Westinghouse Non-Proprietary Class 3

WCAP-14732
Revision 1

Probabilistic Analysis of Reduction in Turbine Valve Test Frequency for Nuclear Plants with Westinghouse BB-296 Turbines with Steam Chests

Westinghouse Energy Systems

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Probabilistic Analysis of Reduction in Turbine Valve Test Frequency for Nuclear Plants with Westinghouse BB-296 Turbines with Steam Chests

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June 1997

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ABSTRACT

The objective of this program is to provide the probabilistic justification for extending the test intervals of the turbine governor valves and throttle valves. This program applies to nuclear power plants with Westinghouse BB-296 turbines with steam chests. Increasing the valve test interval increases the calculated valve failure probability, which is a major contributor to the probability of turbine overspeed. The annual frequency of missile ejection due to turbine overspeed is examined and compared to acceptance criterion from the U.S. Nuclear Regulatory Commission.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge J.D. Campbell, R.G. Thompson, D.A. Drnach, and J. R. McCracken for their guidance and contributions to this project.

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1 INTRODUCTION

Historically, Westinghouse has recommended that turbine valves be tested at periodic intervals. For some plants the technical specifications require weekly testing, for others monthly testing, and for others no technical specification requirement exists. Periodic valve testing requires a temporary power reduction that results in lost electrical generation. In addition, inadvertent reactor trip can become more likely during the transient power reduction and increase.

In recognition of the effects of turbine valve testing on plant equipment and electrical power generation, a Westinghouse Owners Group mini group was established to perform an evaluation of turbine valve test frequency (TVTF) for nuclear power plants with Westinghouse BB-296 turbines. Several early BB-296 units were built without the steam chest design, using BB-95/96 turbine valves. These units are not part of the BB-296 steam chest mini group.

This report contains the results of extending the test interval of turbine valves on the annual probability of turbine missile ejection due to overspeed, using BB-296 turbine throttle and governor valve failure rates and system separation frequency. The turbine missile ejection frequencies for varying valve test intervals presented in this report were calculated following the applied basic methodology described in the 1987 Westinghouse report WCAP-11525, "Probabilistic Evaluation of Reduction in Turbine Valve Test Frequency" (Reference 1).

After publishing WCAP-11525, several incidents of sticking of governor and throttle valves in Westinghouse BB-296 steam chests in late 1987 and in 1988 resulted in the determination that the turbine valve failure rates used in WCAP-11525 for BB-296 steam chests were no longer valid. The failure rates for BB-296 steam chests were recalculated in 1988 and the resultant probabilities of turbine destructive overspeed were sent to all operating plants with BB-296 steam chests in Westinghouse Operations and Maintenance Memo 093 (OMM-093, Reference 2). Included in this report are revised failure rates for BB-296 steam chest valves for the operating years since the 1988 study. Six years, 1990-1995, have been used for data collection. Using the most recent six years takes credit for improvements in design and maintenance while retaining adequate time for rare events to occur. The methodology for revising BB-296 steam chest valve failure rates is consistent with the methodology presented in OMM-093 and WCAP-11525.

The methodology developed to calculate the probability of missile ejection due to overspeed events applied in WCAP-11525 is employed in this study. WCAP-11525, Section 5.2, identifies three turbine overspeed events that can result from the failure of turbine valves to close following a system separation or a total loss of load. These overspeed events are design overspeed (approximately 120% of rated turbine speed), intermediate overspeed (approximately 130%), and destructive overspeed (runaway speed in excess of approximately

180%). Design overspeed is assumed when a system separation occurs and a turbine trip does not occur at event initiation, one or more governor valves or two or more reheat interceptor valves fail to close immediately, and a successful overspeed trip closes the throttle valves and the reheat stop valves. Intermediate overspeed is assumed to occur when there is a system separation and one or more alignments of reheat stop valves and reheat interceptor valves fail to close. Destructive overspeed is assumed to occur when a system separation occurs and at least one governor valve and one throttle valve in the same steam chest fail to close.

The missile ejection frequency results in WCAP-11525, for BB-296 steam chests, indicate that the design and intermediate overspeed failure probabilities are not major contributors to turbine missile ejection probability for plants with fully integral or heavy disc keyplate low pressure rotors. Therefore, this study focuses on calculating the probability of destructive overspeed. Generic values for the probability of design and intermediate overspeed are based upon the results for BB-296 steam chest models presented in WCAP-11525. Vandellos 2 has light disc keyway low-pressure rotors. Design and intermediate overspeed probabilities for Vandellos 2 are presented in Appendix C.

The analyses reported herein were authorized by the following utilities and are specific to the turbines and valves at their respective nuclear plant sites as indicated in Table 1-1.

Table 1-1 WOG BB-296 TVTF Mini Group Members

Utility	Plant
Asociacion Nuclear ASCO	ASCO Units 1 & 2
Baltimore Electric & Gas	Calvert Cliffs Unit 2
Central Nuclear de Almaraz	Almaraz Units 1 & 2
Central Nuclear Vandellos II	Vandellos 2
Commonwealth Edison	Byron Units 1 & 2 Braidwood Units 1 & 2
Duke Power	McGuire Units 1 & 2
Virginia Power	North Anna Units 1 & 2
Washington Public Power Supply System	Washington Nuclear Plant 2

This report provides a description of the analysis and data used for WOG BB-296 mini group. Throughout the report, references are made to the detailed information in WCAP-11525. The methodology described in WCAP-11525 was reviewed and approved by the NRC (Reference 3).

2 REVIEW OF PLANT-SPECIFIC TURBINE INFORMATION

Sections 4 and 5 of WCAP-11525 describe in detail turbine valves, control systems, and turbine classifications for overspeed analysis. The information in Sections 4 and 5 was compared to plant specific information supplied by BB-296 mini group members to select the appropriate plant variation category and fault tree model.

As illustrated and discussed in WCAP-11525, the BB-296 unit has two steam chests, one on each side of the high pressure turbine. In each steam chest there are two throttle valves with two governor valves downstream. All plants in the BB-296 TVTF mini group have this steam chest valve arrangement. WCAP-11525 also discusses two types of overspeed control and trip systems: the 300 psi system and variations of the Electrohydraulic (EH) control system. All plants in the BB-296 TVTF mini group have the EH control system design.

The EH control system has several orders of overspeed and trip redundancy and diversity. There are two overspeed protection control solenoid dump valves (20-1 OPC and 20-2 OPC), either of which will dump the control emergency trip fluid (ETF) line on overspeed, closing the interceptor valves and the governor valves. The control oil system has a mechanical overspeed trip valve and a 20-AST solenoid valve, either of which dumps the autostop oil and initiates a turbine trip at overspeed conditions. The dump of the autostop oil opens an oil-operated interface valve and a 20/ET solenoid valve, either of which dumps the governor and throttle valve emergency trip fluid.

WCAP-11525 uses a variation number to classify plants according to inlet valve arrangement and control and trip system type. The classification of the BB-296 mini group plants by variation number from WCAP-11525 is given in Table 2-1. All plants in the mini group are either Variation 7 or 8.

Differences between Variation 7 and 8 concern the electrical overspeed trip mechanisms. Variation 7 contains an electrical trip mechanism consisting of a solenoid and plunger valve (20AST-1) that will activate with system separation due to a generator trip signal. The plunger valve drains the autostop oil which causes the interface valves to open and the turbine valves to close. Throttle, governor, reheat stop, and reheat interceptor valves close on this signal. On BB-296 steam chests, the solenoid valve is also activated by an overspeed signal of approximately 111 percent. Some plants include, for backup, an additional autostop oil solenoid dump valve (20AST-2) which is redundant to 20AST-1. Instead of a one or two valve 20-AST system, Variation 8 has an electrical trip system consisting of four 20/AST solenoid dump valves. The opening of two of the four solenoid valves results in draining of the emergency trip headers and the closure of the turbine valves.

