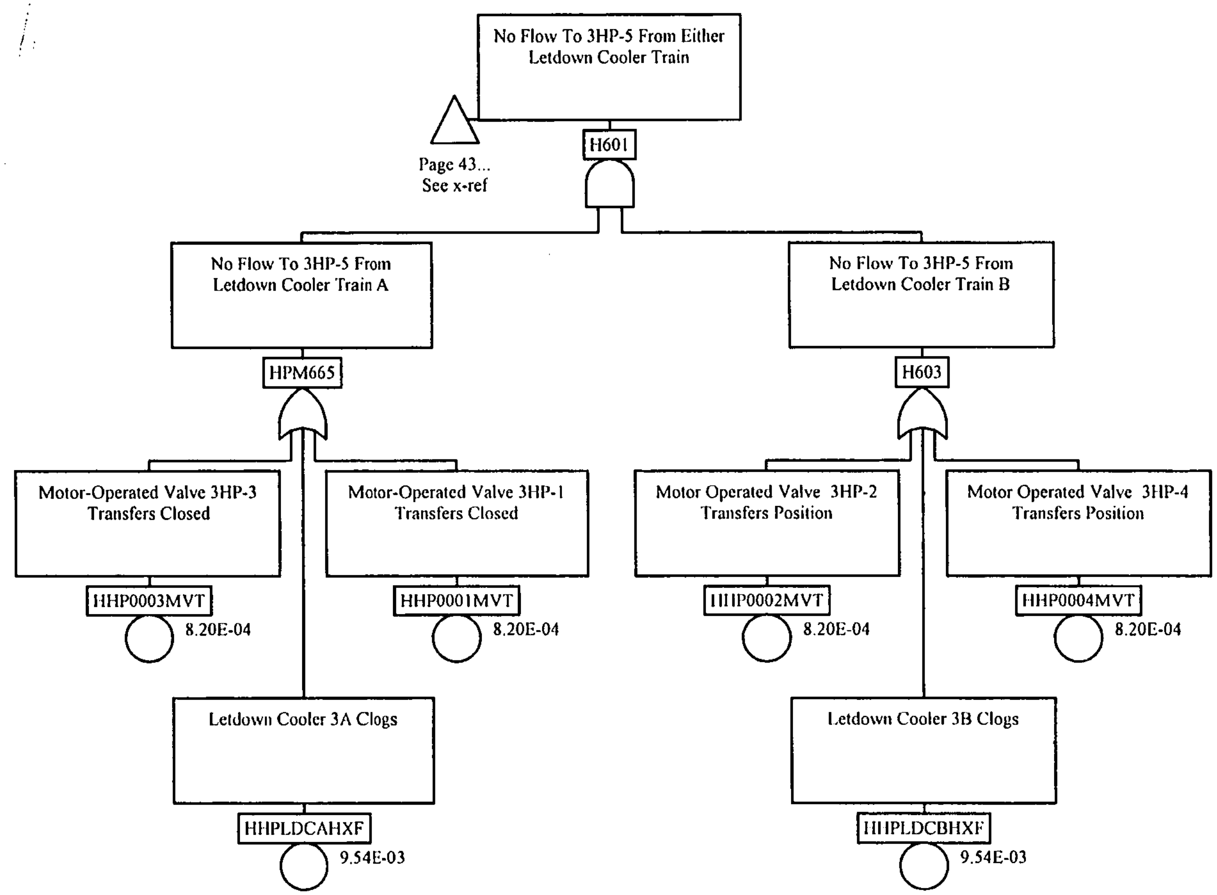

No Flow Through Operating Purification Demineralizer Train
HPM672
Page 39... See x-ref
Check Valve 3HP-47 Transfers Closed
HHP0047CVT
1.09E-03
Loss Of Power On 208/120 V ac Panelboard 3KD
P2C3KD
3
1.60E-02
Purification Demineralizer 3A Fails To Pass Flow
HHPDEMAFLF
1.25E-02
208/120 V ac Panelboard 3KD Breaker 17 Transfers Open (3HP-8)
HHPKD17CLT
3.64E-03
Air-Operated Valve 3HP-8 Transfers Closed
HHP0008AVT
5.01E-03
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
4.32E-02



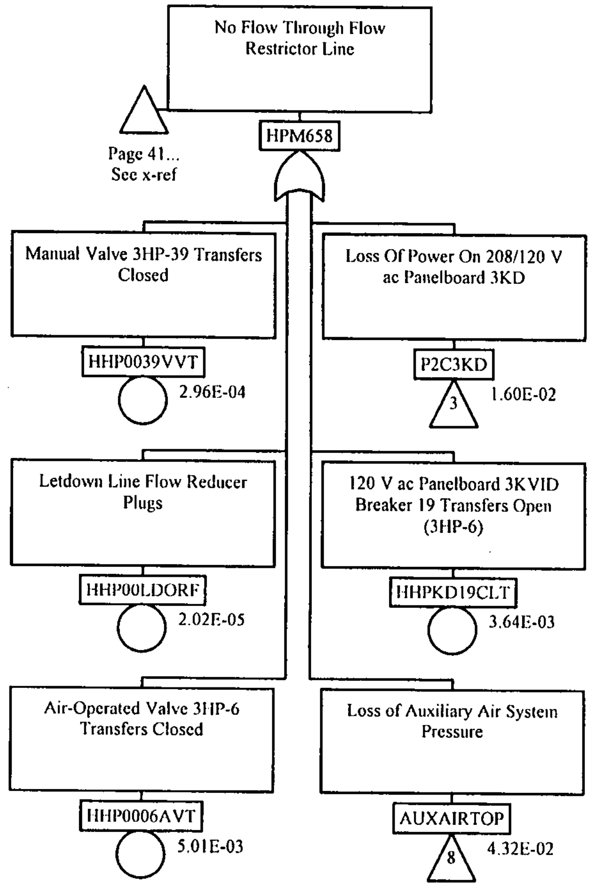
No Flow To Purification Demineralizer Trains From 3HP-195
Page 39... See x-ref
HPM671
No Flow To 3HP-195
Manual Valve 3HP-195 Transfers CLosed
HPM670
HHP0195VVT
2.96E-04
No Flow To 3HP-195 From 3HP-41
No Flow To 3HP-195 From Flow Restrictor Line
HPM669
HPM659
No Flow Through 3HP-40, 3HP-7, Or 3HP-41
No Flow To 3HP-6 Or 3HP-40 From 3HP-5
No Flow To 3HP-6 Or 3HP-40 From 3HP-5
No Flow Through Flow Restrictor Line
HPM668
HPM667
HPM667
HPM658
Page 42
Page 43
Page 43
Page 45

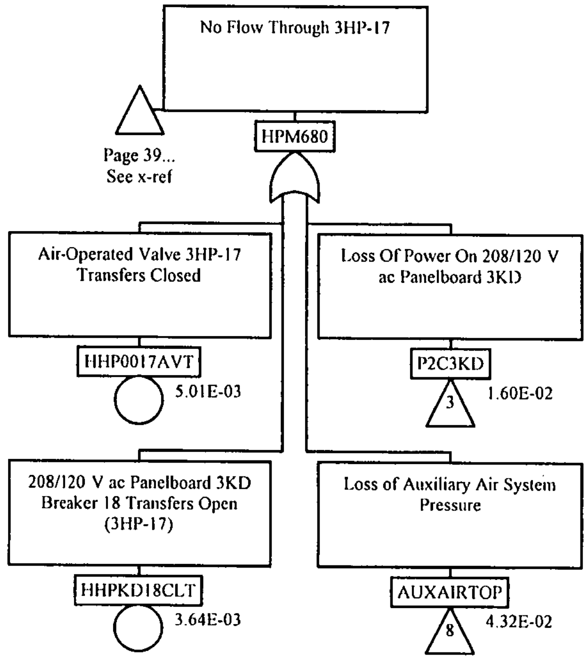

No Flow Through 3HP-40, 3HP-7, Or 3HP-41
HPM668
Page 41... See x-ref
Manual Valve 3HP-41 Transfers Closed
HHP0041VVT
2.96E-04
Manual Valve 3HP-40 Transfers Closed
HHP0040VVT
2.96E-04
Air-Operated Valve 3HP-7 Transfers Closed
HHP0007AVT
5.01E-03
3HP-7 Transfers Closed on Loss of Power
HPM668AC
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
4.32E-02
Loss of Power on 240/120 V ac Power Panelboards 3KI and 3KU
HD3KIKU
Page 36
Page 37
Page 18...
See x-ref
120 V ac Circuit Breaker 3KU-21 Transfers Opens (ICS Cab. 7)
HHPKU21CLT
3.64E-03
Loss of Power on 240/120 V ac Power Panelboard 3KI
D3KI
1.20E-02
Loss of Power on 240/120 V ac Power Panelboard 3KU
D3KU
1.20E-02


No Flow To 3HP-6 Or 3HP-40 From 3HP-5
HPM667
Page 41
Page 41...
See x-ref
3HP-5 Fails To Remain Open
HPM666
No Flow To 3HP-5 From Either Letdown Cooler Train
H601
Page 44
Air-Operated Valve 3HP-5 Transfers Closed
HHP0005AVT
5.01E-03
Solenoid Valve 3HPISV0090 Transfers Position
HHPSV90SVT
3.14E-03
125 V dc Panelboard 3DIB Breaker 25 Transfers Open (3CC-8, 3HP-5)
HDCIB25CDT
2.79E-03
High Letdown Temp. Pressure Switch 3HPIPS0357 Spurious Operation
HHP0357PST
4.68E-03
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB
5.40E-05
Low Instrument Air Pressure Switch 3IAPS0331 Spurious Operation
HHP0331PST
4.68E-03
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
4.32E-02

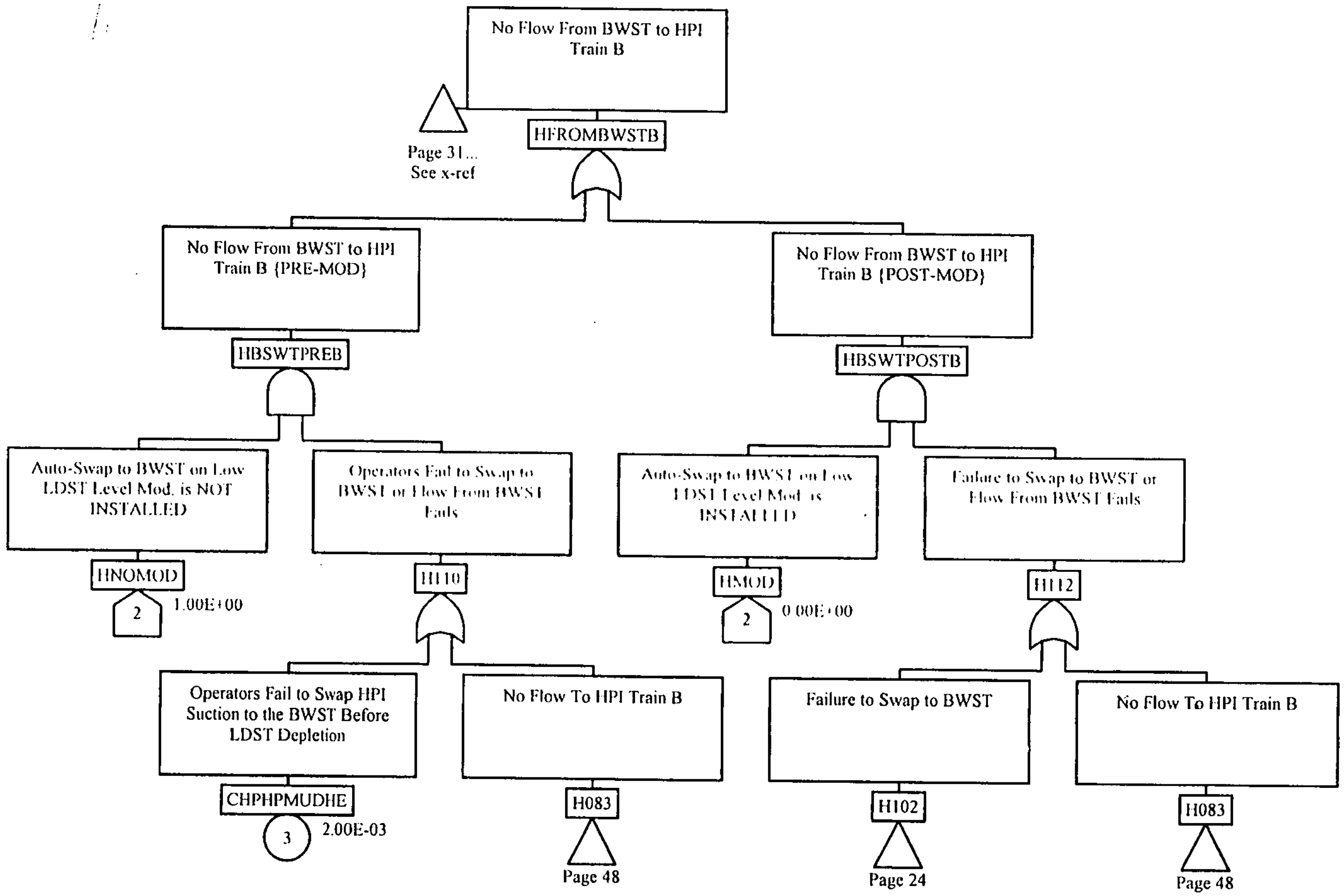


No Flow To 3HP-5 From Either Letdown Cooler Train
H601
Page 43... See x-ref
No Flow To 3HP-5 From Letdown Cooler Train A
HPM665
No Flow To 3HP-5 From Letdown Cooler Train B
H603
Motor-Operated Valve 3HP-3 Transfers Closed
HHP0003MVT
8.20E-04
Motor-Operated Valve 3HP-1 Transfers Closed
HHP0001MVT
8.20E-04
Motor Operated Valve 3HP-2 Transfers Position
HHP0002MVT
8.20E-04
Motor Operated Valve 3HP-4 Transfers Position
HHP0004MVT
8.20E-04
Letdown Cooler 3A Clogs
HHPLDCAHXF
9.54E-03
Letdown Cooler 3B Clogs
HHPLDCBHXF
9.54E-03

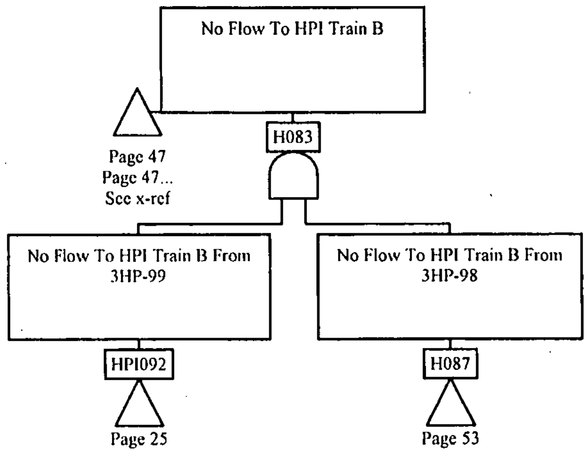

No Flow Through Flow Restrictor Line
Page 41... See x-ref
HPM658
Manual Valve 3HP-39 Transfers Closed
HHP0039VVT
2.96E-04
Loss Of Power On 208/120 V ac Panelboard 3KD
P2C3KD
3
1.60E-02
Letdown Line Flow Reducer Plugs
HHP00LDORF
2.02E-05
120 V ac Panelboard 3KVID Breaker 19 Transfers Open (3HP-6)
HHPKD19CLT
3.64E-03
Air-Operated Valve 3HP-6 Transfers Closed
HHP0006AVT
5.01E-03
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
4.32E-02



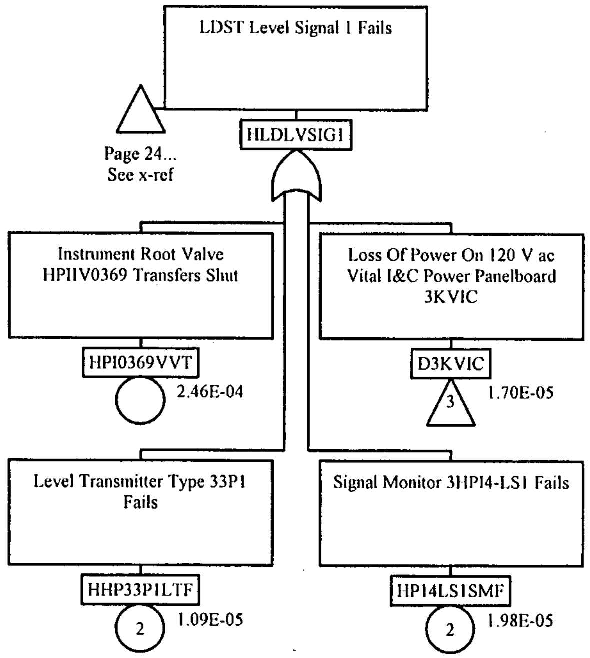
No Flow Through 3HP-17
HPM680
Page 39...
See x-ref
Air-Operated Valve 3HP-17 Transfers Closed
HHP0017AVT
5.01E-03
Loss Of Power On 208/120 V ac Panelboard 3KD
P2C3KD
3
1.60E-02
208/120 V ac Panelboard 3KD Breaker 18 Transfers Open (3HP-17)
HHPKD18CLT
3.64E-03
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
4.32E-02

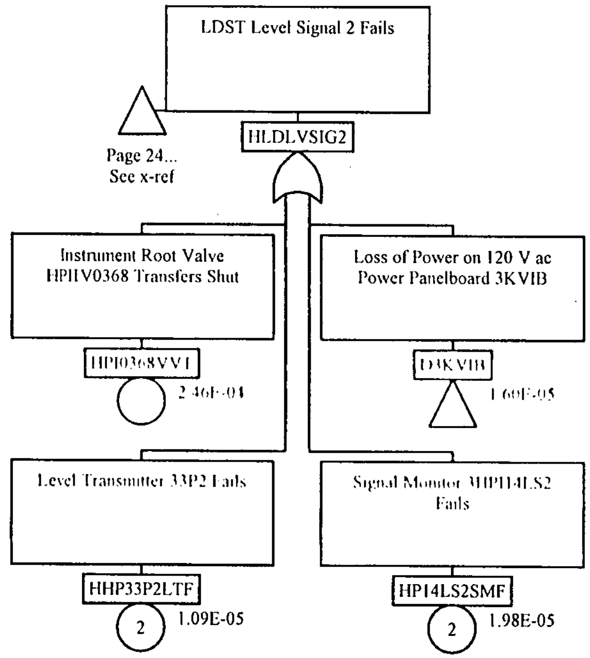


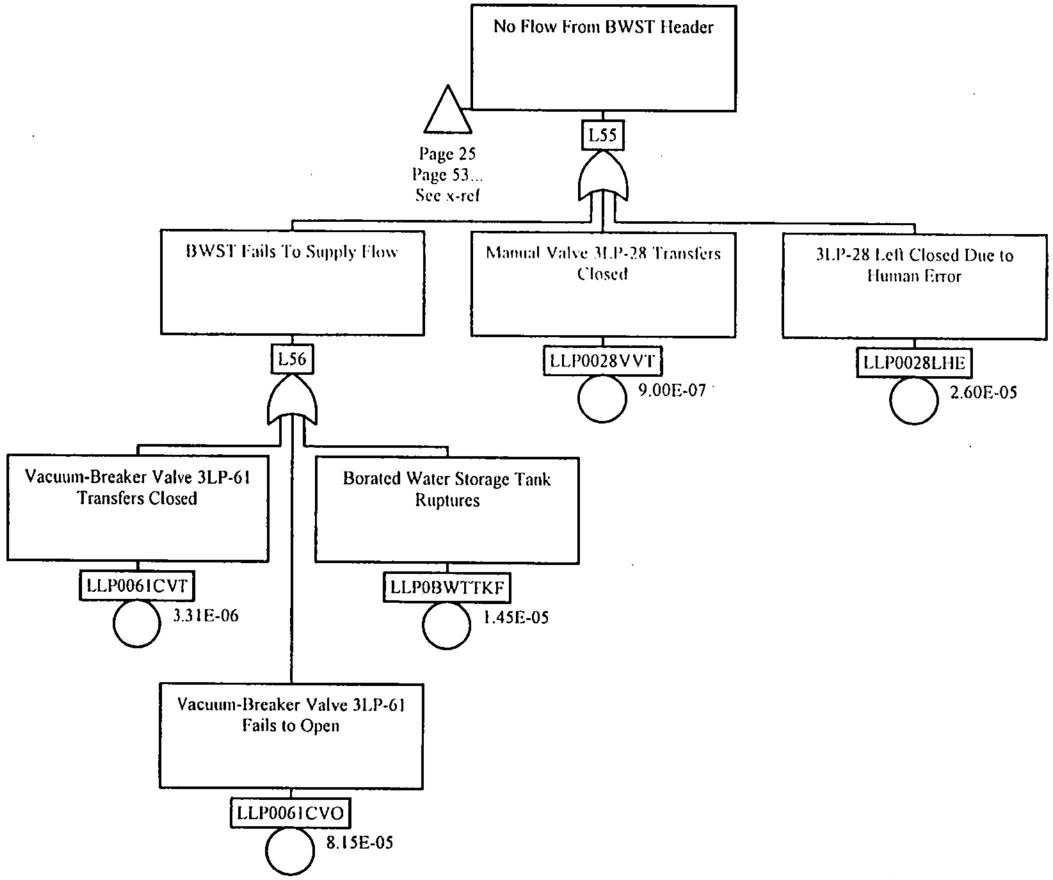
No Flow From BWST to HPI Train B
Page 31... See x-ref
HFROMBWSTB
No Flow From BWST to HPI Train B {PRE-MOD}
HBSWTPREB
No Flow From BWST to HPI Train B {POST-MOD}
HBSWTPOSTB
Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED
HNOMOD
2
1.00E+00
Operators Fail to Swap to BWST or Flow From BWST Fails
H110
Auto-Swap to BWST on Low LDST Level Mod. is INSTALLED
HMOD
2
0.00E+00
Failure to Swap to BWST or Flow From BWST Fails
H112
Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion
CHPHPMUDHE
3
2.00E-03
No Flow To HPI Train B
H083
Page 48
Failure to Swap to BWST
H102
Page 24
No Flow To HPI Train B
H083
Page 48

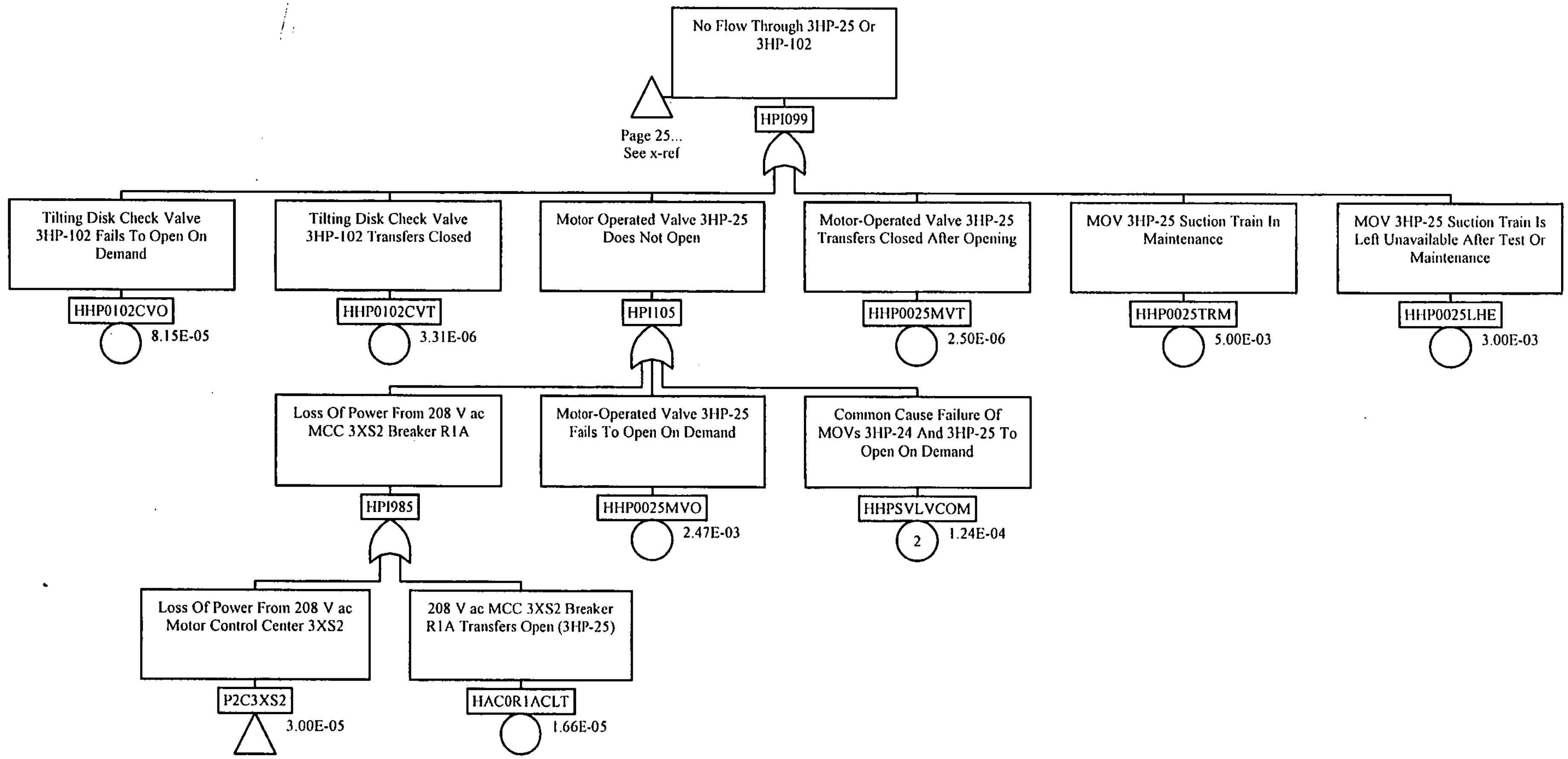


No Flow To HPI Train B
Page 47
Page 47...
See x-ref
H083
No Flow To HPI Train B From 3HP-99
No Flow To HPI Train B From 3HP-98
HPI092
H087
Page 25
Page 53

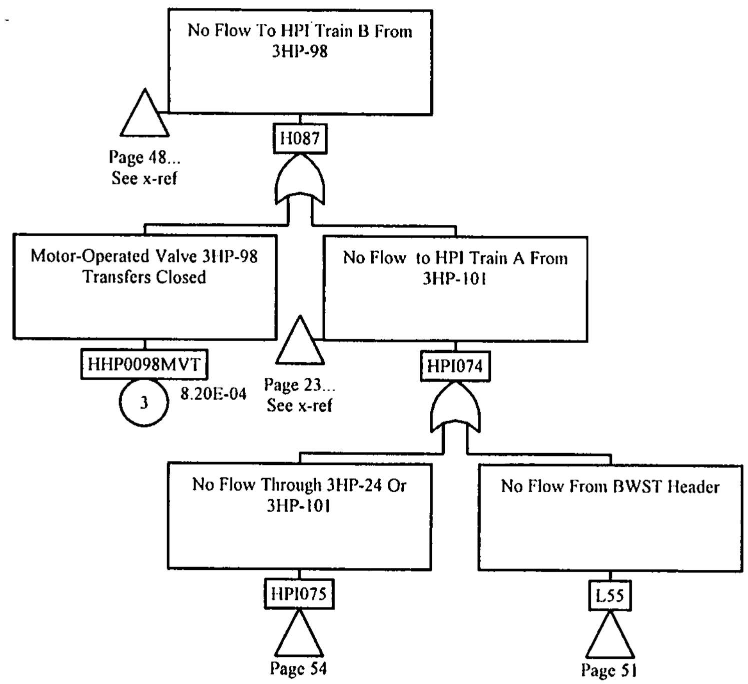

LDST Level Signal 1 Fails
HLDLVSIG1
Page 24...
See x-ref
Instrument Root Valve
HPIIV0369 Transfers Shut
HPI0369VVT
2.46E-04
Loss Of Power On 120 V ac
Vital I&C Power Panelboard
3KVIC
D3KVIC
3
1.70E-05
Level Transmitter Type 33P1
Fails
HHP33P1LTF
2
1.09E-05
Signal Monitor 3HPI4-LS1 Fails
HP14LS1SMF
2
1.98E-05

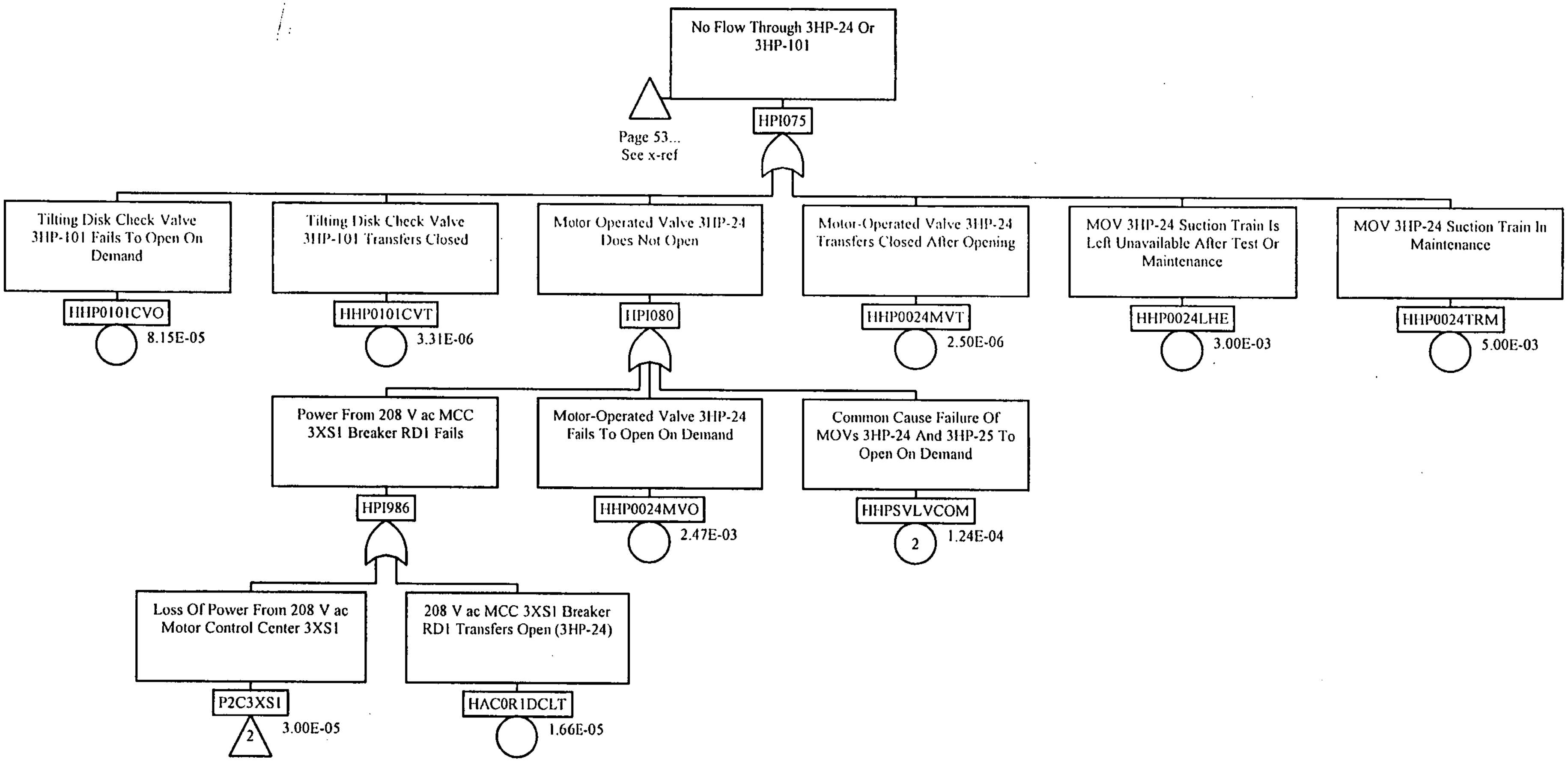

LDST Level Signal 2 Fails
HLDLVSIG2
Page 24...
See x-ref
Instrument Root Valve
HPIIV0368 Transfers Shut
HPI0368VVT
Loss of Power on 120 V ac
Power Panelboard 3KVIB
D3KVIB
Level Transmitter 33P2 Fails
HHP33P2LTF
2
1.09E-05
Signal Monitor 3HPI14LS2
Fails
HP14LS2SMF
2
1.98E-05

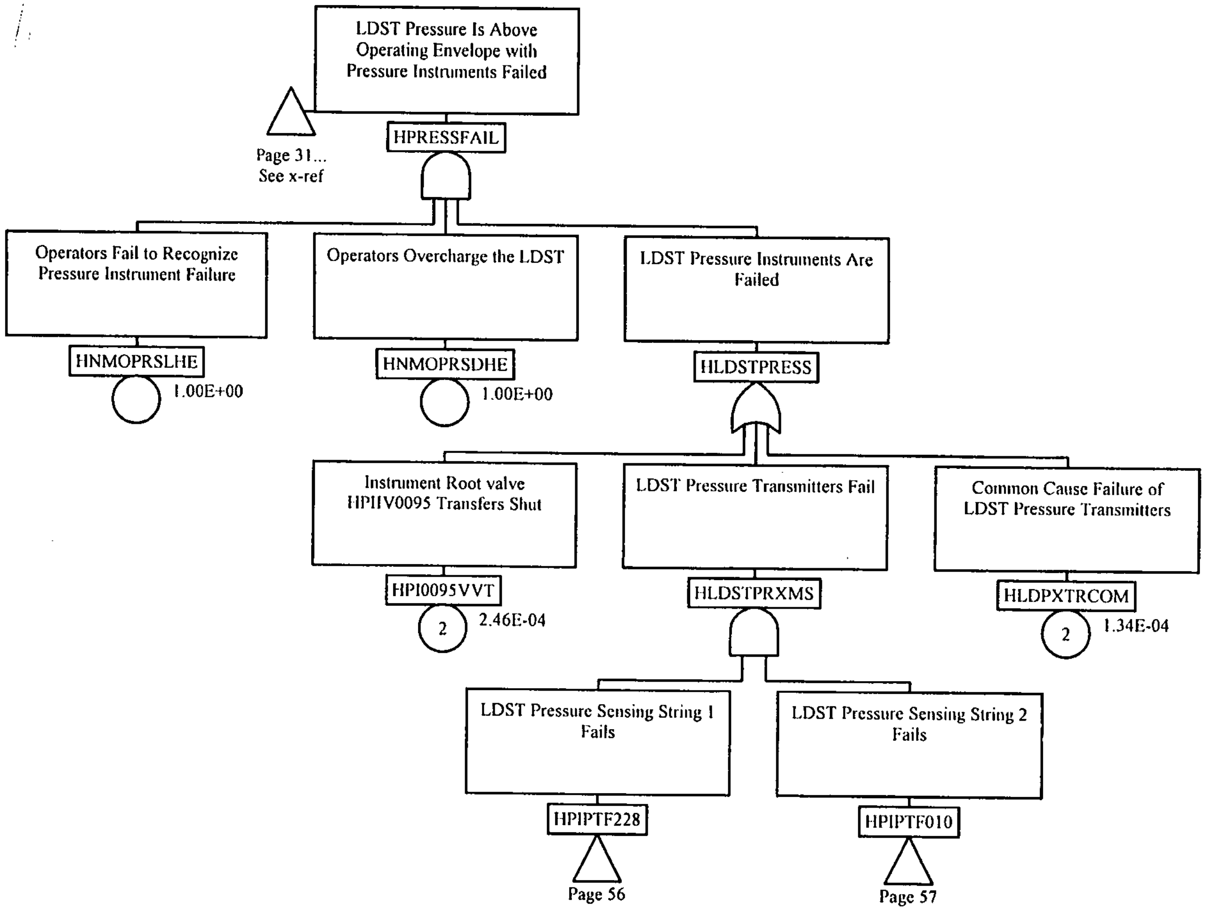

No Flow From BWST Header
Page 25
Page 53...
See x-ref
L55
BWST Fails To Supply Flow
Manual Valve 3LP-28 Transfers Closed
3LP-28 Left Closed Due to Human Error
L56
LLP0028VVT
9.00E-07
LLP0028LHE
2.60E-05
Vacuum-Breaker Valve 3LP-61 Transfers Closed
Borated Water Storage Tank Ruptures
LLP0061CVT
3.31E-06
LLP0BWTTKF
1.45E-05
Vacuum-Breaker Valve 3LP-61 Fails to Open
LLP0061CVO
8.15E-05



No Flow Through 3HP-25 Or 3HP-102
HPI099
Page 25... See x-ref
Tilting Disk Check Valve 3HP-102 Fails To Open On Demand
HHP0102CVO
8.15E-05
Tilting Disk Check Valve 3HP-102 Transfers Closed
HHP0102CVT
3.31E-06
Motor Operated Valve 3HP-25 Does Not Open
HPI105
Motor-Operated Valve 3HP-25 Transfers Closed After Opening
HHP0025MVT
2.50E-06
MOV 3HP-25 Suction Train In Maintenance
HHP0025TRM
5.00E-03
MOV 3HP-25 Suction Train Is Left Unavailable After Test Or Maintenance
HHP0025LHE
3.00E-03
Loss Of Power From 208 V ac MCC 3XS2 Breaker R1A
HPI985
Motor-Operated Valve 3HP-25 Fails To Open On Demand
HHP0025MVO
2.47E-03
Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand
HHPSVLVCOM
2
1.24E-04
Loss Of Power From 208 V ac Motor Control Center 3XS2
P2C3XS2
3.00E-05
208 V ac MCC 3XS2 Breaker R1A Transfers Open (3HP-25)
HAC0R1ACLT
1.66E-05


No Flow To HPI Train B From 3HP-98
H087
Page 48...
See x-ref
Motor-Operated Valve 3HP-98 Transfers Closed
HHP0098MVT
3
8.20E-04
Page 23...
See x-ref
No Flow to HPI Train A From 3HP-101
HPI074
No Flow Through 3HP-24 Or 3HP-101
HPI075
Page 54
No Flow From BWST Header
L55
Page 51


No Flow Through 3HP-24 Or 3HP-101
HPI075
Page 53... See x-ref
Tilting Disk Check Valve 3HP-101 Fails To Open On Demand
HHP0101CVO
8.15E-05
Tilting Disk Check Valve 3HP-101 Transfers Closed
HHP0101CVT
3.31E-06
Motor Operated Valve 3HP-24 Does Not Open
HPI080
Motor-Operated Valve 3HP-24 Transfers Closed After Opening
HHP0024MVT
2.50E-06
MOV 3HP-24 Suction Train Is Left Unavailable After Test Or Maintenance
HHP0024LHE
3.00E-03
MOV 3HP-24 Suction Train In Maintenance
HHP0024TRM
5.00E-03
Power From 208 V ac MCC 3XS1 Breaker RD1 Fails
HPI986
Motor-Operated Valve 3HP-24 Fails To Open On Demand
HHP0024MVO
2.47E-03
Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand
HHPSVLVCOM
2
1.24E-04
Loss Of Power From 208 V ac Motor Control Center 3XS1
P2C3XS1
2
3.00E-05
208 V ac MCC 3XS1 Breaker RD1 Transfers Open (3HP-24)
HAC0R1DCLT
1.66E-05



LDST Pressure Is Above Operating Envelope with Pressure Instruments Failed
HPRESSFAIL
Page 31... See x-ref
Operators Fail to Recognize Pressure Instrument Failure
HNMOPRSLHE
1.00E+00
Operators Overcharge the LDST
HNMOPRSDHE
1.00E+00
LDST Pressure Instruments Are Failed
HLDSTPRESS
Instrument Root valve HPHV0095 Transfers Shut
HPI0095VVT
2
2.46E-04
LDST Pressure Transmitters Fail
HLDSTPRXMS
Common Cause Failure of LDST Pressure Transmitters
HLDPXTRCOM
2
1.34E-04
LDST Pressure Sensing String 1 Fails
HPIPTF228
Page 56
LDST Pressure Sensing String 2 Fails
HPIPTF010
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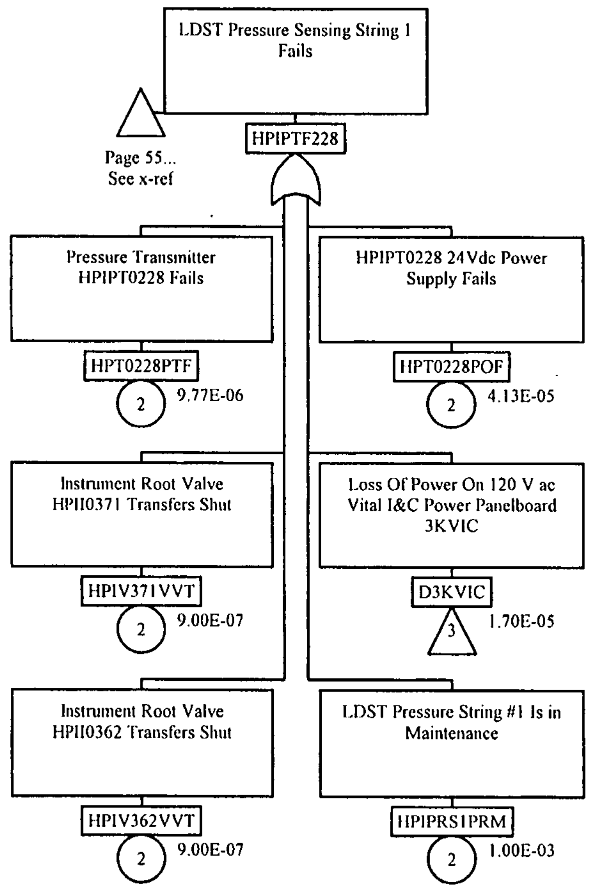
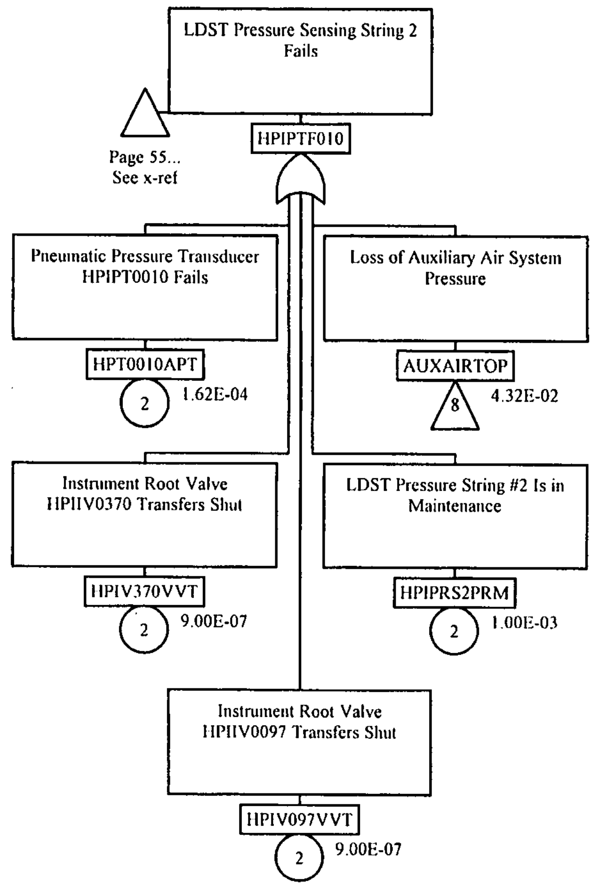