Table 2-1 BB-296 TVTF Mini Group Design Variation

Plant	Variation
Almaraz Units 1 & 2	7
ASCO Units 1 & 2	7
Braidwood Units 1 and 2	7
Byron Units 1 and 2	7
Calvert Cliffs Unit 2	7
McGuire Units 1 and 2	7
North Anna Units 1 and 2	7
Washington Nuclear Plant 2	7
Vandellos 2	8[1]

(1) Vandellos 2 is similar to Variation 8, but has three low-pressure turbines with a total of six reheat stop valves and six interceptor valves.

For plants in the mini group, variations exist in the number of reheat stop and interceptor valves. Some plants have four reheat stop valves and four interceptor valves leading to two low pressure (LP) turbines. Other plants have six reheat stop valves and six interceptor valves leading to three low pressure turbines. Variations in the number of reheat stop and interceptor valves affect the analysis for the design and intermediate overspeed events. Section 4 discusses the treatment of design and intermediate overspeed events. The E. H. Fluid System & Lube Diagrams for the plants in the mini group are in Appendix A.

3 REVISION OF BB-296 TURBINE VALVE FAILURE RATES

BB-296 failure rates for governor and throttle valves were updated using the most recent valve failure and operating data. The data base contains governor valve and throttle valve data for operating nuclear plants with Westinghouse BB-296 turbines with steam chests. The determination of the failure rates for governor and throttle valves was based upon the methodology used in WCAP-11525 and OMM-93.

Data for the failure of throttle and governor valves to close has been collected by Westinghouse. The plant specific data used in this program was reviewed by the utilities in the mini group for accuracy and completeness. The collection period includes the time from January 1, 1990 through December 31, 1995. This time period provides failure rates based on current valve design and maintenance practices while retaining adequate time for rare events to occur. The data indicates [ ]$^{+a,c}$ failures in 4,266,679 operating hours.

The governor valve failure rate is calculated as [ ]$^{+a,c}$ failures per hour. [ ]$^{+a,c}$

[ ]$^{+a,c}$ The throttle valve failure rate is then [ ]$^{+a,c}$ failures per hour. This calculation is also equivalent to the result obtained by using Bayesian statistical methods, [ ]$^{+a,c}$

There is a known condition of potential thermal binding of BB-296 throttle valves during presynchronization valve testing. The factors common to all binding incidents are described in CAL 87-03, titled "BB296 Throttle Valves," dated August 24, 1987. The recommendations to minimize the potential for binding are listed in OMM 091, titled "Maintenance of BB296/0296 Throttle Valves," dated November 18, 1988, so past thermal binding failures are not included as random failures to close on demand. Users of this study are cautioned to follow the recommendations in the documents listed above to minimize the potential for binding of the throttle valves.

Failure rates for other components modeled in the fault trees are the same as those in WCAP-11525, Section 7, with the exception of the failure rates for the 20/ET and 20/OPC solenoid valves. The solenoid valve model incorporates additional common cause failures of the EH trip system 20/ET and 20/OPC solenoid valves compared to the model in WCAP-11525. The revised modeling resulted from a review of overspeed events that occurred at the Salem and St. Lucie stations in 1991 and 1992. Revised solenoid valve failure rates have also been incorporated into the model. A maximum solenoid failure rate of 1.0E-5 per hour was selected from NUREG/CR-2815 (Reference 7). This is approximately 25 times greater than the failure rate used in WCAP-11525. The solenoid valve failure rates used in the revised model are summarized in Table 3-1.

Table 3-1 Solenoid Valve Failure Rates

Failure Mode	Failure Rate (per hour)
20-1/OPC solenoid valve fails to open (random)	1.0E-5
20-2/OPC solenoid valve fails to open (random)	1.0E-5
20/ET solenoid valve fails to open (random)	1.0E-5
20-1/OPC & 20-2/OPC SOVs fail due to common cause	2.0E-6
20-1/OPC & 20/ET SOVs fail due to common cause	2.0E-6
20-2/OPC & 20/ET SOVs fail due to common cause	2.0E-6
20-1/OPC, 20-2/OPC and 20/ET SOVs fail due to common cause	2.0E-6

4 REVIEW OF DESIGN AND INTERMEDIATE OVERSPEED MISSILE EJECTION PROBABILITIES

Probabilities of turbine missile ejection at design and intermediate overspeed are not explicitly calculated for this study. All plants examined in the mini group have reheat stop and interceptor valves, and design and intermediate overspeeds are 120 and 130 percent of rated speed, respectively.

Missile ejection at design or intermediate overspeed can only occur if a crack of sufficient size is present in the LP rotor discs. The fully integral rotor construction greatly reduces the chance of formation of stress corrosion cracks that can lead to turbine missiles. This results in design and intermediate overspeed probabilities of less than [ ]$^{+a,c}$, even with inspection intervals up to 30 years of operation (Reference 4). Typically, plants in the mini group with shrunk-on discs (heavy disc keyplates) perform periodic inspections of the LP rotor discs using ultrasonic methods at 5 year intervals, or in accordance with Westinghouse recommendations. These inspections detect and monitor crack growth, if any, and eliminate the possibility of operation with a disc crack of critical or near-critical size. The inspection and monitoring of cracks assures that the probability of missile ejection at design and intermediate overspeed is sufficiently small for turbines with shrunk-on discs that the impacts of these events are small in comparison to the impact of destructive overspeed. Note that Almaraz Units 1 and 2 have replaced their low pressure rotors. An evaluation by Siemens has concluded that the probability for missile generation of the new rotors is bounded by that for the Westinghouse rotors. Therefore, the calculation of the annual probability of destructive overspeed provides a good estimate of the total annual probability of turbine missile ejection. An allowance for the turbine overspeed missile ejection probability for design and intermediate overspeed is based upon the BB-296 steam chest models in WCAP-11525 for heavy disk and keyplate LP rotors. The allowance is discussed further in Section 7. Vandellos 2 has three light disc keyway low-pressure rotors which are addressed in Appendix C.

5 QUANTIFICATION OF DESTRUCTIVE OVERSPEED

The destructive overspeed model, developed in WCAP-11525, assumes that upon a loss of load or system separation, failure to isolate one of the four steam paths to the high pressure turbine is sufficient to cause the destructive overspeed event. Given that destructive overspeed occurs, all LP rotor types, including fully integrated rotors, are assumed to experience ductile failure of at least one disc, or disc section and ejection of a turbine missile through the turbine casing.

The St. Lucie EH and control oil diagrams were the basis for developing the destructive overspeed fault tree for Variation 7 in WCAP-11525. Updates to the EH fluid system dump logic and overspeed protection control solenoid valve (OPC) common cause modeling have been made. These updates are included in the destructive overspeed fault trees used in this study. In addition, the basic event that represents the frequency of system separation was removed from the fault tree. System separation frequency is applied as described in Section 7.

Analogous to Variation 7, the Shearon Harris EH and control oil diagrams were the basis for developing the destructive overspeed fault tree for variation 8 in WCAP-11525. The Variation 8 destructive overspeed fault tree from WCAP-11525 is used in this study with changes made to the fault tree logic to model valve closure on the dump of EH fluid through the drain path from the valves to the top of the cylinder. In addition, the basic event that represents the frequency of system separation was removed from the fault tree. System separation frequency is applied as described in Section 7.

The following items apply to destructive overspeed fault tree quantification:

- Destructive overspeed occurs when one governor valve and one throttle valve in the same steam chest fail to close after a system separation.

- All destructive overspeed probability results are calculated for BB-296 turbines with two throttle valves and two governor valves per steam chest, with two steam chests per turbine, and an EH control system.

- Calculations were performed for turbine valve test intervals of 1 week, 1 month, 3 months, 6 months, and 12 months.

- The failure probability for the governor and throttle valves is time-related and is the fraction of time that the component is in a failed state. As discussed in WCAP-11525 Section 7.3, the unavailability is determined using the following formula:

unavailability = $0.5\lambda t$
where λ = failure rate in failures per hour
t = time interval between tests in hours

The occurrence of component failures in time is assumed to be random, therefore, it is modeled by a constant failure rate λ. Because λ is constant, the average or expected downtime of the component is one-half of the time interval, thus the coefficient of 0.5 in the unavailability formula.

- Destructive overspeed probabilities are presented as conditional probabilities given that system separation occurs.

- For components in the destructive overspeed fault tree which are assumed to be tested once every refueling outage, a 24 month refueling cycle was assumed. This conservatively bounds shorter refueling cycles.

Probabilities of destructive overspeed, given a system separation has occurred, are presented in Table 5-1. The results are presented for various turbine valve test intervals.

[ ]$^{+a,c}$

Table 5-1 Conditional Probability of Destructive Overspeed

Typical destructive overspeed probabilities for test intervals of one to three months range from [ ]$^{+a,c}$. Note that because the LP rotor is assumed to eject a missile through the turbine casing when destructive overspeed is reached, the conditional destructive overspeed probabilities in Table 5-1 are also the conditional turbine missile ejection probabilities due to destructive overspeed. The destructive overspeed fault trees used to quantify the overspeed probabilities are in Appendix B.

Quantification results indicate the governor valve failures are the dominant contributors to destructive overspeed probability and that in comparison to valve failures, the failures of individual elements of EH, control oil, and trip systems have a smaller impact. The exception to this is the plugging failure of the common drain lines. Table 5-2 lists the combination of failures that contribute significantly to the destructive overspeed event for each variation, as well as their percent contribution to destructive overspeed probability (based on the results calculated for a three-month test interval).

Table 5-2 Dominant Contributors to Destructive Overspeed

Variation	Event(s)	Percent Contribution to Destructive Overspeed Probability (3-Month Valve Test Interval)
7	A governor valve fails to close and the ETF drain line clogs (causing the throttle valves to remain open).	52
7	A governor valve fails to close and a throttle valve fails to close (in the same steam chest).	22
8	A governor valve fails to close and ETF drain line clogs (causing the throttle valves to remain open).	55
8	A governor valve fails to close and a throttle valve fails to close (in the same steam chest).	23

6 CALCULATION OF SYSTEM SEPARATION

System separation is defined as the sudden and total loss of load on the generator, such as the load loss that is experienced if the generator output breakers opened while the plant is at full power.

The sources of generator trip data were the Westinghouse Individual Plant Examination Initiating Event Reactor Trip Database program and the Institute for Nuclear Power Operations database containing the Licensing Event Reports (LERs) for generator trip data. Generator trip data was obtained for nuclear power plants with Westinghouse BB-296 steam chests. The data collected represents 24 domestic units and 5 international units. The data covers the time period from January 1986 through September of 1995. Generator trip data for the applicable international plants was supplied by the international utilities.

Generator service time refers to the time that the plant's turbine generator is operating. This parameter is important because system separation frequency (per year) is a function of the time that the generator is in-service or operating. NUREG-0020 (Reference 5) contains plant information for generator on-line hours. Generator service hours were available for all domestic plants with the BB-296 steam chest design. The hours were totaled from January 1986 through September 1995. Service hours for the international plants were supplied by the international utilities.

System Separation Frequency Results

System separation is calculated using the following formula:

System Separation Frequency = (# generator trips / generator hours)*8760 (hrs/yr)

There were 49 generator trips reported during 1,492,038 service hours. The resulting frequency of system separation for all plants with BB-296 turbines is estimated at .29 separations per year.

7 TURBINE MISSILE EJECTION FREQUENCY RESULTS AND CONCLUSIONS

The updated BB-296 turbine valve failure rates, system separation frequency, probability of destructive overspeed, and annual missile ejection probability presented in this report are applicable to all the BB-296 TVTF mini group plants.

In verifying the suitability of turbine valve test interval, it is recommended that the general NRC acceptance criteria for turbine missile ejection (Reference 6) be used. The general acceptance criteria states that the annual probability of turbine missile ejection should not exceed 1.0E-05 per year for unfavorably oriented turbines and 1.0E-04 for favorably-oriented turbines. To be consistent with the methodology of WCAP-11525 and good engineering judgement, it is suggested that an allowance be set aside to account for the fact that a complete analysis of missile ejection at design and intermediate overspeed has not been conducted. In addition, the allowance accounts for the effects of the extraction nonreturn valves. Closure of these valves isolates the extraction lines and feedwater heaters from the turbine and prevents reverse flow of steam through the lines which might cause the turbine to overspeed. Section 8.4 of WCAP-11525 discusses these valves in detail. The suggested allowance is [ ]$^{+a,c}$ per year. Evaluations performed for this study indicate that the allowance of [ ]$^{+a,c}$ per year conservatively covers the missile ejection probabilities at design and intermediate overspeed and provides margin for uncertainties in the model and for the effects of the extraction nonreturn valves. This allowance does not apply to the Vandellos 2 light disc keyway rotors. Refer to Appendix C for the missile ejection probabilities for these rotors.

The destructive overspeed model was constructed assuming that a loss of load or system separation had occurred. Section 6 calculates the annual frequency of system separation to be .29 per year. However, a more conservative value of .4 for system separation is used. Therefore, destructive overspeed probabilities should be multiplied by .4 to obtain the annual probability of destructive overspeed and the frequency of missile ejection per year.

To correctly assess the frequency of missile ejection for a given turbine valve test frequency the following steps are taken:

1) Add the allowance of [ ]$^{+a,c}$ to the destructive overspeed probabilities in Table 5-1 to obtain the conditional probability of missile ejection from overspeed.

2) Multiply the conditional probability of missile ejection by .4, the frequency of system separation. The result is the frequency of missile ejection per year.

3) Compare the frequency of missile ejection to the acceptance criteria of 1.0E-05.

Applying steps 1 and 2 to the results presented in Table 5-1 gives the turbine missile ejection frequency for varying test intervals. The missile ejection frequencies are shown in Table 7-1.

(+a,c)

Table 7-1 Annual Frequency of Missile Ejection

The missile ejection frequencies for both variations are almost the same. Therefore, to represent them in graphical form, the slightly more limiting results for Variation 7 are plotted in Figure 7-1. The missile ejection frequencies shown in Figure 7-1 meet the acceptance criterion of 1.0E-5 per year for all test intervals analyzed. These results include conservative values for the system separation frequency and the allowance for design and intermediate overspeed probabilities. The governor and throttle valve failure rates are based on plant operating experience (primarily monthly testing). Although extending the valve test interval is not expected to dramatically increase the valve failure rates, sufficient failure information at longer tests intervals does not currently exist. It is therefore prudent to conservatively interpret the missile ejection frequency results as supporting quarterly testing until reasonable failure rate data can be accumulated based on quarterly testing. The missile ejection frequencies for the Vandellos 2 light disc keyway rotors also support quarterly testing as discussed in Appendix C.