LDST Pressure Sensing String 1 Fails
HPIPTF228
Page 55... See x-ref
Pressure Transmitter HPIPT0228 Fails
HPT0228PTF
2
9.77E-06
HPIPT0228 24Vdc Power Supply Fails
HPT0228POF
2
4.13E-05
Instrument Root Valve HPII0371 Transfers Shut
HPIV371VVT
2
9.00E-07
Loss Of Power On 120 V ac Vital I&C Power Panelboard 3KVIC
D3KVIC
3
1.70E-05
Instrument Root Valve HPII0362 Transfers Shut
HPIV362VVT
2
9.00E-07
LDST Pressure String #1 Is in Maintenance
HPIPRS1PRM
2
1.00E-03



LDST Pressure Sensing String 2 Fails
HPIPTF010
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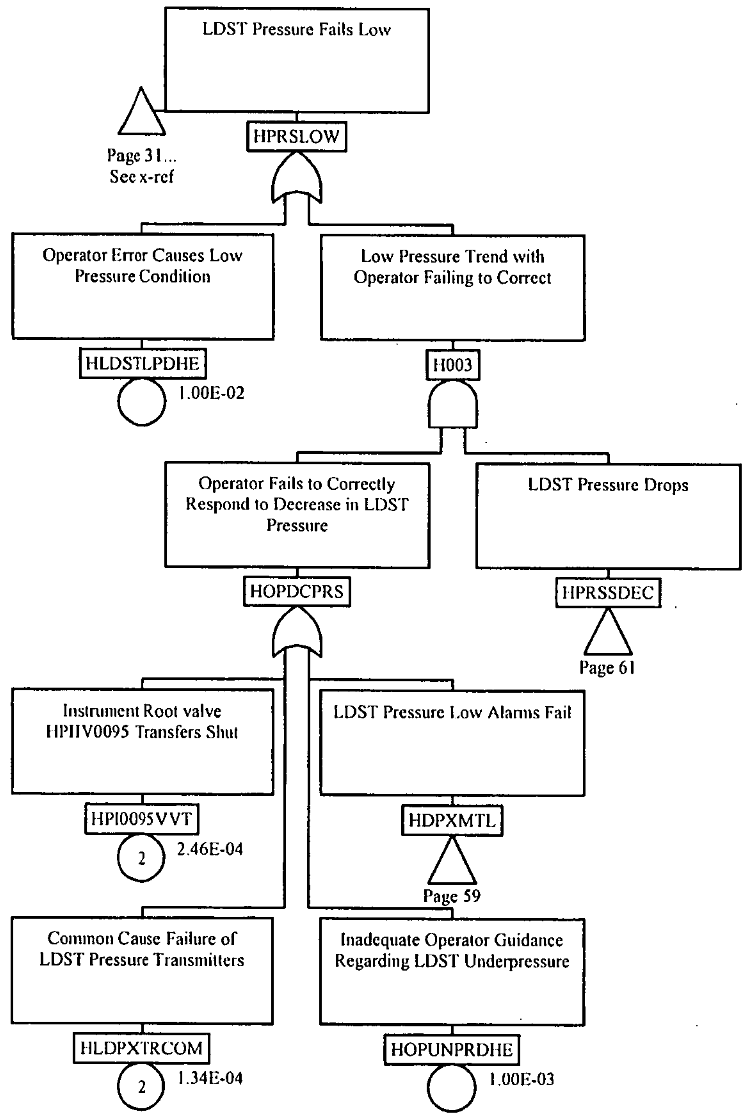
Pneumatic Pressure Transducer HPIPT0010 Fails
HPT0010APT
2
1.62E-04
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
4.32E-02
Instrument Root Valve HPIIV0370 Transfers Shut
HPIV370VVT
2
9.00E-07
LDST Pressure String #2 Is in Maintenance
HPIPRS2PRM
2
1.00E-03
Instrument Root Valve HPIIV0097 Transfers Shut
HPIV097VVT
2
9.00E-07


LDST Pressure Fails Low
Page 31...
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HPRSLOW
Operator Error Causes Low Pressure Condition
Low Pressure Trend with Operator Failing to Correct
HLDSTLPDHE
1.00E-02
H003
Operator Fails to Correctly Respond to Decrease in LDST Pressure
LDST Pressure Drops
HOPDCPRS
HPRSSDEC
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Instrument Root valve HPIIV0095 Transfers Shut
LDST Pressure Low Alarms Fail
HPI0095VVT
2
2.46E-04
HDPXMTL
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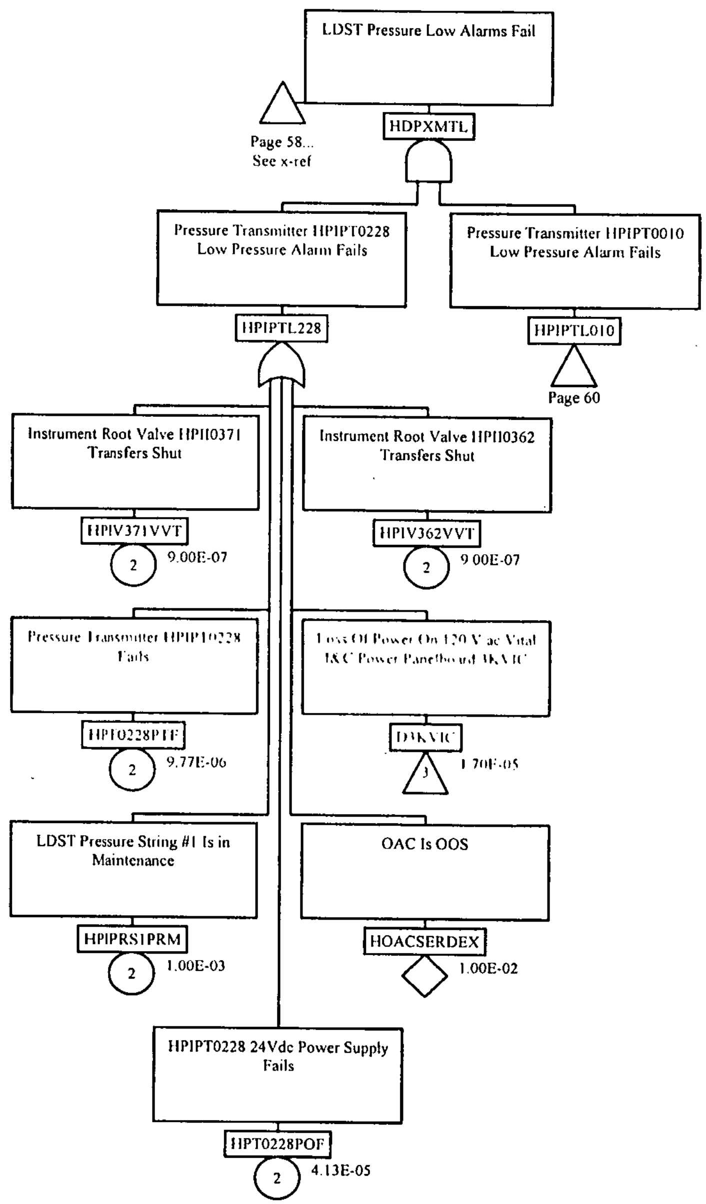
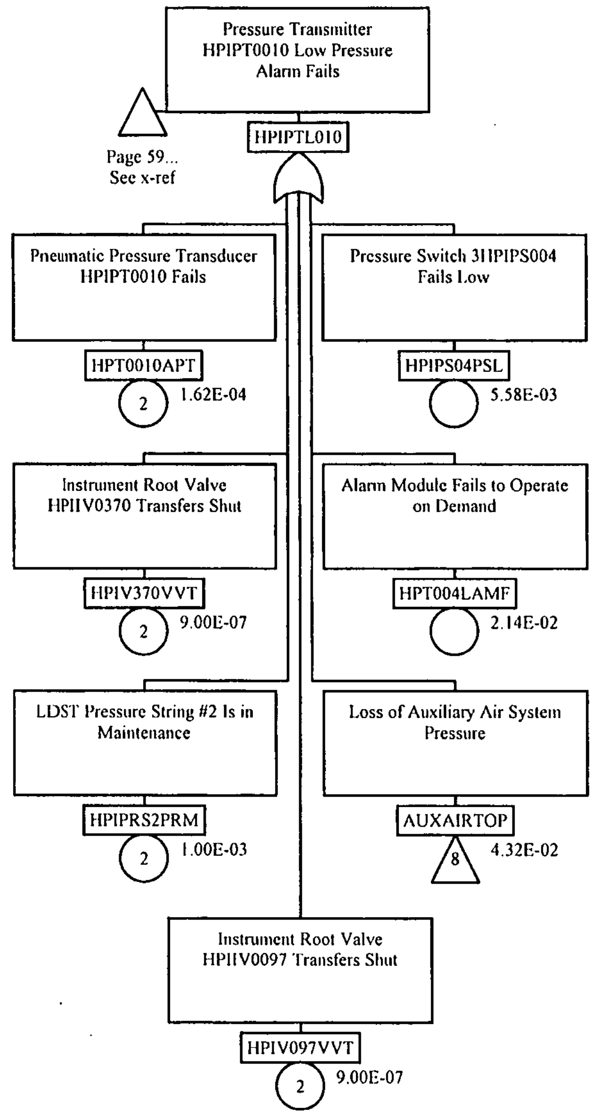
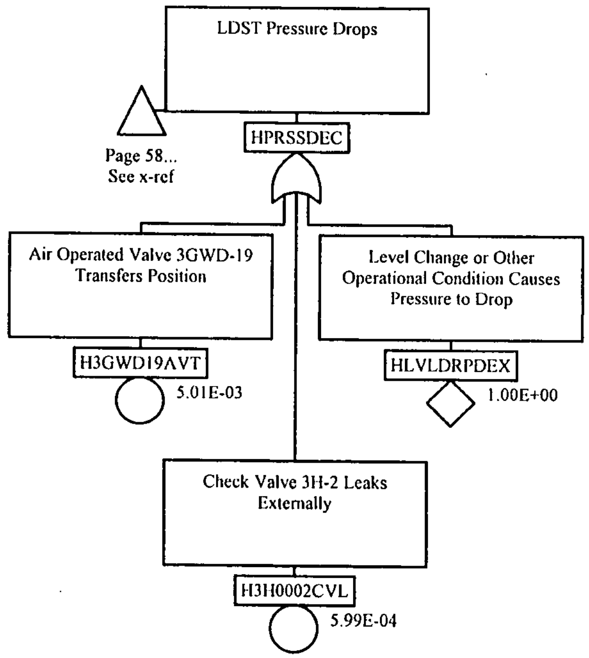
Common Cause Failure of LDST Pressure Transmitters
Inadequate Operator Guidance Regarding LDST Underpressure
HLDPXTRCOM
2
1.34E-04
HOPUNPRDHE
1.00E-03


LDST Pressure Low Alarms Fail
HDPXMTL
Page 58...
See x-ref
Pressure Transmitter HPIPT0228 Low Pressure Alarm Fails
Pressure Transmitter HPIPT0010 Low Pressure Alarm Fails
HPIPTL228
HPIPTL010
Page 60
Instrument Root Valve HPII0371 Transfers Shut
HPIV371VVT
2
9.00E-07
Instrument Root Valve HPII0362 Transfers Shut
HPIV362VVT
2
9.00E-07
Pressure Transmitter HPIPT0228 Fails
HPT0228PTF
2
9.77E-06
Loss Of Power On 120 Vac Vital I&C Power Panelboard 3KVIC
D3KVIC
3
1.70E-05
LDST Pressure String #1 Is in Maintenance
HPIPRS1PRM
2
1.00E-03
OAC Is OOS
HOACSERDEX
1.00E-02
HPIPT0228 24Vdc Power Supply Fails
HPT0228POF
2
4.13E-05


Pressure Transmitter HPIPT0010 Low Pressure Alarm Fails
HPIPTL010
Page 59...
See x-ref
Pneumatic Pressure Transducer HPIPT0010 Fails
HPT0010APT
2
1.62E-04
Pressure Switch 3HPIPS004 Fails Low
HPIPS04PSL
5.58E-03
Instrument Root Valve HPIIV0370 Transfers Shut
HPIV370VVT
2
9.00E-07
Alarm Module Fails to Operate on Demand
HPT004LAMF
2.14E-02
LDST Pressure String #2 Is in Maintenance
HPIPRS2PRM
2
1.00E-03
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
4.32E-02
Instrument Root Valve HPIIV0097 Transfers Shut
HPIV097VVT
2
9.00E-07


LDST Pressure Drops
Page 58...
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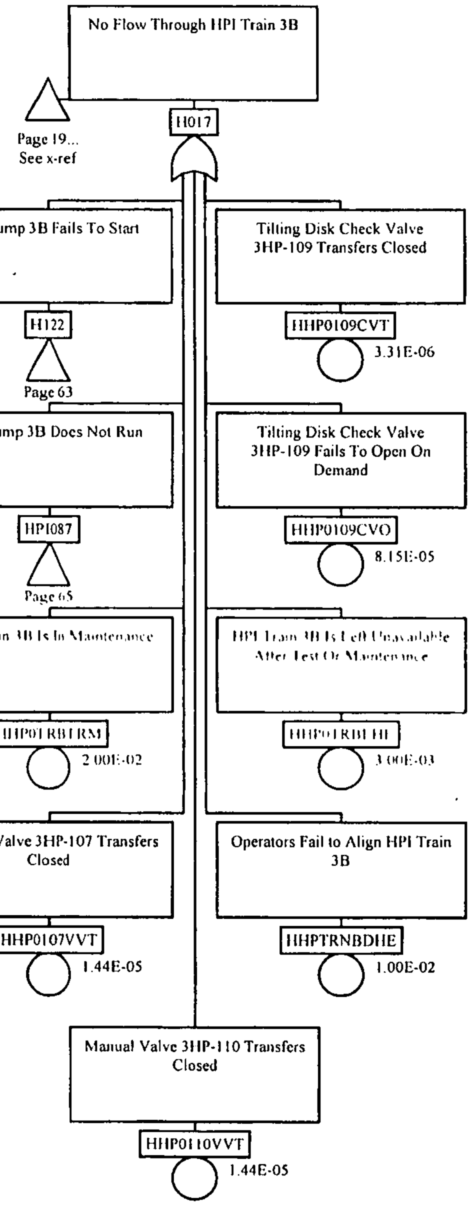
HPRSSDEC
Air Operated Valve 3GWD-19
Transfers Position
H3GWD19AVT
5.01E-03
Level Change or Other
Operational Condition Causes
Pressure to Drop
HLVLDRPDEX
1.00E+00
Check Valve 3H-2 Leaks
Externally
H3H0002CVL
5.99E-04


No Flow Through HPI Train 3B
H017
Page 19...
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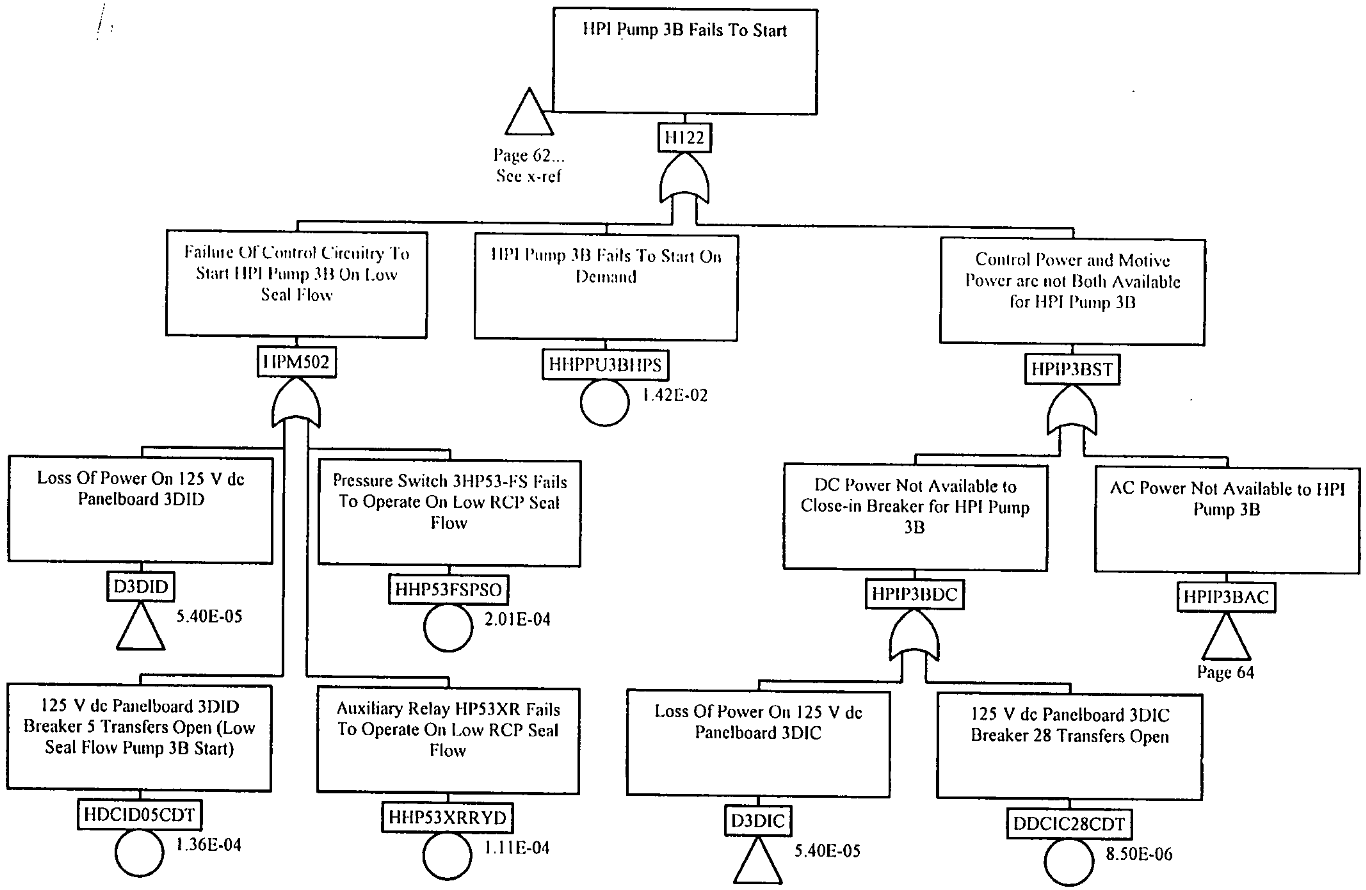
HPI Pump 3B Fails To Start
H122
Page 63
Tilting Disk Check Valve 3HP-109 Transfers Closed
HHP0109CVT
3.31E-06
HPI Pump 3B Does Not Run
HPI087
Page 65
Tilting Disk Check Valve 3HP-109 Fails To Open On Demand
HHP0109CVO
8.15E-05
HPI Train 3B Is In Maintenance
HHP0TRBTRM
2.00E-02
HPI Train 3B Is Left Unavailable After Test Or Maintenance
HHP0TRBTHE
3.00E-03
Manual Valve 3HP-107 Transfers Closed
HHP0107VVT
1.44E-05
Operators Fail to Align HPI Train 3B
HHPTRNBDHE
1.00E-02
Manual Valve 3HP-110 Transfers Closed
HHP0110VVT
1.44E-05


HPI Pump 3B Fails To Start
Page 62...
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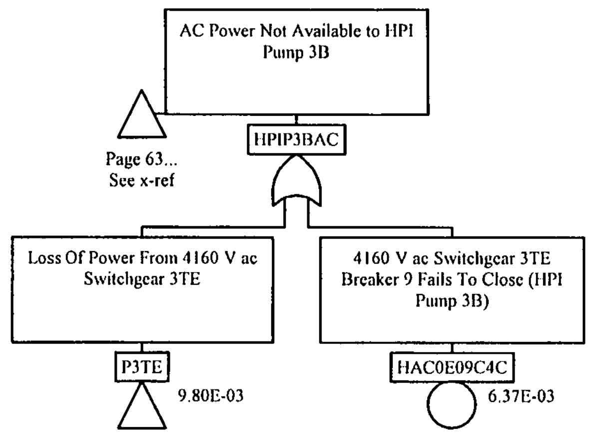
H122
Failure Of Control Circuitry To Start HPI Pump 3B On Low Seal Flow
HPI Pump 3B Fails To Start On Demand
Control Power and Motive Power are not Both Available for HPI Pump 3B
HPM502
HHPPU3BHPS
1.42E-02
HPIP3BST
Loss Of Power On 125 V dc Panelboard 3DID
Pressure Switch 3HP53-FS Fails To Operate On Low RCP Seal Flow
DC Power Not Available to Close-in Breaker for HPI Pump 3B
AC Power Not Available to HPI Pump 3B
D3DID
5.40E-05
HHP53FSPSO
2.01E-04
HPIP3BDC
HPIP3BAC
Page 64
125 V dc Panelboard 3DID Breaker 5 Transfers Open (Low Seal Flow Pump 3B Start)
Auxiliary Relay HP53XR Fails To Operate On Low RCP Seal Flow
Loss Of Power On 125 V dc Panelboard 3DIC
125 V dc Panelboard 3DIC Breaker 28 Transfers Open
HDCID05CDT
1.36E-04
HHP53XRRYD
1.11E-04
D3DIC
5.40E-05
DDCIC28CDT
8.50E-06



AC Power Not Available to HPI Pump 3B
HPIP3BAC
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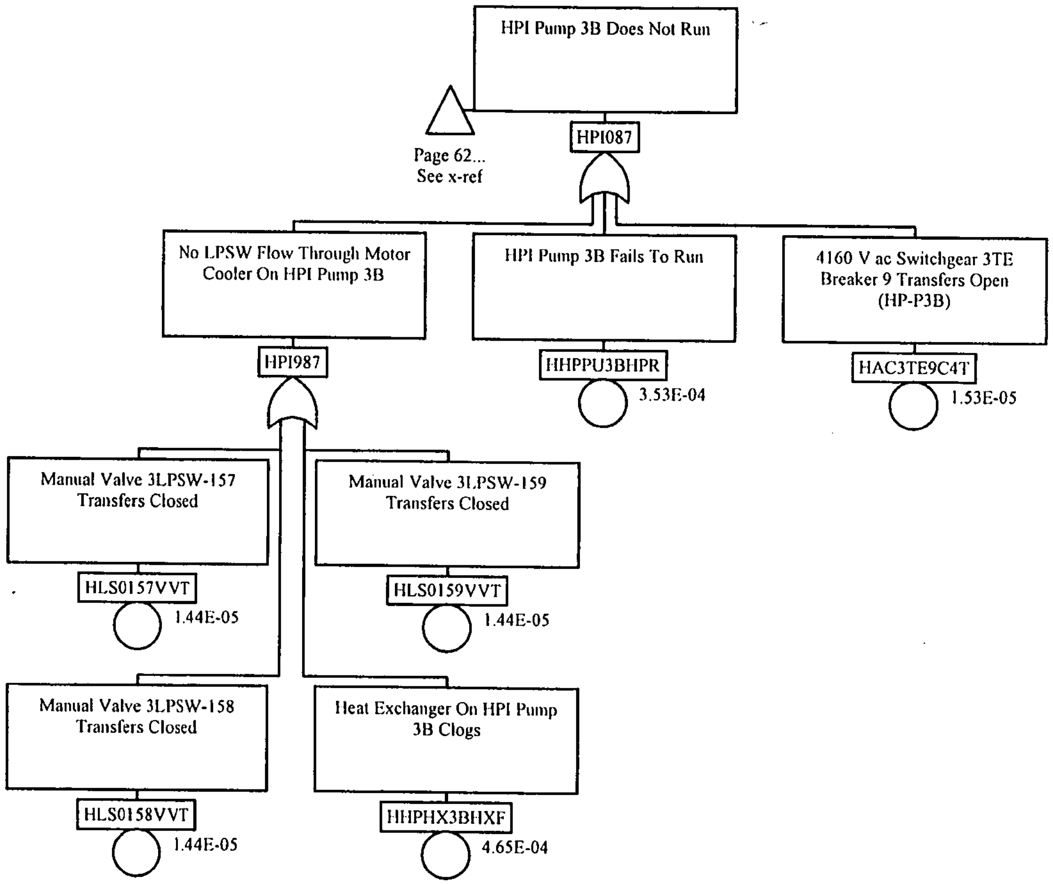
Loss Of Power From 4160 V ac Switchgear 3TE
P3TE
9.80E-03
4160 V ac Switchgear 3TE Breaker 9 Fails To Close (HPI Pump 3B)
HAC0E09C4C
6.37E-03


HPI Pump 3B Does Not Run
Page 62...
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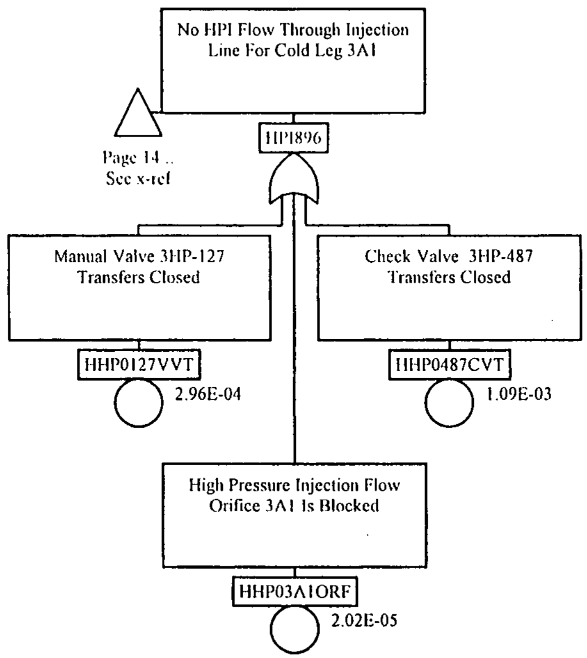
HPI087
No LPSW Flow Through Motor Cooler On HPI Pump 3B
HPI Pump 3B Fails To Run
4160 V ac Switchgear 3TE Breaker 9 Transfers Open (HP-P3B)
HPI987
HHPPU3BHPR
3.53E-04
HAC3TE9C4T
1.53E-05
Manual Valve 3LPSW-157 Transfers Closed
Manual Valve 3LPSW-159 Transfers Closed
HLS0157VVT
1.44E-05
HLS0159VVT
1.44E-05
Manual Valve 3LPSW-158 Transfers Closed
Heat Exchanger On HPI Pump 3B Clogs
HLS0158VVT
1.44E-05
HHPHX3BHXF
4.65E-04


No HPI Flow Through Injection Line For Cold Leg 3A1
HPI896
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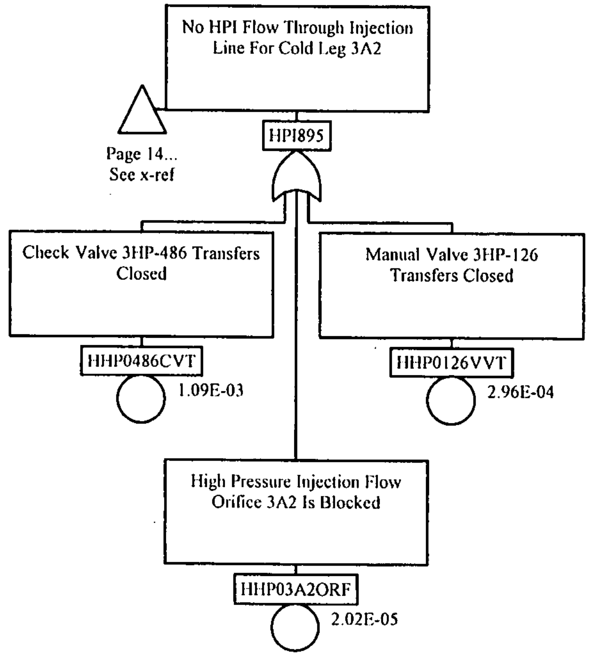
Manual Valve 3HP-127 Transfers Closed
HHP0127VVT
2.96E-04
Check Valve 3HP-487 Transfers Closed
HHP0487CVT
1.09E-03
High Pressure Injection Flow Orifice 3A1 Is Blocked
HHP03A1ORF
2.02E-05


No HPI Flow Through Injection Line For Cold Leg 3A2
HPI895
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Check Valve 3HP-486 Transfers Closed
HHP0486CVT
1.09E-03
Manual Valve 3HP-126 Transfers Closed
HHP0126VVT
2.96E-04
High Pressure Injection Flow Orifice 3A2 Is Blocked
HHP03A2ORF
2.02E-05

Name	Page	Zone	Name	Page	Zone	Name	Page	Zone
AUXAIRTOP	18	1	H132	19	2	HHP0001MVT	44	2
AUXAIRTOP	40	2	H134	19	2	HHP0002MVT	44	3
AUXAIRTOP	42	5	H134	20	2	HHP0003MVT	44	1
AUXAIRTOP	43	2	H3AFLOW	14	3	HHP0004MVT	44	4
AUXAIRTOP	45	2	H3GWD19AVT	61	1	HHP0005AVT	43	1
AUXAIRTOP	46	2	H3H0002CVL	61	2	HHP0006AVT	45	1
AUXAIRTOP	57	2	H601	43	3	HHP0007AVT	42	3
AUXAIRTOP	60	2	H601	44	3	HHP0008AVT	40	1
CHPHPMUDHE	22	1	H603	44	4	HHP0014MVT	39	3
CHPHPMUDHE	24	3	H638	17	1	HHP0017AVT	46	1
CHPHPMUDHE	47	2	H638	21	3	HHP0023MVT	32	4
D3DIB	43	1	H639	21	1	HHP0024LHE	54	5
D3DIC	63	3	H639	32	2	HHP0024MVO	54	3
D3DID	63	1	H640	21	2	HHP0024MVT	54	4
D3KI	42	3	H646	31	2	HHP0024TRM	54	6
D3KU	42	4	H648	31	1	HHP0025LHE	52	6
D3KVIB	50	2	H648	32	3	HHP0025MVO	52	3
D3KVIC	49	2	HAC0008C4T	28	1	HHP0025MVT	52	4
D3KVIC	56	2	HAC0E09C4C	64	2	HHP0025TRM	52	5
D3KVIC	59	2	HAC0R1ACLT	52	3	HHP0026DHE	19	1
DDCIC28CDT	63	4	HAC0R1DCLT	54	3	HHP0026MVO	20	1
H003	58	2	HAC0R2ACLT	20	3	HHP0028VVT	13	2
H00COOLDEX	2	7	HAC3TE9C4T	65	4	HHP0031AVT	12	2
H00LDSTDEX	32	5	HBSWTPOSTA	21	5	HHP0039VVT	45	1
H00LDSTTKF	32	5	HBSWTPOSTB	47	4	HHP0040VVT	42	2
H017	19	7	HBSWTPREA	21	3	HHP0041VVT	42	1
H017	62	2	HBSWTPREB	47	2	HHP0047CVT	40	1
H066	22	2	HBWSTOPEN	24	2	HHP0057VVT	39	4
H066	23	2	HD3KIKU	18	2	HHP0064VVT	8	2
H083	47	3	HD3KIKU	36	1	HHP0065VVT	9	2
H083	47	5	HD3KIKU	37	1	HHP0066VVT	10	2
H083	48	2	HD3KIKU	42	4	HHP0067VVT	11	2
H087	48	2	HDCIB25CDT	43	1	HHP0078CVT	39	3
H087	53	2	HDCID05CDT	63	1	HHP0079RVT	30	2
H096	21	4	HDFLWALM	33	4	HHP0097CVT	32	4
H096	22	2	HDISCHADEX	14	4	HHP0098MVT	17	4
H100	21	6	HDLVXMR1	35	2	HHP0098MVT	23	3
H100	23	2	HDLVXMR1	36	2	HHP0098MVT	53	1
H102	23	1	HDLVXMR2	35	3	HHP0099VVT	25	2
H102	24	3	HDLVXMR2	37	2	HHP00LDORF	45	1
H102	47	4	HDPXMTL	58	2	HHP0100VVT	25	2
H110	47	2	HDPXMTL	59	2	HHP0101CVO	54	1
H112	47	4	HEADER	8	6	HHP0101CVT	54	2
H117	15	2	HEADER	12	3	HHP0102CVO	52	1
H122	62	1	HEMERLILHE	24	1	HHP0102CVT	52	2
H122	63	3	HEMERLIMNT	24	2	HHP0103VVT	29	2
H128	17	5	HEXCMAKEUP	32	3	HHP0105CVT	29	2
H128	19	7	HFRMLDSTNORM	21	2	HHP0106VVT	29	1
H128	30	2	HFRMLDSTNORM	32	4	HHP0107VVT	62	1
H130	15	3	HFROMBWSTA	21	4	HHP0109CVO	62	2
H130	19	3	HFROMBWSTB	31	2	HHP0109CVT	62	2
H131	19	2	HFROMBWSTB	47	3	HHP0110VVT	62	2

Name	Page	Zone	Name	Page	Zone	Name	Page	Zone
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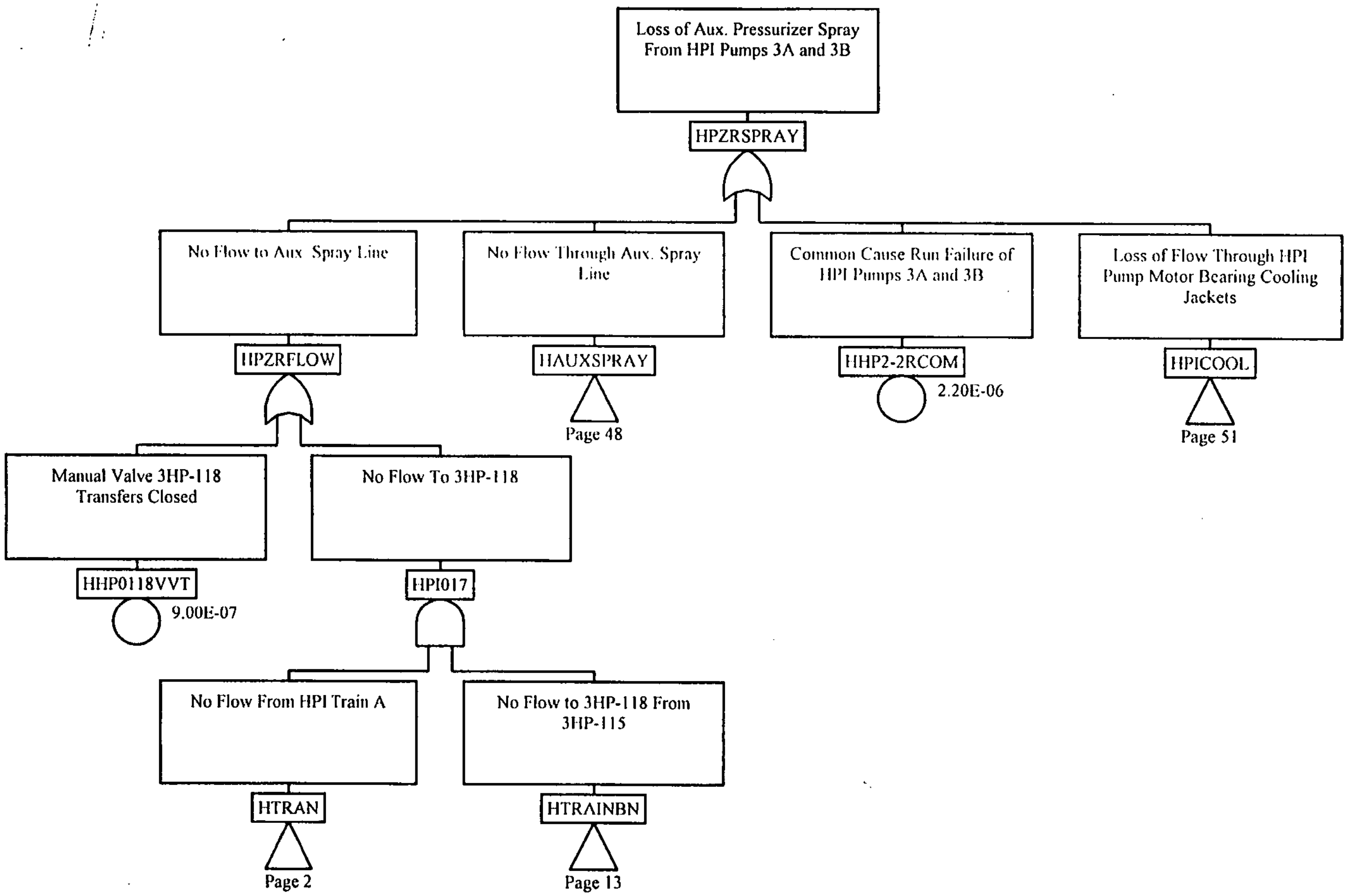
HHP0115MVT	19	6	HHP33P2LTF	37	1	HLDSTLPDHE	58	1
HHP0118VVT	15	1	HHP33P2LTF	50	1	HLDSTLVL	17	2
HHP0119VVT	15	2	HHP53FSPSO	63	2	HLDSTLVLB	31	2
HHP0120AVT	18	1	HHP53XRRYD	63	2	HLDSTLVXMS	35	2
HHP0121VVT	15	2	HHPDEMAFLF	40	1	HLDSTPERN	17	2
HHP0122VVO	19	3	HHPEP03PCF	18	2	HLDSTPERNB	19	6
HHP0126VVT	67	2	HHPHX3AHXF	27	2	HLDSTPERNB	31	3
HHP0127VVT	66	1	HHPHX3BHXF	65	2	HLDSTPRESS	55	3
HHP0128VVT	12	4	HHPKD17CLT	40	2	HLDSTPRS	17	3
HHP0129VVT	13	1	HHPKD18CLT	46	1	HLDSTPRS	31	4
HHP0130VVT	13	2	HHPKD19CLT	45	2	HLDSTPRXMS	55	3
HHP0131VVT	13	2	HHPKU21CLT	42	5	HLDSTSIG	24	3
HHP0138VVT	12	1	HHPLDCAHXF	44	2	HLDXMTRCOM	35	1
HHP0139VVT	12	1	HHPLDCBHXF	44	4	HLEVELFAIL	17	2
HHP0144CVT	9	1	HHPPU3AHPR	17	3	HLEVELFAIL	26	2
HHP0145CVT	8	1	HHPPU3BHPR	65	3	HLEVELFAIL	31	3
HHP0146CVT	11	1	HHPPU3BHPS	63	3	HLS0147VVT	3	1
HHP0147CVT	10	1	HHPSV90SVT	43	2	HLS0148CVT	3	2
HHP0191SVT	12	2	HHPSVLVCOM	52	4	HLS0149VVT	2	1
HHP0194CVT	15	1	HHPSVLVCOM	54	4	HLS0150VVT	4	1
HHP0195VVT	41	4	HHPTRNBDHE	62	2	HLS0152VVT	27	1
HHP0283VVT	8	1	HHS0017MVT	6	2	HLS0153VVT	27	1
HHP0284VVT	9	1	HHS0112VVT	6	1	HLS0154VVT	27	2
HHP0285VVT	10	1	HHS0202VVT	7	1	HLS0157VVT	65	1
HHP0286VVT	11	1	HHS0450VVT	7	2	HLS0158VVT	65	1
HHP0331PST	43	2	HHS0555VVT	5	5	HLS0159VVT	65	2
HHP0357PST	43	2	HHS0556RGO	5	7	HLS0204ORF	5	1
HHP0385VVT	10	2	HHS0556RGT	5	6	HLS0246VVT	2	2
HHP0387VVT	11	2	HHS2017MVT	7	2	HLS0500VVT	2	4
HHP0390CVT	8	2	HLDDIVTCHE	30	1	HLS0503CVT	4	2
HHP0393CVT	11	2	HLDFLOW	32	2	HLS0708VVT	3	2
HHP03A1ORF	66	2	HLDFLOW	39	4	HLS0709VVT	4	2
HHP03A2ORF	67	2	HLDFLOWAMF	33	4	HLS0711VVT	2	3
HHP0446VVT	10	1	HLDFLOWDHE	33	2	HLS0771VVT	5	3
HHP0447VVT	8	1	HLDISOLCHE	39	1	HLS0C01FLF	3	1
HHP0448VVT	11	1	HLDLVLALM	33	5	HLS0C02FLF	4	1
HHP0449VVT	9	1	HLDLVLALM	34	2	HLS0C18FLF	5	2
HHP0454CVT	9	2	HLDLVSIG1	24	3	HLSFILTCOM	2	6
HHP0457CVT	10	2	HLDLVSIG1	49	2	HLVLDRPDEX	61	2
HHP0477VVT	9	2	HLDLVSIG2	24	4	HLVLST1LTM	36	2
HHP0482VVT	8	2	HLDLVSIG2	50	2	HLVLST2LTM	37	2
HHP0486CVT	67	1	HLDMONITOR	33	4	HMAKE-UP	15	2
HHP0487CVT	66	2	HLDPATHDEX	39	7	HMAKE-UP	18	2
HHP0LDAFLF	39	5	HLDPXTRCOM	55	4	HMOD	21	5
HHP0SFAFLF	13	1	HLDPXTRCOM	58	1	HMOD	47	3
HHP0SGOLHE	25	1	HLDRESTORE	32	1	HNMOPLVDHE	26	1
HHP0TRBLHE	62	2	HLDRESTORE	33	2	HNMOPRSDHE	55	2
HHP0TRBTRM	62	1	HLDSLVLAMF	34	1	HNMOPRSLHE	55	1
HHP2-2RCOM	1	2	HLDSTL1DHE	33	1	HNOMOD	21	3
HHP2-2RCOM	14	1	HLDSTLEVEL	26	2	HNOMOD	47	1
HHP33P1LTF	36	1	HLDSTLEVEL	34	2	HNORMLDINT	32	2

Name	Page	Zone	Name	Page	Zone	Name	Page	Zone
HSEALLINE	8	4						
HTRAINBN	16	2						
HTRAINBN	19	6						
HTRAN	16	1						
HTRAN	17	4						
HTRAN	19	5						
HUBFLOW	33	2						
L55	25	3						
L55	51	3						
L55	53	3						
L56	51	2						
LLP0028LHE	51	4						
LLP0028VVT	51	3						
LLP0061CVO	51	2						
LLP0061CVT	51	1						
LLP0BWTTKF	51	2						
P2C3KD	40	2						
P2C3KD	45	2						
P2C3KD	46	2						
P2C3XS1	20	2						
P2C3XS1	54	2						
P2C3XS2	52	2						
P3TC	28	2						
P3TE	64	1						
PRZRCHAL	38	1						
PRZRLVLDEX	38	2						
PZRLVLV	33	6						
PZRLVLV	38	2						
W100	3	2						
W200	4	2						
WCW0087VVT	2	5						
WH3	5	5						

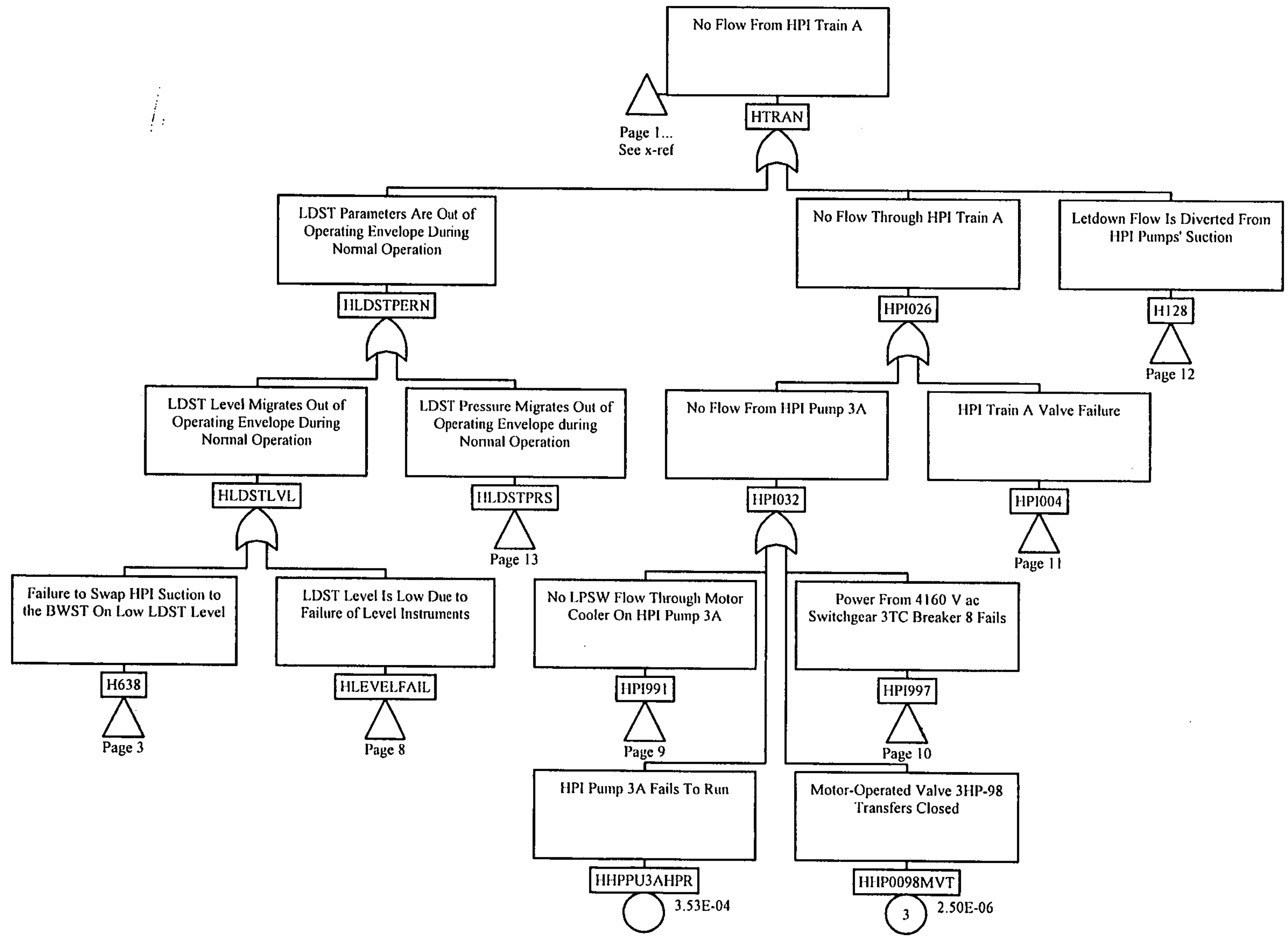
APPENDIX B3

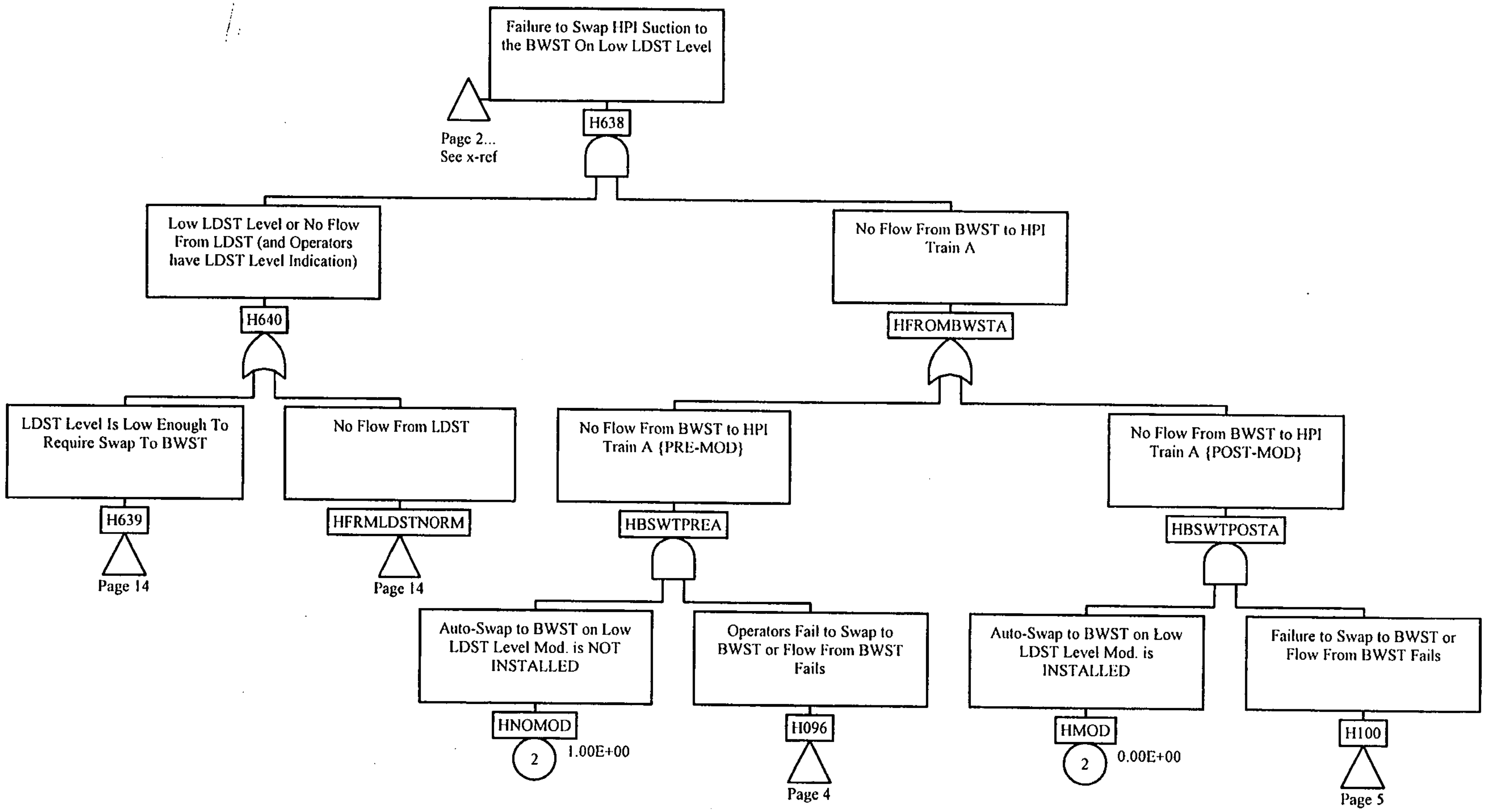
HPI SYSTEM

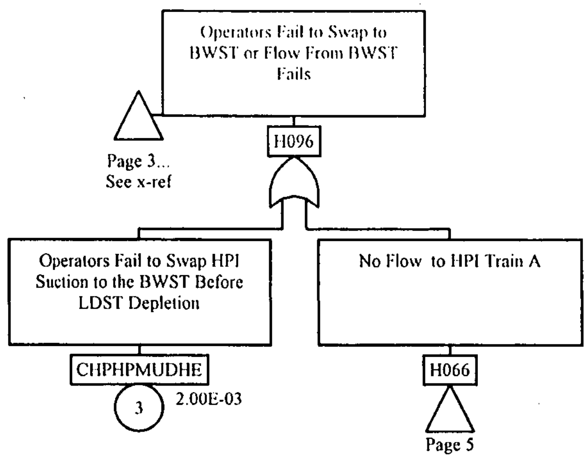
AUXILIARY SPRAY FAULT TREE

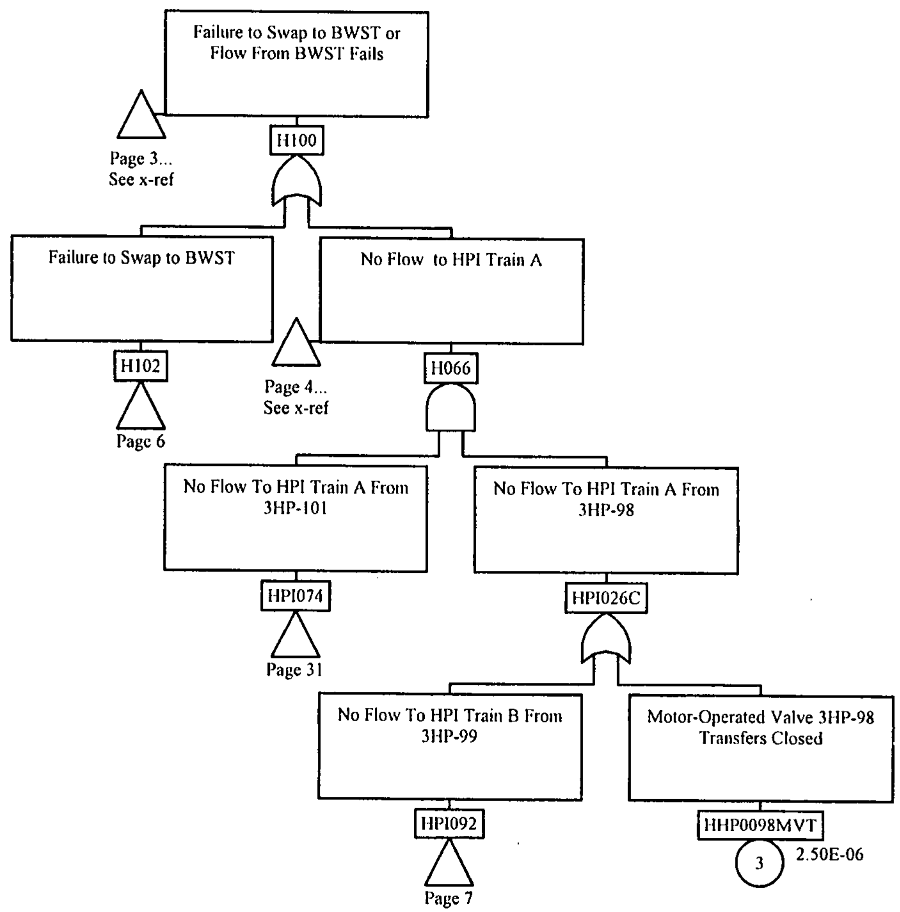


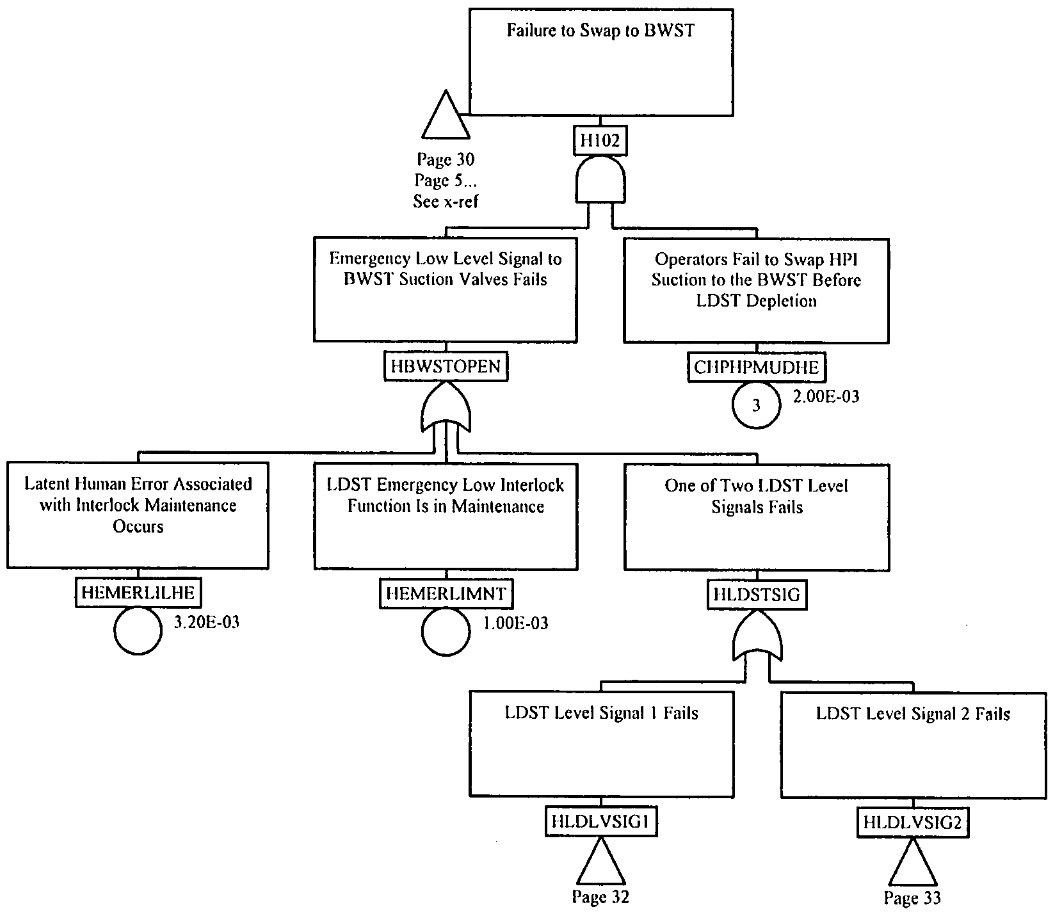
Loss of Aux. Pressurizer Spray From HPI Pumps 3A and 3B
HPZRSPRAY
No Flow to Aux. Spray Line
HPZRFLOW
No Flow Through Aux. Spray Line
HAUXSPRAY
Page 48
Common Cause Run Failure of HPI Pumps 3A and 3B
HHP2-2RCOM
2.20E-06
Loss of Flow Through HPI Pump Motor Bearing Cooling Jackets
HPICOOL
Page 51
Manual Valve 3HP-118 Transfers Closed
HHP0118VVT
9.00E-07
No Flow To 3HP-118
HPI017
No Flow From HPI Train A
HTRAN
Page 2
No Flow to 3HP-118 From 3HP-115
HTRAINBN
Page 13


No Flow From HPI Train A
Page 1... See x-ref
HTRAN
LDST Parameters Are Out of Operating Envelope During Normal Operation
HLDSTPERN
No Flow Through HPI Train A
HPI026
Letdown Flow Is Diverted From HPI Pumps' Suction
H128
Page 12
LDST Level Migrates Out of Operating Envelope During Normal Operation
HLDSTLVL
LDST Pressure Migrates Out of Operating Envelope during Normal Operation
HLDSTPRS
Page 13
No Flow From HPI Pump 3A
HPI032
HPI Train A Valve Failure
HPI004
Page 11
Failure to Swap HPI Suction to the BWST On Low LDST Level
H638
Page 3
LDST Level Is Low Due to Failure of Level Instruments
HLEVELFAIL
Page 8
No LPSW Flow Through Motor Cooler On HPI Pump 3A
HPI991
Page 9
Power From 4160 V ac Switchgear 3TC Breaker 8 Fails
HPI997
Page 10
HPI Pump 3A Fails To Run
HHPPU3AHPR
3.53E-04
Motor-Operated Valve 3HP-98 Transfers Closed
HHP0098MVT
3
2.50E-06

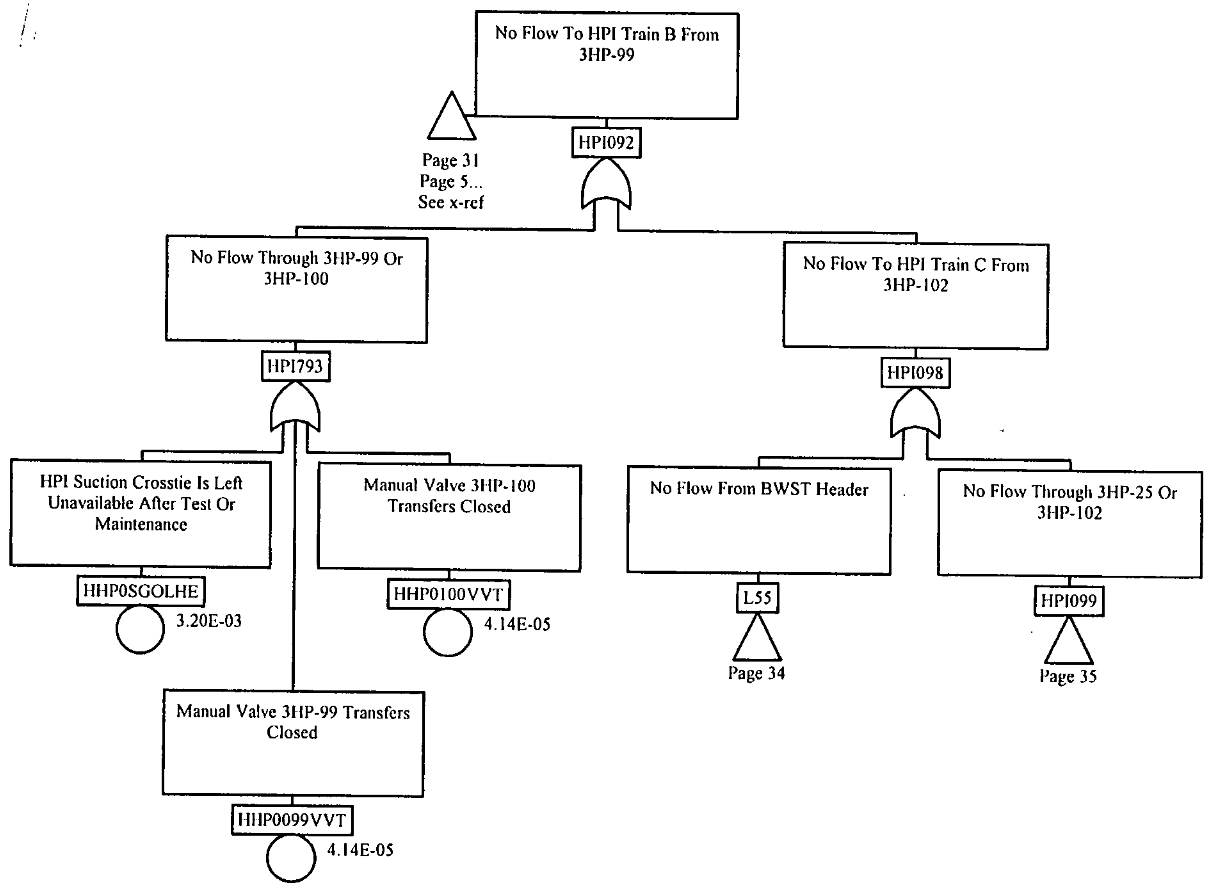

Failure to Swap HPI Suction to the BWST On Low LDST Level
Page 2... See x-ref
H638
Low LDST Level or No Flow From LDST (and Operators have LDST Level Indication)
H640
No Flow From BWST to HPI Train A
HFROMBWSTA
LDST Level Is Low Enough To Require Swap To BWST
H639
Page 14
No Flow From LDST
HFRMLDSTNORM
Page 14
No Flow From BWST to HPI Train A {PRE-MOD}
HBSWTPREA
No Flow From BWST to HPI Train A {POST-MOD}
HBSWTPOSTA
Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED
HNOMOD
2
1.00E+00
Operators Fail to Swap to BWST or Flow From BWST Fails
H096
Page 4
Auto-Swap to BWST on Low LDST Level Mod. is INSTALLED
HMOD
2
0.00E+00
Failure to Swap to BWST or Flow From BWST Fails
H100
Page 5

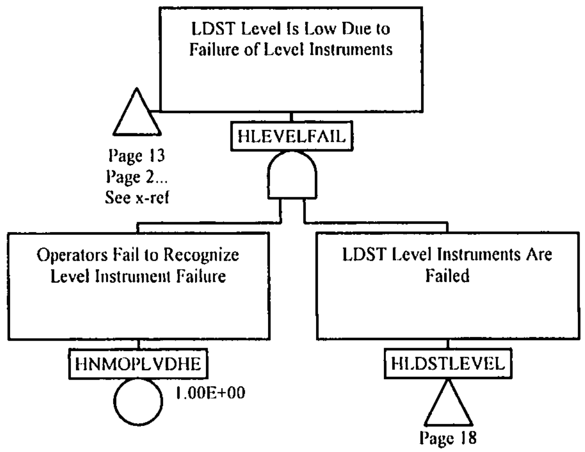

Operators Fail to Swap to BWST or Flow From BWST Fails
H096
Page 3...
See x-ref
Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion
CHPHPMUDHE
3
2.00E-03
No Flow to HPI Train A
H066
Page 5

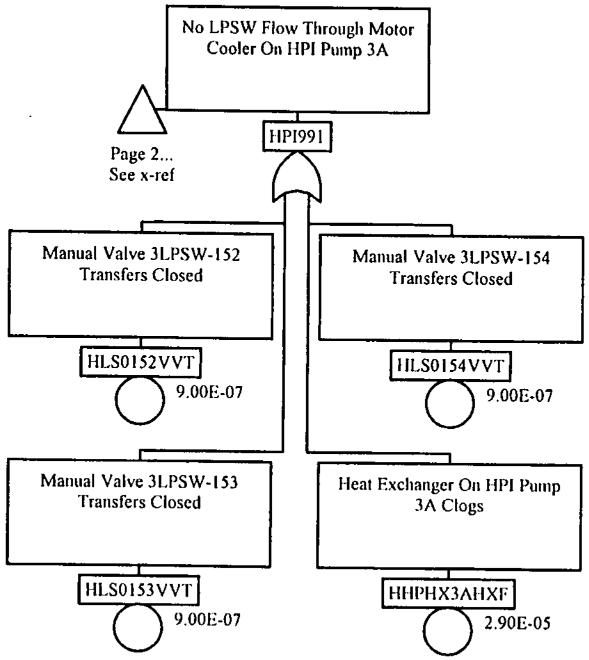

Failure to Swap to BWST or Flow From BWST Fails
H100
Page 3... See x-ref
Failure to Swap to BWST
H102
Page 6
Page 4... See x-ref
No Flow to HPI Train A
H066
No Flow To HPI Train A From 3HP-101
HPI074
Page 31
No Flow To HPI Train A From 3HP-98
HPI026C
No Flow To HPI Train B From 3HP-99
HPI092
Page 7
Motor-Operated Valve 3HP-98 Transfers Closed
HHP0098MVT
3
2.50E-06



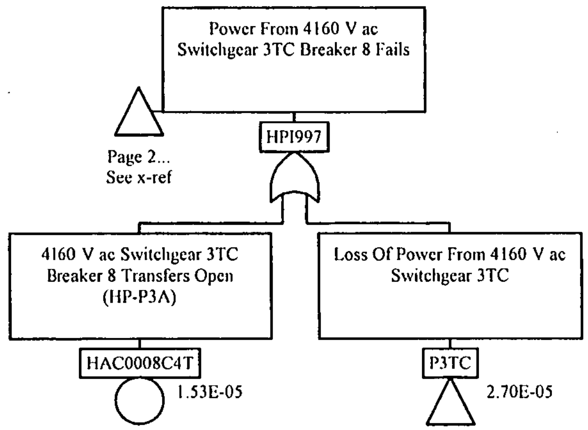
Failure to Swap to BWST
H102
Page 30
Page 5...
See x-ref
Emergency Low Level Signal to BWST Suction Valves Fails
HBWSTOPEN
Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion
CHPHPMUDHE
3
2.00E-03
Latent Human Error Associated with Interlock Maintenance Occurs
HEMERLILHE
3.20E-03
LDST Emergency Low Interlock Function Is in Maintenance
HEMERLIMNT
1.00E-03
One of Two LDST Level Signals Fails
HLDSTSIG
LDST Level Signal 1 Fails
HLDLVSIG1
Page 32
LDST Level Signal 2 Fails
HLDLVSIG2
Page 33

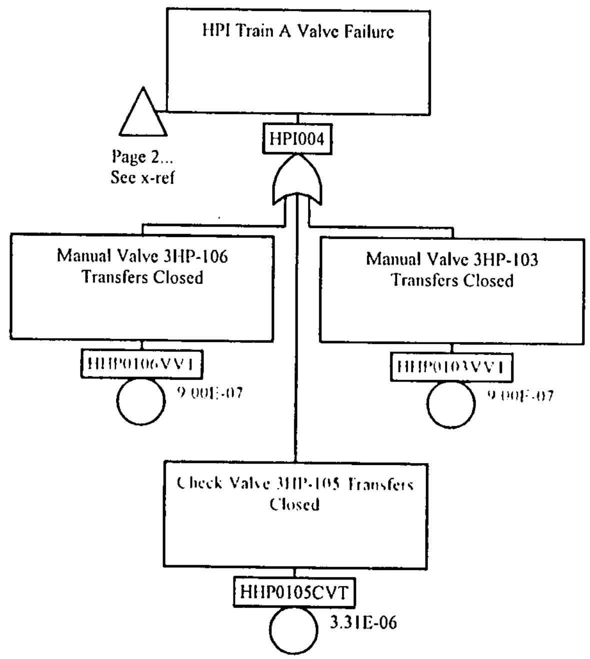

No Flow To HPI Train B From 3HP-99
HPI092
Page 31
Page 5...
See x-ref
No Flow Through 3HP-99 Or 3HP-100
HPI793
No Flow To HPI Train C From 3HP-102
HPI098
HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance
HHP0SGOLHE
3.20E-03
Manual Valve 3HP-100 Transfers Closed
HHP0100VVT
4.14E-05
No Flow From BWST Header
L55
Page 34
No Flow Through 3HP-25 Or 3HP-102
HPI099
Page 35
Manual Valve 3HP-99 Transfers Closed
HHP0099VVT
4.14E-05

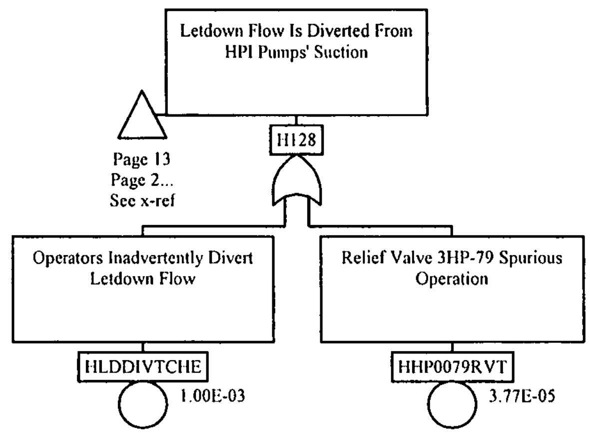

LDST Level Is Low Due to Failure of Level Instruments
HLEVELFAIL
Page 13
Page 2...
See x-ref
Operators Fail to Recognize Level Instrument Failure
HNMOPLVDHE
1.00E+00
LDST Level Instruments Are Failed
HLDSTLEVEL
Page 18



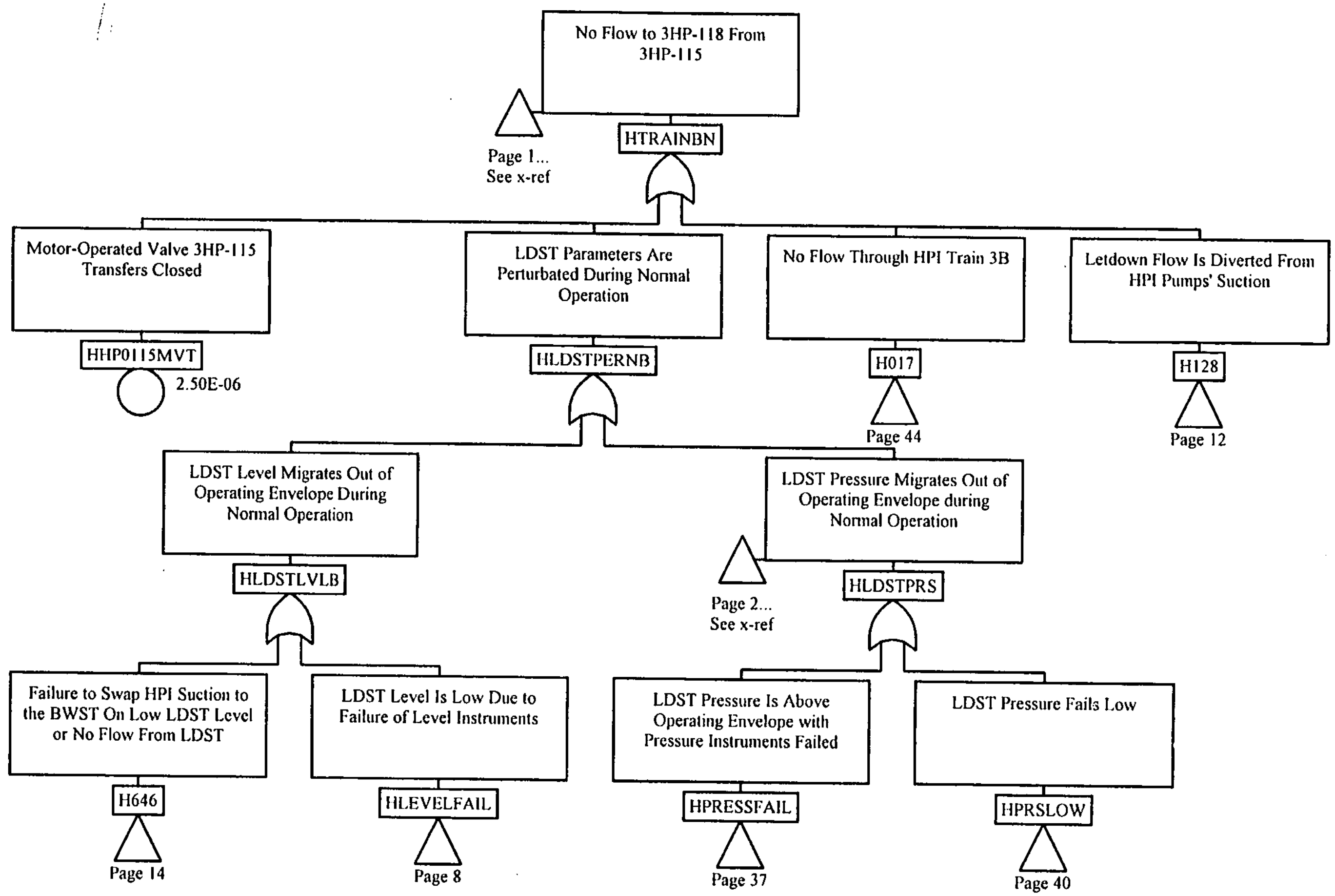
No LPSW Flow Through Motor Cooler On HPI Pump 3A
HPI991
Page 2...
See x-ref
Manual Valve 3LPSW-152 Transfers Closed
HLS0152VVT
9.00E-07
Manual Valve 3LPSW-154 Transfers Closed
HLS0154VVT
9.00E-07
Manual Valve 3LPSW-153 Transfers Closed
HLS0153VVT
9.00E-07
Heat Exchanger On HPI Pump 3A Clogs
HHPHX3AHXF
2.90E-05

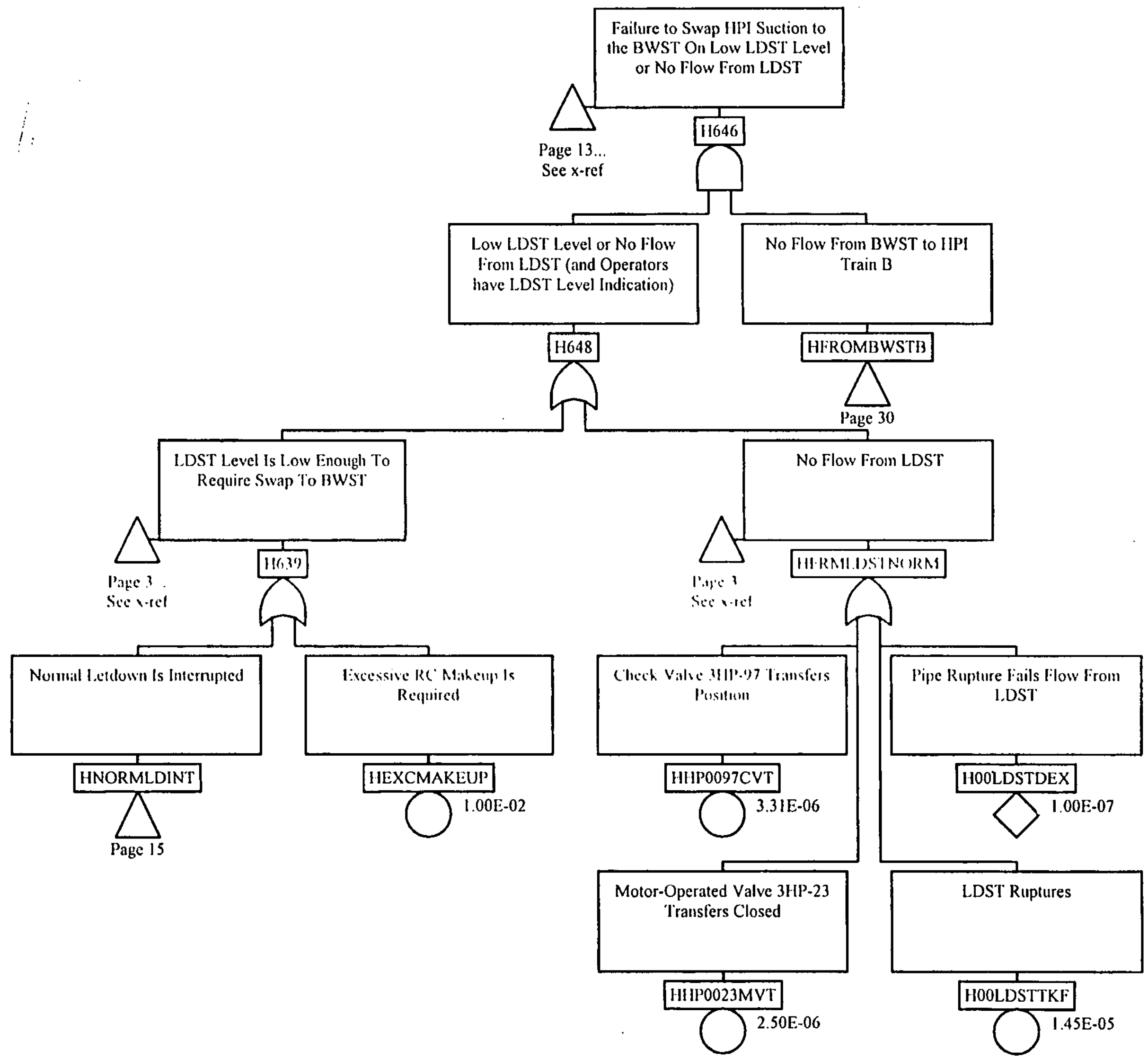

Power From 4160 V ac Switchgear 3TC Breaker 8 Fails
Page 2...
See x-ref
HPI997
4160 V ac Switchgear 3TC Breaker 8 Transfers Open (HP-P3A)
HAC0008C4T
1.53E-05
Loss Of Power From 4160 V ac Switchgear 3TC
P3TC
2.70E-05


HPI Train A Valve Failure
HPI004
Page 2...
See x-ref
Manual Valve 3HP-106 Transfers Closed
HHP0106VV1
9.00E-07
Manual Valve 3HP-103 Transfers Closed
HHP0103VV1
9.00E-07
Check Valve 3HP-105 Transfers Closed
HHP0105CVT
3.31E-06

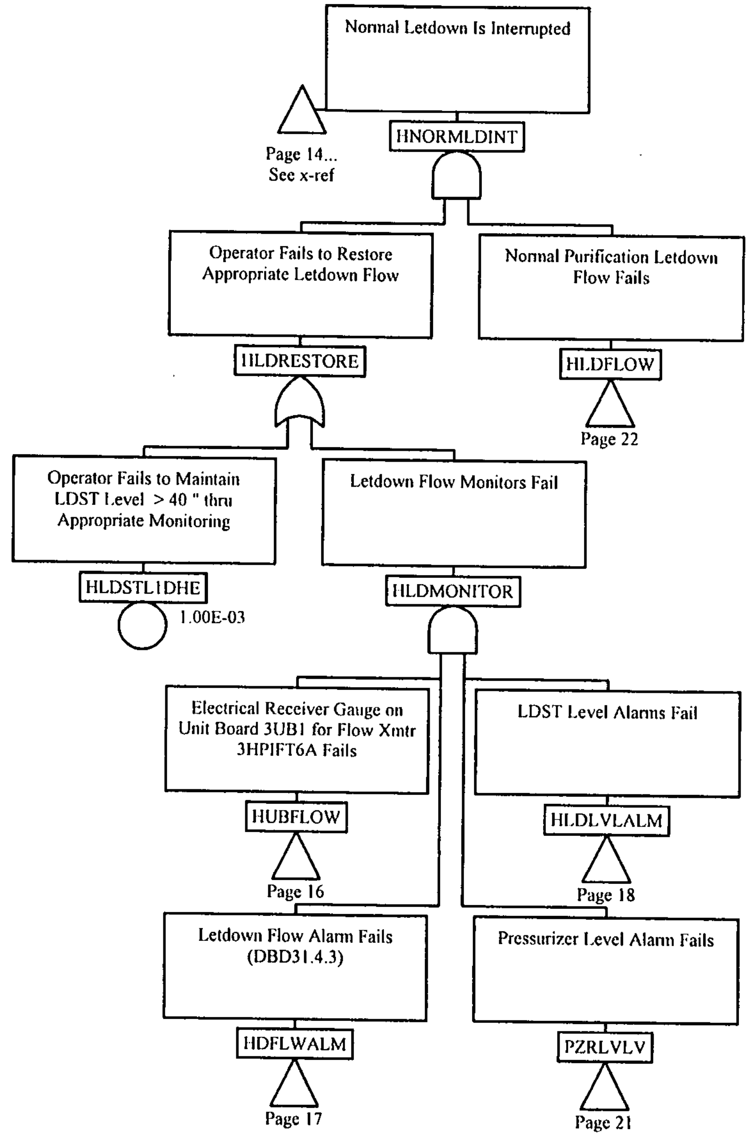


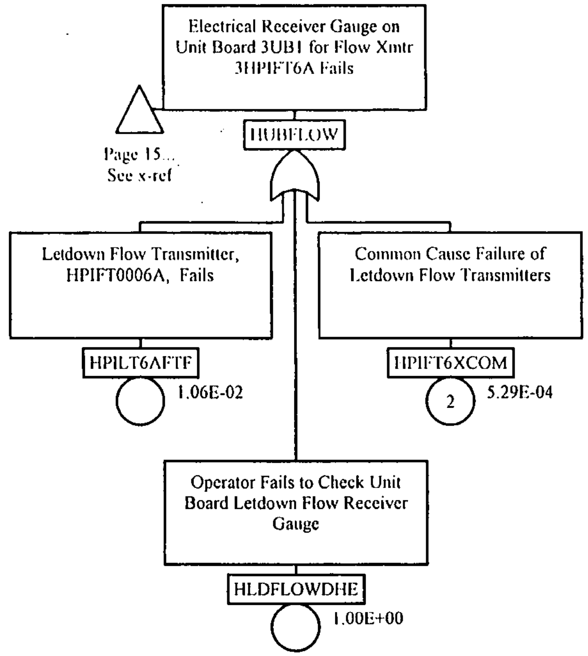
Letdown Flow Is Diverted From HPI Pumps' Suction
H128
Page 13
Page 2...
See x-ref
Operators Inadvertently Divert Letdown Flow
HLDDIVTCHE
1.00E-03
Relief Valve 3HP-79 Spurious Operation
HHP0079RVT
3.77E-05

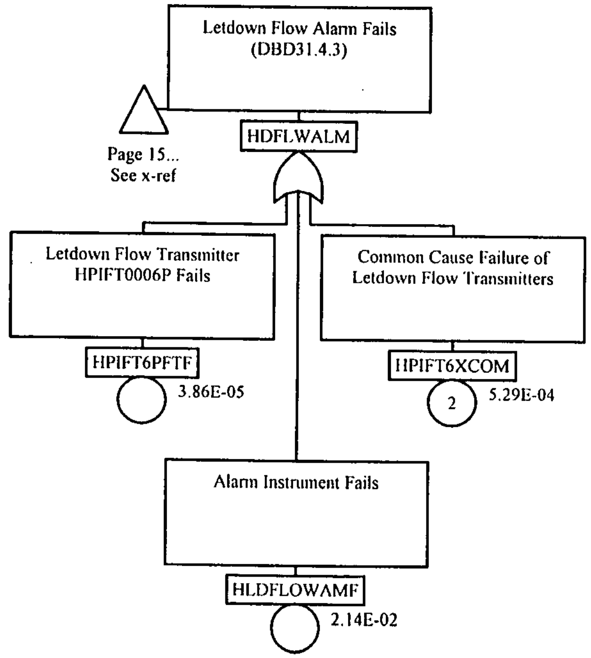

No Flow to 3HP-118 From 3HP-115
HTRAINBN
Page 1... See x-ref
Motor-Operated Valve 3HP-115 Transfers Closed
HHP0115MVT
2.50E-06
LDST Parameters Are Perturbated During Normal Operation
HLDSTPERNB
No Flow Through HPI Train 3B
H017
Page 44
Letdown Flow Is Diverted From HPI Pumps' Suction
H128
Page 12
LDST Level Migrates Out of Operating Envelope During Normal Operation
HLDSTLVLB
LDST Pressure Migrates Out of Operating Envelope during Normal Operation
HLDSTPRS
Page 2... See x-ref
Failure to Swap HPI Suction to the BWST On Low LDST Level or No Flow From LDST
H646
Page 14
LDST Level Is Low Due to Failure of Level Instruments
HLEVELFAIL
Page 8
LDST Pressure Is Above Operating Envelope with Pressure Instruments Failed
HPRESSFAIL
Page 37
LDST Pressure Fails Low
HPRSLOW
Page 40