The results presented in this report supersede the results in WCAP-11525 and OMM-093. TVTF mini group plants that currently use WCAP-11525 or OMM-093 as a basis for determining the appropriate turbine valve test intervals should use the information provided in this report as the new probabilistic basis for determining the turbine valve test interval.

(+a,c)

Figure 7-1 BB-296 Turbine Missile Ejection

8 REFERENCES

1. WCAP-11525, "Probabilistic Evaluation of Reduction in Turbine Valve Test Frequency," June 1987.

2. OMM-093, "BB296 & BB0296 Destructive Overspeed Protection," November 1988.

3. Letter from D.C. Dilanni (USNRC) to D.M. Musolf (Northern States Power Co.), Docket Nos. 50-282 and 50-306, "Amendments Nos. 86 and 79 to Facility Operating Licenses Nos. DPR-42 and DPR-60: Turbine Valve Test Frequency Reduction (TACS nos. 66867 and 66868)," February 7, 1989.

4. WSTG-4-P, "Analysis of the Probability of the Generation of Missiles from Fully Integrated Low Pressure Rotors," October 1984.

5. NUREG-0200, "Licensed Operating Reactors Status Summary Report."

6. Letter from C.E. Rossi of U.S. Nuclear Regulatory Commission to J.A. Martin of Westinghouse Electric Corp., February 2, 1987.

7. NUREG/CR-2815, "Probabilistic Safety Analysis Procedures Guide," Volume 1 Revision 1, Section 5, Appendix C, August 1985.

8. CT-24926, "Turbine Missile Report, Results of Probability Analyses of Disc Rupture and Missile Generation," Vandellos Unit No. II, Revision 1, January, 1982.

APPENDIX A

E.H. FLUID SYSTEM & LUBE DIAGRAMS

	Electro Hydraulic Fluid System and Lubrication Diagrams
Figure Number	Plant
A-1	Almaraz Units 1 & 2
A-2	ASCO Units 1 & 2
A-3	Braidwood Units 1 & 2 Byron Units 1& 2
A-4	Calvert Cliffs Unit 2
A-5	McGuire Units 1 & 2
A-6	North Anna Units 1 & 2
A-7	Washington Nuclear Plant 2
A-8	Vandellos 2

APPENDIX B

DESTRUCTIVE OVERSPEED FAULT TREES FOR VARIATION 7 AND VARIATION 8

DESTRUCTIVE OVERSPEED FAULT TREE FOR VARIATION 7

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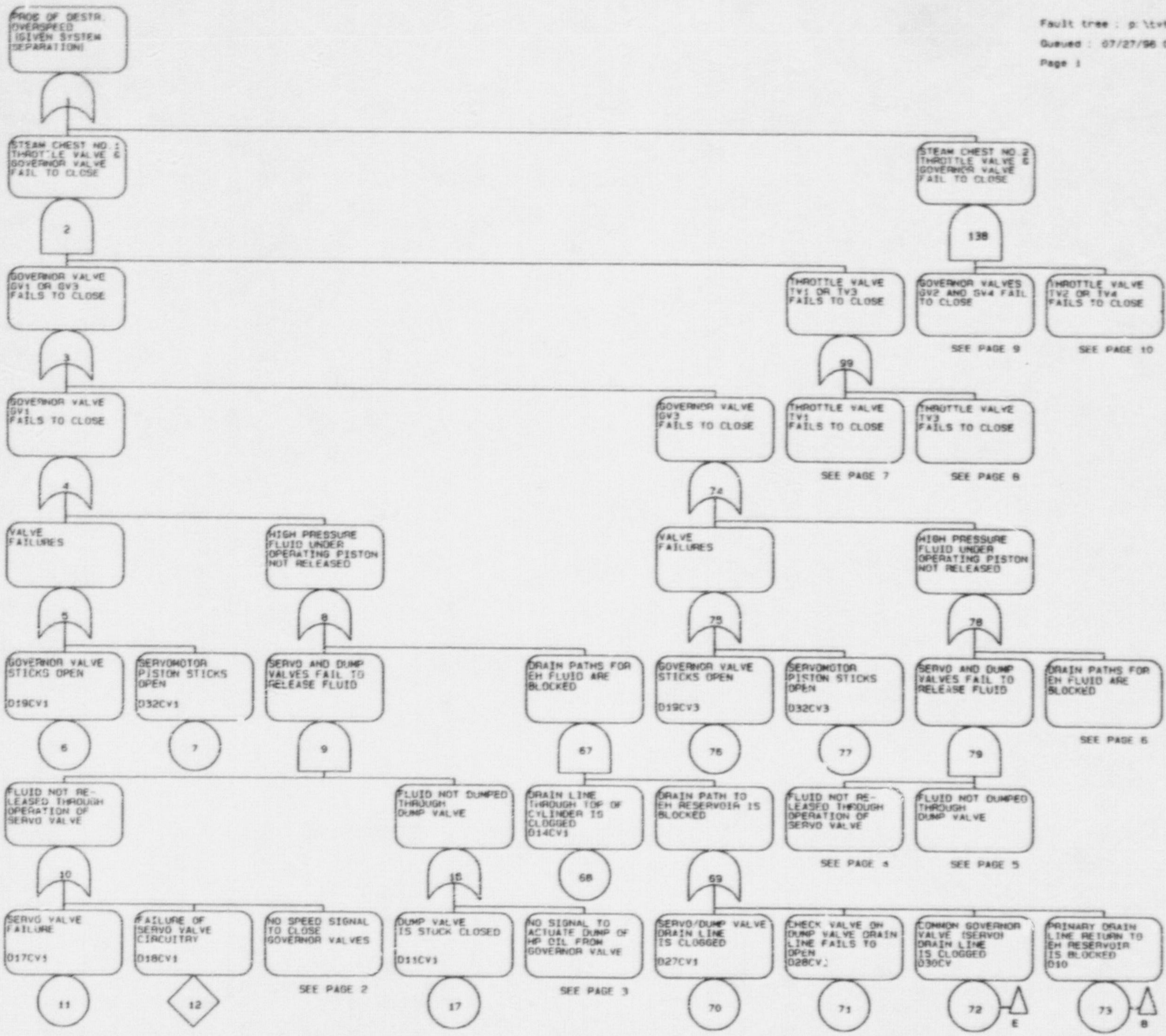