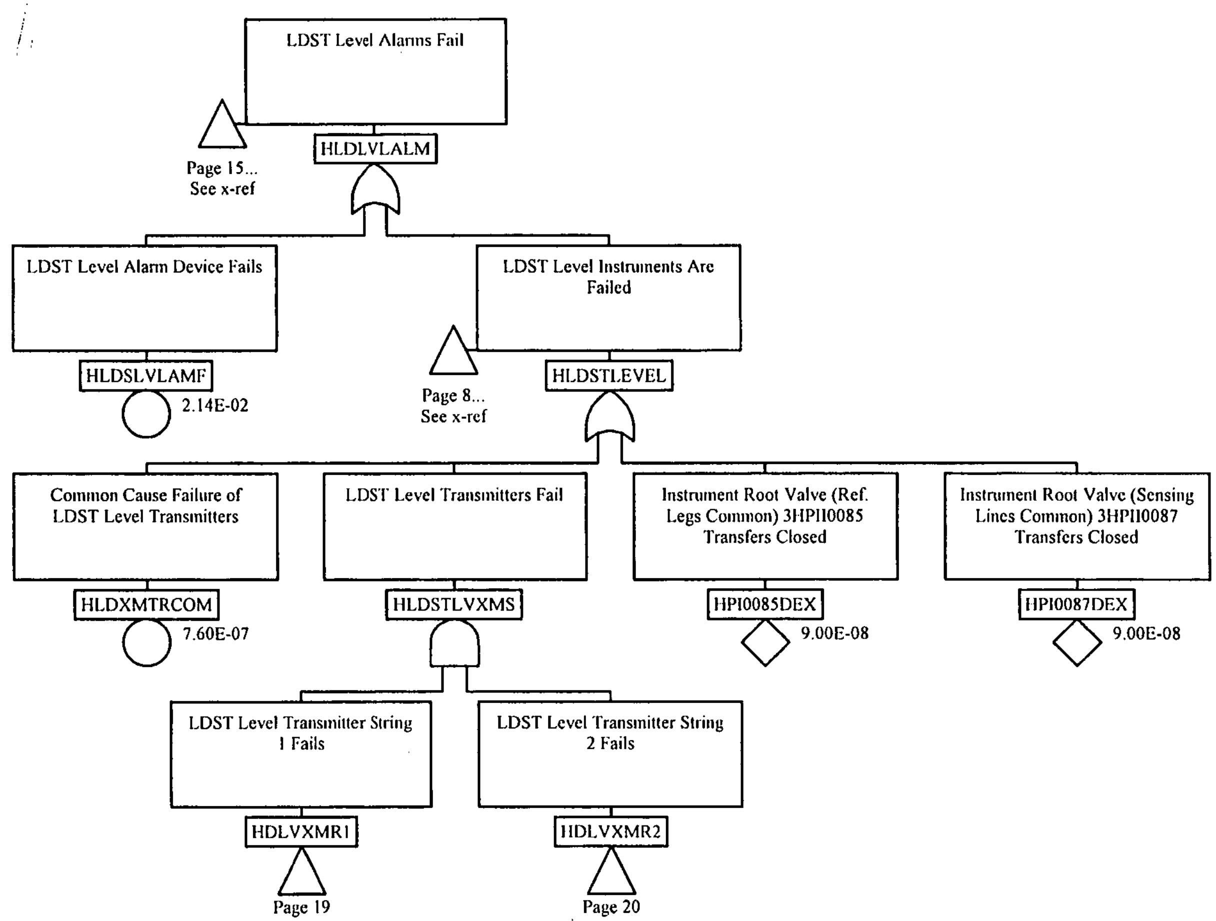


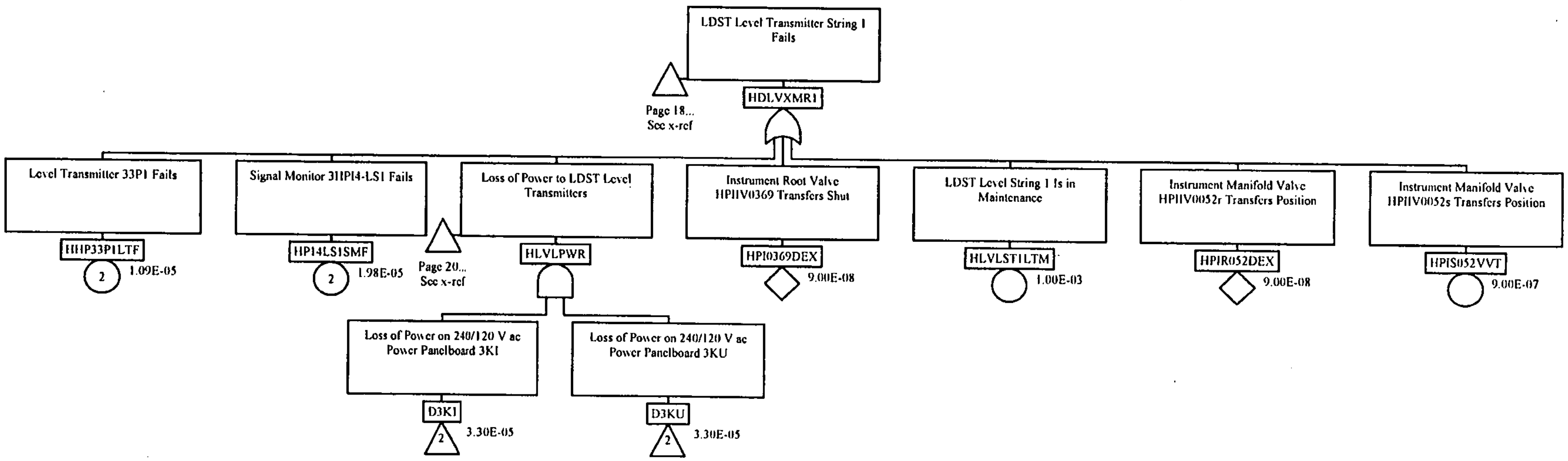
Failure to Swap HPI Suction to the BWST On Low LDST Level or No Flow From LDST
H646
Page 13...
See x-ref
Low LDST Level or No Flow From LDST (and Operators have LDST Level Indication)
H648
No Flow From BWST to HPI Train B
HFROMBWSTB
Page 30
LDST Level Is Low Enough To Require Swap To BWST
H639
No Flow From LDST
HFRMLDSTNORM
Normal Letdown Is Interrupted
HNORMLDINT
Page 15
Excessive RC Makeup Is Required
HEXCMAKEUP
1.00E-02
Check Valve 3HP-97 Transfers Position
HHP0097CVT
3.31E-06
Pipe Rupture Fails Flow From LDST
H00LDSTDEX
1.00E-07
Motor-Operated Valve 3HP-23 Transfers Closed
HHP0023MVT
2.50E-06
LDST Ruptures
H00LDSTTKF
1.45E-05


Normal Letdown Is Interrupted
HNORMLDINT
Page 14...
See x-ref
Operator Fails to Restore Appropriate Letdown Flow
HLDRESTORE
Normal Purification Letdown Flow Fails
HLDFLOW
Page 22
Operator Fails to Maintain LDST Level > 40 " thru Appropriate Monitoring
HLDSTL1DHE
1.00E-03
Letdown Flow Monitors Fail
HLDMONITOR
Electrical Receiver Gauge on Unit Board 3UB1 for Flow Xmtr 3HPIFT6A Fails
HUBFLOW
Page 16
LDST Level Alarms Fail
HLDLVLALM
Page 18
Letdown Flow Alarm Fails (DBD31.4.3)
HDFLWALM
Page 17
Pressurizer Level Alarm Fails
PZRLVLV
Page 21

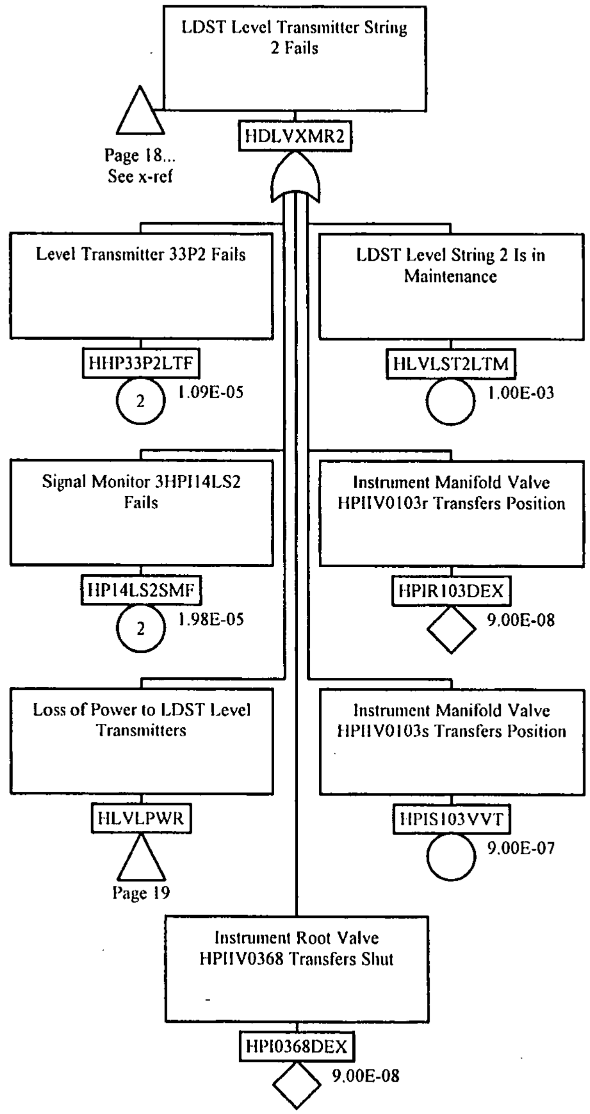

Electrical Receiver Gauge on Unit Board 3UB1 for Flow Xmtr 3HPIFT6A Fails
HUBFLOW
Page 15...
See x-ref
Letdown Flow Transmitter, HPIFT0006A, Fails
HPILT6AFTF
1.06E-02
Common Cause Failure of Letdown Flow Transmitters
HPIFT6XCOM
2
5.29E-04
Operator Fails to Check Unit Board Letdown Flow Receiver Gauge
HLDFLOWDHE
1.00E+00

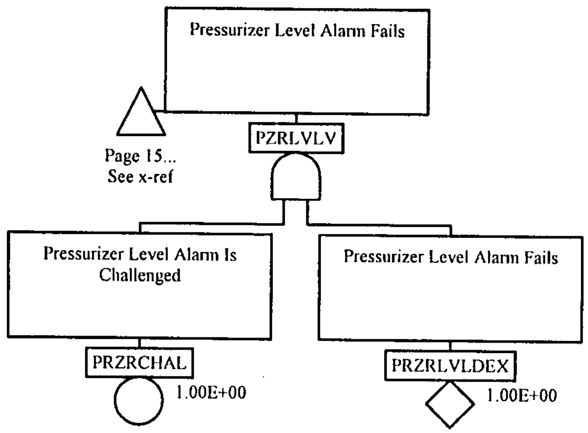

Letdown Flow Alarm Fails
(DBD31.4.3)
HDFLWALM
Page 15...
See x-ref
Letdown Flow Transmitter
HPIFT0006P Fails
HPIFT6PFTF
3.86E-05
Common Cause Failure of
Letdown Flow Transmitters
HPIFT6XCOM
2
5.29E-04
Alarm Instrument Fails
HLDFLOWAMF
2.14E-02

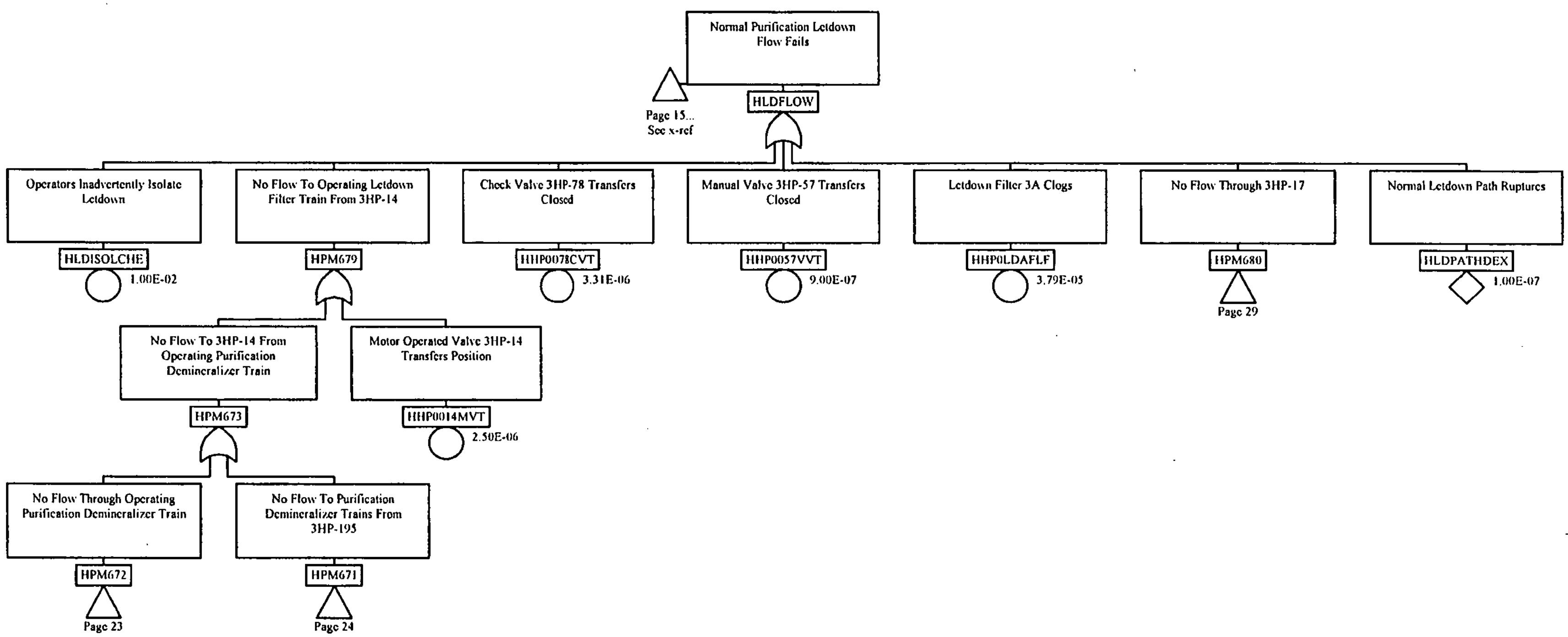

LDST Level Alarms Fail
HLDLVLALM
Page 15...
See x-ref
LDST Level Alarm Device Fails
HLDSLVLAMF
2.14E-02
LDST Level Instruments Are Failed
HLDSTLEVEL
Page 8...
See x-ref
Common Cause Failure of LDST Level Transmitters
HLDXMTRCOM
7.60E-07
LDST Level Transmitters Fail
HLDSTLVXMS
Instrument Root Valve (Ref. Legs Common) 3HPI10085 Transfers Closed
HPI0085DEX
9.00E-08
Instrument Root Valve (Sensing Lines Common) 3HPI10087 Transfers Closed
HPI0087DEX
9.00E-08
LDST Level Transmitter String 1 Fails
HDLVXMR1
Page 19
LDST Level Transmitter String 2 Fails
HDLVXMR2
Page 20

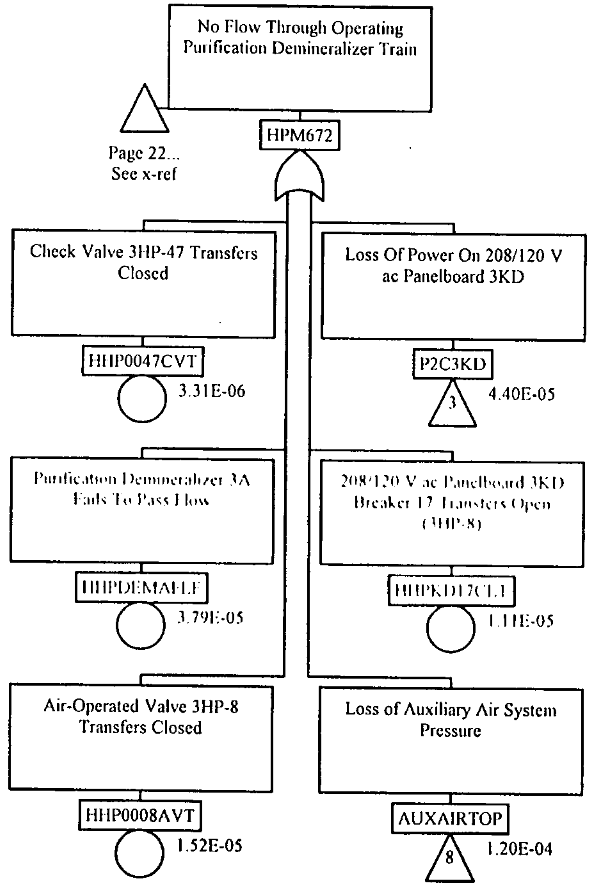


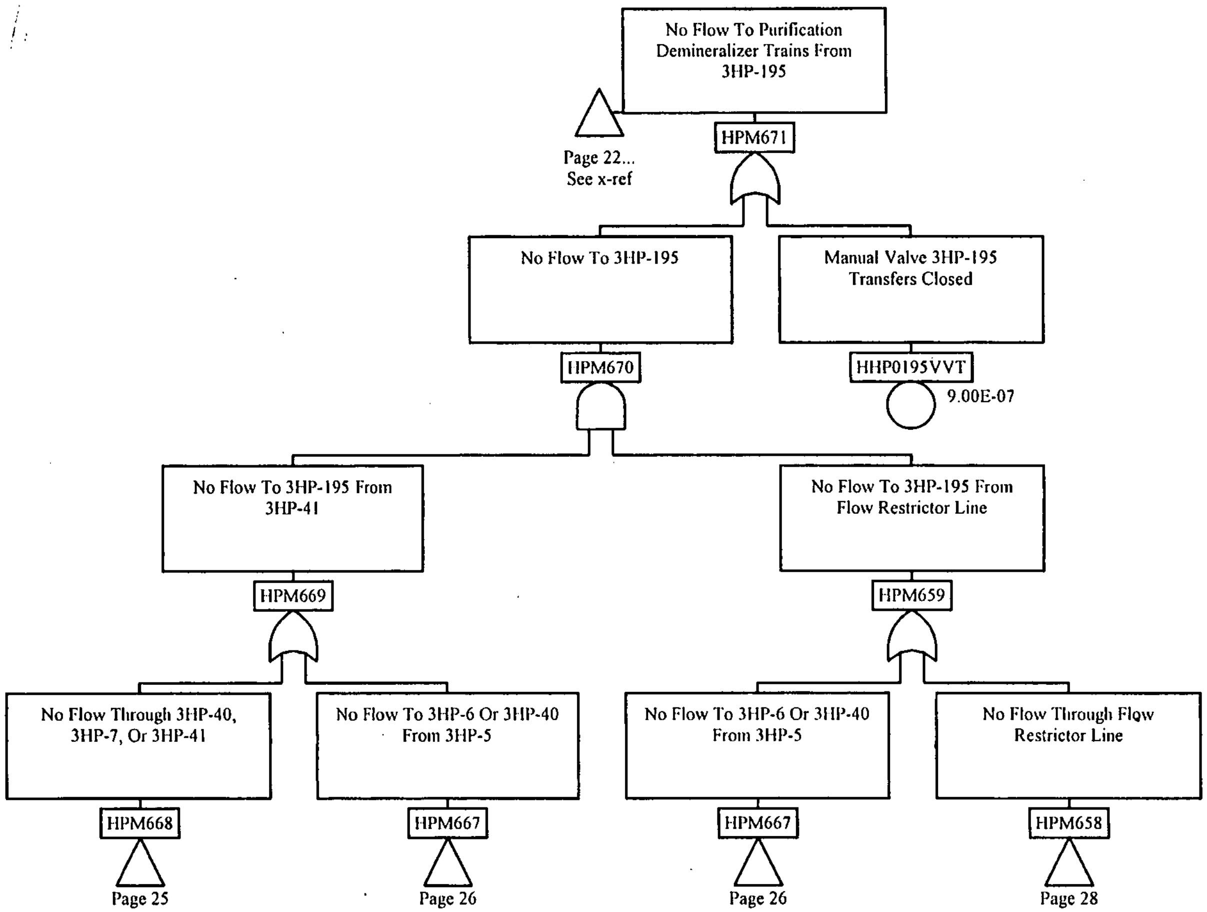
LDST Level Transmitter String 1 Fails
HDLVXMR1
Page 18... See x-ref
Level Transmitter 33P1 Fails
HHP33P1LTF
2
1.09E-05
Signal Monitor 3HP14-LS1 Fails
HP14LS1SMF
2
1.98E-05
Page 20... See x-ref
Loss of Power to LDST Level Transmitters
HLVLPWR
Loss of Power on 240/120 V ac Power Panelboard 3KI
D3KI
2
3.30E-05
Loss of Power on 240/120 V ac Power Panelboard 3KU
D3KU
2
3.30E-05
Instrument Root Valve HPHV0369 Transfers Shut
HP10369DEX
9.00E-08
LDST Level String 1 Is in Maintenance
HLVLST1LTM
1.00E-03
Instrument Manifold Valve HPHV0052r Transfers Position
HPIR052DEX
9.00E-08
Instrument Manifold Valve HPHV0052s Transfers Position
HPIS052VVT
9.00E-07

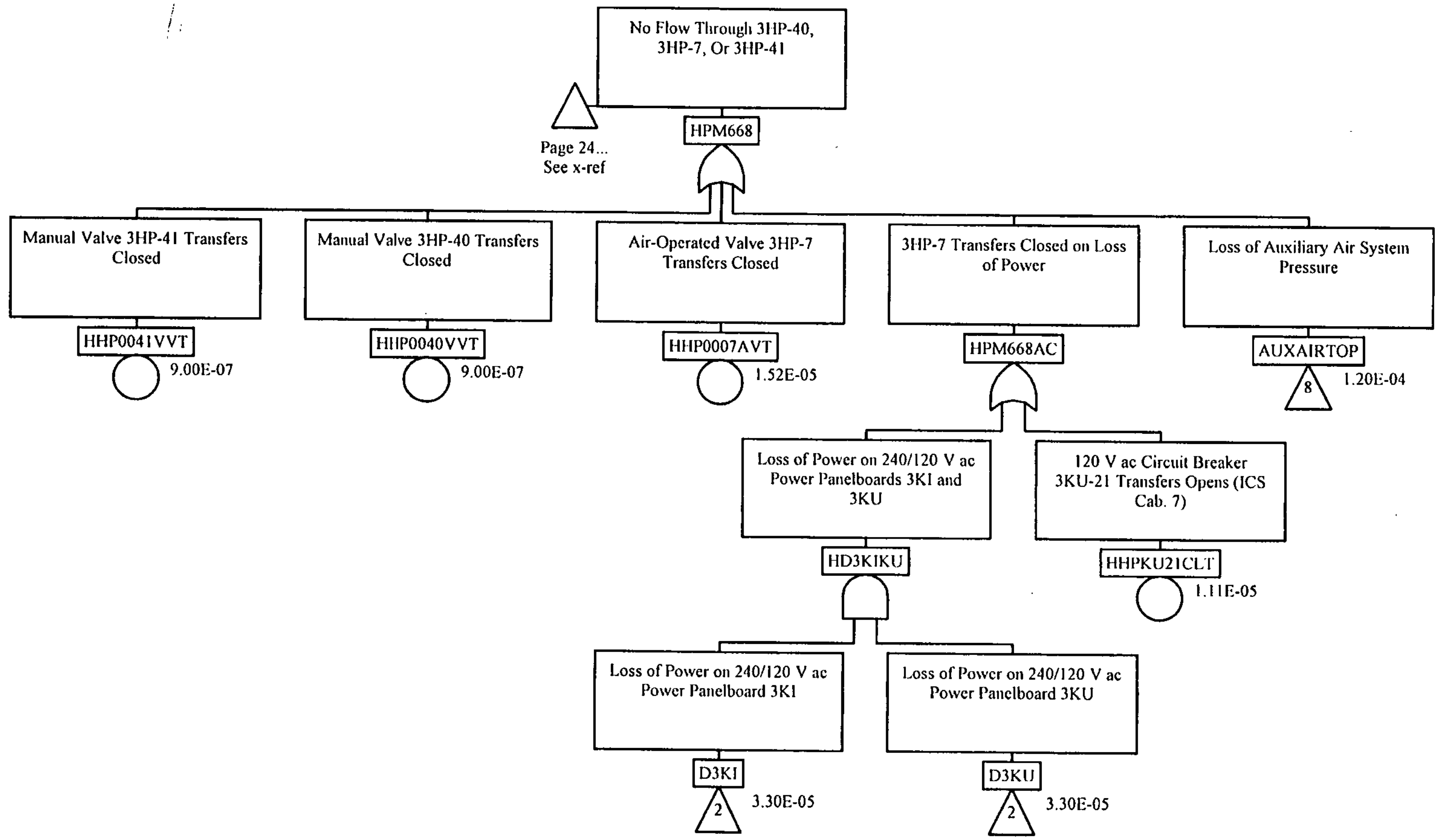

LDST Level Transmitter String 2 Fails
HDLVXMR2
Page 18...
See x-ref
Level Transmitter 33P2 Fails
HHP33P2LTF
2
1.09E-05
LDST Level String 2 Is in Maintenance
HLVLST2LTM
1.00E-03
Signal Monitor 3HPI14LS2 Fails
HP14LS2SMF
2
1.98E-05
Instrument Manifold Valve HPIIV0103r Transfers Position
HPIR103DEX
9.00E-08
Loss of Power to LDST Level Transmitters
HLVLPWR
Page 19
Instrument Manifold Valve HPIIV0103s Transfers Position
HPIS103VVT
9.00E-07
Instrument Root Valve HPIIV0368 Transfers Shut
HPI0368DEX
9.00E-08

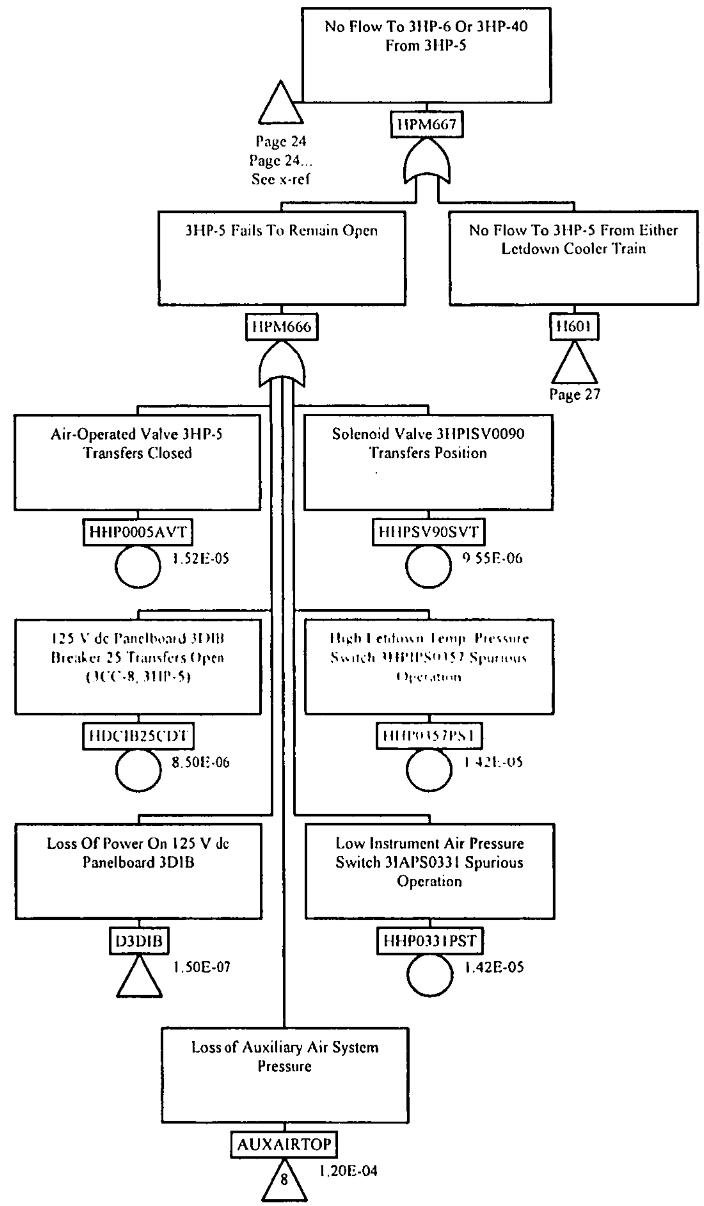

Pressurizer Level Alarm Fails
Page 15...
See x-ref
PZRLVLV
Pressurizer Level Alarm Is Challenged
Pressurizer Level Alarm Fails
PRZRCHAL
1.00E+00
PRZRLVLDEX
1.00E+00

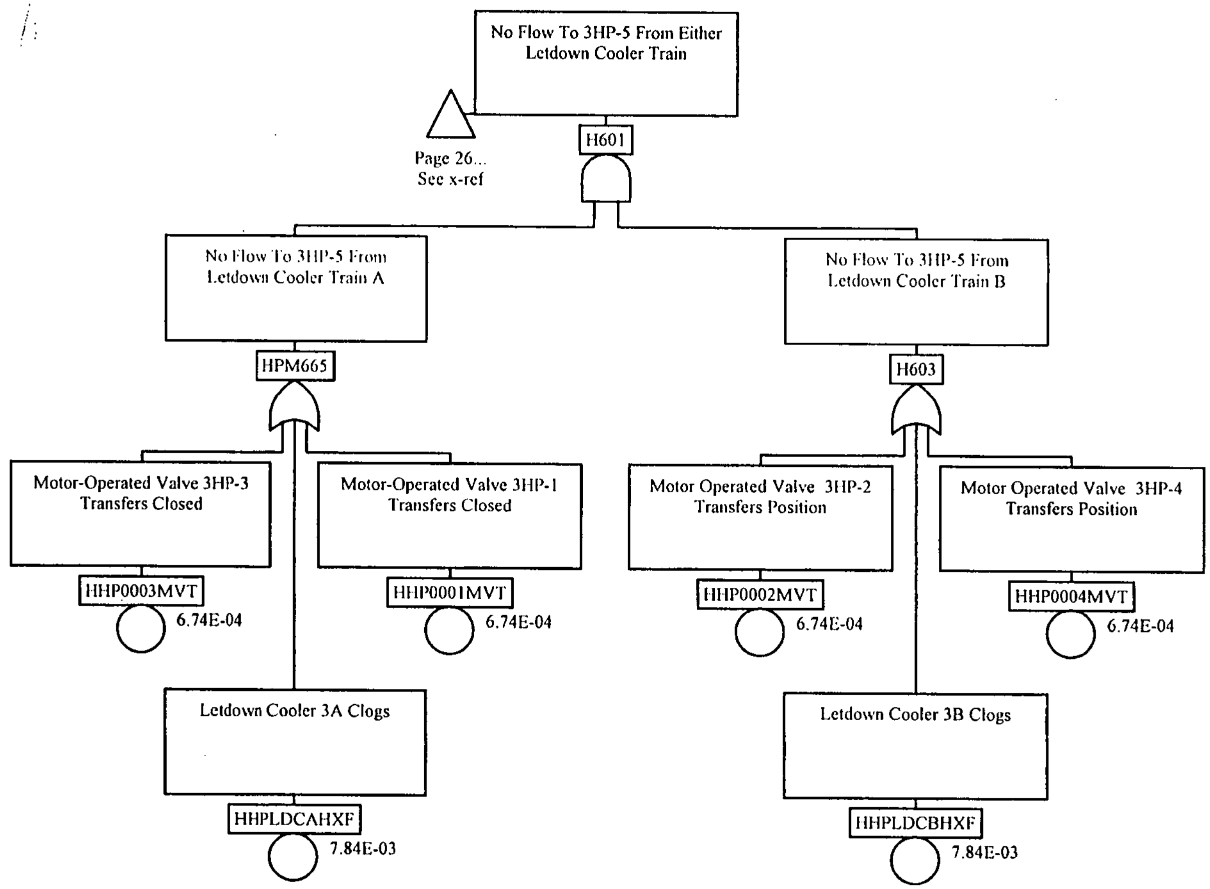

Normal Purification Letdown Flow Fails
HLDFLOW
Page 15... See x-ref
Operators Inadvertently Isolate Letdown
HLDISOLCHE
1.00E-02
No Flow To Operating Letdown Filter Train From 3HP-14
HPM679
Check Valve 3HP-78 Transfers Closed
HHP0078CVT
3.31E-06
Manual Valve 3HP-57 Transfers Closed
HHP0057VVT
9.00E-07
Letdown Filter 3A Clogs
HHP0LDAFLF
3.79E-05
No Flow Through 3HP-17
HPM680
Page 29
Normal Letdown Path Ruptures
HLDPATHDEX
1.00E-07
No Flow To 3HP-14 From Operating Purification Demineralizer Train
HPM673
Motor Operated Valve 3HP-14 Transfers Position
HHP0014MVT
2.50E-06
No Flow Through Operating Purification Demineralizer Train
HPM672
Page 23
No Flow To Purification Demineralizer Trains From 3HP-195
HPM671
Page 24

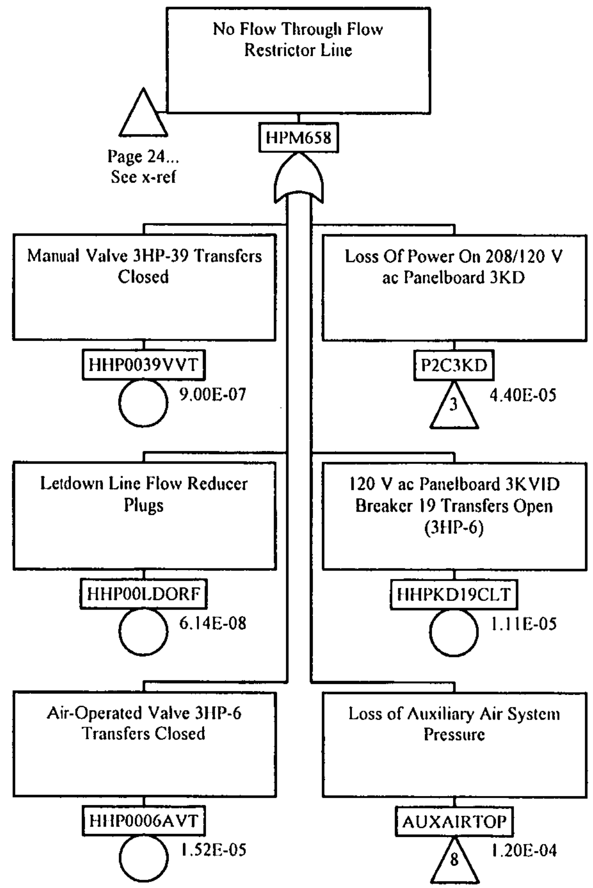

No Flow Through Operating Purification Demineralizer Train
HPM672
Page 22...
See x-ref
Check Valve 3HP-47 Transfers Closed
HHP0047CVT
3.31E-06
Loss Of Power On 208/120 V ac Panelboard 3KD
P2C3KD
3
4.40E-05
Purification Demineralizer 3A Fails To Pass Flow
HHPDEMAFLF
3.79E-05
208/120 V ac Panelboard 3KD Breaker 17 Transfers Open (3HP-8)
HHPKD17CLT
1.11E-05
Air-Operated Valve 3HP-8 Transfers Closed
HHP0008AVT
1.52E-05
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
1.20E-04


No Flow To Purification Demineralizer Trains From 3HP-195
HPM671
Page 22... See x-ref
No Flow To 3HP-195
HPM670
Manual Valve 3HP-195 Transfers Closed
HHP0195VVT
9.00E-07
No Flow To 3HP-195 From 3HP-41
HPM669
No Flow To 3HP-195 From Flow Restrictor Line
HPM659
No Flow Through 3HP-40, 3HP-7, Or 3HP-41
HPM668
Page 25
No Flow To 3HP-6 Or 3HP-40 From 3HP-5
HPM667
Page 26
No Flow To 3HP-6 Or 3HP-40 From 3HP-5
HPM667
Page 26
No Flow Through Flow Restrictor Line
HPM658
Page 28

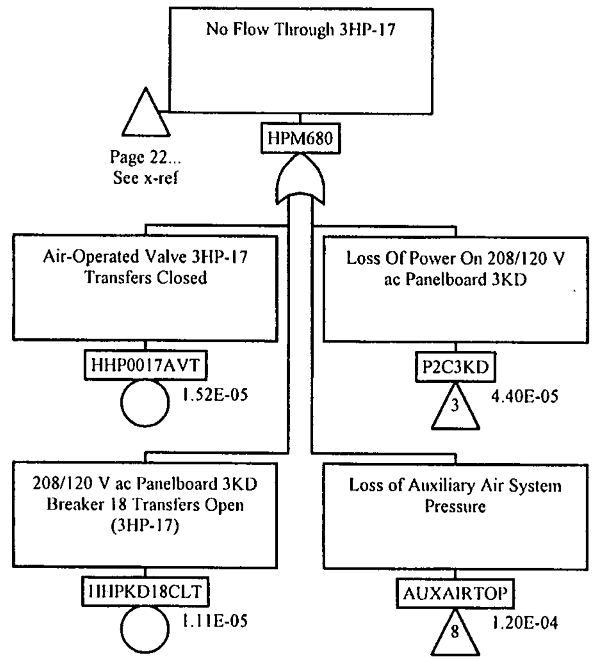

No Flow Through 3HP-40, 3HP-7, Or 3HP-41
HPM668
Page 24...
See x-ref
Manual Valve 3HP-41 Transfers Closed
HHP0041VVT
9.00E-07
Manual Valve 3HP-40 Transfers Closed
HHP0040VVT
9.00E-07
Air-Operated Valve 3HP-7 Transfers Closed
HHP0007AVT
1.52E-05
3HP-7 Transfers Closed on Loss of Power
HPM668AC
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
1.20E-04
Loss of Power on 240/120 V ac Power Panelboards 3KI and 3KU
HD3KIKU
120 V ac Circuit Breaker 3KU-21 Transfers Opens (ICS Cab. 7)
HHPKU21CLT
1.11E-05
Loss of Power on 240/120 V ac Power Panelboard 3KI
D3KI
2
3.30E-05
Loss of Power on 240/120 V ac Power Panelboard 3KU
D3KU
2
3.30E-05

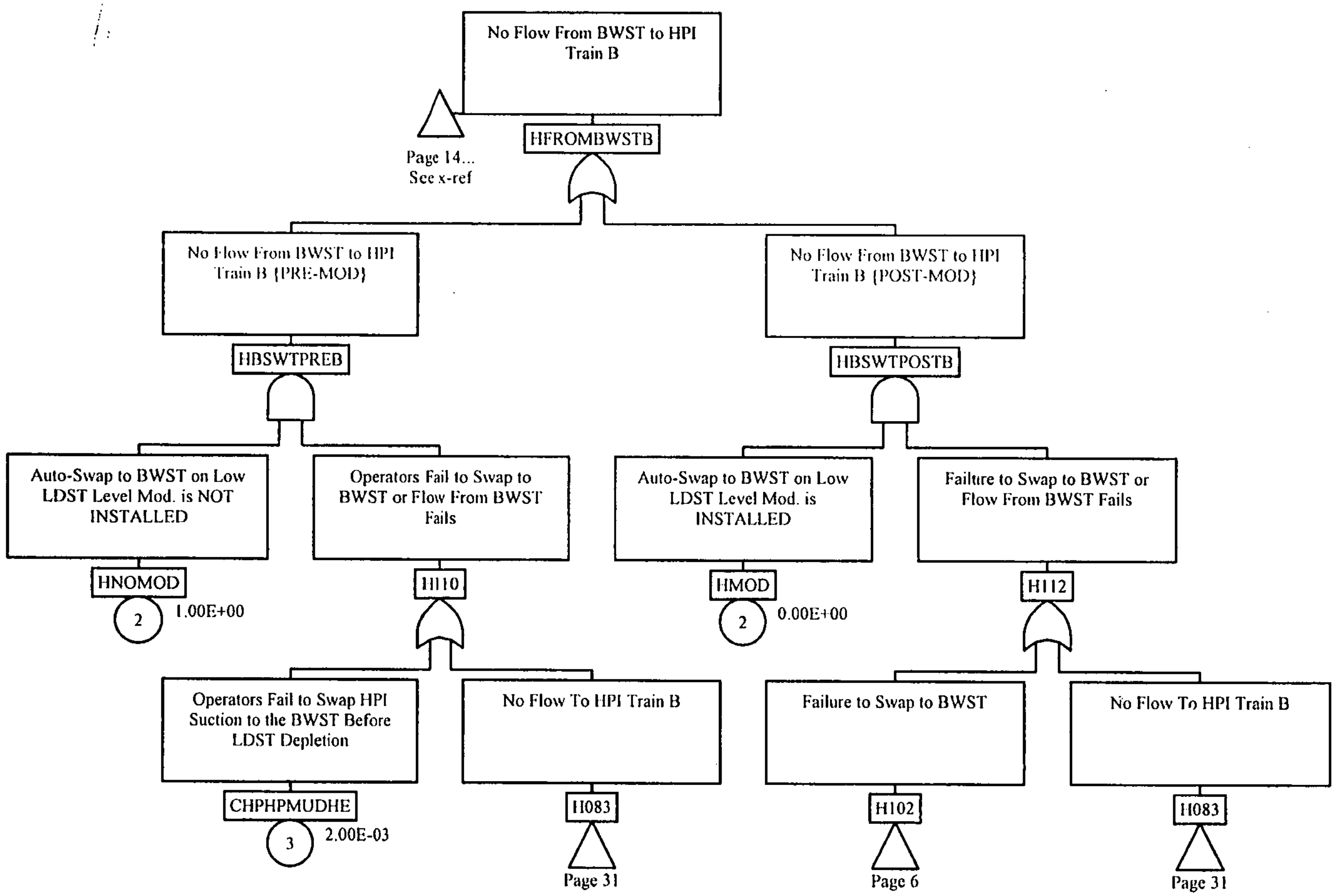

No Flow To 3HP-6 Or 3HP-40 From 3HP-5
HPM667
Page 24
Page 24...
See x-ref
3HP-5 Fails To Remain Open
HPM666
No Flow To 3HP-5 From Either Letdown Cooler Train
H601
Page 27
Air-Operated Valve 3HP-5 Transfers Closed
HHP0005AVT
1.52E-05
Solenoid Valve 3HPISV0090 Transfers Position
HHPSV90SVT
9.55E-06
125 V dc Panelboard 3DIB Breaker 25 Transfers Open (3CC-8, 3HP-5)
HDCIB25CDT
8.50E-06
High Letdown Temp Pressure Switch 3HPIPS0157 Spurious Operation
HHP0157PST
1.42E-05
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB
1.50E-07
Low Instrument Air Pressure Switch 3IAPS0331 Spurious Operation
HHP0331PST
1.42E-05
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
1.20E-04


No Flow To 3HP-5 From Either Letdown Cooler Train
Page 26...
See x-ref
H601
No Flow To 3HP-5 From Letdown Cooler Train A
HPM665
No Flow To 3HP-5 From Letdown Cooler Train B
H603
Motor-Operated Valve 3HP-3 Transfers Closed
HHP0003MVT
6.74E-04
Motor-Operated Valve 3HP-1 Transfers Closed
HHP0001MVT
6.74E-04
Motor Operated Valve 3HP-2 Transfers Position
HHP0002MVT
6.74E-04
Motor Operated Valve 3HP-4 Transfers Position
HHP0004MVT
6.74E-04
Letdown Cooler 3A Clogs
HHPLDCAHXF
7.84E-03
Letdown Cooler 3B Clogs
HHPLDCBHXF
7.84E-03

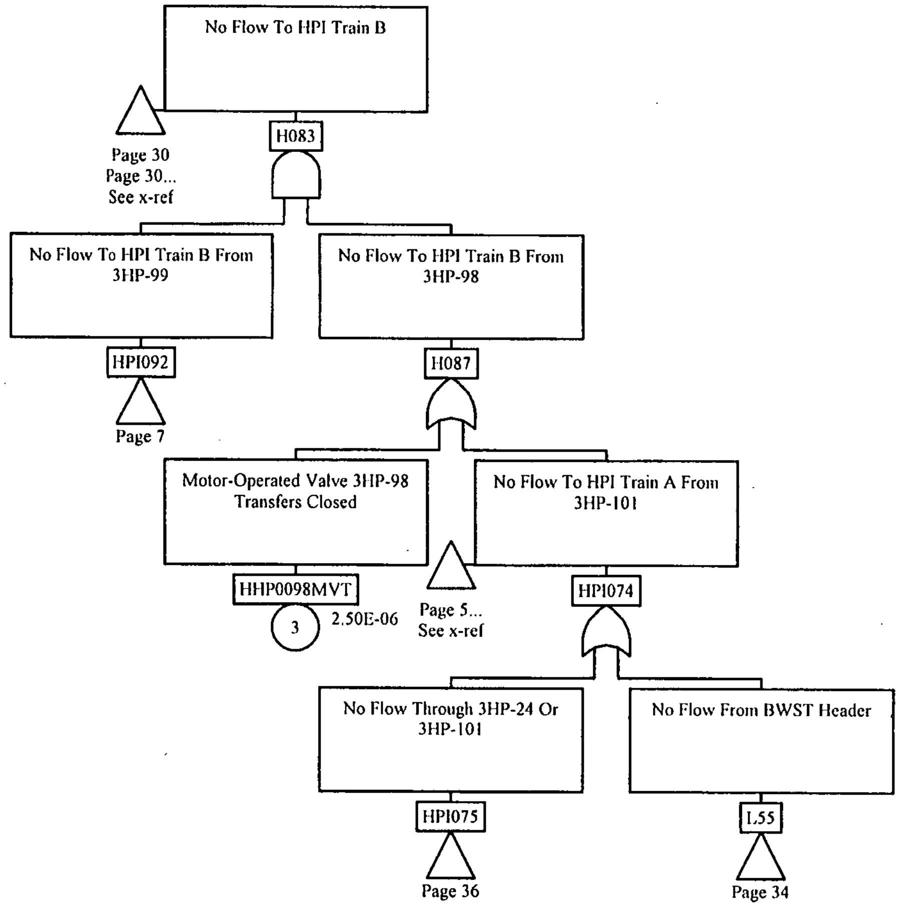


No Flow Through Flow Restrictor Line
Page 24... See x-ref
HPM658
Manual Valve 3HP-39 Transfers Closed
HHP0039VVT
9.00E-07
Loss Of Power On 208/120 V ac Panelboard 3KD
P2C3KD
3
4.40E-05
Letdown Line Flow Reducer Plugs
HHP00LDORF
6.14E-08
120 V ac Panelboard 3KVID Breaker 19 Transfers Open (3HP-6)
HHPKD19CLT
1.11E-05
Air-Operated Valve 3HP-6 Transfers Closed
HHP0006AVT
1.52E-05
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
1.20E-04

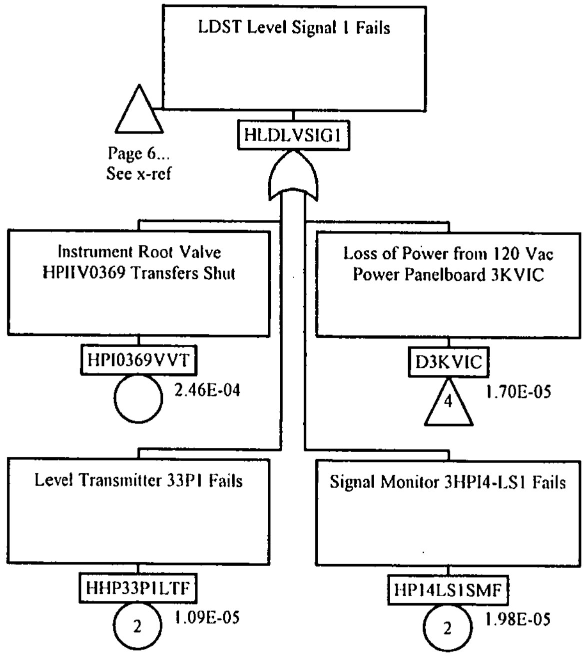

No Flow Through 3HP-17
Page 22...
See x-ref
HPM680
Air-Operated Valve 3HP-17 Transfers Closed
HHP0017AVT
1.52E-05
Loss Of Power On 208/120 V ac Panelboard 3KD
P2C3KD
3
4.40E-05
208/120 V ac Panelboard 3KD Breaker 18 Transfers Open (3HP-17)
HHPKD18CLT
1.11E-05
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
1.20E-04

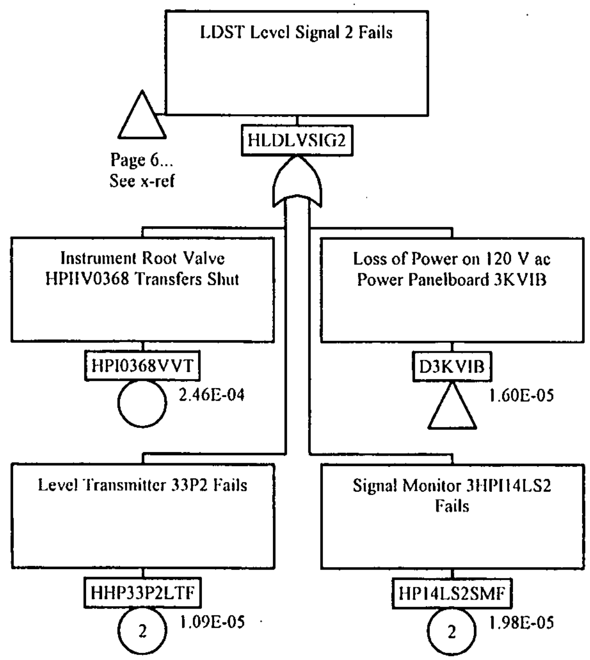


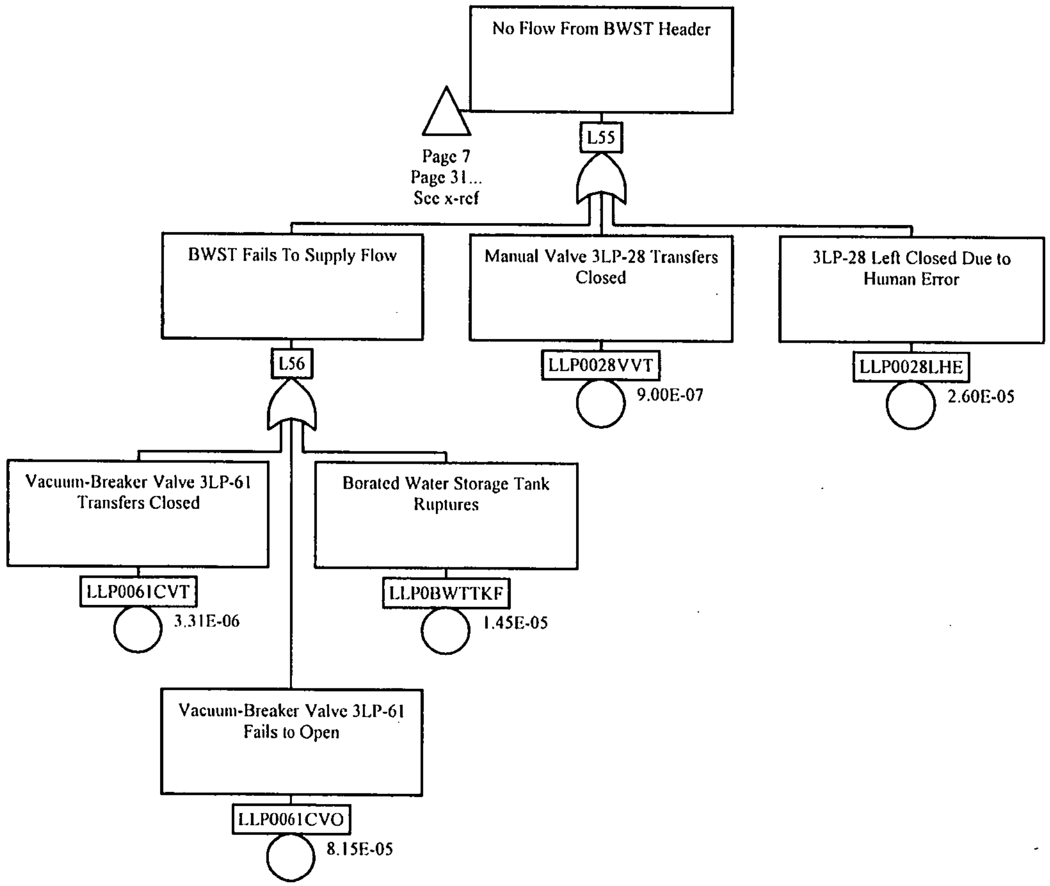
No Flow From BWST to HPI Train B
HFROMBWSTB
Page 14... See x-ref
No Flow From BWST to HPI Train B {PRE-MOD}
HBSWTPREB
No Flow From BWST to HPI Train B {POST-MOD}
HBSWTPOSTB
Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED
HNOMOD
2
1.00E+00
Operators Fail to Swap to BWST or Flow From BWST Fails
H110
Auto-Swap to BWST on Low LDST Level Mod. is INSTALLED
HMOD
2
0.00E+00
Failure to Swap to BWST or Flow From BWST Fails
H112
Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion
CHPHPMUDHE
3
2.00E-03
No Flow To HPI Train B
H083
Page 31
Failure to Swap to BWST
H102
Page 6
No Flow To HPI Train B
H083
Page 31

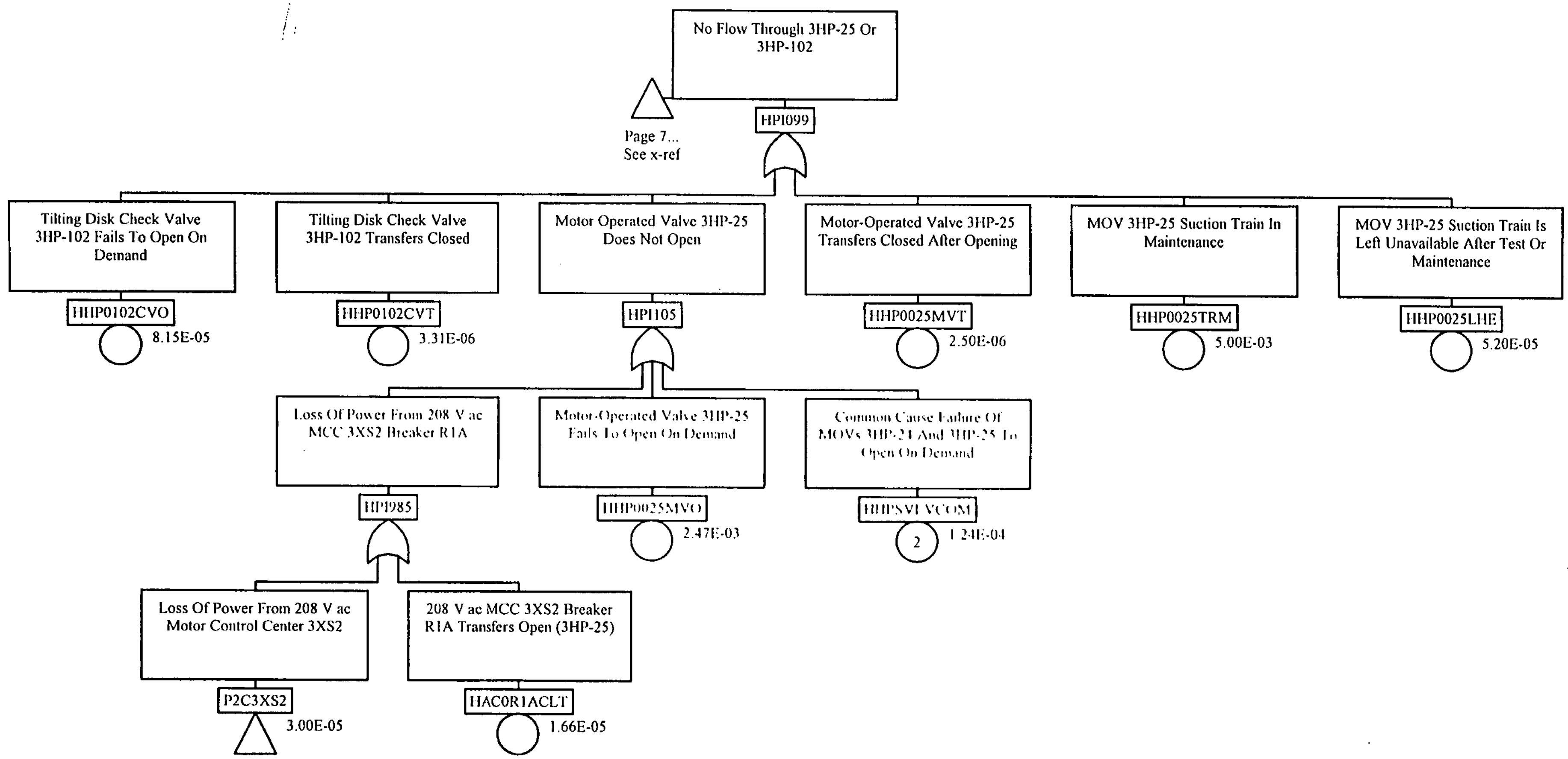


No Flow To HPI Train B
Page 30
Page 30...
See x-ref
H083
No Flow To HPI Train B From 3HP-99
No Flow To HPI Train B From 3HP-98
HPI092
Page 7
H087
Motor-Operated Valve 3HP-98 Transfers Closed
No Flow To HPI Train A From 3HP-101
HHP0098MVT
3
2.50E-06
Page 5...
See x-ref
HPI074
No Flow Through 3HP-24 Or 3HP-101
No Flow From BWST Header
HPI075
Page 36
L55
Page 34

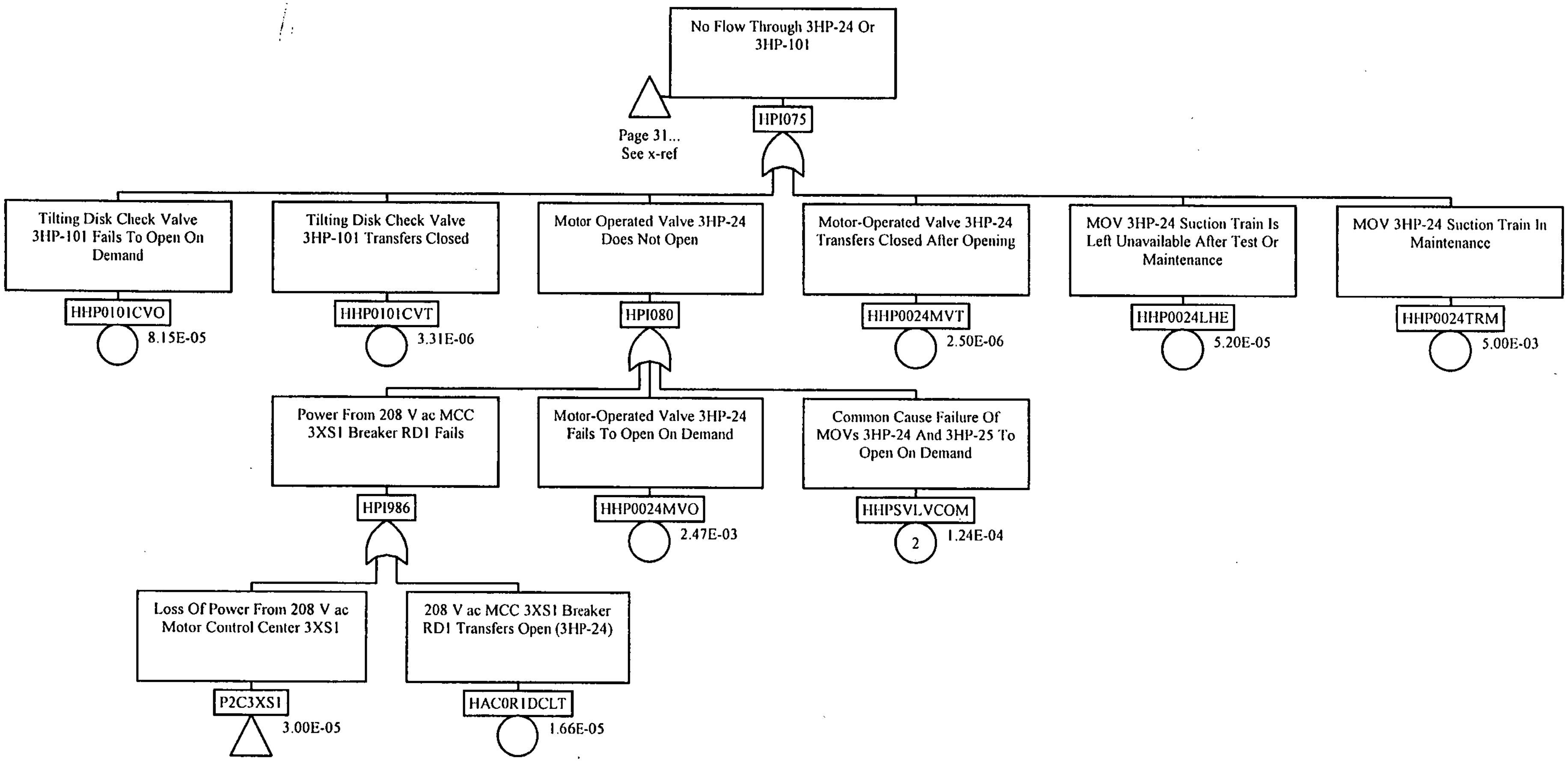

LDST Level Signal 1 Fails
HLDLVSIG1
Page 6...
See x-ref
Instrument Root Valve
HPIIV0369 Transfers Shut
HPI0369VVT
2.46E-04
Loss of Power from 120 Vac
Power Panelboard 3KVIC
D3KVIC
4
1.70E-05
Level Transmitter 33P1 Fails
HHP33P1LTF
2
1.09E-05
Signal Monitor 3HPI4-LS1 Fails
HP14LS1SMF
2
1.98E-05

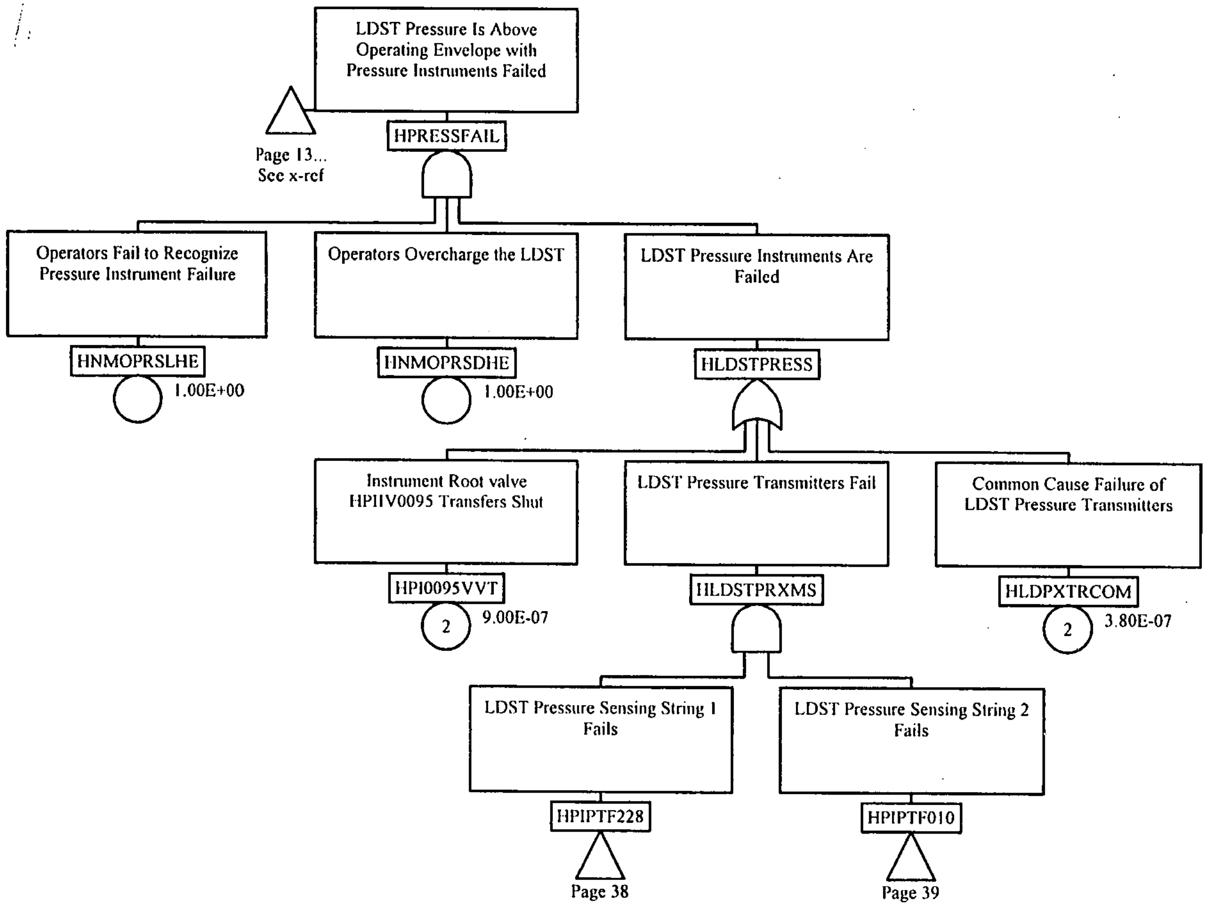

LDST Level Signal 2 Fails
HLDLVSIG2
Page 6...
See x-ref
Instrument Root Valve HPIIV0368 Transfers Shut
HPI0368VVT
2.46E-04
Loss of Power on 120 V ac Power Panelboard 3KVIB
D3KVIB
1.60E-05
Level Transmitter 33P2 Fails
HHP33P2LTF
2
1.09E-05
Signal Monitor 3HPI14LS2 Fails
HP14LS2SMF
2
1.98E-05

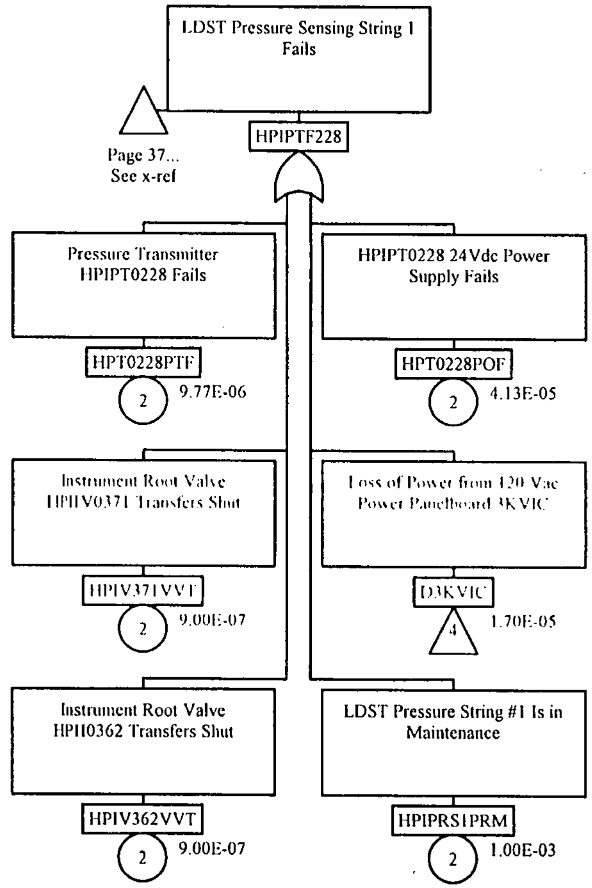

No Flow From BWST Header
Page 7
Page 31...
See x-ref
L55
BWST Fails To Supply Flow
Manual Valve 3LP-28 Transfers Closed
3LP-28 Left Closed Due to Human Error
L56
LLP0028VVT
9.00E-07
LLP0028LHE
2.60E-05
Vacuum-Breaker Valve 3LP-61 Transfers Closed
Borated Water Storage Tank Ruptures
LLP0061CVT
3.31E-06
LLP0BWTTKF
1.45E-05
Vacuum-Breaker Valve 3LP-61 Fails to Open
LLP0061CVO
8.15E-05

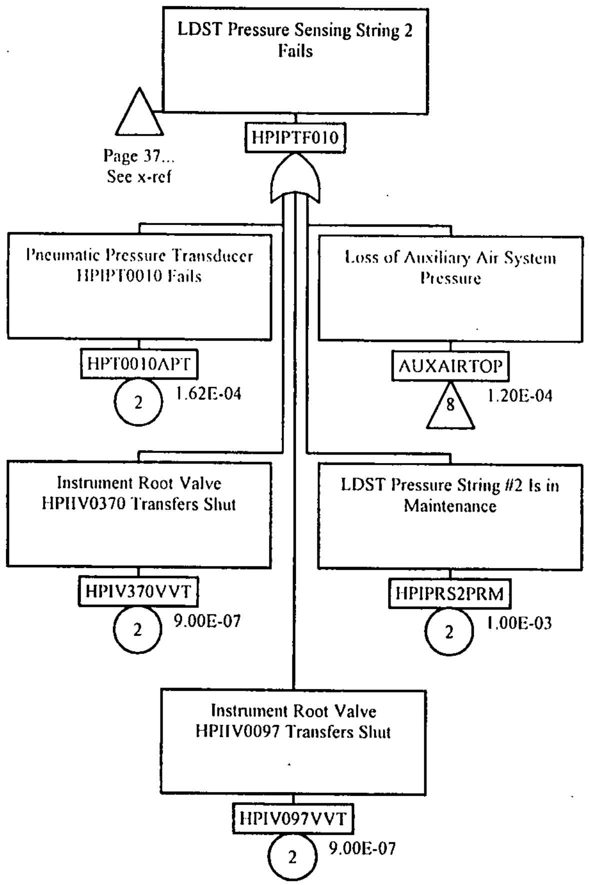


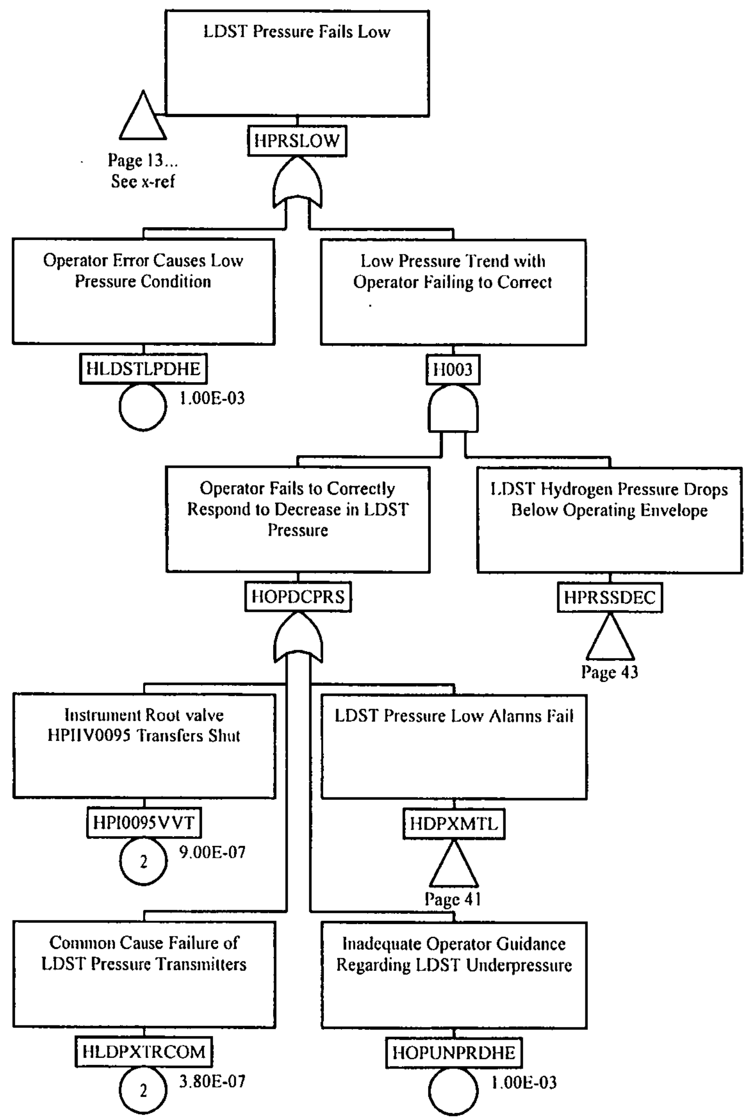
No Flow Through 3HP-25 Or 3HP-102
HPI099
Page 7... See x-ref
Tilting Disk Check Valve 3HP-102 Fails To Open On Demand
HHP0102CVO
8.15E-05
Tilting Disk Check Valve 3HP-102 Transfers Closed
HHP0102CVT
3.31E-06
Motor Operated Valve 3HP-25 Does Not Open
HPI105
Motor-Operated Valve 3HP-25 Transfers Closed After Opening
HHP0025MVT
2.50E-06
MOV 3HP-25 Suction Train In Maintenance
HHP0025TRM
5.00E-03
MOV 3HP-25 Suction Train Is Left Unavailable After Test Or Maintenance
HHP0025LHE
5.20E-05
Loss Of Power From 208 V ac MCC 3XS2 Breaker R1A
HPI985
Motor-Operated Valve 3HP-25 Fails To Open On Demand
HHP0025MVO
2.47E-03
Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand
HHPSVLVCOM
2
1.24E-04
Loss Of Power From 208 V ac Motor Control Center 3XS2
P2C3XS2
3.00E-05
208 V ac MCC 3XS2 Breaker R1A Transfers Open (3HP-25)
HACOR1ACLT
1.66E-05


No Flow Through 3HP-24 Or 3HP-101
Page 31...
See x-ref
HPI075
Tilting Disk Check Valve 3HP-101 Fails To Open On Demand
HHP0101CVO
8.15E-05
Tilting Disk Check Valve 3HP-101 Transfers Closed
HHP0101CVT
3.31E-06
Motor Operated Valve 3HP-24 Does Not Open
HPI080
Motor-Operated Valve 3HP-24 Transfers Closed After Opening
HHP0024MVT
2.50E-06
MOV 3HP-24 Suction Train Is Left Unavailable After Test Or Maintenance
HHP0024LHE
5.20E-05
MOV 3HP-24 Suction Train In Maintenance
HHP0024TRM
5.00E-03
Power From 208 V ac MCC 3XS1 Breaker RD1 Fails
HPI986
Motor-Operated Valve 3HP-24 Fails To Open On Demand
HHP0024MVO
2.47E-03
Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand
HHPSVLVCOM
2
1.24E-04
Loss Of Power From 208 V ac Motor Control Center 3XS1
P2C3XS1
3.00E-05
208 V ac MCC 3XS1 Breaker RD1 Transfers Open (3HP-24)
HAC0R1DCLT
1.66E-05

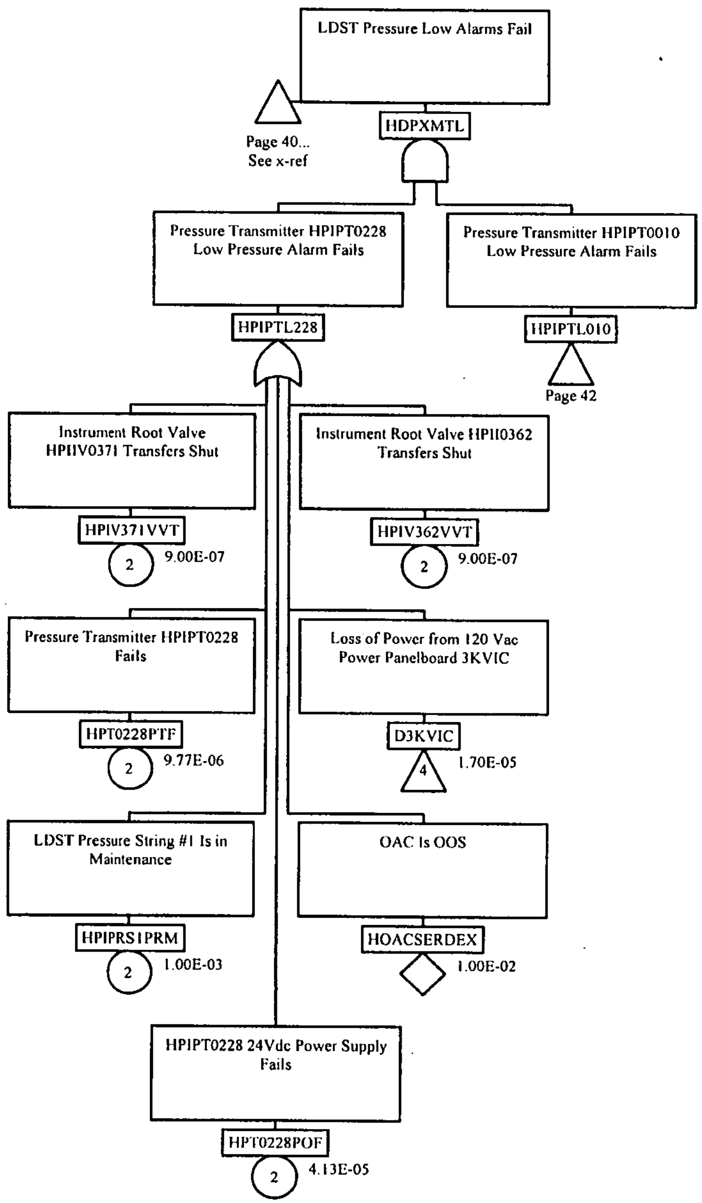

LDST Pressure Is Above Operating Envelope with Pressure Instruments Failed
HPRESSFAIL
Page 13... See x-ref
Operators Fail to Recognize Pressure Instrument Failure
HNMOPRSLHE
1.00E+00
Operators Overcharge the LDST
HNMOPRSDHE
1.00E+00
LDST Pressure Instruments Are Failed
HLDSTPRESS
Instrument Root valve HPHV0095 Transfers Shut
HPI0095VVT
2
9.00E-07
LDST Pressure Transmitters Fail
HLDSTPRXMS
Common Cause Failure of LDST Pressure Transmitters
HLDPXTRCOM
2
3.80E-07
LDST Pressure Sensing String 1 Fails
HPIPTF228
Page 38
LDST Pressure Sensing String 2 Fails
HPIPTF010
Page 39


LDST Pressure Sensing String 1 Fails
HPIPTF228
Page 37...
See x-ref
Pressure Transmitter HPIPT0228 Fails
HPT0228PTF
2
9.77E-06
HPIPT0228 24Vdc Power Supply Fails
HPT0228POF
2
4.13E-05
Instrument Root Valve HPIIV0371 Transfers Shut
HPIV371VVT
2
9.00E-07
Loss of Power from 120 Vac Power Panelboard 3KVIC
D3KVIC
4
1.70E-05
Instrument Root Valve HPII0362 Transfers Shut
HPIV362VVT
2
9.00E-07
LDST Pressure String #1 Is in Maintenance
HPIPRS1PRM
2
1.00E-03

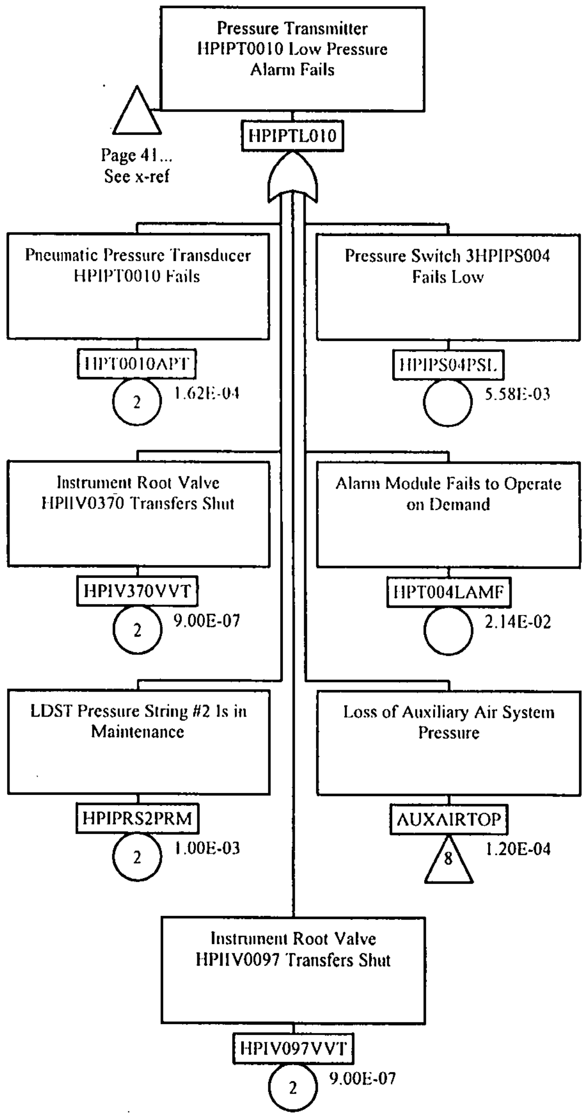

LDST Pressure Sensing String 2 Fails
HPIPTF010
Page 37... See x-ref
Pneumatic Pressure Transducer HPIPT0010 Fails
HPT0010APT
2
1.62E-04
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
1.20E-04
Instrument Root Valve HPIIV0370 Transfers Shut
HPIV370VVT
2
9.00E-07
LDST Pressure String #2 Is in Maintenance
HPIPRS2PRM
2
1.00E-03
Instrument Root Valve HPIIV0097 Transfers Shut
HPIV097VVT
2
9.00E-07

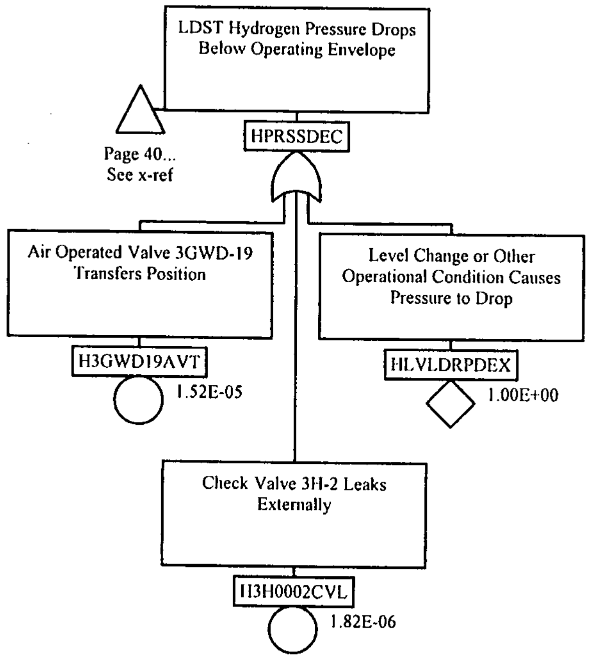


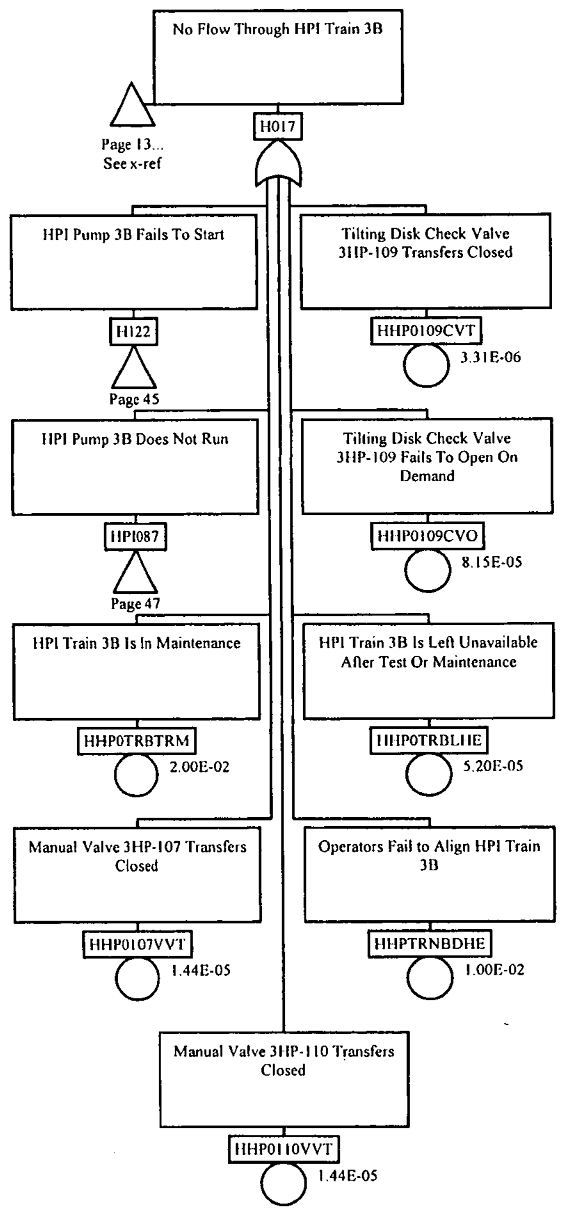
LDST Pressure Fails Low
HPRSLOW
Page 13...
See x-ref
Operator Error Causes Low Pressure Condition
HLDSTLPDHE
1.00E-03
Low Pressure Trend with Operator Failing to Correct
H003
Operator Fails to Correctly Respond to Decrease in LDST Pressure
HOPDCPRS
LDST Hydrogen Pressure Drops Below Operating Envelope
HPRSSDEC
Page 43
Instrument Root valve HPIIV0095 Transfers Shut
HPI0095VVT
2
9.00E-07
LDST Pressure Low Alarms Fail
HDPXMTL
Page 41
Common Cause Failure of LDST Pressure Transmitters
HLDPXTRCOM
2
3.80E-07
Inadequate Operator Guidance Regarding LDST Underpressure
HOPUNPRDHE
1.00E-03