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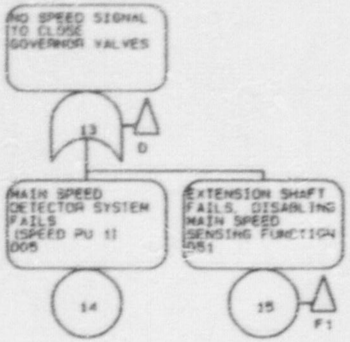
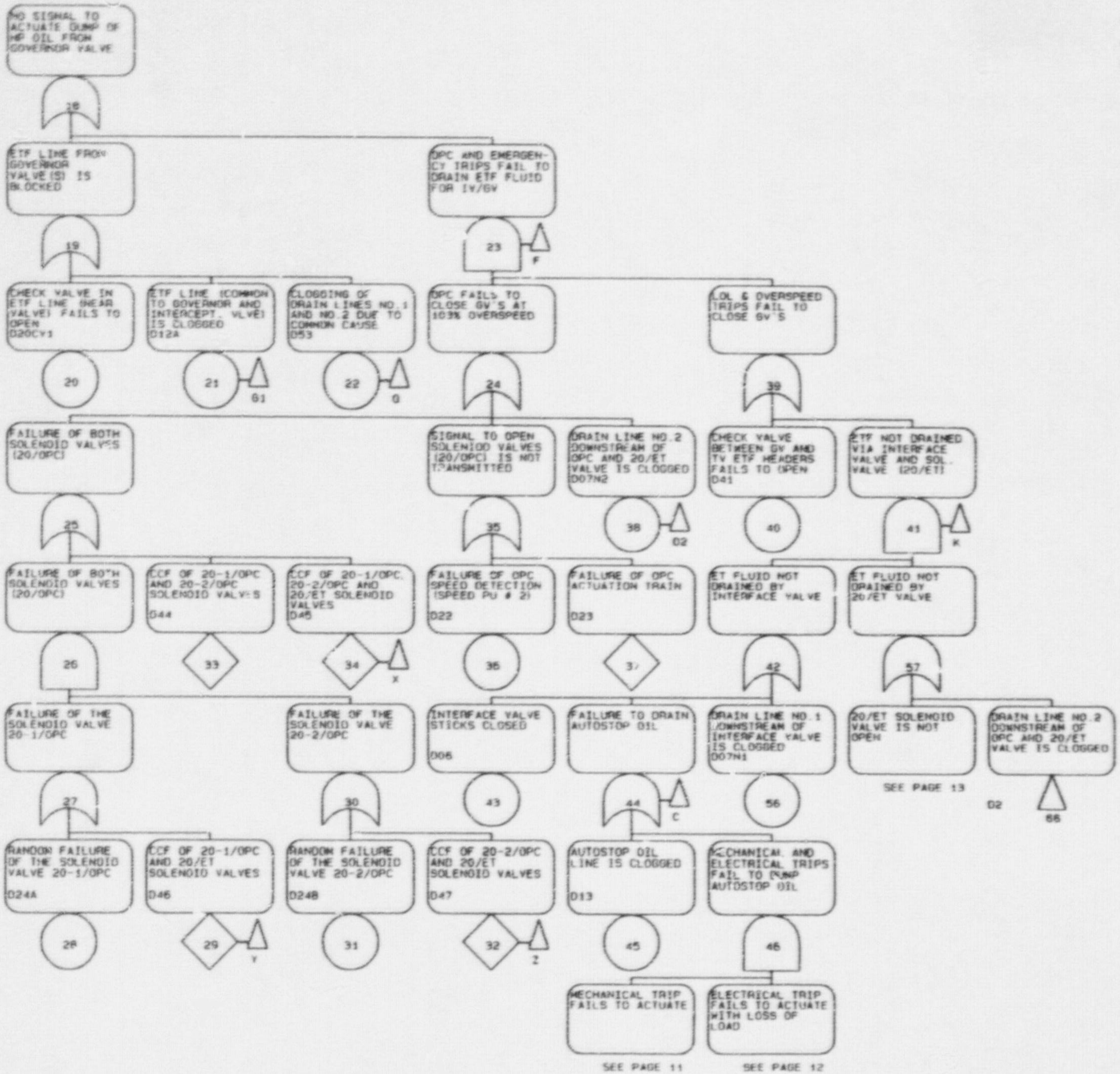
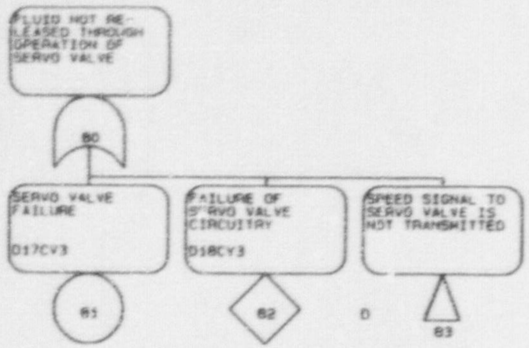
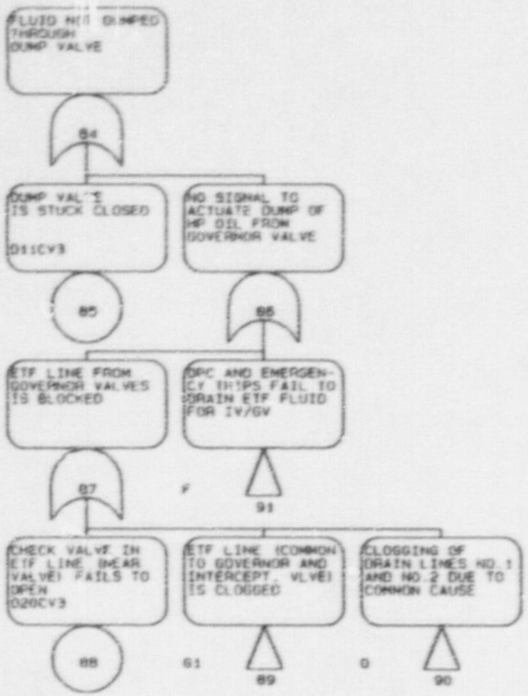
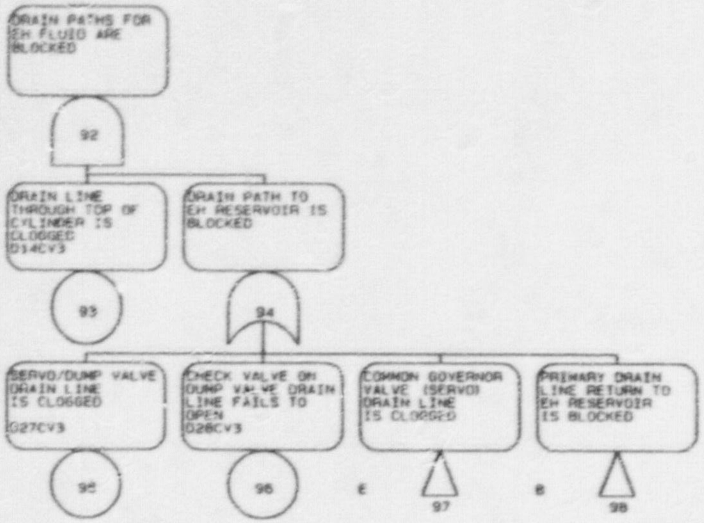