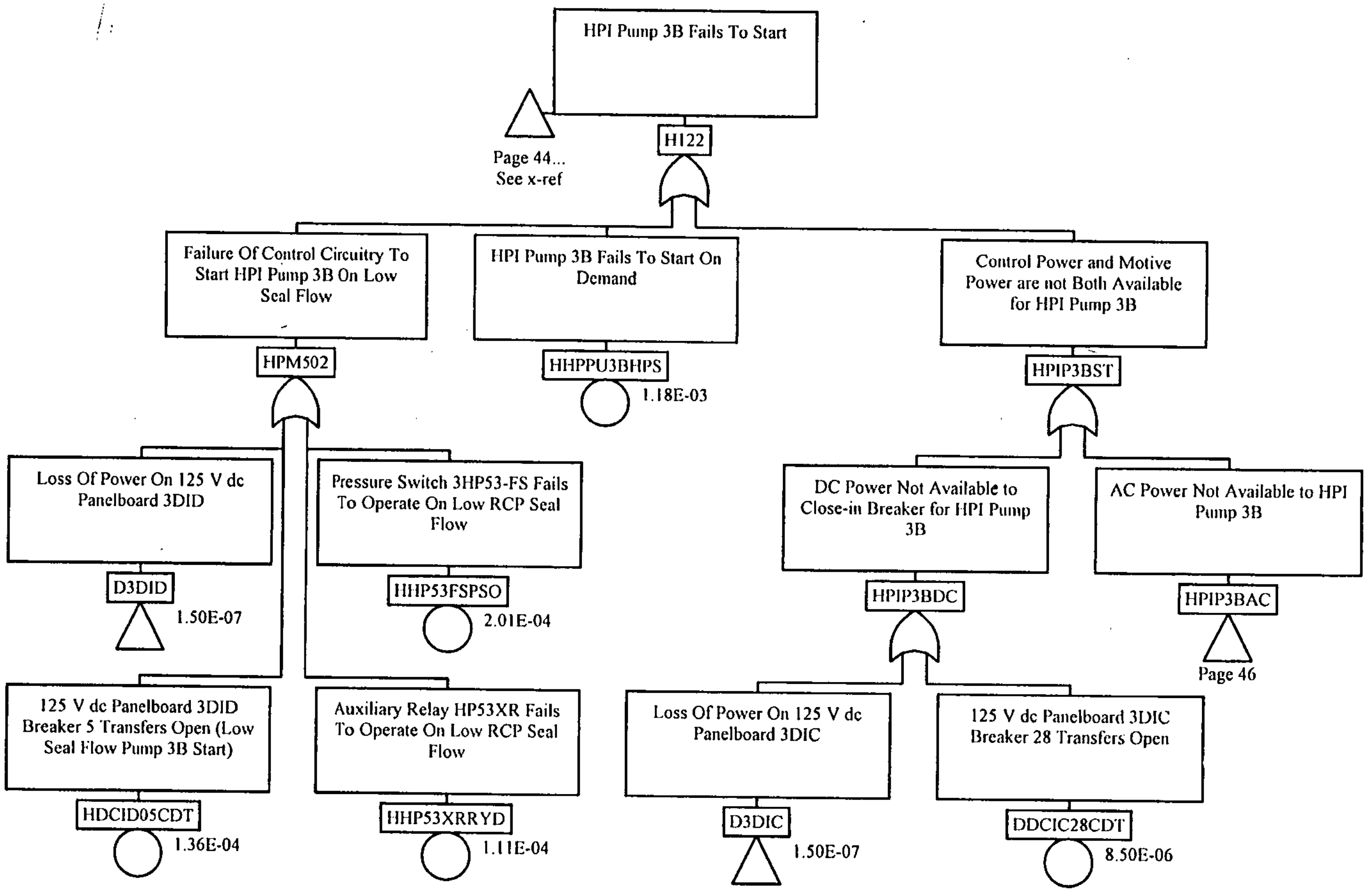
LDST Pressure Low Alarms Fail
HDPXMTL
Page 40...
See x-ref
Pressure Transmitter HPIPT0228 Low Pressure Alarm Fails
HPIPTL228
Pressure Transmitter HPIPT0010 Low Pressure Alarm Fails
HPIPTL010
Page 42
Instrument Root Valve HPIIV0371 Transfers Shut
HPIV371VVT
2
9.00E-07
Instrument Root Valve HPII0362 Transfers Shut
HPIV362VVT
2
9.00E-07
Pressure Transmitter HPIPT0228 Fails
HPT0228PTF
2
9.77E-06
Loss of Power from 120 Vac Power Panelboard 3KVIC
D3KVIC
4
1.70E-05
LDST Pressure String #1 Is in Maintenance
HPIPRS1PRM
2
1.00E-03
OAC Is OOS
HOACSERDEX
1.00E-02
HPIPT0228 24Vdc Power Supply Fails
HPT0228POF
2
4.13E-05

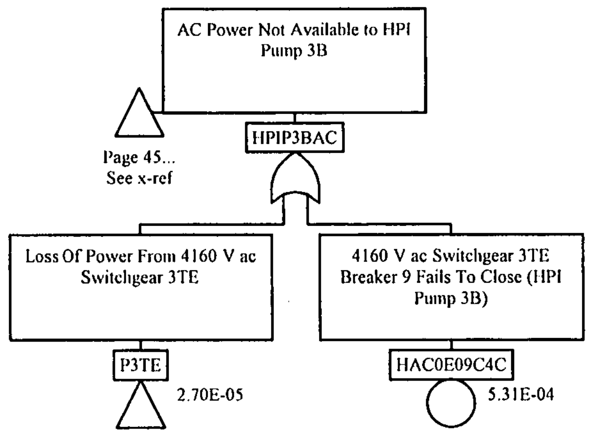

Pressure Transmitter HPIPT0010 Low Pressure Alarm Fails
HPIPTL010
Page 41...
See x-ref
Pneumatic Pressure Transducer HPIPT0010 Fails
HPT0010APT
2
1.62E-04
Pressure Switch 3HPIPS004 Fails Low
HPIPS04PSL
5.58E-03
Instrument Root Valve HPIIV0370 Transfers Shut
HPIV370VVT
2
9.00E-07
Alarm Module Fails to Operate on Demand
HPT004LAMF
2.14E-02
LDST Pressure String #2 Is in Maintenance
HPIPRS2PRM
2
1.00E-03
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
1.20E-04
Instrument Root Valve HPIIV0097 Transfers Shut
HPIV097VVT
2
9.00E-07

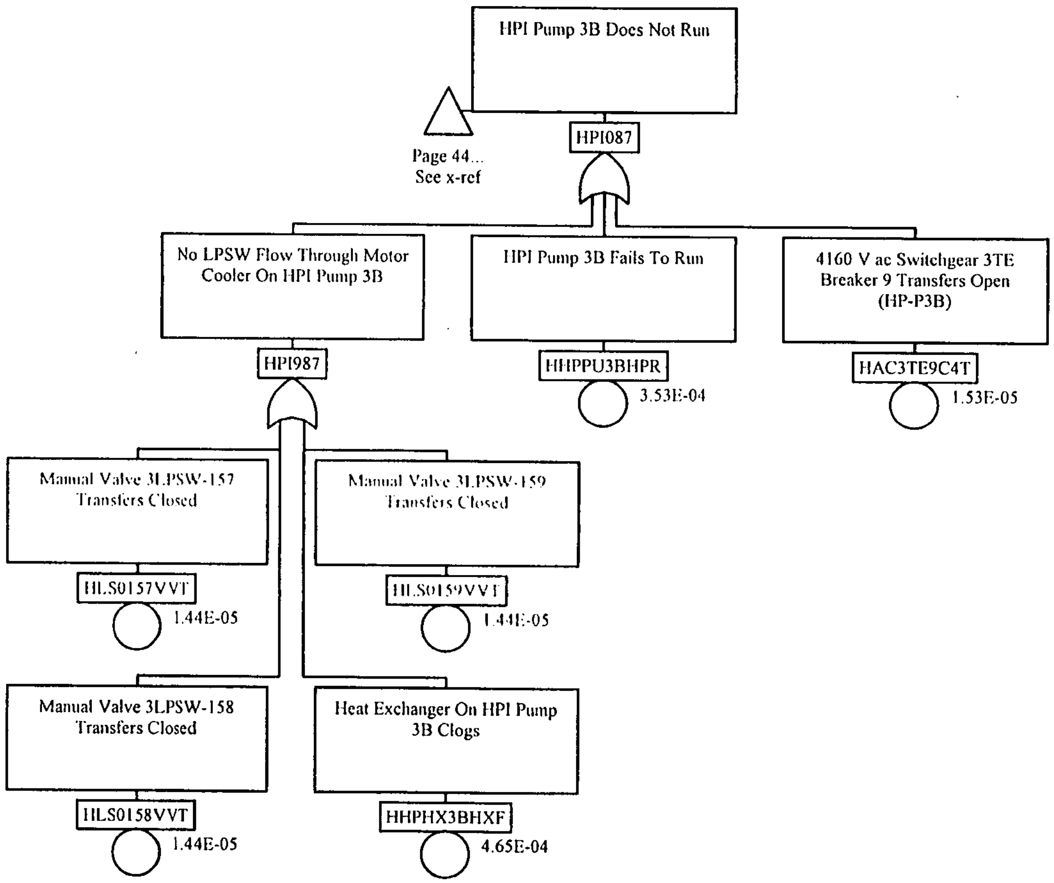

LDST Hydrogen Pressure Drops Below Operating Envelope
HPRSSDEC
Page 40...
See x-ref
Air Operated Valve 3GWD-19 Transfers Position
H3GWD19AVT
1.52E-05
Level Change or Other Operational Condition Causes Pressure to Drop
HLVLDRPDEX
1.00E+00
Check Valve 3H-2 Leaks Externally
H3H0002CVL
1.82E-06

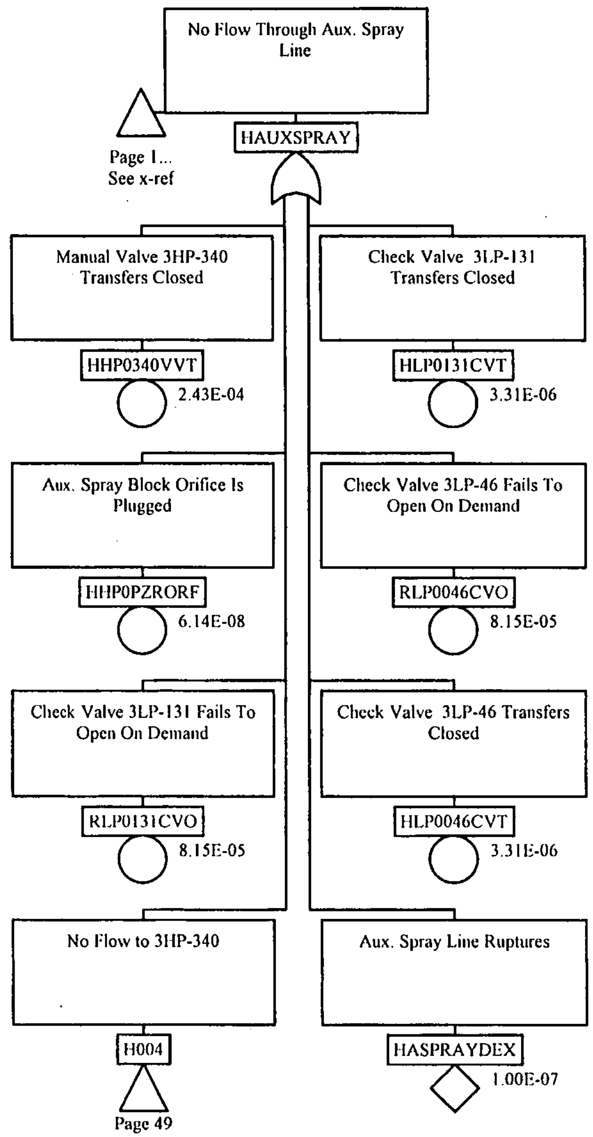


No Flow Through HPI Train 3B
Page 13...
See x-ref
H017
HPI Pump 3B Fails To Start
H122
Page 45
Tilting Disk Check Valve 3HP-109 Transfers Closed
HHP0109CVT
3.31E-06
HPI Pump 3B Does Not Run
HPI087
Page 47
Tilting Disk Check Valve 3HP-109 Fails To Open On Demand
HHP0109CVO
8.15E-05
HPI Train 3B Is In Maintenance
HHP0TRBTRM
2.00E-02
HPI Train 3B Is Left Unavailable After Test Or Maintenance
HHP0TRBLHE
5.20E-05
Manual Valve 3HP-107 Transfers Closed
HHP0107VVT
1.44E-05
Operators Fail to Align HPI Train 3B
HHPTRNBDHE
1.00E-02
Manual Valve 3HP-110 Transfers Closed
HHP0110VVT
1.44E-05

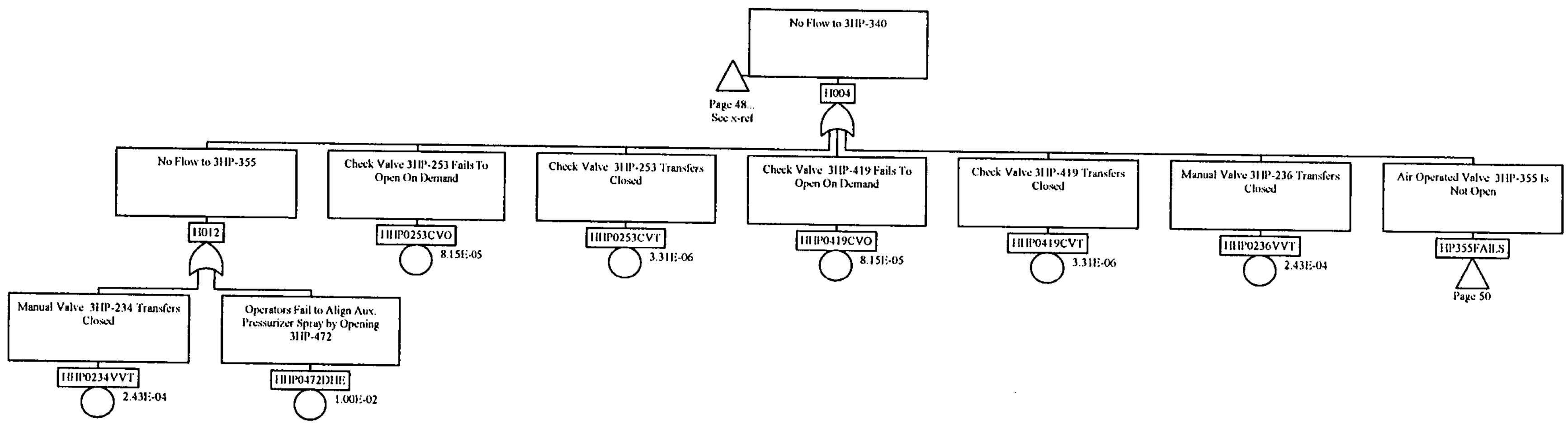

HPI Pump 3B Fails To Start
Page 44...
See x-ref
H122
Failure Of Control Circuitry To Start HPI Pump 3B On Low Seal Flow
HPI Pump 3B Fails To Start On Demand
Control Power and Motive Power are not Both Available for HPI Pump 3B
HPM502
HHPPU3BHPS
1.18E-03
HPIP3BST
Loss Of Power On 125 V dc Panelboard 3DID
Pressure Switch 3HP53-FS Fails To Operate On Low RCP Seal Flow
DC Power Not Available to Close-in Breaker for HPI Pump 3B
AC Power Not Available to HPI Pump 3B
D3DID
1.50E-07
HHP53FSPSO
2.01E-04
HPIP3BDC
HPIP3BAC
Page 46
125 V dc Panelboard 3DID Breaker 5 Transfers Open (Low Seal Flow Pump 3B Start)
Auxiliary Relay HP53XR Fails To Operate On Low RCP Seal Flow
Loss Of Power On 125 V dc Panelboard 3DIC
125 V dc Panelboard 3DIC Breaker 28 Transfers Open
HDCID05CDT
1.36E-04
HHP53XRRYD
1.11E-04
D3DIC
1.50E-07
DDCIC28CDT
8.50E-06


AC Power Not Available to HPI Pump 3B
HPIP3BAC
Page 45...
See x-ref
Loss Of Power From 4160 V ac Switchgear 3TE
P3TE
2.70E-05
4160 V ac Switchgear 3TE Breaker 9 Fails To Close (HPI Pump 3B)
HAC0E09C4C
5.31E-04

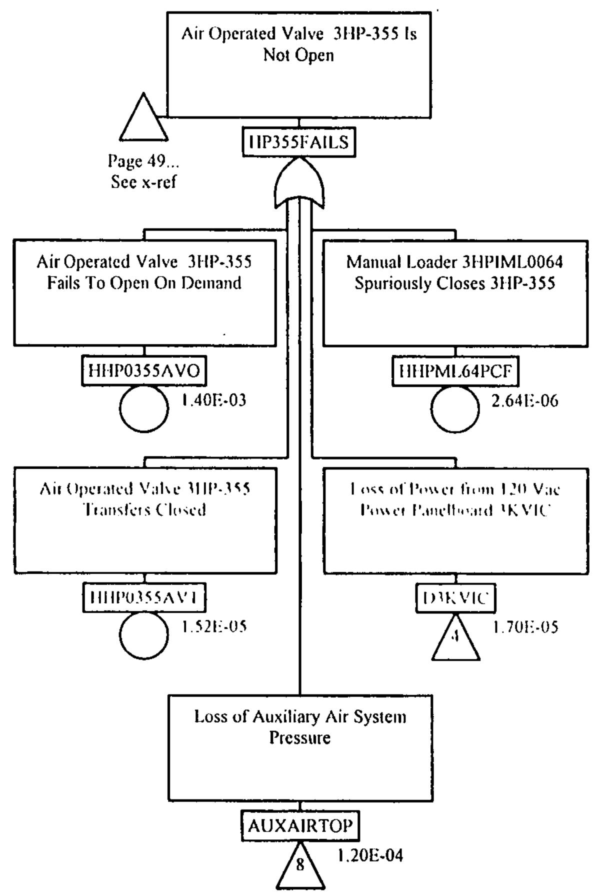

HPI Pump 3B Does Not Run
HPI087
Page 44...
See x-ref
No LPSW Flow Through Motor Cooler On HPI Pump 3B
HPI987
HPI Pump 3B Fails To Run
HHPPU3BHPR
3.53E-04
4160 V ac Switchgear 3TE Breaker 9 Transfers Open (HP-P3B)
HAC3TE9C4T
1.53E-05
Manual Valve 3LPSW-157 Transfers Closed
HLS0157VVT
1.44E-05
Manual Valve 3LPSW-159 Transfers Closed
HLS0159VVT
1.44E-05
Manual Valve 3LPSW-158 Transfers Closed
HLS0158VVT
1.44E-05
Heat Exchanger On HPI Pump 3B Clogs
HHPHX3BHXF
4.65E-04

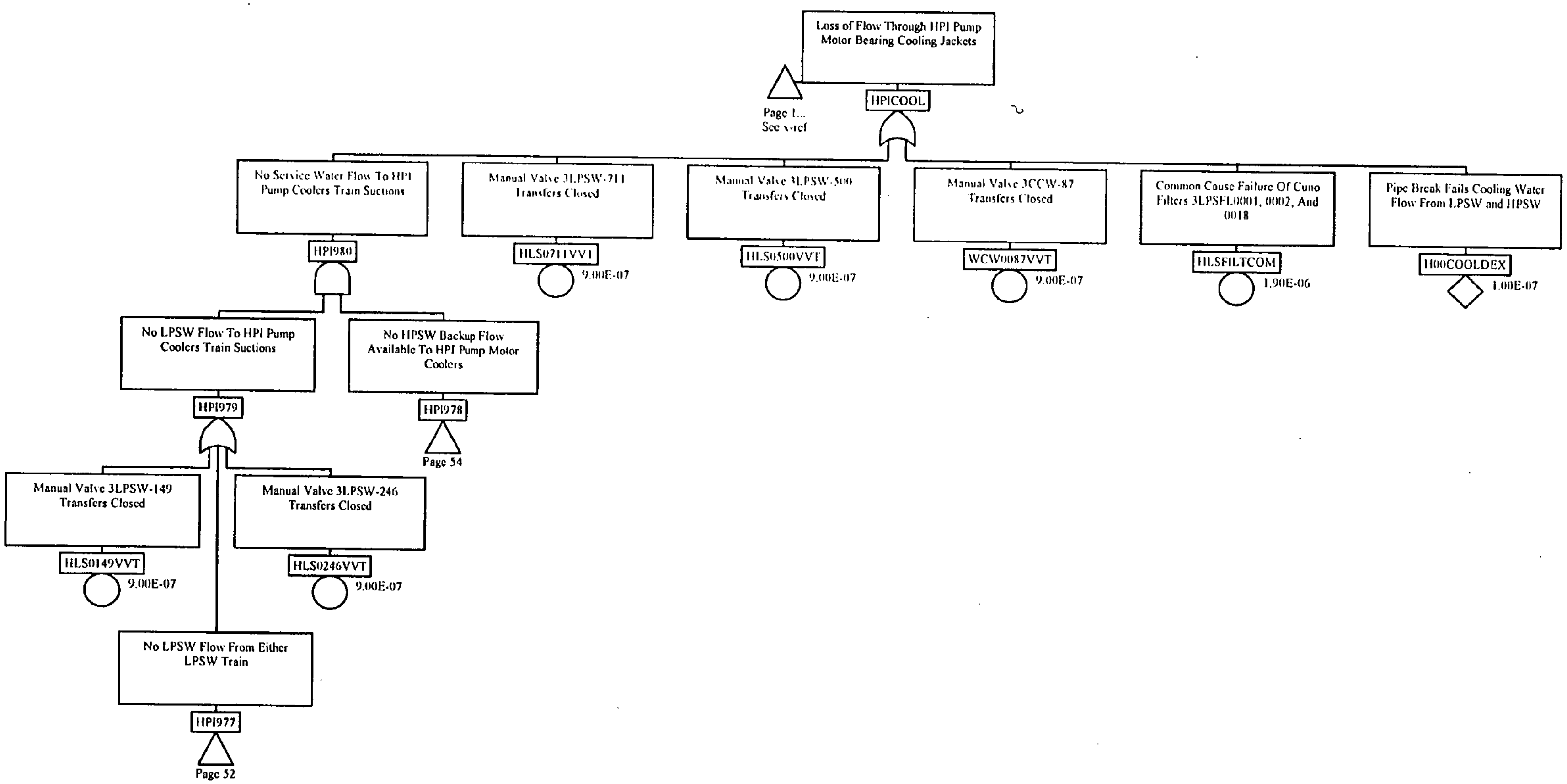


No Flow Through Aux. Spray Line
HAUXSPRAY
Page 1...
See x-ref
Manual Valve 3HP-340 Transfers Closed
HHP0340VVT
2.43E-04
Check Valve 3LP-131 Transfers Closed
HLP0131CVT
3.31E-06
Aux. Spray Block Orifice Is Plugged
HHP0PZRORF
6.14E-08
Check Valve 3LP-46 Fails To Open On Demand
RLP0046CVO
8.15E-05
Check Valve 3LP-131 Fails To Open On Demand
RLP0131CVO
8.15E-05
Check Valve 3LP-46 Transfers Closed
HLP0046CVT
3.31E-06
No Flow to 3HP-340
H004
Page 49
Aux. Spray Line Ruptures
HASPRAYDEX
1.00E-07

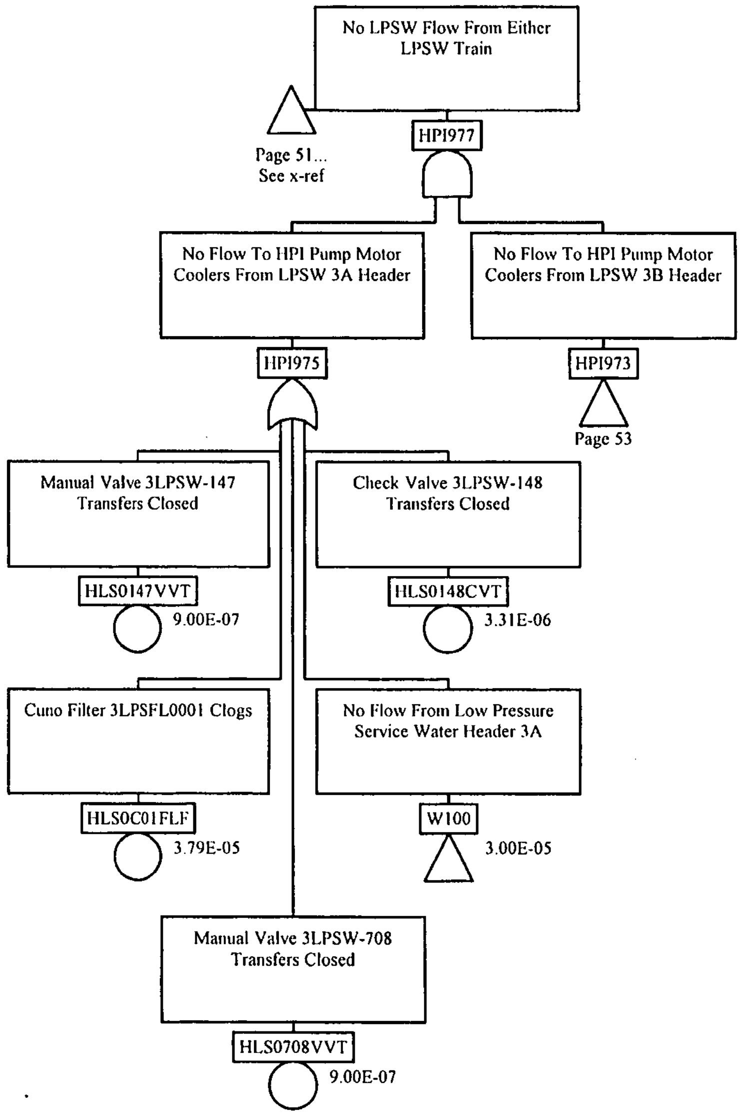


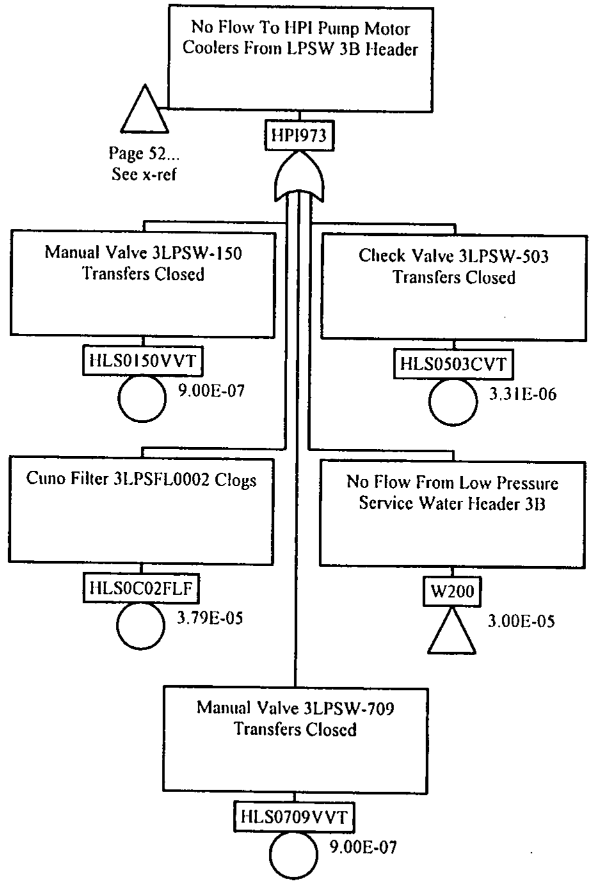
APPENDIX B3 - HPI SYSTEM AUXILIARY SPRAY FAULT TREE


Air Operated Valve 3HP-355 Is Not Open
HP355FAILS
Page 49...
See x-ref
Air Operated Valve 3HP-355 Fails To Open On Demand
HHP0355AVO
1.40E-03
Manual Loader 3HPIML0064 Spuriously Closes 3HP-355
HHPML64PCF
2.64E-06
Air Operated Valve 3HP-355 Transfers Closed
HHP0355AVT
1.52E-05
Loss of Power from 120 Vac Power Panelboard 3KVIC
D3KVIC
4
1.70E-05
Loss of Auxiliary Air System Pressure
AUXAIRTOP
8
1.20E-04

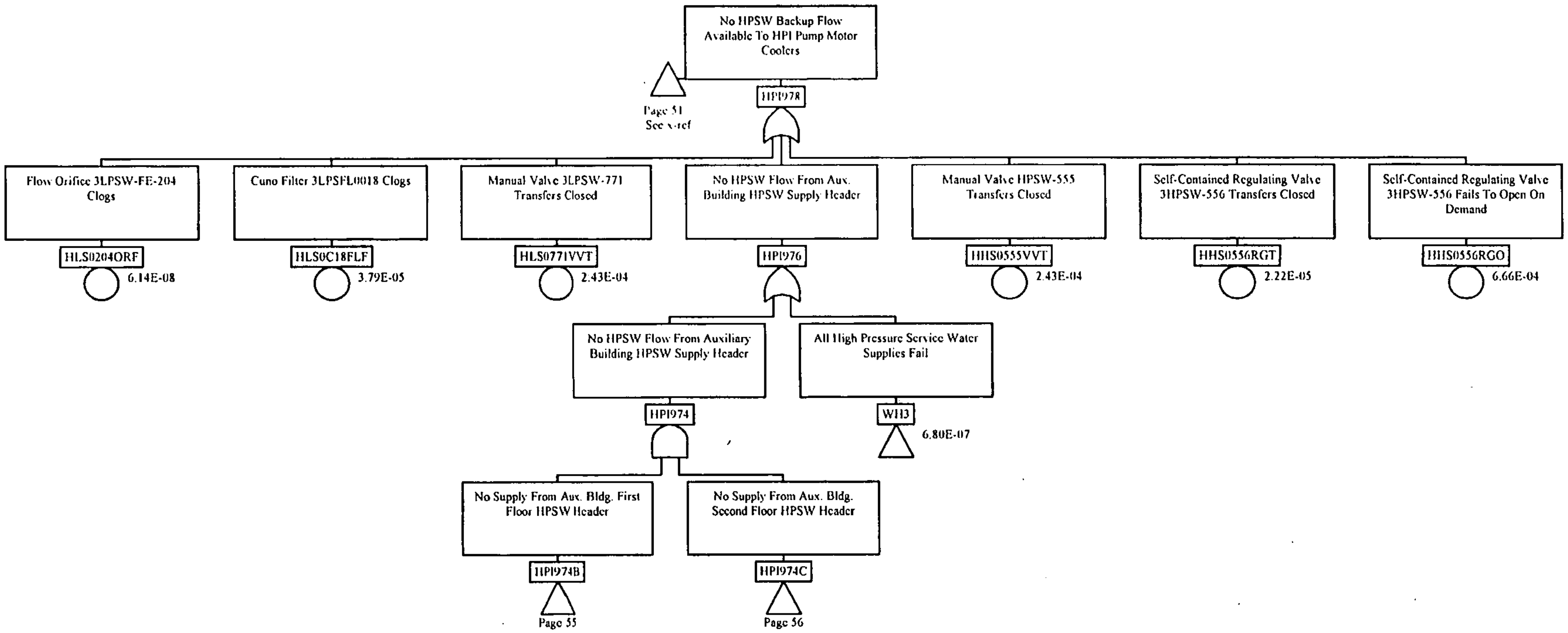


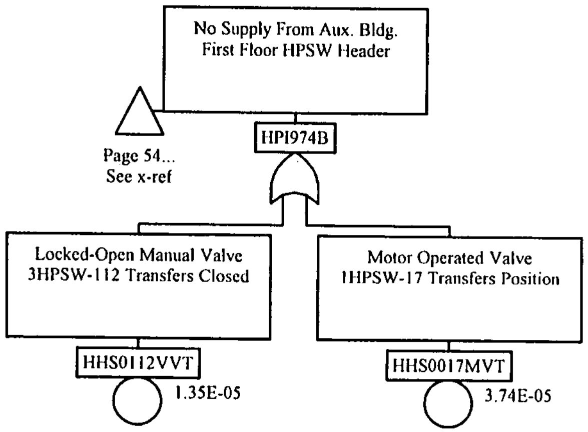
Loss of Flow Through HPI Pump Motor Bearing Cooling Jackets
HPICOOL
Page 1... See x-ref
No Service Water Flow To HPI Pump Coolers Train Suctions
HPI980
Manual Valve 3LPSW-711 Transfers Closed
HLS0711VVT
9.00E-07
Manual Valve 3LPSW-500 Transfers Closed
HLS0500VVT
9.00E-07
Manual Valve 3CCW-87 Transfers Closed
WCW0087VVT
9.00E-07
Common Cause Failure Of Cuno Filters 3LPSFL0001, 0002, And 0018
HLSFILTCOM
1.90E-06
Pipe Break Fails Cooling Water Flow From LPSW and HPSW
H00COOLDEX
1.00E-07
No LPSW Flow To HPI Pump Coolers Train Suctions
HPI979
No HPSW Backup Flow Available To HPI Pump Motor Coolers
HPI978
Page 54
Manual Valve 3LPSW-149 Transfers Closed
HLS0149VVT
9.00E-07
Manual Valve 3LPSW-246 Transfers Closed
HLS0246VVT
9.00E-07
No LPSW Flow From Either LPSW Train
HPI977
Page 52

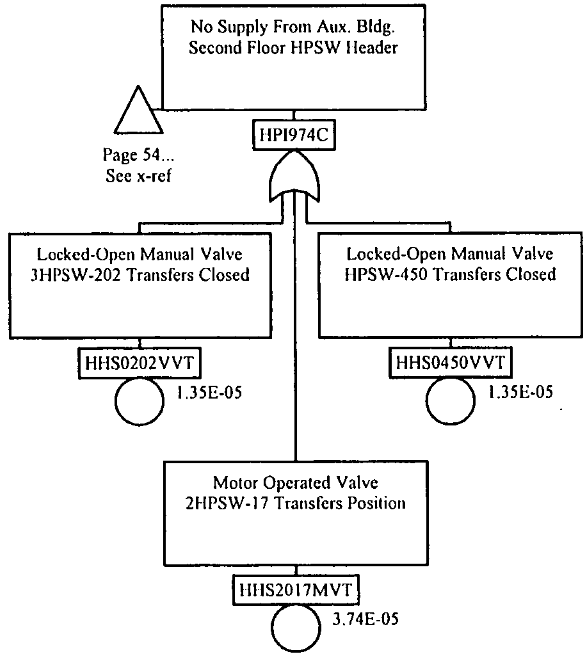

No LPSW Flow From Either LPSW Train
Page 51... See x-ref
HPI977
No Flow To HPI Pump Motor Coolers From LPSW 3A Header
No Flow To HPI Pump Motor Coolers From LPSW 3B Header
HPI975
HPI973
Page 53
Manual Valve 3LPSW-147 Transfers Closed
HLS0147VVT
9.00E-07
Check Valve 3LPSW-148 Transfers Closed
HLS0148CVT
3.31E-06
Cuno Filter 3LPSFL0001 Clogs
HLS0C01FLF
3.79E-05
No Flow From Low Pressure Service Water Header 3A
W100
3.00E-05
Manual Valve 3LPSW-708 Transfers Closed
HLS0708VVT
9.00E-07



No Flow To HPI Pump Motor Coolers From LPSW 3B Header
HPI973
Page 52...
See x-ref
Manual Valve 3LPSW-150 Transfers Closed
HLS0150VVT
9.00E-07
Check Valve 3LPSW-503 Transfers Closed
HLS0503CVT
3.31E-06
Cuno Filter 3LPSFL0002 Clogs
HLS0C02FLF
3.79E-05
No Flow From Low Pressure Service Water Header 3B
W200
3.00E-05
Manual Valve 3LPSW-709 Transfers Closed
HLS0709VVT
9.00E-07


No HPSW Backup Flow Available To HPI Pump Motor Coolers
HPI978
Page 51
See x-ref
Flow Orifice 3LPSW-FE-204 Clogs
HLS0204ORF
6.14E-08
Cuno Filter 3LPSFL0018 Clogs
HLS0C18FLF
3.79E-05
Manual Valve 3LPSW-771 Transfers Closed
HLS0771VVT
2.43E-04
No HPSW Flow From Aux. Building HPSW Supply Header
HPI976
Manual Valve HPSW-555 Transfers Closed
HHS0555VVT
2.43E-04
Self-Contained Regulating Valve 3HPSW-556 Transfers Closed
HHS0556RGT
2.22E-05
Self-Contained Regulating Valve 3HPSW-556 Fails To Open On Demand
HHS0556RGO
6.66E-04
No HPSW Flow From Auxiliary Building HPSW Supply Header
HPI974
All High Pressure Service Water Supplies Fail
WH3
6.80E-07
No Supply From Aux. Bldg. First Floor HPSW Header
HPI974B
Page 55
No Supply From Aux. Bldg. Second Floor HPSW Header
HPI974C
Page 56


No Supply From Aux. Bldg. First Floor HPSW Header
HPI974B
Page 54... See x-ref
Locked-Open Manual Valve 3HPSW-112 Transfers Closed
HHS0112VVT
1.35E-05
Motor Operated Valve 1HPSW-17 Transfers Position
HHS0017MVT
3.74E-05


No Supply From Aux. Bldg. Second Floor HPSW Header
HPI974C
Page 54... See x-ref
Locked-Open Manual Valve 3HPSW-202 Transfers Closed
HHS0202VVT
1.35E-05
Locked-Open Manual Valve HPSW-450 Transfers Closed
HHS0450VVT
1.35E-05
Motor Operated Valve 2HPSW-17 Transfers Position
HHS2017MVT
3.74E-05

Name	Page	Zone	Name	Page	Zone	Name	Page	Zone
AUXAIRTOP	23	2	H128	13	5	HHP0007AVT	25	3
AUXAIRTOP	25	5	H3GWD19AVT	43	1	HHP0008AVT	23	1
AUXAIRTOP	26	2	H3H0002CVL	43	2	HHP0014MVT	22	3
AUXAIRTOP	28	2	H601	26	3	HHP0017AVT	29	1
AUXAIRTOP	29	2	H601	27	3	HHP0023MVT	14	3
AUXAIRTOP	39	2	H603	27	4	HHP0024LHE	36	5
AUXAIRTOP	42	2	H638	2	1	HHP0024MVO	36	3
AUXAIRTOP	50	2	H638	3	3	HHP0024MVT	36	4
CHPHPMUDHE	4	1	H639	3	1	HHP0024TRM	36	6
CHPHPMUDHE	6	3	H639	14	2	HHP0025LHE	35	6
CHPHPMUDHE	30	2	H640	3	2	HHP0025MVO	35	3
D3DIB	26	1	H646	13	1	HHP0025MVT	35	4
D3DIC	45	3	H646	14	3	HHP0025TRM	35	5
D3DID	45	1	H648	14	3	HHP0039VVT	28	1
D3KI	19	3	HAC0008C4T	10	1	HHP0040VVT	25	2
D3KI	25	3	HAC0E09C4C	46	2	HHP0041VVT	25	1
D3KU	19	4	HAC0R1ACLT	35	3	HHP0047CVT	23	1
D3KU	25	4	HAC0R1DCLT	36	3	HHP0057VVT	22	4
D3KVIB	33	2	HAC3TE9C4T	47	4	HHP0078CVT	22	3
D3KVIC	32	2	HASPRAYDEX	48	2	HHP0079RVT	12	2
D3KVIC	38	2	HAUXSPRAY	1	3	HHP0097CVT	14	3
D3KVIC	41	2	HAUXSPRAY	48	2	HHP0098MVT	2	4
D3KVIC	50	2	HBSWTPOSTA	3	5	HHP0098MVT	5	3
DDCIC28CDT	45	4	HBSWTPOSTB	30	4	HHP0098MVT	31	2
H003	40	2	HBSWTPREA	3	3	HHP0099VVT	7	2
H004	48	1	HBSWTPREB	30	2	HHP00LDORF	28	1
H004	49	5	HBWSTOPEN	6	2	HHP0100VVT	7	2
H00COOLDEX	51	7	HD3KIKU	25	4	HHP0101CVO	36	1
H00LDSTDEX	14	4	HDCIB25CDT	26	1	HHP0101CVT	36	2
H00LDSTTKF	14	4	HDCID05CDT	45	1	HHP0102CVO	35	1
H012	49	2	HDFLWALM	15	2	HHP0102CVT	35	2
H017	13	4	HDFLWALM	17	2	HHP0103VVT	11	2
H017	44	2	HDLVXMR1	18	2	HHP0105CVT	11	2
H066	4	2	HDLVXMR1	19	4	HHP0106VVT	11	1
H066	5	2	HDLVXMR2	18	3	HHP0107VVT	44	1
H083	30	3	HDLVXMR2	20	2	HHP0109CVO	44	2
H083	30	5	HDPXMTL	40	2	HHP0109CVT	44	2
H083	31	2	HDPXMTL	41	2	HHP0110VVT	44	2
H087	31	2	HEMERLILHE	6	1	HHP0115MVT	13	1
H096	3	4	HEMERLIMNT	6	2	HHP0118VVT	1	1
H096	4	2	HEXCMAKEUP	14	2	HHP0195VVT	24	4
H100	3	6	HFRMLDSTNORM	3	2	HHP0234VVT	49	1
H100	5	2	HFRMLDSTNORM	14	4	HHP0236VVT	49	7
H102	5	1	HFROMBWSTA	3	4	HHP0253CVO	49	3
H102	6	3	HFROMBWSTB	14	4	HHP0253CVT	49	4
H102	30	4	HFROMBWSTB	30	3	HHP0331PST	26	2
H110	30	2	HHP0001MVT	27	2	HHP0340VVT	48	1
H112	30	4	HHP0002MVT	27	3	HHP0355AVO	50	1
H122	44	1	HHP0003MVT	27	1	HHP0355AVT	50	1
H122	45	3	HHP0004MVT	27	4	HHP0357PST	26	2
H128	2	5	HHP0005AVT	26	1	HHP0419CVO	49	5
H128	12	2	HHP0006AVT	28	1	HHP0419CVT	49	6

Name	Page	Zone	Name	Page	Zone	Name	Page	Zone
HHP0472DHE	49	2	HLDPXTRCOM	37	4	HMOD	30	3
HHP0LDAFLF	22	5	HLDPXTRCOM	40	1	HNMOPLVDHE	8	1
HHP0PZRORF	48	1	HLDRESTORE	15	2	HNMOPRSDHE	37	2
HHP0SGOLHE	7	1	HLDSLVLAMF	18	1	HNMOPRSLHE	37	1
HHP0TRBLHE	44	2	HLDSTL1DHE	15	1	HNOMOD	3	3
HHP0TRBTRM	44	1	HLDSTLEVEL	8	2	HNOMOD	30	1
HHP2-2RCOM	1	4	HLDSTLEVEL	18	3	HNORMLDINT	14	1
HHP33P1LTF	19	1	HLDSTLPDHE	40	1	HNORMLDINT	15	2
HHP33P1LTF	32	1	HLDSTLVL	2	2	HOACSERDEX	41	2
HHP33P2LTF	20	1	HLDSTLVLB	13	2	HOPDCPRS	40	2
HHP33P2LTF	33	1	HLDSTLVXMS	18	2	HOPUNPRDHE	40	2
HHP53FSPSO	45	2	HLDSTPERN	2	2	HP14LS1SMF	19	2
HHP53XRRYD	45	2	HLDSTPERNB	13	3	HP14LS1SMF	32	2
HHPDEMAFLF	23	1	HLDSTPRESS	37	3	HP14LS2SMF	20	1
HHPHX3AHXF	9	2	HLDSTPRS	2	3	HP14LS2SMF	33	2
HHPHX3BHXF	47	2	HLDSTPRS	13	4	HP355FAILS	49	8
HHPKD17CLT	23	2	HLDSTPRXMS	37	3	HP355FAILS	50	2
HHPKD18CLT	29	1	HLDSTSIG	6	3	HPI004	2	5
HHPKD19CLT	28	2	HLDXMTRCOM	18	1	HPI004	11	2
HHPKU21CLT	25	5	HLEVELFAIL	2	2	HPI0085DEX	18	3
HHPLDCAHXF	27	2	HLEVELFAIL	8	2	HPI0087DEX	18	4
HHPLDCBHXF	27	4	HLEVELFAIL	13	2	HPI0095VVT	37	2
HHPML64PCF	50	2	HLP0046CVT	48	2	HPI0095VVT	40	1
HHPPU3AHPR	2	3	HLP0131CVT	48	2	HPI017	1	2
HHPPU3BHPR	47	3	HLS0147VVT	52	1	HPI026	2	4
HHPPU3BHPS	45	3	HLS0148CVT	52	2	HPI026C	5	3
HHPSV90SVT	26	2	HLS0149VVT	51	1	HPI032	2	4
HHPSVLVCOM	35	4	HLS0150VVT	53	1	HPI0368DEX	20	2
HHPSVLVCOM	36	4	HLS0152VVT	9	1	HPI0368VVT	33	1
HHPTRNBDHE	44	2	HLS0153VVT	9	1	HPI0369DEX	19	4
HHS0017MVT	55	2	HLS0154VVT	9	2	HPI0369VVT	32	1
HHS0112VVT	55	1	HLS0157VVT	47	1	HPI074	5	2
HHS0202VVT	56	1	HLS0158VVT	47	1	HPI074	31	3
HHS0450VVT	56	2	HLS0159VVT	47	2	HPI075	31	2
HHS0555VVT	54	5	HLS0204ORF	54	1	HPI075	36	4
HHS0556RGO	54	7	HLS0246VVT	51	2	HPI080	36	3
HHS0556RGT	54	6	HLS0500VVT	51	4	HPI087	44	1
HHS2017MVT	56	2	HLS0503CVT	53	2	HPI087	47	3
HLDDIVTCHE	12	1	HLS0708VVT	52	2	HPI092	5	2
HLDFLOW	15	3	HLS0709VVT	53	2	HPI092	7	3
HLDFLOW	22	4	HLS0711VVT	51	3	HPI092	31	1
HLDFLOWAMF	17	2	HLS0771VVT	54	3	HPI098	7	4
HLDFLOWDHE	16	2	HLS0C01FLF	52	1	HPI099	7	4
HLDISOLCHE	22	1	HLS0C02FLF	53	1	HPI099	35	4
HLDLVLALM	15	3	HLS0C18FLF	54	2	HPI105	35	3
HLDLVLALM	18	2	HLSFILTCOM	51	6	HPI793	7	2
HLDLVSIG1	6	3	HLVLDRPDEX	43	2	HPI973	52	3
HLDLVSIG1	32	2	HLVLPWR	19	3	HPI973	53	2
HLDLVSIG2	6	4	HLVLPWR	20	1	HPI974	54	4
HLDLVSIG2	33	2	HLVLST1LTM	19	5	HPI974B	54	3
HLDMONITOR	15	2	HLVLST2LTM	20	2	HPI974B	55	2
HLDPATHDEX	22	7	HMOD	3	5	HPI974C	54	4

Name	Page	Zone
HPI974C	56	2
HPI975	52	2
HPI976	54	4
HPI977	51	2
HPI977	52	2
HPI978	51	3
HPI978	54	4
HPI979	51	2
HPI980	51	2
HPI985	35	2
HPI986	36	2
HPI987	47	2
HPI991	2	3
HPI991	9	2
HPI997	2	4
HPI997	10	2
HPICOOL	1	5
HPICOOL	51	5
HPIFT6PFTF	17	1
HPIFT6XCOM	16	2
HPIFT6XCOM	17	2
HPILT6AFTF	16	1
HPIP3BAC	45	5
HPIP3BAC	46	2
HPIP3BDC	45	4
HPIP3BST	45	4
HPIPRS1PRM	38	2
HPIPRS1PRM	41	1
HPIPRS2PRM	39	2
HPIPRS2PRM	42	1
HPIPS04PSL	42	2
HPIPTF010	37	4
HPIPTF010	39	2
HPIPTF228	37	3
HPIPTF228	38	2
HPIPTL010	41	3
HPIPTL010	42	2
HPIPTL228	41	2
HPIR052DEX	19	6
HPIR103DEX	20	2
HPIS052VVT	19	7
HPIS103VVT	20	2
HPIV097VVT	39	2
HPIV097VVT	42	2
HPIV362VVT	38	1
HPIV362VVT	41	2
HPIV370VVT	39	1
HPIV370VVT	42	1
HPIV371VVT	38	1
HPIV371VVT	41	1
HPM502	45	2
HPM658	24	4
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HPM665	27	2
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HPM668AC	25	4
HPM669	24	2
HPM670	24	3
HPM671	22	2
HPM671	24	3
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HPM679	22	2
HPM680	22	6
HPM680	29	2
HPRESSFAIL	13	3
HPRESSFAIL	37	2
HPRSLOW	13	4
HPRSLOW	40	2
HPRSSDEC	40	3
HPRSSDEC	43	2
HPT0010APT	39	1
HPT0010APT	42	1
HPT004LAMF	42	2
HPT0228POF	38	2
HPT0228POF	41	2
HPT0228PTF	38	1
HPT0228PTF	41	1
HPZRFLOW	1	2
HPZRSPRAY	1	3
HTRAINBN	1	3
HTRAINBN	13	3
HTRAN	1	2
HTRAN	2	4
HUBFLOW	15	2
HUBFLOW	16	2
L55	7	3
L55	31	3
L55	34	3
L56	34	2
LLP0028LHE	34	4
LLP0028VVT	34	3
LLP0061CVO	34	2
LLP0061CVT	34	1
LLP0BWTTKF	34	2
P2C3KD	23	2
P2C3KD	28	2
P2C3KD	29	2
P2C3XS1	36	2
P2C3XS2	35	2
P3TC	10	2
P3TE	46	1
PRZRCHAL	21	1
PRZRLVLDEX	21	2
PZRLVLV	15	3
PZRLVLV	21	2
RLP0046CVO	48	2
RLP0131CVO	48	1
W100	52	2
W200	53	2
WCW0087VVT	51	5
WH3	54	5

APPENDIX C1

HPI SYSTEM
ACCIDENT MITIGATION DATABASE

APPENDIX C1

HPI SYSTEM ACCIDENT MITIGATION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
AUXAIRTOP	Loss of Auxiliary Air System Pressure	*	*	*	*	1.20E-04
CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	*	*	*	*	2.00E-03
D3DIB	Loss Of Power On 125 V dc Panelboard 3DIB	*	*	*	*	1.50E-07
D3DIC	Loss Of Power On 125 V dc Panelboard 3DIC	*	*	*	*	1.50E-07
D3DID	Loss Of Power On 125 V dc Panelboard 3DID	*	*	*	*	1.50E-07
D3KI	Loss of Power on 240/120 V ac Power Panelboard 3KI	*	*	*	*	3.30E-05
D3KU	Loss of Power on 240/120 V ac Power Panelboard 3KU	*	*	*	*	3.30E-05
D3KVIB	Loss of Power on 120 V ac Power Panelboard 3KVIB	*	*	*	*	1.60E-05
D3KVIC	Loss of Power from 120 Vac Power Panelboard 3KVIC	*	*	*	*	1.70E-05
DDCIB32CDT	125 V dc Panelboard 3DIB Breaker 32 Transfers Open	3.54E-07	/H	24	H	8.50E-06
DDCIC28CDT	125 V dc Panelboard 3DIC Breaker 28 Transfers Open	3.54E-07	/H	24	H	8.50E-06
EKSFASODHE	Operators Fail To Respond to Engineered Safeguards Failure	*	*	*	*	4.00E-03
ESAS1	Enginered Safeguards Channel 1 Signal Fails	*	*	*	*	2.00E-06
ESAS2	Engineered Safeguards Channel 2 Signal Fails	*	*	*	*	2.00E-06
H00COOLDEX	Pipe Break Fails Cooling Water Flow From LPSW and HPSW	*	*	*	*	1.00E-07
H00HP97RHE	Operators Fail to Isolate Diversion Flow From RB Sump to LDST	*	*	*	*	1.00E+00
H00LDSTDEX	Pipe Rupture Fails Flow From LDST	*	*	*	*	1.00E-07
H3ABREAK	HPI Line Break Occurs on 3A Side	*	*	*	*	5.00E-01
H3BBREAK	HPI Line Break Occurs on 3B Side	*	*	*	*	5.00E-01
HAC0008C4T	4160 V ac Switchgear 3TC Breaker 8 Transfers Open (HP-P3A)	6.38E-07	/H	24	H	1.53E-05
HAC0009C4T	4160 V ac Switchgear 3TD Breaker 9 Transfers Open (HP-P3C)	6.38E-07	/H	24	H	1.53E-05
HAC0D09C4C	4160 V ac Switchgear 3TD Breaker 9 Fails To Close (HPI Pump 3C)	5.31E-04	/N	1	N	5.31E-04
HAC0E09C4C	4160 V ac Switchgear 3TE Breaker 9 Fails To Close (HPI Pump 3B)	5.31E-04	/N	1	N	5.31E-04
HAC0R1ACLT	208 V ac MCC 3XS2 Breaker R1A Transfers Open (3HP-25)	4.62E-07	/H	36	H	1.66E-05
HAC0R1DCLT	208 V ac MCC 3XS1 Breaker RD1 Transfers Open (3HP-24)	4.62E-07	/H	36	H	1.66E-05
HAC0R2ACLT	208 V ac MCC 3XS1 Breaker R2A Transfers Open (3HP-26)	4.62E-07	/H	12	H	5.54E-06
HAC3TE9C4T	4160 V ac Switchgear 3TE Breaker 9 Transfers Open (HP-P3B)	6.38E-07	/H	24	H	1.53E-05
HACXL9DCLT	208 V ac MCC 3XL Breaker 9D Transfers Open (3LP-15)	4.62E-07	/H	36	H	1.66E-05
HACXN6DCLT	208 V ac MCC 3XN Breaker 6D Transfers Open (3LP-16)	4.62E-07	/H	36	H	1.66E-05
HBWST3ADEX	Pipe Rupture Fails HPI Supply From BWST Through 3HP-24	*	*	*	*	3.23E-08

APPENDIX C1

HPI SYSTEM ACCIDENT MITIGATION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HBWST3BDEX	Pipe Rupture Fails HPI Supply From BWST Through 3HP-25	*	*	*	*	1.38E-08
HCH15BREAK	HPI Line Break Occurs on Another HPI Line	*	*	*	*	7.50E-01
HDCIB25CDT	125 V dc Panelboard 3DIB Breaker 25 Transfers Open (3CC-8, 3HP-5)	3.54E-07	/H	24	H	8.50E-06
HDCID05CDT	125 V dc Panelboard 3DID Breaker 5 Transfers Open (Low Seal Flow Pump 3B Start)	3.54E-07	/H	16	D	1.36E-04
HDISCHADEX	Pipe Rupture Fails Flow From HPI Pumps to 3A Cold Legs	*	*	*	*	6.24E-08
HDISCHBDEX	Pipe Rupture Fails Flow From HPI Pumps to 3B Cold Legs	*	*	*	*	5.97E-08
HEMERLILHE	Latent Human Error Associated with Interlock Maintenance Occurs	*	*	*	*	3.20E-03
HEMERLIMNT	LDST Emergency Low Interlock Function Is in Maintenance	*	*	*	*	1.00E-03
HES001BUCD	Unit Control Module ES1B Fails	6.00E-08	/N	1	N	6.00E-08
HES001CUCD	Unit Control Module ES1C Fails	6.00E-08	/N	1	N	6.00E-08
HES002AUCD	Unit Control Module ES2A Fails	6.00E-08	/N	1	N	6.00E-08
HES002BUCD	Unit Control Module ES2B Fails	6.00E-08	/N	1	N	6.00E-08
HES002CUCD	Unit Control Module ES2C Fails	6.00E-08	/N	1	N	6.00E-08
HEXCMAKEUP	Excessive RC Makeup Is Required	*	*	*	*	1.00E-02
HHP0001MVT	Motor-Operated Valve 3HP-1 Transfers Closed	1.04E-07	/H	9	M	6.74E-04
HHP0002MVT	Motor Operated Valve 3HP-2 Transfers Position	1.04E-07	/H	9	M	6.74E-04
HHP0003MVT	Motor-Operated Valve 3HP-3 Transfers Closed	1.04E-07	/H	9	M	6.74E-04
HHP0004MVT	Motor Operated Valve 3HP-4 Transfers Position	1.04E-07	/H	9	M	6.74E-04
HHP0005AVT	Air-Operated Valve 3HP-5 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0006AVT	Air-Operated Valve 3HP-6 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0007AVT	Air-Operated Valve 3HP-7 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0008AVT	Air-Operated Valve 3HP-8 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0014MVT	Motor Operated Valve 3HP-14 Transfers Position	1.04E-07	/H	24	H	2.50E-06
HHP0017AVT	Air-Operated Valve 3HP-17 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0023MVT	Motor-Operated Valve 3HP-23 Transfers Closed	1.04E-07	/H	24	H	2.50E-06
HHP0024LHE	MOV 3HP-24 Suction Train Is Left Unavailable After Test Or Maintenance	*	*	*	*	5.20E-05
HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0024MVT	Motor-Operated Valve 3HP-24 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	*	*	*	*	5.00E-03

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NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0025LHE	MOV 3HP-25 Suction Train Is Left Unavailable After Test Or Maintenance	*	*	*	*	5.20E-05
HHP0025MVO	Motor-Operated Valve 3HP-25 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0025MVT	Motor-Operated Valve 3HP-25 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HHP0025TRM	MOV 3HP-25 Suction Train In Maintenance	*	*	*	*	5.00E-03
HHP0026MVO	Motor-Operated Valve 3HP-26 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0026MVT	Motor-Operated Valve 3HP-26 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HHP0027MVT	Motor-Operated Valve 3HP-27 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HHP0028VVT	Manual Valve 3HP-28 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0031AVT	Air-Operated Valve 3HP-31 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0039VVT	Manual Valve 3HP-39 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0040VVT	Manual Valve 3HP-40 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0041VVT	Manual Valve 3HP-41 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0047CVT	Check Valve 3HP-47 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0057VVT	Manual Valve 3HP-57 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0064VVT	Manual Valve 3HP-64 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0065VVT	Manual Valve 3HP-65 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0066VVT	Manual Valve 3HP-66 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0067VVT	Manual Valve 3HP-67 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0078CVT	Check Valve 3HP-78 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0097CVC	Check Valve 3HP-97 Fails To Close On Demand	8.81E-04	/N	10	N	8.81E-03
HHP0097CVT	Check Valve 3HP-97 Transfers Position	1.38E-07	/H	24	H	3.31E-06
HHP0098MVT	Motor-Operated Valve 3HP-98 Transfers Closed	1.04E-07	/H	24	H	2.50E-06
HHP0099VVT	Manual Valve 3HP-99 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HHP00LDORF	Letdown Line Flow Reducer Plugs	2.56E-09	/H	24	H	6.14E-08
HHP0100VVT	Manual Valve 3HP-100 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HHP0101CVO	Tilting Disk Check Valve 3HP-101 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0101CVT	Tilting Disk Check Valve 3HP-101 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0102CVO	Tilting Disk Check Valve 3HP-102 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0102CVT	Tilting Disk Check Valve 3HP-102 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0103VVT	Manual Valve 3HP-103 Transfers Closed	3.75E-08	/H	24	H	9.00E-07

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NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0105CVT	Check Valve 3HP-105 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0106VVT	Manual Valve 3HP-106 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0107VVT	Manual Valve 3HP-107 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HHP0109CVO	Tilting Disk Check Valve 3HP-109 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0109CVT	Tilting Disk Check Valve 3HP-109 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0110VVT	Manual Valve 3HP-110 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HHP0111VVT	Manual Valve 3HP-111 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HHP0113CVO	Tilting Disk Check Valve 3HP-113 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0113CVT	Tilting Disk Check Valve 3HP-113 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0114VVT	Manual Valve 3HP-114 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HHP0115MVT	Motor-Operated Valve 3HP-115 Transfers Closed	1.04E-07	/H	24	H	2.50E-06
HHP0118VVT	Manual Valve 3HP-118 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0126VVT	Manual Valve 3HP-126 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHP0127VVT	Manual Valve 3HP-127 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHP0128VVT	Manual Valve 3HP-128 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0129VVT	Manual Valve 3HP-129 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0130VVT	Manual Valve 3HP-130 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0131VVT	Manual Valve 3HP-131 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0138VVT	Manual Valve 3HP-138 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0139VVT	Manual Valve 3HP-139 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0144CVT	Check Valve 3HP-144 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0145CVT	Check Valve 3HP-145 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0146CVT	Check Valve 3HP-146 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0147CVT	Check Valve 3HP-147 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0148VVT	Manual Valve 3HP-148 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHP0152VVT	Manual Valve 3HP-152 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHP0153VVT	Manual Valve 3HP-153 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHP0188CVO	Swing Check Valve 3HP-188 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0188CVT	Swing Check Valve 3HP-188 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0191SVT	Solenoid Valve 3HPISV0191 Transfers Position, Closing 3HP-31	3.98E-07	/H	24	H	9.55E-06

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HPI SYSTEM ACCIDENT MITIGATION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0194CVT	Check Valve 3HP-194 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0195VVT	Manual Valve 3HP-195 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0283VVT	Manual Valve 3HP-283 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0284VVT	Manual Valve 3HP-284 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0285VVT	Manual Valve 3HP-285 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0286VVT	Manual Valve 3HP-286 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0331PST	Low Instrument Air Pressure Switch 3IAPS0331 Spurious Operation	5.93E-07	/H	24	H	1.42E-05
HHP0357PST	High Letdown Temp. Pressure Switch 3HPIPS0357 Spurious Operation	5.93E-07	/H	24	H	1.42E-05
HHP0385VVT	Manual Valve 3HP-385 Transfers Position	3.75E-08	/H	24	H	9.00E-07
HHP0387VVT	Manual Valve 3HP-387 Transfers Position	3.75E-08	/H	24	H	9.00E-07
HHP0390CVT	Check Valve 3HP-390 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0393CVT	Check Valve 3HP-393 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP03A1ORF	High Pressure Injection Flow Orifice 3A1 Is Blocked	2.56E-09	/H	9	M	1.66E-05
HHP03A2ORF	High Pressure Injection Flow Orifice 3A2 Is Blocked	2.56E-09	/H	9	M	1.66E-05
HHP03B1ORF	High Pressure Injection Flow Orifice 3B1 Is Blocked	2.56E-09	/H	9	M	1.66E-05
HHP03B2ORF	High Pressure Injection Flow Orifice 3B2 Is Blocked	2.56E-09	/H	9	M	1.66E-05
HHP0409DHE	Operators Fail to Open 3HP-409 (-410)	*	*	*	*	1.00E-03
HHP0409MVO	Motor Operated Valve 3HP-409 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0409MVT	Motor Operated Valve 3HP-409 Transfers Position	1.04E-07	/H	24	H	2.50E-06
HHP0410MVO	Motor Operated Valve 3HP-410 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0410MVT	Motor Operated Valve 3HP-410 Transfers Position	1.04E-07	/H	24	H	2.50E-06
HHP0446VVT	Manual Valve 3HP-446 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0447VVT	Manual Valve 3HP-447 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0448VVT	Manual Valve 3HP-448 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0449VVT	Manual Valve 3HP-449 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0454CVT	Check Valve 3HP-454 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0457CVT	Check Valve 3HP-457 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0477VVT	Manual Valve 3HP-477 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0482VVT	Manual Valve 3HP-482 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0486CVT	Check Valve 3HP-486 Transfers Closed	1.38E-07	/H	9	M	8.94E-04

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HPI SYSTEM ACCIDENT MITIGATION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0487CVT	Check Valve 3HP-487 Transfers Closed	1.38E-07	/H	9	M	8.94E-04
HHP0488CVO	Check Valve 3HP-488 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0488CVT	Check Valve 3HP-488 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0489CVO	Check Valve 3HP-489 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0489CVT	Check Valve 3HP-489 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0LDAFLF	Letdown Filter 3A Clogs	1.58E-06	/H	24	H	3.79E-05
HHP0SFAFLF	Reactor Coolant Pump Seal Supply Filter 3A Clogs	1.58E-06	/H	24	H	3.79E-05
HHP0SGOLHE	HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance	*	*	*	*	3.20E-03
HHP0T10DEX	Fraction of T10 Transients Which Do Not Cause an ES Signal to Occur	*	*	*	*	9.00E-01
HHP0TRBLHE	HPI Train 3B Is Left Unavailable After Test Or Maintenance	*	*	*	*	5.20E-05
HHP0TRBTRM	HPI Train 3B Is In Maintenance	*	*	*	*	2.00E-02
HHP0TRCLHE	HPI Train 3C Is Left Unavailable After Test Or Maintenance	*	*	*	*	5.20E-05
HHP0TRCTRM	HPI Train 3C Is In Maintenance	*	*	*	*	1.00E-02
HHP23RICOM	Common Cause Failure Of 2 Of 3 HPI Pumps To Run During Injection	*	*	*	*	9.57E-07
HHP23SICOM	Common Cause Failure Of 2 Of 3 HPI Pumps To Restart For Injection After LOOP	*	*	*	*	1.19E-04
HHP33P1LTF	Level Transmitter 33P1 Fails	4.55E-07	/H	24	H	1.09E-05
HHP33P2LTF	Level Transmitter 33P2 Fails	4.55E-07	/H	24	H	1.09E-05
HHP33RICOM	Common Cause Failure Of 3 Of 3 HPI Pumps To Run During Injection	*	*	*	*	5.55E-07
HHP33RRCOM	Common Cause Failure Of 3 Of 3 HPI Pumps To Run During Recirculation	*	*	*	*	6.11E-06
HHP33SICOM	Common Cause Failure Of 3 Of 3 HPI Pumps To Start	*	*	*	*	5.98E-05
HHP53FSPSO	Pressure Switch 3HP53-FS Fails To Operate On Low RCP Seal Flow	2.01E-04	/N	1	N	2.01E-04
HHP53XRRYD	Auxiliary Relay HP53XR Fails To Operate On Low RCP Seal Flow	1.11E-04	/N	1	N	1.11E-04
HHPDEMAFLF	Purification Demineralizer 3A Fails To Pass Flow	1.58E-06	/H	24	H	3.79E-05
HHPHPR0DHE	Operators Fail to Initiate High Pressure Recirculation	*	*	*	*	2.20E-03
HHPHX3AHXF	Heat Exchanger On HPI Pump 3A Clogs	1.21E-06	/H	24	H	2.90E-05
HHPHX3BHXF	Heat Exchanger On HPI Pump 3B Clogs	1.21E-06	/H	16	D	4.65E-04
HHPHX3CHXF	Heat Exchanger On HPI Pump 3C Clogs	1.21E-06	/H	46	D	1.34E-03
HHPKD17CLT	208/120 V ac Panelboard 3KD Breaker 17 Transfers Open (3HP-8)	4.62E-07	/H	24	H	1.11E-05
HHPKD18CLT	208/120 V ac Panelboard 3KD Breaker 18 Transfers Open (3HP-17)	4.62E-07	/H	24	H	1.11E-05
HHPKD19CLT	120 V ac Panelboard 3KVID Breaker 19 Transfers Open (3HP-6)	4.62E-07	/H	24	H	1.11E-05

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NAME	DESCRIPTION	RATE		FACTOR		PROB
HHPKU21CLT	120 V ac Circuit Breaker 3KU-21 Transfers Opens (ICS Cab. 7)	4.62E-07	/H	24	H	1.11E-05
HHPLDCAHXF	Letdown Cooler 3A Clogs	1.21E-06	/H	9	M	7.84E-03
HHPLDCBHXF	Letdown Cooler 3B Clogs	1.21E-06	/H	9	M	7.84E-03
HHPLDSTTKF	Letdown Storage Tank Fails	6.03E-07	/H	24	H	1.45E-05
HHPPMPSCOM	Common Cause Failure of HPI Pumps 3B and 3C to Start	*	*	*	*	8.87E-04
HHPPU3AHPR	HPI Pump 3A Fails To Run	1.47E-04	/H	24	H	3.53E-03
HHPPU3BHPR	HPI Pump 3B Fails To Run	1.47E-04	/H	24	H	3.53E-03
HHPPU3BHPS	HPI Pump 3B Fails To Start On Demand	1.18E-02	/N	1	N	1.18E-02
HHPPU3CHPR	HPI Pump 3C Fails To Run	1.47E-04	/H	24	H	3.53E-03
HHPPU3CHPS	HPI Pump 3C Fails To Start On Demand	1.18E-02	/N	1	N	1.18E-02
HHPSV90SVT	Solenoid Valve 3HPISV0090 Transfers Position	3.98E-07	/H	24	H	9.55E-06
HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	*	*	*	*	1.24E-04
HHPT10EDEX	Fraction of T10 Transients Which Cause an ES Signal to Occur	*	*	*	*	1.00E-01
HHS0017MVT	Motor Operated Valve 1HPSW-17 Transfers Position	1.04E-07	/H	0.5	M	3.74E-05
HHS0112VVT	Locked-Open Manual Valve 3HPSW-112 Transfers Closed	3.75E-08	/H	0.5	M	1.35E-05
HHS0202VVT	Locked-Open Manual Valve 3HPSW-202 Transfers Closed	3.75E-08	/H	0.5	M	1.35E-05
HHS0450VVT	Locked-Open Manual Valve HPSW-450 Transfers Closed	3.75E-08	/H	0.5	M	1.35E-05
HHS0555VVT	Manual Valve HPSW-555 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHS0556RGO	Self-Contained Regulating Valve 3HPSW-556 Fails To Open On Demand	6.66E-04	/N	1	N	6.66E-04
HHS0556RGT	Self-Contained Regulating Valve 3HPSW-556 Transfers Closed	9.27E-07	/H	24	H	2.22E-05
HHS2017MVT	Motor Operated Valve 2HPSW-17 Transfers Position	1.04E-07	/H	0.5	M	3.74E-05
HLDFLOWAMF	Alarm Instrument Fails	3.26E-06	/H	6570	H	2.14E-02
HLDFLOWDHE	Operator Fails to Check Unit Board Letdown Flow Receiver Gauge	*	*	*	*	1.00E+00
HLDISOLCHE	Operators Inadvertently Isolate Letdown	*	*	*	*	1.00E-02
HLDPATHDEX	Normal Letdown Path Ruptures	*	*	*	*	1.00E-07
HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	*	*	*	*	1.34E-04
HLDSLVLAMF	LDST Level Alarm Device Fails	3.26E-06	/H	6570	H	2.14E-02
HLDSTL1DHE	Operator Fails to Maintain LDST Level > 40 " thru Appropriate Monitoring	*	*	*	*	1.00E-03
HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	*	*	*	*	2.09E-04
HLOCALOOP	LOCA/LOOP Occurs	*	*	*	*	1.00E+00

APPENDIX C1

HPI SYSTEM ACCIDENT MITIGATION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HLP0015MVO	Motor-Operated Valve 3LP-15 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HLP0015MVT	Motor-Operated Valve 3LP-15 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HLP0016MVO	Motor-Operated Valve 3LP-16 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HLP0016MVT	Motor-Operated Valve 3LP-16 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HLP0054LHE	Manual Valve 3LP-54 Is Left Closed After Test Or Maintenance	*	*	*	*	3.20E-03
HLP0054VVT	Manual Valve 3LP-54 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HLP0055CVO	Swing Check Valve 3LP-55 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HLP0055CVT	Swing Check Valve 3LP-55 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HLP0056LHE	Manual Valve 3LP-56 Is Left Closed After Test Or Maintenance	*	*	*	*	3.20E-03
HLP0056VVT	Manual Valve 3LP-56 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HLP0057CVO	Swing Check Valve 3LP-57 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HLP0057CVT	Swing Check Valve 3LP-57 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HLPSVLVCOM	Common Cause Failure Of MOVs 3LP-15 And 3LP-16 To Open On Demand	*	*	*	*	1.24E-04
HLS0147VVT	Manual Valve 3LPSW-147 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0148CVT	Check Valve 3LPSW-148 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HLS0149VVT	Manual Valve 3LPSW-149 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0150VVT	Manual Valve 3LPSW-150 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0152VVT	Manual Valve 3LPSW-152 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0153VVT	Manual Valve 3LPSW-153 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0154VVT	Manual Valve 3LPSW-154 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0157VVT	Manual Valve 3LPSW-157 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HLS0158VVT	Manual Valve 3LPSW-158 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HLS0159VVT	Manual Valve 3LPSW-159 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HLS0162VVT	Manual Valve 3LPSW-162 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HLS0163VVT	Manual Valve 3LPSW-163 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HLS0164VVT	Manual Valve 3LPSW-164 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HLS0204ORF	Flow Orifice 3LPSW-FE-204 Clogs	2.56E-09	/H	24	H	6.14E-08
HLS0246VVT	Manual Valve 3LPSW-246 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0500VVT	Manual Valve 3LPSW-500 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0503CVT	Check Valve 3LPSW-503 Transfers Closed	1.38E-07	/H	24	H	3.31E-06

APPENDIX C1

HPI SYSTEM ACCIDENT MITIGATION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HLS0708VVT	Manual Valve 3LPSW-708 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0709VVT	Manual Valve 3LPSW-709 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0711VVT	Manual Valve 3LPSW-711 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0771VVT	Manual Valve 3LPSW-771 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HLS0C01FLF	Cuno Filter 3LPSFL0001 Clogs	1.58E-06	/H	24	H	3.79E-05
HLS0C02FLF	Cuno Filter 3LPSFL0002 Clogs	1.58E-06	/H	24	H	3.79E-05
HLS0C18FLF	Cuno Filter 3LPSFL0018 Clogs	1.58E-06	/H	24	H	3.79E-05
HLSFILTCOM	Common Cause Failure Of Cuno Filters 3LPSFL0001, 0002, And 0018	*	*	*	*	1.90E-06
HLVLST1LTM	LDST Level String 1 Is in Maintenance	*	*	*	*	1.00E-03
HLVLST2LTM	LDST Level String 2 Is in Maintenance	*	*	*	*	1.00E-03
HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	*	*	*	*	1.00E+00
HNMOPRSDHE	Operators Overcharge the LDST	*	*	*	*	1.00E+00
HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	*	*	*	*	1.00E+00
HP14LS1SMF	Signal Monitor 3HPI4-LS1 Fails	8.26E-07	/H	24	H	1.98E-05
HP14LS2SMF	Signal Monitor 3HPI14LS2 Fails	8.26E-07	/H	24	H	1.98E-05
HPI0085DEX	Instrument Root Valve (Ref. Legs Common) 3HPII0085 Transfers Closed	*	*	*	*	2.50E-05
HPI0087DEX	Instrument Root Valve (Sensing Lines Common) 3HPII0087 Transfers Closed	*	*	*	*	2.50E-05
HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	3.75E-08	/H	6570	H	2.46E-04
HPI0368DEX	Instrument Root Valve HPIIV0368 Transfers Shut	*	*	*	*	9.00E-08
HPI0368VVT	Instrument Root Valve HPIIV0368 Transfers Shut	3.75E-08	/H	6570	H	2.46E-04
HPI0369DEX	Instrument Root Valve HPIIV0369 Transfers Shut	*	*	*	*	9.00E-08
HPI0369VVT	Instrument Root Valve HPIIV0369 Transfers Shut	3.75E-08	/H	6570	H	2.46E-04
HPIFT6PFTF	Letdown Flow Transmitter HPIFT0006P Fails	1.58E-06	/H	24	H	3.86E-05
HPIFT6XCOM	Common Cause Failure of Letdown Flow Transmitters	*	*	*	*	5.29E-04
HPILT6AFTF	Letdown Flow Transmitter, HPIFT0006A, Fails	1.58E-06	/H	6570	H	1.06E-02
HPIPRS1PRM	LDST Pressure String #1 Is in Maintenance	*	*	*	*	1.00E-03
HPIPRS2PRM	LDST Pressure String #2 Is in Maintenance	*	*	*	*	1.00E-03
HPIR052DEX	Instrument Manifold Valve HPIIV0052r Transfers Position	*	*	*	*	9.00E-08
HPIR103DEX	Instrument Manifold Valve HPIIV0103r Transfers Position	*	*	*	*	9.00E-08
HPIS052VVT	Instrument Manifold Valve HPIIV0052s Transfers Position	3.75E-08	/H	24	H	9.00E-07

APPENDIX C1

HPI SYSTEM ACCIDENT MITIGATION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HPIS103VVT	Instrument Manifold Valve HPIIV0103s Transfers Position	3.75E-08	/H	24	H	9.00E-07
HPIV097VVT	Instrument Root Valve HPIIV0097 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPIV362VVT	Instrument Root Valve HPII0362 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPIV370VVT	Instrument Root Valve HPIIV0370 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPIV371VVT	Instrument Root Valve HPIIV0371 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPT0010APT	Pneumatic Pressure Transducer HPIPT0010 Fails	6.76E-06	/H	24	H	1.62E-04
HPT0228POF	HPIPT0228 24Vdc Power Supply Fails	1.72E-06	/H	24	H	4.13E-05
HPT0228PTF	Pressure Transmitter HPIPT0228 Fails	4.07E-07	/H	24	H	9.77E-06
HSEALINDEX	Pipe Rupture Fails Seal Injection	*	*	*	*	1.00E-07
LLP0028LHE	3LP-28 Left Closed Due to Human Error	*	*	*	*	2.60E-05
LLP0028VVT	Manual Valve 3LP-28 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	/N	1	N	8.15E-05
LLP0061CVT	Vacuum-Breaker Valve 3LP-61 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
LLP0BWTTKF	Borated Water Storage Tank Ruptures	6.03E-07	/H	24	H	1.45E-05
LR20A	Loss Of Cooled Water Flow From LPI Cooler 3A	*	*	*	*	2.20E-04
LR20B	Loss Of Cooled Water Flow From LPI Cooler 3B	*	*	*	*	2.20E-04
P2C3KD	Loss Of Power On 208/120 V ac Panelboard 3KD	*	*	*	*	4.40E-05
P2C3XL	Loss Of Power From 208 V ac Motor Control Center 3XL	*	*	*	*	3.00E-05
P2C3XN	Loss Of Power From 208 V ac Motor Control Center 3XN	*	*	*	*	3.00E-05
P2C3XS1	Loss Of Power From 208 V ac Motor Control Center 3XS1	*	*	*	*	3.00E-05
P2C3XS2	Loss Of Power From 208 V ac Motor Control Center 3XS2	*	*	*	*	3.00E-05
P3TC	Loss Of Power From 4160 V ac Switchgear 3TC	*	*	*	*	2.70E-05
P3TD	Loss Of Power From 4160 V ac Switchgear 3TD	*	*	*	*	2.70E-05
P3TE	Loss Of Power From 4160 V ac Switchgear 3TE	*	*	*	*	2.70E-05
P6C3XS3	Loss Of Power From 600 V ac Motor Control Center 3XS3	*	*	*	*	1.50E-05
POSTMOD	Postmod Condition	*	*	*	*	0.00E+00
PREMOD	Premod Condition	*	*	*	*	1.00E+00
PRZRCHAL	Pressurizer Level Alarm Is Challenged	*	*	*	*	1.00E+00
PRZRLVLDEX	Pressurizer Level Alarm Fails	*	*	*	*	1.00E+00
T	Transient Causes An Engineered Safeguards Actuation	*	*	*	*	1.00E+00

APPENDIX C1

HPI SYSTEM ACCIDENT MITIGATION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
W100	No Flow From Low Pressure Service Water Header 3A	*	*	*	*	3.00E-05
W200	No Flow From Low Pressure Service Water Header 3B	*	*	*	*	3.00E-05
WCW0087VVT	Manual Valve 3CCW-87 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
WH3	All High Pressure Service Water Supplies Fail	*	*	*	*	6.80E-07

APPENDIX C2

HPI SYSTEM
RC MAKE-UP AND RCP SEAL INJECTION
DATABASE

APPENDIX C2

HPI SYSTEM RC MAKE-UP AND RCP SEAL INJECTION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
AUXAIRTOP	Loss of Auxiliary Air System Pressure	*	*	*	*	4.32E-02
CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	*	*	*	*	2.00E-03
D3DIB	Loss Of Power On 125 V dc Panelboard 3DIB	*	*	*	*	5.40E-05
D3DIC	Loss Of Power On 125 V dc Panelboard 3DIC	*	*	*	*	5.40E-05
D3DID	Loss Of Power On 125 V dc Panelboard 3DID	*	*	*	*	5.40E-05
D3KI	Loss of Power on 240/120 V ac Power Panelboard 3KI	*	*	*	*	3.30E-05
D3KU	Loss of Power on 240/120 V ac Power Panelboard 3KU	*	*	*	*	3.30E-05
D3KVIB	Loss of Power on 120 V ac Power Panelboard 3KVIB	*	*	*	*	1.60E-05
D3KVIC	Loss Of Power On 120 V ac Vital I&C Power Panelboard 3KVIC	*	*	*	*	1.70E-05
DDCIC28CDT	125 V dc Panelboard 3DIC Breaker 28 Transfers Open	3.54E-07	/H	24	H	8.50E-06
H00COOLDEX	Pipe Break Fails Cooling Water Flow From LPSW and HPSW	*	*	*	*	1.00E-04
H00LDSTDEX	Pipe Rupture Fails Flow From LDST	*	*	*	*	1.00E-04
H00LDSTTKF	LDST Ruptures	6.03E-07	/H	7884	H	4.75E-03
H3GWD19AVT	Air Operated Valve 3GWD-19 Transfers Position	6.35E-07	/H	7884	H	5.01E-03
H3H0002CVL	Check Valve 3H-2 Leaks Externally	7.60E-08	/H	7884	H	5.99E-04
HAC0008C4T	4160 V ac Switchgear 3TC Breaker 8 Transfers Open (HP-P3A)	6.38E-07	/H	7884	H	5.03E-03
HAC0E09C4C	4160 V ac Switchgear 3TE Breaker 9 Fails To Close (HPI Pump 3B)	5.31E-04	/N	12	N	6.37E-03
HAC0R1ACLT	208 V ac MCC 3XS2 Breaker R1A Transfers Open (3HP-25)	4.62E-07	/H	36	H	1.66E-05
HAC0R1DCLT	208 V ac MCC 3XS1 Breaker RD1 Transfers Open (3HP-24)	4.62E-07	/H	36	H	1.66E-05
HAC0R2ACLT	208 V ac MCC 3XS1 Breaker R2A Transfers Open (3HP-26)	4.62E-07	/H	12	H	5.54E-06
HAC3TE9C4T	4160 V ac Switchgear 3TE Breaker 9 Transfers Open (HP-P3B)	6.38E-07	/H	24	H	1.53E-05
HDCIB25CDT	125 V dc Panelboard 3DIB Breaker 25 Transfers Open (3CC-8, 3HP-5)	3.54E-07	/H	7884	H	2.79E-03
HDCID05CDT	125 V dc Panelboard 3DID Breaker 5 Transfers Open (Low Seal Flow Pump 3B Start)	3.54E-07	/H	16	D	1.36E-04
HDISCHADEX	Pipe Rupture Fails Flow From HPI Pumps to 3A Cold Legs	*	*	*	*	2.30E-05
HEMERLILHE	Latent Human Error Associated with Interlock Maintenance Occurs	*	*	*	*	3.00E-03
HEMERLIMNT	LDST Emergency Low Interlock Function Is in Maintenance	*	*	*	*	1.00E-03
HEXCMAKEUP	Excessive RC Makeup Is Required	*	*	*	*	3.00E+00
HHP0001MVT	Motor-Operated Valve 3HP-1 Transfers Closed	1.04E-07	/H	7884	H	8.20E-04
HHP0002MVT	Motor Operated Valve 3HP-2 Transfers Position	1.04E-07	/H	7884	H	8.20E-04