NO SIGNAL TO ACTUATE DUMP OF HP OIL FROM GOVERNOR VALVE
18
ETF LINE FROM GOVERNOR VALVE(S) IS BLOCKED
OPC AND EMERGENCY TRIPS FAIL TO DRAIN ETF FLUID FOR IV/GV
19
23
F
CHECK VALVE IN ETF LINE (NEAR VALVE) FAILS TO OPEN D20CY1
ETF LINE (COMMON TO GOVERNOR AND INTERCEPT. VLVE) IS CLOGGED D12A
CLOGGING OF DRAIN LINES NO.1 AND NO.2 DUE TO COMMON CAUSE D53
OPC FAILS TO CLOSE GV'S AT 103% OVERSPEED
LOL & OVERSPEED TRIPS FAIL TO CLOSE GV'S
20
21
G1
22
G
24
39
FAILURE OF BOTH SOLENOID VALVES (20/OPC)
SIGNAL TO OPEN SOLENOID VALVES (20/OPC) IS NOT TRANSMITTED
DRAIN LINE NO.2 DOWNSTREAM OF OPC AND 20/ET VALVE IS CLOGGED D07N2
CHECK VALVE BETWEEN GV AND TV ETF HEADERS FAILS TO OPEN D41
ETF NOT DRAINED VIA INTERFACE VALVE AND SOL. VALVE (20/ET)
25
35
38
D2
40
41
K
FAILURE OF BOTH SOLENOID VALVES (20/OPC)
CCF OF 20-1/OPC AND 20-2/OPC SOLENOID VALVES D44
CCF OF 20-1/OPC, 20-2/OPC AND 20/ET SOLENOID VALVES D45
FAILURE OF OPC SPEED DETECTION (SPEED PU # 2) D22
FAILURE OF OPC ACTUATION TRAIN D23
ET FLUID NOT DRAINED BY INTERFACE VALVE
ET FLUID NOT DRAINED BY 20/ET VALVE
26
33
34
X
36
37
42
57
FAILURE OF THE SOLENOID VALVE 20-1/OPC
FAILURE OF THE SOLENOID VALVE 20-2/OPC
INTERFACE VALVE STICKS CLOSED D06
FAILURE TO DRAIN AUTOSTOP OIL
DRAIN LINE NO.1 DOWNSTREAM OF INTERFACE VALVE IS CLOGGED D07N1
20/ET SOLENOID VALVE IS NOT OPEN
DRAIN LINE NO.2 DOWNSTREAM OF OPC AND 20/ET VALVE IS CLOGGED
SEE PAGE 13
D2
66
27
30
43
44
C
56
RANDOM FAILURE OF THE SOLENOID VALVE 20-1/OPC D24A
CCF OF 20-1/OPC AND 20/ET SOLENOID VALVES D46
RANDOM FAILURE OF THE SOLENOID VALVE 20-2/OPC D24B
CCF OF 20-2/OPC AND 20/ET SOLENOID VALVES D47
AUTOSTOP OIL LINE IS CLOGGED D13
MECHANICAL AND ELECTRICAL TRIPS FAIL TO DUMP AUTOSTOP OIL
28
29
Y
31
32
Z
45
46
MECHANICAL TRIP FAILS TO ACTUATE
ELECTRICAL TRIP FAILS TO ACTUATE WITH LOSS OF LOAD
SEE PAGE 11
SEE PAGE 12

Fault tree : p:\tvtf\bb296\ver-7.txt
Queued : 07/27/96 09:18:11




FLUID NOT DUMPED THROUGH DUMP VALVE
84
DUMP VALVE IS STUCK CLOSED
D11CV3
85
NO SIGNAL TO ACTUATE DUMP OF HP OIL FROM GOVERNOR VALVE
86
ETF LINE FROM GOVERNOR VALVES IS BLOCKED
87
OPC AND EMERGENCY TRIPS FAIL TO DRAIN ETF FLUID FOR IV/GV
91
CHECK VALVE IN ETF LINE (NEAR VALVE) FAILS TO OPEN
D20CV3
88
ETF LINE (COMMON TO GOVERNOR AND INTERCEPT. VLVE) IS CLOGGED
61
89
CLOGGING OF DRAIN LINES NO.1 AND NO.2 DUE TO COMMON CAUSE
0
90



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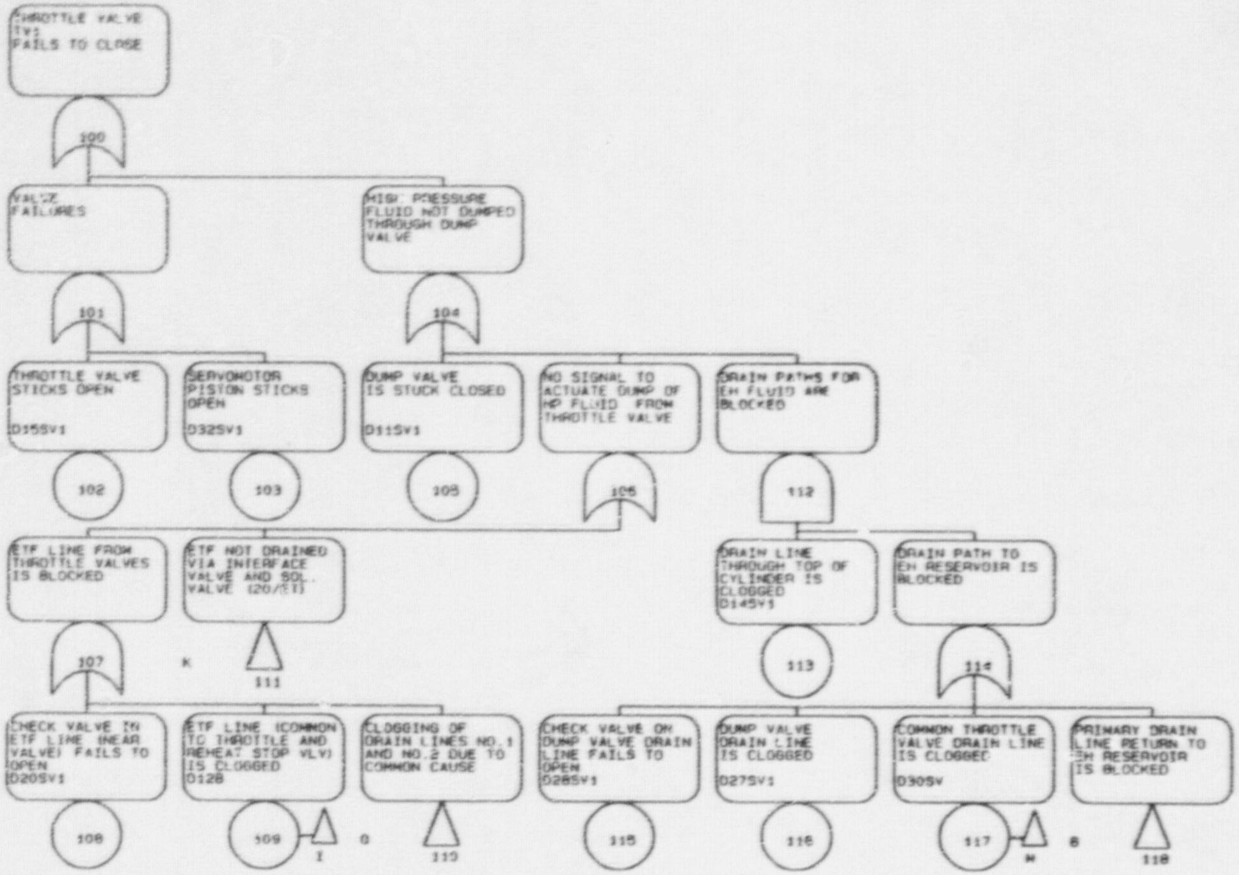
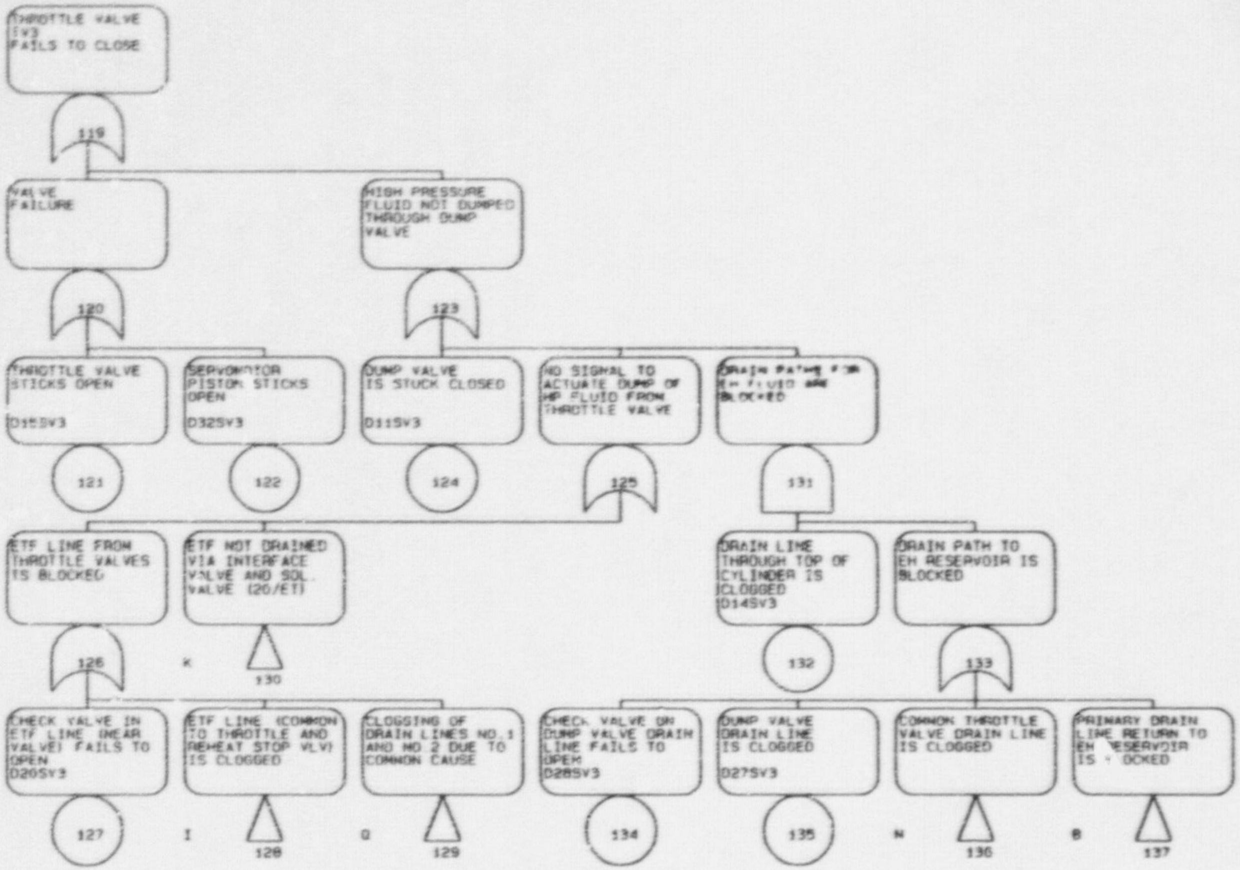
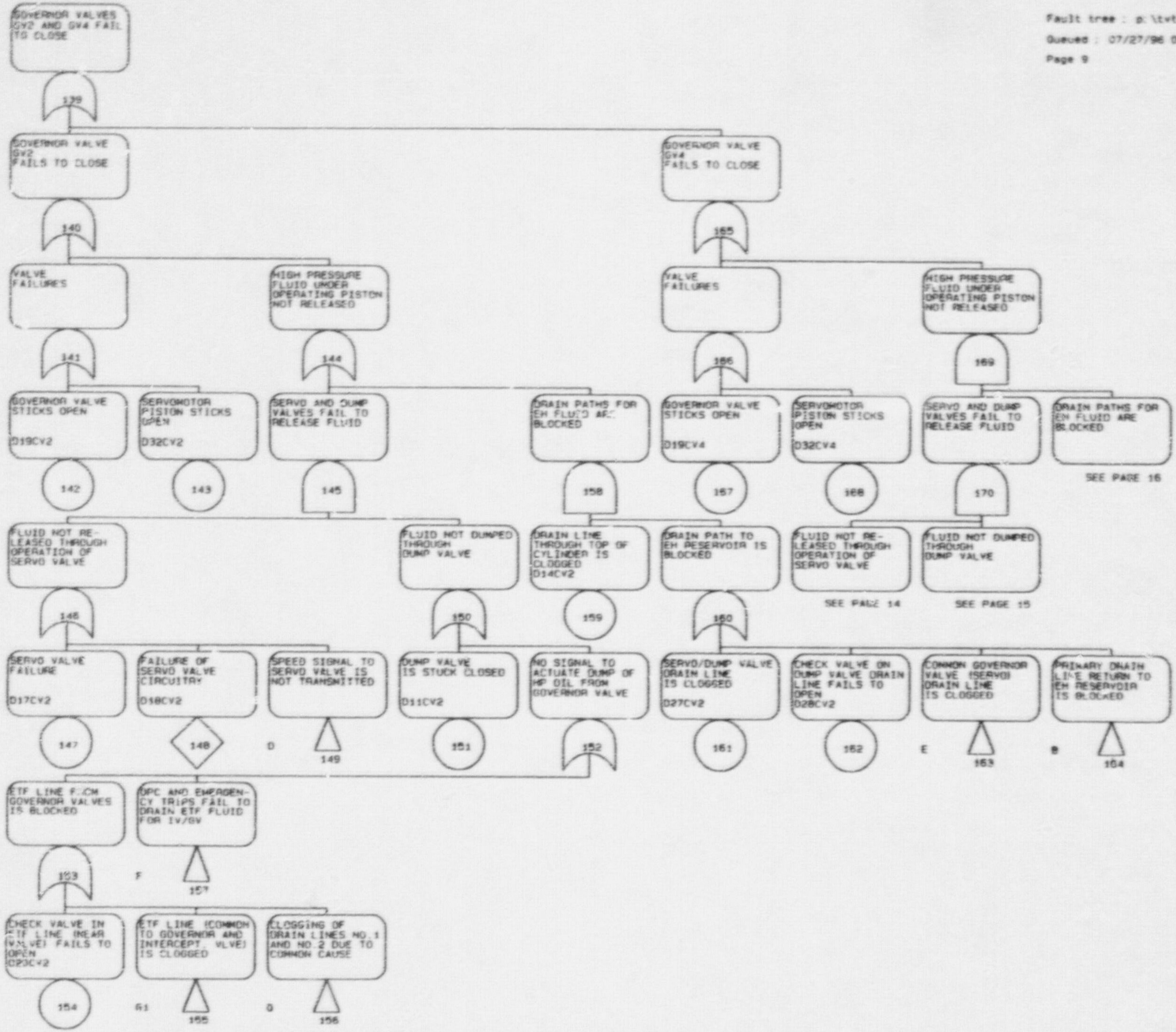
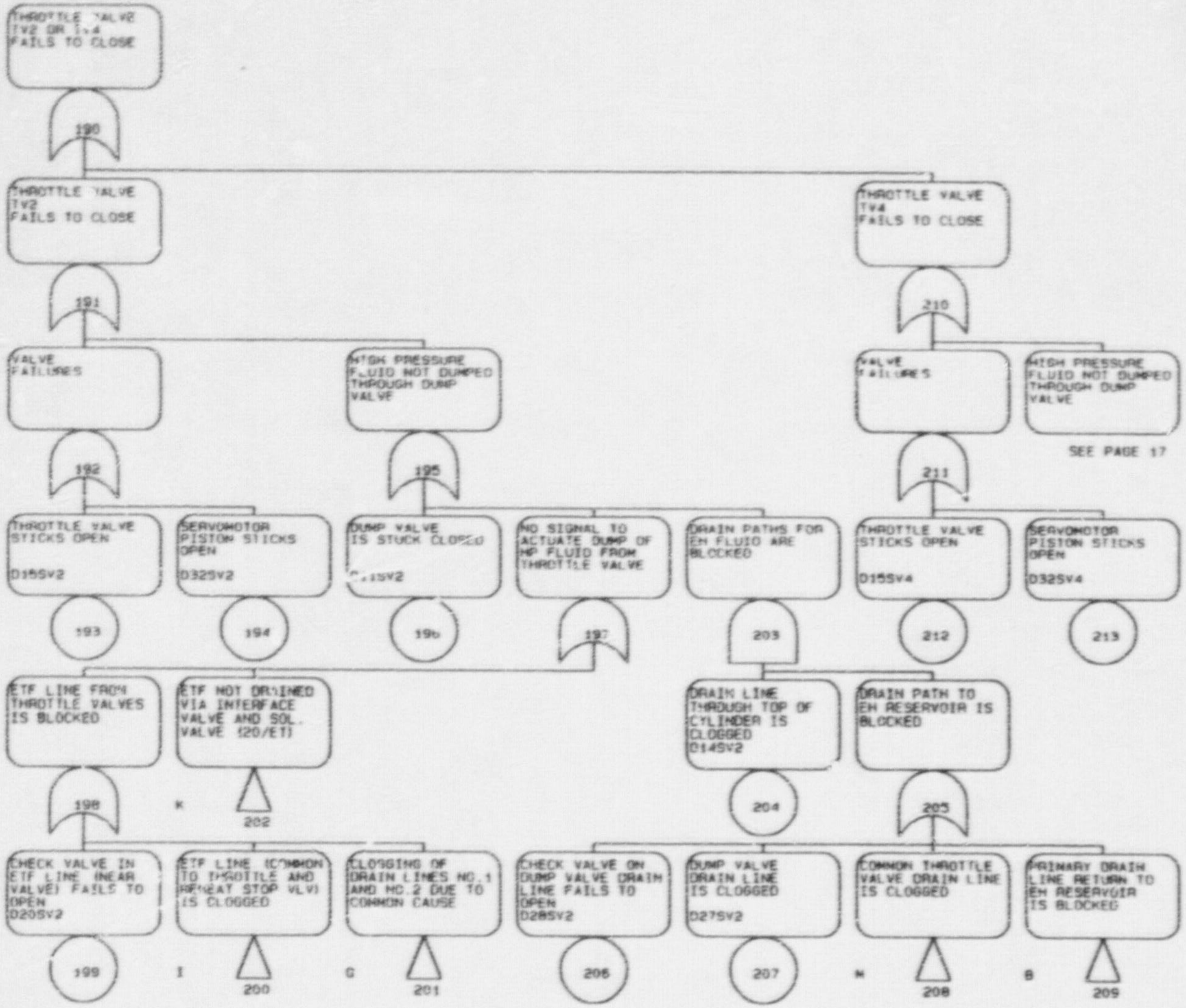
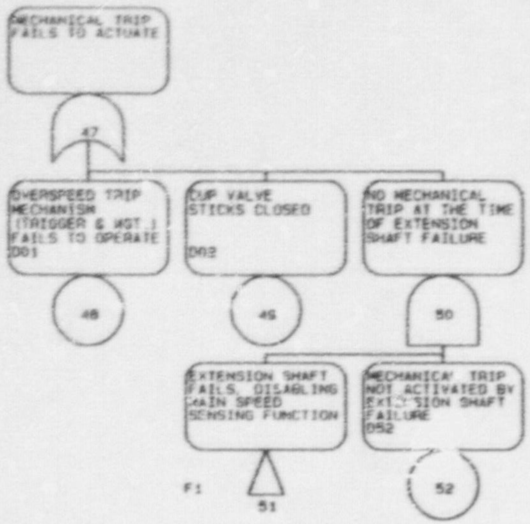
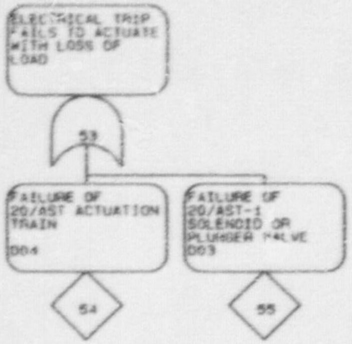