APPENDIX C2

HPI SYSTEM RC MAKE-UP AND RCP SEAL INJECTION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0003MVT	Motor-Operated Valve 3HP-3 Transfers Closed	1.04E-07	/H	7884	H	8.20E-04
HHP0004MVT	Motor Operated Valve 3HP-4 Transfers Position	1.04E-07	/H	7884	H	8.20E-04
HHP0005AVT	Air-Operated Valve 3HP-5 Transfers Closed	6.35E-07	/H	7884	H	5.01E-03
HHP0006AVT	Air-Operated Valve 3HP-6 Transfers Closed	6.35E-07	/H	7884	H	5.01E-03
HHP0007AVT	Air-Operated Valve 3HP-7 Transfers Closed	6.35E-07	/H	7884	H	5.01E-03
HHP0008AVT	Air-Operated Valve 3HP-8 Transfers Closed	6.35E-07	/H	7884	H	5.01E-03
HHP0014MVT	Motor Operated Valve 3HP-14 Transfers Position	1.04E-07	/H	7884	H	8.20E-04
HHP0017AVT	Air-Operated Valve 3HP-17 Transfers Closed	6.35E-07	/H	7884	H	5.01E-03
HHP0023MVT	Motor-Operated Valve 3HP-23 Transfers Closed	1.04E-07	/H	7884	H	8.20E-04
HHP0024LHE	MOV 3HP-24 Suction Train Is Left Unavailable After Test Or Maintenance	*	*	*	*	3.00E-03
HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0024MVT	Motor-Operated Valve 3HP-24 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	*	*	*	*	5.00E-03
HHP0025LHE	MOV 3HP-25 Suction Train Is Left Unavailable After Test Or Maintenance	*	*	*	*	3.00E-03
HHP0025MVO	Motor-Operated Valve 3HP-25 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0025MVT	Motor-Operated Valve 3HP-25 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HHP0025TRM	MOV 3HP-25 Suction Train In Maintenance	*	*	*	*	5.00E-03
HHP0026DHE	Operators Fail to Open 3HP-26 And/Or 3HP-122	*	*	*	*	1.00E-03
HHP0026MVO	Motor-Operated Valve 3HP-26 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0028VVT	Manual Valve 3HP-28 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0031AVT	Air-Operated Valve 3HP-31 Transfers Closed	6.35E-07	/H	7884	H	5.01E-03
HHP0039VVT	Manual Valve 3HP-39 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0040VVT	Manual Valve 3HP-40 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0041VVT	Manual Valve 3HP-41 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0047CVT	Check Valve 3HP-47 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0057VVT	Manual Valve 3HP-57 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0064VVT	Manual Valve 3HP-64 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0065VVT	Manual Valve 3HP-65 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0066VVT	Manual Valve 3HP-66 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0067VVT	Manual Valve 3HP-67 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04

APPENDIX C2

HPI SYSTEM RC MAKE-UP AND RCP SEAL INJECTION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0078CVT	Check Valve 3HP-78 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0079RVT	Relief Valve 3HP-79 Spurious Operation	1.57E-06	/H	7884	H	1.24E-02
HHP0097CVT	Check Valve 3HP-97 Transfers Position	1.38E-07	/H	7884	H	1.09E-03
HHP0098MVT	Motor-Operated Valve 3HP-98 Transfers Closed	1.04E-07	/H	7884	H	8.20E-04
HHP0099VVT	Manual Valve 3HP-99 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HHP00LDORF	Letdown Line Flow Reducer Plugs	2.56E-09	/H	7884	H	2.02E-05
HHP0100VVT	Manual Valve 3HP-100 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HHP0101CVO	Tilting Disk Check Valve 3HP-101 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0101CVT	Tilting Disk Check Valve 3HP-101 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0102CVO	Tilting Disk Check Valve 3HP-102 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0102CVT	Tilting Disk Check Valve 3HP-102 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0103VVT	Manual Valve 3HP-103 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0105CVT	Check Valve 3HP-105 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0106VVT	Manual Valve 3HP-106 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0107VVT	Manual Valve 3HP-107 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HHP0109CVO	Tilting Disk Check Valve 3HP-109 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0109CVT	Tilting Disk Check Valve 3HP-109 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0110VVT	Manual Valve 3HP-110 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HHP0115MVT	Motor-Operated Valve 3HP-115 Transfers Closed	1.04E-07	/H	36	H	3.74E-06
HHP0118VVT	Manual Valve 3HP-118 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0119VVT	Manual Valve 3HP-119 Transfers Position	3.75E-08	/H	7884	H	2.96E-04
HHP0120AVT	Air Operated Valve 3HP-120 Transfers Position	6.35E-07	/H	7884	H	5.01E-03
HHP0121VVT	Manual Valve 3HP-121 Transfers Position	3.75E-08	/H	7884	H	2.96E-04
HHP0122VVO	3HP-122 Fails to Open on Demand	2.90E-04	/N	1	N	2.90E-04
HHP0126VVT	Manual Valve 3HP-126 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0127VVT	Manual Valve 3HP-127 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0128VVT	Manual Valve 3HP-128 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0129VVT	Manual Valve 3HP-129 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0130VVT	Manual Valve 3HP-130 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0131VVT	Manual Valve 3HP-131 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04

APPENDIX C2

HPI SYSTEM RC MAKE-UP AND RCP SEAL INJECTION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0138VVT	Manual Valve 3HP-138 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0139VVT	Manual Valve 3HP-139 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0144CVT	Check Valve 3HP-144 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0145CVT	Check Valve 3HP-145 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0146CVT	Check Valve 3HP-146 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0147CVT	Check Valve 3HP-147 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0191SVT	Solenoid Valve 3HPISV0191 Transfers Position, Closing 3HP-31	3.98E-07	/H	7884	H	3.14E-03
HHP0194CVT	Check Valve 3HP-194 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0195VVT	Manual Valve 3HP-195 Transfers CLosed	3.75E-08	/H	7884	H	2.96E-04
HHP0283VVT	Manual Valve 3HP-283 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0284VVT	Manual Valve 3HP-284 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0285VVT	Manual Valve 3HP-285 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0286VVT	Manual Valve 3HP-286 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0331PST	Low Instrument Air Pressure Switch 3IAPS0331 Spurious Operation	5.93E-07	/H	7884	H	4.68E-03
HHP0357PST	High Letdown Temp. Pressure Switch 3HPIPS0357 Spurious Operation	5.93E-07	/H	7884	H	4.68E-03
HHP0385VVT	Manual Valve 3HP-385 Transfers Position	3.75E-08	/H	7884	H	2.96E-04
HHP0387VVT	Manual Valve 3HP-387 Transfers Position	3.75E-08	/H	7884	H	2.96E-04
HHP0390CVT	Check Valve 3HP-390 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0393CVT	Check Valve 3HP-393 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP03A1ORF	High Pressure Injection Flow Orifice 3A1 Is Blocked	2.56E-09	/H	7884	H	2.02E-05
HHP03A2ORF	High Pressure Injection Flow Orifice 3A2 Is Blocked	2.56E-09	/H	7884	H	2.02E-05
HHP0446VVT	Manual Valve 3HP-446 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0447VVT	Manual Valve 3HP-447 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0448VVT	Manual Valve 3HP-448 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0449VVT	Manual Valve 3HP-449 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0454CVT	Check Valve 3HP-454 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0457CVT	Check Valve 3HP-457 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0477VVT	Manual Valve 3HP-477 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0482VVT	Manual Valve 3HP-482 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HHP0486CVT	Check Valve 3HP-486 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03

APPENDIX C2

HPI SYSTEM RC MAKE-UP AND RCP SEAL INJECTION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0487CVT	Check Valve 3HP-487 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HHP0LDAFLF	Letdown Filter 3A Clogs	1.61E-06	/H	7884	H	1.25E-02
HHP0SFAFLF	Reactor Coolant Pump Seal Supply Filter 3A Clogs	1.61E-06	/H	24	H	3.79E-05
HHP0SGOLHE	HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance	*	*	*	*	3.00E-03
HHP0TRBLHE	HPI Train 3B Is Left Unavailable After Test Or Maintenance	*	*	*	*	3.00E-03
HHP0TRBTRM	HPI Train 3B Is In Maintenance	*	*	*	*	2.00E-02
HHP2-2RCOM	Common Cause Run Failure of HPI Pumps 3A and 3B	*	*	*	*	7.22E-04
HHP33P1LTF	Level Transmitter Type 33P1 Fails	4.55E-07	/H	24	H	1.09E-05
HHP33P2LTF	Level Transmitter 33P2 Fails	4.55E-07	/H	24	H	1.09E-05
HHP53FSPSO	Pressure Switch 3HP53-FS Fails To Operate On Low RCP Seal Flow	2.01E-04	/N	1	N	2.01E-04
HHP53XRRYD	Auxiliary Relay HP53XR Fails To Operate On Low RCP Seal Flow	1.11E-04	/N	1	N	1.11E-04
HHPDEMAFLF	Purification Demineralizer 3A Fails To Pass Flow	1.61E-06	/H	7884	H	1.25E-02
HHPEP03PCF	Electro-Pneumatic Positioner 3HPIEP0003 Spuriously Closes 3HP-120	1.10E-07	/H	7884	H	8.67E-04
HHPHX3AHXF	Heat Exchanger On HPI Pump 3A Clogs	1.21E-06	/H	7884	H	9.54E-03
HHPHX3BHXF	Heat Exchanger On HPI Pump 3B Clogs	1.21E-06	/H	16	D	4.65E-04
HHPKD17CLT	208/120 V ac Panelboard 3KD Breaker 17 Transfers Open (3HP-8)	4.62E-07	/H	7884	H	3.64E-03
HHPKD18CLT	208/120 V ac Panelboard 3KD Breaker 18 Transfers Open (3HP-17)	4.62E-07	/H	7884	H	3.64E-03
HHPKD19CLT	120 V ac Panelboard 3KVID Breaker 19 Transfers Open (3HP-6)	4.62E-07	/H	7884	H	3.64E-03
HHPKU21CLT	120 V ac Circuit Breaker 3KU-21 Transfers Opens (ICS Cab. 7)	4.62E-07	/H	7884	H	3.64E-03
HHPLDCAHXF	Letdown Cooler 3A Clogs	1.21E-06	/H	7884	H	9.54E-03
HHPLDCBHXF	Letdown Cooler 3B Clogs	1.21E-06	/H	7884	H	9.54E-03
HHPPU3AHPR	HPI Pump 3A Fails To Run	1.47E-05	/H	7884	H	1.16E-01
HHPPU3BHPR	HPI Pump 3B Fails To Run	1.47E-05	/H	24	H	3.53E-04
HHPPU3BHPS	HPI Pump 3B Fails To Start On Demand	1.18E-03	/N	12	N	1.42E-02
HHPSV90SVT	Solenoid Valve 3HPISV0090 Transfers Position	3.98E-07	/H	7884	H	3.14E-03
HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	*	*	*	*	1.24E-04
HHPTRNBDHE	Operators Fail to Align HPI Train 3B	*	*	*	*	1.00E-02
HHS0017MVT	Motor Operated Valve 1HPSW-17 Transfers Position	1.04E-07	/H	36	H	3.74E-06
HHS0112VVT	Locked-Open Manual Valve 3HPSW-112 Transfers Closed	3.75E-08	/H	0.5	M	1.35E-05
HHS0202VVT	Locked-Open Manual Valve 3HPSW-202 Transfers Closed	3.75E-08	/H	0.5	M	1.35E-05

APPENDIX C2

HPI SYSTEM RC MAKE-UP AND RCP SEAL INJECTION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHS0450VVT	Locked-Open Manual Valve HPSW-450 Transfers Closed	3.75E-08	/H	0.5	M	1.35E-05
HHS0555VVT	Manual Valve HPSW-555 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHS0556RGO	Self-Contained Regulating Valve 3HPSW-556 Fails To Open On Demand	6.66E-04	/N	1	N	6.66E-04
HHS0556RGT	Self-Contained Regulating Valve 3HPSW-556 Transfers Closed	9.27E-07	/H	24	H	2.22E-05
HHS2017MVT	Motor Operated Valve 2HPSW-17 Transfers Position	1.04E-07	/H	36	H	3.74E-06
HLDDIVTCHE	Operators Inadvertently Divert Letdown Flow	*	*	*	*	1.00E-02
HLDFLOWAMF	Alarm Instrument Fails	3.26E-06	/H	6570	H	2.14E-02
HLDFLOWDHE	Operator Fails to Check Unit Board Letdown Flow Receiver Gauge	*	*	*	*	1.00E-02
HLDISOLCHE	Operators Inadvertently Isolate Letdown	*	*	*	*	1.00E-02
HLDPATHDEX	Normal Letdown Path Ruptures	*	*	*	*	1.00E-04
HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	*	*	*	*	1.34E-04
HLDSLVLAMF	LDST Level Alarm Device Fails	3.26E-06	/H	6570	H	2.14E-02
HLDSTL1DHE	Operator Fails to Maintain LDST Level > 40 " thru Appropriate Monitoring	*	*	*	*	1.00E-03
HLDSTLPDHE	Operator Error Causes Low Pressure Condition	*	*	*	*	1.00E-02
HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	*	*	*	*	2.09E-04
HLS0147VVT	Manual Valve 3LPSW-147 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HLS0148CVT	Check Valve 3LPSW-148 Transfers Closed	1.38E-07	/H	7884	H	1.09E-03
HLS0149VVT	Manual Valve 3LPSW-149 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HLS0150VVT	Manual Valve 3LPSW-150 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0152VVT	Manual Valve 3LPSW-152 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HLS0153VVT	Manual Valve 3LPSW-153 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HLS0154VVT	Manual Valve 3LPSW-154 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HLS0157VVT	Manual Valve 3LPSW-157 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HLS0158VVT	Manual Valve 3LPSW-158 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HLS0159VVT	Manual Valve 3LPSW-159 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HLS0204ORF	Flow Orifice 3LPSW-FE-204 Clogs	2.56E-09	/H	24	H	6.14E-08
HLS0246VVT	Manual Valve 3LPSW-246 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HLS0500VVT	Manual Valve 3LPSW-500 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HLS0503CVT	Check Valve 3LPSW-503 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HLS0708VVT	Manual Valve 3LPSW-708 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04

APPENDIX C2

HPI SYSTEM RC MAKE-UP AND RCP SEAL INJECTION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HLS0709VVT	Manual Valve 3LPSW-709 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0711VVT	Manual Valve 3LPSW-711 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
HLS0771VVT	Manual Valve 3LPSW-771 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HLS0C01FLF	Cuno Filter 3LPSFL0001 Clogs	1.61E-06	/H	7884	H	1.25E-02
HLS0C02FLF	Cuno Filter 3LPSFL0002 Clogs	1.61E-06	/H	24	H	3.79E-05
HLS0C18FLF	Cuno Filter 3LPSFL0018 Clogs	1.61E-06	/H	24	H	3.79E-05
HLSFILTCOM	Common Cause Failure Of Cuno Filters 3LPSFL0001, 0002, And 0018	*	*	*	*	1.90E-06
HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	*	*	*	*	1.00E+00
HLVLST1LTM	LDST Level String 1 Is in Maintenance	*	*	*	*	1.00E-03
HLVLST2LTM	LDST Level String 2 Is in Maintenance	*	*	*	*	1.00E-03
HMOD	Auto-Swap to BWST on Low LDST Level Mod. is INSTALLED	*	*	*	*	0.00E+00
HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	*	*	*	*	1.00E+00
HNMOPRSDHE	Operators Overcharge the LDST	*	*	*	*	1.00E+00
HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	*	*	*	*	1.00E+00
HNOMOD	Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED	*	*	*	*	1.00E+00
HOACSERDEX	OAC Is OOS	*	*	*	*	1.00E-02
HOPUNPRDHE	Inadequate Operator Guidance Regarding LDST Underpressure	*	*	*	*	1.00E-03
HP14LS1SMF	Signal Monitor 3HPI4-LS1 Fails	8.26E-07	/H	24	H	1.98E-05
HP14LS2SMF	Signal Monitor 3HPI14LS2 Fails	8.26E-07	/H	24	H	1.98E-05
HPI0085DEX	Instrument Root Valve (Ref. Legs Common) 3HPII0085 Transfers Closed	*	*	*	*	2.50E-05
HPI0087DEX	Instrument Root Valve (Sensing Lines Common) 3HPII0087 Transfers Closed	*	*	*	*	2.50E-05
HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	3.75E-08		6570		2.46E-04
HPI0368DEX	Instrument Root Valve HPIIV0368 Transfers Shut	*	*	*	*	9.00E-08
HPI0368VVT	Instrument Root Valve HPIIV0368 Transfers Shut	3.75E-08	/H	6570	H	2.46E-04
HPI0369DEX	Instrument Root Valve HPIIV0369 Transfers Shut	*	*	*	*	9.00E-08
HPI0369VVT	Instrument Root Valve HPIIV0369 Transfers Shut	3.75E-08	/H	6570	H	2.46E-04
HPIFT6PFTF	Letdown Flow Transmitter, HPIFT0006P, Fails	1.61E-06	/H	12	H	1.93E-05
HPIFT6XCOM	Common Cause Failure of Letdown Flow Transmitters	*	*	*	*	5.29E-04
HPILT6AFTF	Letdown Flow Instrument HPIFT6A Fails	1.61E-06	/H	6570	H	1.06E-02
HPIPRS1PRM	LDST Pressure String #1 Is in Maintenance	*	*	*	*	1.00E-03

APPENDIX C2

HPI SYSTEM RC MAKE-UP AND RCP SEAL INJECTION DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HPIPRS2PRM	LDST Pressure String #2 Is in Maintenance	*	*	*	*	1.00E-03
HPIPS04PSL	Pressure Switch 3HPIPS004 Fails Low	8.50E-07	/H	6570	H	5.58E-03
HPIR052DEX	Instrument Manifold Valve HPIIV0052r Transfers Position	*	*	*	*	9.00E-08
HPIR103DEX	Instrument Manifold Valve HPIIV0103r Transfers Position	*	*	*	*	9.00E-08
HPIS052VVT	Instrument Manifold Valve HPIIV0052s Transfers Position	3.75E-08	/H	24	H	9.00E-07
HPIS103VVT	Instrument Manifold Valve HPIIV0103s Transfers Position	3.75E-08	/H	24	H	9.00E-07
HPIV097VVT	Instrument Root Valve HPIIV0097 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPIV362VVT	Instrument Root Valve HPII0362 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPIV370VVT	Instrument Root Valve HPIIV0370 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPIV371VVT	Instrument Root Valve HPII0371 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPT0010APT	Pneumatic Pressure Transducer HPIPT0010 Fails	6.76E-06	/H	24	H	1.62E-04
HPT004LAMF	Alarm Module Fails to Operate on Demand	3.26E-06	/H	6570	H	2.14E-02
HPT0228POF	HPIPT0228 24Vdc Power Supply Fails	1.72E-06	/H	24	H	4.13E-05
HPT0228PTF	Pressure Transmitter HPIPT0228 Fails	4.07E-07	/H	24	H	9.77E-06
HSEALINDEX	Pipe Rupture Fails Seal Injection	*	*	*	*	1.00E-04
LLP0028LHE	3LP-28 Left Closed Due to Human Error	*	*	*	*	2.60E-05
LLP0028VVT	Manual Valve 3LP-28 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	/N	1	N	8.15E-05
LLP0061CVT	Vacuum-Breaker Valve 3LP-61 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
LLP0BWTTKF	Borated Water Storage Tank Ruptures	6.03E-07	/H	24	H	1.45E-05
P2C3KD	Loss Of Power On 208/120 V ac Panelboard 3KD	*	*	*	*	1.60E-02
P2C3XS1	Loss Of Power From 208 V ac Motor Control Center 3XS1	*	*	*	*	3.00E-05
P2C3XS2	Loss Of Power From 208 V ac Motor Control Center 3XS2	*	*	*	*	3.00E-05
P3TC	Loss Of Power From 4160 V ac Switchgear 3TC	*	*	*	*	9.80E-03
P3TE	Loss Of Power From 4160 V ac Switchgear 3TE	*	*	*	*	9.80E-03
PRZRCHAL	Pressurizer Level Alarm Is Challenged	*	*	*	*	1.00E+00
W100	No Flow From Low Pressure Service Water Header 3A	*	*	*	*	1.10E-02
W200	No Flow From Low Pressure Service Water Header 3B	*	*	*	*	1.10E-02
WCW0087VVT	Manual Valve 3CCW-87 Transfers Closed	3.75E-08	/H	7884	H	2.96E-04
WH3	All High Pressure Service Water Supplies Fail	*	*	*	*	6.80E-07

APPENDIX C3

HPI SYSTEM
AUXILIARY SPRAY DATABASE

APPENDIX C3

HPI SYSTEM AUXILIARY SPRAY DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
AUXAIRTOP	Loss of Auxiliary Air System Pressure	*	*	*	*	1.20E-04
CHPHPMUDHE	Operators Fail to Swap HPI Suction to the BWST Before LDST Depletion	*	*	*	*	2.00E-03
D3DIB	Loss Of Power On 125 V dc Panelboard 3DIB	*	*	*	*	1.50E-07
D3DIC	Loss Of Power On 125 V dc Panelboard 3DIC	*	*	*	*	1.50E-07
D3DID	Loss Of Power On 125 V dc Panelboard 3DID	*	*	*	*	1.50E-07
D3KI	Loss of Power on 240/120 V ac Power Panelboard 3KI	*	*	*	*	3.30E-05
D3KU	Loss of Power on 240/120 V ac Power Panelboard 3KU	*	*	*	*	3.30E-05
D3KVIB	Loss of Power on 120 V ac Power Panelboard 3KVIB	*	*	*	*	1.60E-05
D3KVIC	Loss of Power from 120 Vac Power Panelboard 3KVIC	*	*	*	*	1.70E-05
DDCIC28CDT	125 V dc Panelboard 3DIC Breaker 28 Transfers Open	3.54E-07	/H	24	H	8.50E-06
H00COOLDEX	Pipe Break Fails Cooling Water Flow From LPSW and HPSW	*	*	*	*	1.00E-07
H00LDSTDEX	Pipe Rupture Fails Flow From LDST	*	*	*	*	1.00E-07
H00LDSTTKF	LDST Ruptures	6.03E-07	/H	24	H	1.45E-05
H3GWD19AVT	Air Operated Valve 3GWD-19 Transfers Position	6.35E-07	/H	24	H	1.52E-05
H3H0002CVL	Check Valve 3H-2 Leaks Externally	7.60E-08	/H	24	H	1.82E-06
HAC0008C4T	4160 V ac Switchgear 3TC Breaker 8 Transfers Open (HP-P3A)	6.38E-07	/H	24	H	1.53E-05
HAC0E09C4C	4160 V ac Switchgear 3TE Breaker 9 Fails To Close (HPI Pump 3B)	5.31E-04	/N	1	N	5.31E-04
HAC0R1ACLT	208 V ac MCC 3XS2 Breaker R1A Transfers Open (3HP-25)	4.62E-07	/H	36	H	1.66E-05
HAC0R1DCLT	208 V ac MCC 3XS1 Breaker RD1 Transfers Open (3HP-24)	4.62E-07	/H	36	H	1.66E-05
HAC3TE9C4T	4160 V ac Switchgear 3TE Breaker 9 Transfers Open (HP-P3B)	6.38E-07	/H	24	H	1.53E-05
HASPRAYDEX	Aux. Spray Line Ruptures	*	*	*	*	1.00E-07
HDCIB25CDT	125 V dc Panelboard 3DIB Breaker 25 Transfers Open (3CC-8, 3HP-5)	3.54E-07	/H	24	H	8.50E-06
HDCID05CDT	125 V dc Panelboard 3DID Breaker 5 Transfers Open (Low Seal Flow Pump 3B Start)	3.54E-07	/H	16	D	1.36E-04
HEMERLILHE	Latent Human Error Associated with Interlock Maintenance Occurs	*	*	*	*	3.20E-03
HEMERLIMNT	LDST Emergency Low Interlock Function Is in Maintenance	*	*	*	*	1.00E-03
HEXCMAKEUP	Excessive RC Makeup Is Required	*	*	*	*	1.00E-02
HHP0001MVT	Motor-Operated Valve 3HP-1 Transfers Closed	1.04E-07	/H	9	M	6.74E-04
HHP0002MVT	Motor Operated Valve 3HP-2 Transfers Position	1.04E-07	/H	9	M	6.74E-04
HHP0003MVT	Motor-Operated Valve 3HP-3 Transfers Closed	1.04E-07	/H	9	M	6.74E-04

APPENDIX C3

HPI SYSTEM AUXILIARY SPRAY DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0004MVT	Motor Operated Valve 3HP-4 Transfers Position	1.04E-07	/H	9	M	6.74E-04
HHP0005AVT	Air-Operated Valve 3HP-5 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0006AVT	Air-Operated Valve 3HP-6 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0007AVT	Air-Operated Valve 3HP-7 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0008AVT	Air-Operated Valve 3HP-8 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0014MVT	Motor Operated Valve 3HP-14 Transfers Position	1.04E-07	/H	24	H	2.50E-06
HHP0017AVT	Air-Operated Valve 3HP-17 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0023MVT	Motor-Operated Valve 3HP-23 Transfers Closed	1.04E-07	/H	24	H	2.50E-06
HHP0024LHE	MOV 3HP-24 Suction Train Is Left Unavailable After Test Or Maintenance	*	*	*	*	5.20E-05
HHP0024MVO	Motor-Operated Valve 3HP-24 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0024MVT	Motor-Operated Valve 3HP-24 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HHP0024TRM	MOV 3HP-24 Suction Train In Maintenance	*	*	*	*	5.00E-03
HHP0025LHE	MOV 3HP-25 Suction Train Is Left Unavailable After Test Or Maintenance	*	*	*	*	5.20E-05
HHP0025MVO	Motor-Operated Valve 3HP-25 Fails To Open On Demand	2.47E-03	/N	1	N	2.47E-03
HHP0025MVT	Motor-Operated Valve 3HP-25 Transfers Closed After Opening	1.04E-07	/H	24	H	2.50E-06
HHP0025TRM	MOV 3HP-25 Suction Train In Maintenance	*	*	*	*	5.00E-03
HHP0039VVT	Manual Valve 3HP-39 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0040VVT	Manual Valve 3HP-40 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0041VVT	Manual Valve 3HP-41 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0047CVT	Check Valve 3HP-47 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0057VVT	Manual Valve 3HP-57 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0078CVT	Check Valve 3HP-78 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0079RVT	Relief Valve 3HP-79 Spurious Operation	1.57E-06	/H	24	H	3.77E-05
HHP0097CVT	Check Valve 3HP-97 Transfers Position	1.38E-07	/H	24	H	3.31E-06
HHP0098MVT	Motor-Operated Valve 3HP-98 Transfers Closed	1.04E-07	/H	24	H	2.50E-06
HHP0099VVT	Manual Valve 3HP-99 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HHP00LDORF	Letdown Line Flow Reducer Plugs	2.56E-09	/H	24	H	6.14E-08
HHP0100VVT	Manual Valve 3HP-100 Transfers Closed	3.75E-08	/H	46	D	4.14E-05
HHP0101CVO	Tilting Disk Check Valve 3HP-101 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0101CVT	Tilting Disk Check Valve 3HP-101 Transfers Closed	1.38E-07	/H	24	H	3.31E-06

APPENDIX C3

HPI SYSTEM AUXILIARY SPRAY DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP0102CVO	Tilting Disk Check Valve 3HP-102 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0102CVT	Tilting Disk Check Valve 3HP-102 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0103VVT	Manual Valve 3HP-103 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0105CVT	Check Valve 3HP-105 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0106VVT	Manual Valve 3HP-106 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0107VVT	Manual Valve 3HP-107 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HHP0109CVO	Tilting Disk Check Valve 3HP-109 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0109CVT	Tilting Disk Check Valve 3HP-109 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0110VVT	Manual Valve 3HP-110 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HHP0115MVT	Motor-Operated Valve 3HP-115 Transfers Closed	1.04E-07	/H	24	H	2.50E-06
HHP0118VVT	Manual Valve 3HP-118 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0195VVT	Manual Valve 3HP-195 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HHP0234VVT	Manual Valve 3HP-234 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHP0236VVT	Manual Valve 3HP-236 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHP0253CVO	Check Valve 3HP-253 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0253CVT	Check Valve 3HP-253 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0331PST	Low Instrument Air Pressure Switch 3IAPS0331 Spurious Operation	5.93E-07	/H	24	H	1.42E-05
HHP0340VVT	Manual Valve 3HP-340 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHP0355AVO	Air Operated Valve 3HP-355 Fails To Open On Demand	1.40E-03	/N	1	N	1.40E-03
HHP0355AVT	Air Operated Valve 3HP-355 Transfers Closed	6.35E-07	/H	24	H	1.52E-05
HHP0357PST	High Letdown Temp. Pressure Switch 3HPIPS0357 Spurious Operation	5.93E-07	/H	24	H	1.42E-05
HHP0419CVO	Check Valve 3HP-419 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
HHP0419CVT	Check Valve 3HP-419 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HHP0472DHE	Operators Fail to Align Aux. Pressurizer Spray by Opening 3HP-472	*	*	*	*	1.00E-02
HHP0LDAFLF	Letdown Filter 3A Clogs	1.58E-06	/H	24	H	3.79E-05
HHP0PZRORF	Aux. Spray Block Orifice Is Plugged	2.56E-09	/H	24	H	6.14E-08
HHP0SGOLHE	HPI Suction Crosstie Is Left Unavailable After Test Or Maintenance	*	*	*	*	3.20E-03
HHP0TRBLHE	HPI Train 3B Is Left Unavailable After Test Or Maintenance	*	*	*	*	5.20E-05
HHP0TRBTRM	HPI Train 3B Is In Maintenance	*	*	*	*	2.00E-02
HHP2-2RCOM	Common Cause Run Failure of HPI Pumps 3A and 3B	*	*	*	*	2.20E-06

APPENDIX C3

HPI SYSTEM AUXILIARY SPRAY DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HHP33P1LTF	Level Transmitter 33P1 Fails	4.55E-07	/H	24	H	1.09E-05
HHP33P2LTF	Level Transmitter 33P2 Fails	4.55E-07	/H	24	H	1.09E-05
HHP53FSPSO	Pressure Switch 3HP53-FS Fails To Operate On Low RCP Seal Flow	2.01E-04	/N	1	N	2.01E-04
HHP53XRRYD	Auxiliary Relay HP53XR Fails To Operate On Low RCP Seal Flow	1.11E-04	/N	1	N	1.11E-04
HHPDEMAFLF	Purification Demineralizer 3A Fails To Pass Flow	1.58E-06	/H	24	H	3.79E-05
HHPHX3AHXF	Heat Exchanger On HPI Pump 3A Clogs	1.21E-06	/H	24	H	2.90E-05
HHPHX3BHXF	Heat Exchanger On HPI Pump 3B Clogs	1.21E-06	/H	16	D	4.65E-04
HHPKD17CLT	208/120 V ac Panelboard 3KD Breaker 17 Transfers Open (3HP-8)	4.62E-07	/H	24	H	1.11E-05
HHPKD18CLT	208/120 V ac Panelboard 3KD Breaker 18 Transfers Open (3HP-17)	4.62E-07	/H	24	H	1.11E-05
HHPKD19CLT	120 V ac Panelboard 3KVID Breaker 19 Transfers Open (3HP-6)	4.62E-07	/H	24	H	1.11E-05
HHPKU21CLT	120 V ac Circuit Breaker 3KU-21 Transfers Opens (ICS Cab. 7)	4.62E-07	/H	24	H	1.11E-05
HHPLDCAHXF	Letdown Cooler 3A Clogs	1.21E-06	/H	9	M	7.84E-03
HHPLDCBHXF	Letdown Cooler 3B Clogs	1.21E-06	/H	9	M	7.84E-03
HHPML64PCF	Manual Loader 3HPIML0064 Spuriously Closes 3HP-355	1.10E-07	/H	24	H	2.64E-06
HHPPU3AHPR	HPI Pump 3A Fails To Run	1.47E-05	/H	24	H	3.53E-04
HHPPU3BHPR	HPI Pump 3B Fails To Run	1.47E-05	/H	24	H	3.53E-04
HHPPU3BHPS	HPI Pump 3B Fails To Start On Demand	1.18E-03	/N	1	N	1.18E-03
HHPSV90SVT	Solenoid Valve 3HPISV0090 Transfers Position	3.98E-07	/H	24	H	9.55E-06
HHPSVLVCOM	Common Cause Failure Of MOVs 3HP-24 And 3HP-25 To Open On Demand	*	*	*	*	1.24E-04
HHPTRNBDHE	Operators Fail to Align HPI Train 3B	*	*	*	*	1.00E-02
HHS0017MVT	Motor Operated Valve 1HPSW-17 Transfers Position	1.04E-07	/H	0.5	M	3.74E-05
HHS0112VVT	Locked-Open Manual Valve 3HPSW-112 Transfers Closed	3.75E-08	/H	0.5	M	1.35E-05
HHS0202VVT	Locked-Open Manual Valve 3HPSW-202 Transfers Closed	3.75E-08	/H	0.5	M	1.35E-05
HHS0450VVT	Locked-Open Manual Valve HPSW-450 Transfers Closed	3.75E-08	/H	0.5	M	1.35E-05
HHS0555VVT	Manual Valve HPSW-555 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HHS0556RGO	Self-Contained Regulating Valve 3HPSW-556 Fails To Open On Demand	6.66E-04	/N	1	N	6.66E-04
HHS0556RGT	Self-Contained Regulating Valve 3HPSW-556 Transfers Closed	9.27E-07	/H	24	H	2.22E-05
HHS2017MVT	Motor Operated Valve 2HPSW-17 Transfers Position	1.04E-07	/H	0.5	M	3.74E-05
HLDDIVTCHE	Operators Inadvertently Divert Letdown Flow	*	*	*	*	1.00E-03
HLDFLOWAMF	Alarm Instrument Fails	3.26E-06	/H	6570	H	2.14E-02

APPENDIX C3

HPI SYSTEM AUXILIARY SPRAY DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HLDFLOWDHE	Operator Fails to Check Unit Board Letdown Flow Receiver Gauge	*	*	*	*	1.00E+00
HLDISOLCHE	Operators Inadvertently Isolate Letdown	*	*	*	*	1.00E-02
HLDPATHDEX	Normal Letdown Path Ruptures	*	*	*	*	1.00E-07
HLDPXTRCOM	Common Cause Failure of LDST Pressure Transmitters	*	*	*	*	3.80E-07
HLDSLVLAMF	LDST Level Alarm Device Fails	3.26E-06	/H	6570	H	2.14E-02
HLDSTL1DHE	Operator Fails to Maintain LDST Level > 40 " thru Appropriate Monitoring	*	*	*	*	1.00E-03
HLDSTLPDHE	Operator Error Causes Low Pressure Condition	*	*	*	*	1.00E-03
HLDXMTRCOM	Common Cause Failure of LDST Level Transmitters	*	*	*	*	7.60E-07
HLP0046CVT	Check Valve 3LP-46 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HLP0131CVT	Check Valve 3LP-131 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HLS0147VVT	Manual Valve 3LPSW-147 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0148CVT	Check Valve 3LPSW-148 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HLS0149VVT	Manual Valve 3LPSW-149 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0150VVT	Manual Valve 3LPSW-150 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0152VVT	Manual Valve 3LPSW-152 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0153VVT	Manual Valve 3LPSW-153 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0154VVT	Manual Valve 3LPSW-154 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0157VVT	Manual Valve 3LPSW-157 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HLS0158VVT	Manual Valve 3LPSW-158 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HLS0159VVT	Manual Valve 3LPSW-159 Transfers Closed	3.75E-08	/H	16	D	1.44E-05
HLS0204ORF	Flow Orifice 3LPSW-FE-204 Clogs	2.56E-09	/H	24	H	6.14E-08
HLS0246VVT	Manual Valve 3LPSW-246 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0500VVT	Manual Valve 3LPSW-500 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0503CVT	Check Valve 3LPSW-503 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
HLS0708VVT	Manual Valve 3LPSW-708 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0709VVT	Manual Valve 3LPSW-709 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0711VVT	Manual Valve 3LPSW-711 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
HLS0771VVT	Manual Valve 3LPSW-771 Transfers Closed	3.75E-08	/H	9	M	2.43E-04
HLS0C01FLF	Cuno Filter 3LPSFL0001 Clogs	1.58E-06	/H	24	H	3.79E-05
HLS0C02FLF	Cuno Filter 3LPSFL0002 Clogs	1.58E-06	/H	24	H	3.79E-05

APPENDIX C3

HPI SYSTEM AUXILIARY SPRAY DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HLS0C18FLF	Cuno Filter 3LPSFL0018 Clogs	1.58E-06	/H	24	H	3.79E-05
HLSFILTCOM	Common Cause Failure Of Cuno Filters 3LPSFL0001, 0002, And 0018	*	*	*	*	1.90E-06
HLVLDRPDEX	Level Change or Other Operational Condition Causes Pressure to Drop	*	*	*	*	1.00E+00
HLVLST1LTM	LDST Level String 1 Is in Maintenance	*	*	*	*	1.00E-03
HLVLST2LTM	LDST Level String 2 Is in Maintenance	*	*	*	*	1.00E-03
HMOD	Auto-Swap to BWST on Low LDST Level Mod. is INSTALLED	*	*	*	*	0.00E+00
HNMOPLVDHE	Operators Fail to Recognize Level Instrument Failure	*	*	*	*	1.00E+00
HNMOPRSDHE	Operators Overcharge the LDST	*	*	*	*	1.00E+00
HNMOPRSLHE	Operators Fail to Recognize Pressure Instrument Failure	*	*	*	*	1.00E+00
HNOMOD	Auto-Swap to BWST on Low LDST Level Mod. is NOT INSTALLED	*	*	*	*	1.00E+00
HOACSERDEX	OAC Is OOS	*	*	*	*	1.00E-02
HOPUNPRDHE	Inadequate Operator Guidance Regarding LDST Underpressure	*	*	*	*	1.00E-03
HP14LS1SMF	Signal Monitor 3HPI4-LS1 Fails	8.26E-07	/H	24	H	1.98E-05
HP14LS2SMF	Signal Monitor 3HPI14LS2 Fails	8.26E-07	/H	24	H	1.98E-05
HPI0085DEX	Instrument Root Valve (Ref. Legs Common) 3HPII0085 Transfers Closed	*	*	*	*	9.00E-08
HPI0087DEX	Instrument Root Valve (Sensing Lines Common) 3HPII0087 Transfers Closed	*	*	*	*	9.00E-08
HPI0095VVT	Instrument Root valve HPIIV0095 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPI0368DEX	Instrument Root Valve HPIIV0368 Transfers Shut	*	*	*	*	9.00E-08
HPI0368VVT	Instrument Root Valve HPIIV0368 Transfers Shut	3.75E-08	/H	6570	H	2.46E-04
HPI0369DEX	Instrument Root Valve HPIIV0369 Transfers Shut	*	*	*	*	9.00E-08
HPI0369VVT	Instrument Root Valve HPIIV0369 Transfers Shut	3.75E-08	/H	6570	H	2.46E-04
HPIFT6PFTF	Letdown Flow Transmitter HPIFT0006P Fails	1.58E-06	/H	24	H	3.86E-05
HPIFT6XCOM	Common Cause Failure of Letdown Flow Transmitters	*	*	*	*	5.29E-04
HPILT6AFTF	Letdown Flow Transmitter, HPIFT0006A, Fails	1.58E-06	/H	6570	H	1.06E-02
HPIPRS1PRM	LDST Pressure String #1 Is in Maintenance	*	*	*	*	1.00E-03
HPIPRS2PRM	LDST Pressure String #2 Is in Maintenance	*	*	*	*	1.00E-03
HPIPS04PSL	Pressure Switch 3HPIPS004 Fails Low	8.50E-07	/H	6570	H	5.58E-03
HPIR052DEX	Instrument Manifold Valve HPIIV0052r Transfers Position	*	*	*	*	9.00E-08
HPIR103DEX	Instrument Manifold Valve HPIIV0103r Transfers Position	*	*	*	*	9.00E-08
HPIS052VVT	Instrument Manifold Valve HPIIV0052s Transfers Position	3.75E-08	/H	24	H	9.00E-07

APPENDIX C3

HPI SYSTEM AUXILIARY SPRAY DATABASE

NAME	DESCRIPTION	RATE		FACTOR		PROB
HPIS103VVT	Instrument Manifold Valve HPIIV0103s Transfers Position	3.75E-08	/H	24	H	9.00E-07
HPIV097VVT	Instrument Root Valve HPIIV0097 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPIV362VVT	Instrument Root Valve HPII0362 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPIV370VVT	Instrument Root Valve HPIIV0370 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPIV371VVT	Instrument Root Valve HPIIV0371 Transfers Shut	3.75E-08	/H	24	H	9.00E-07
HPT0010APT	Pneumatic Pressure Transducer HPIPT0010 Fails	6.76E-06	/H	24	H	1.62E-04
HPT004LAMF	Alarm Module Fails to Operate on Demand	3.26E-06	/H	6570	H	2.14E-02
HPT0228POF	HPIPT0228 24Vdc Power Supply Fails	1.72E-06	/H	24	H	4.13E-05
HPT0228PTF	Pressure Transmitter HPIPT0228 Fails	4.07E-07	/H	24	H	9.77E-06
LLP0028LHE	3LP-28 Left Closed Due to Human Error	*	*	*	*	2.60E-05
LLP0028VVT	Manual Valve 3LP-28 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
LLP0061CVO	Vacuum-Breaker Valve 3LP-61 Fails to Open	8.15E-05	/N	1	N	8.15E-05
LLP0061CVT	Vacuum-Breaker Valve 3LP-61 Transfers Closed	1.38E-07	/H	24	H	3.31E-06
LLP0BWTTKF	Borated Water Storage Tank Ruptures	6.03E-07	/H	24	H	1.45E-05
P2C3KD	Loss Of Power On 208/120 V ac Panelboard 3KD	*	*	*	*	4.40E-05
P2C3XS1	Loss Of Power From 208 V ac Motor Control Center 3XS1	*	*	*	*	3.00E-05
P2C3XS2	Loss Of Power From 208 V ac Motor Control Center 3XS2	*	*	*	*	3.00E-05
P3TC	Loss Of Power From 4160 V ac Switchgear 3TC	*	*	*	*	2.70E-05
P3TE	Loss Of Power From 4160 V ac Switchgear 3TE	*	*	*	*	2.70E-05
PRZRCHAL	Pressurizer Level Alarm Is Challenged	*	*	*	*	1.00E+00
PRZRLVLDEX	Pressurizer Level Alarm Fails	*	*	*	*	1.00E+00
RLP0046CVO	Check Valve 3LP-46 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
RLP0131CVO	Check Valve 3LP-131 Fails To Open On Demand	8.15E-05	/N	1	N	8.15E-05
W100	No Flow From Low Pressure Service Water Header 3A	*	*	*	*	3.00E-05
W200	No Flow From Low Pressure Service Water Header 3B	*	*	*	*	3.00E-05
WCW0087VVT	Manual Valve 3CCW-87 Transfers Closed	3.75E-08	/H	24	H	9.00E-07
WH3	All High Pressure Service Water Supplies Fail	*	*	*	*	6.80E-07