THROTTLE VALVE TV1 FAILS TO CLOSE
100
VALVE FAILURES
101
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
104
THROTTLE VALVE STICKS OPEN D15SV1
102
SERVOMOTOR PISTON STICKS OPEN D32SV1
103
DUMP VALVE IS STUCK CLOSED D11SV1
105
NO SIGNAL TO ACTUATE DUMP OF HP FLUID FROM THROTTLE VALVE
106
DRAIN PATHS FOR EH FLUID ARE BLOCKED
112
ETF LINE FROM THROTTLE VALVES IS BLOCKED
107
ETF NOT DRAINED VIA INTERFACE VALVE AND SOL. VALVE (20/ET)
K
111
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14SV1
113
DRAIN PATH TO EH RESERVOIR IS BLOCKED
114
CHECK VALVE IN ETF LINE (NEAR VALVE) FAILS TO OPEN D20SV1
108
ETF LINE (COMMON TO THROTTLE AND REHEAT STOP VLV) IS CLOGGED D12B
109
I
G
CLOGGING OF DRAIN LINES NO.1 AND NO.2 DUE TO COMMON CAUSE
110
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28SV1
115
DUMP VALVE DRAIN LINE IS CLOGGED D27SV1
116
COMMON THROTTLE VALVE DRAIN LINE IS CLOGGED D30SV
117
W
B
PRIMARY DRAIN LINE RETURN TO EH RESERVOIR IS BLOCKED
118

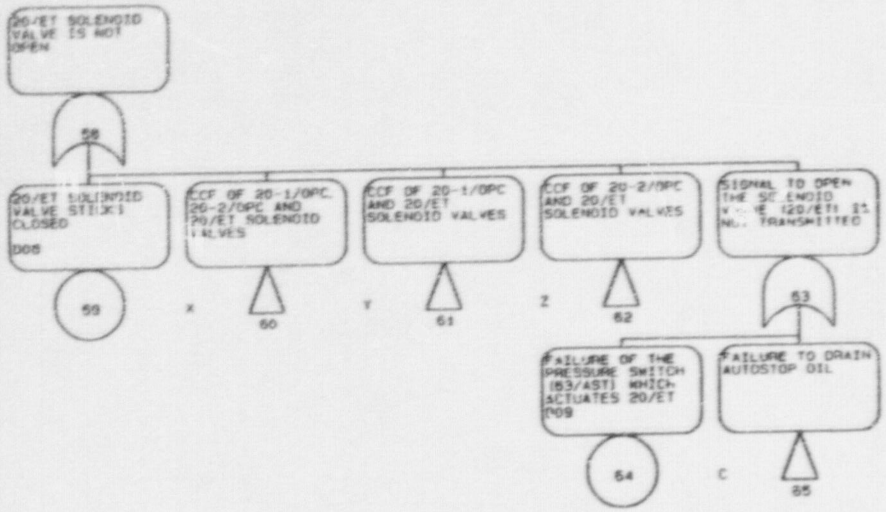

THROTTLE VALVE
TV3
FAILS TO CLOSE
119
VALVE
FAILURE
HIGH PRESSURE
FLUID NOT DUMPED
THROUGH DUMP
VALVE
120
123
THROTTLE VALVE
STICKS OPEN
D15SV3
SERVOMOTOR
PISTON STICKS
OPEN
D32SV3
DUMP VALVE
IS STUCK CLOSED
D11SV3
NO SIGNAL TO
ACTUATE DUMP OF
HP FLUID FROM
THROTTLE VALVE
121
122
124
125
131
ETF LINE FROM
THROTTLE VALVES
IS BLOCKED
ETF NOT DRAINED
VIA INTERFACE
VALVE AND SOL.
VALVE (20/ET)
DRAIN LINE
THROUGH TOP OF
CYLINDER IS
CLOGGED
D14SV3
DRAIN PATH TO
EH RESERVOIR IS
BLOCKED
126
K
130
132
133
CHECK VALVE IN
ETF LINE (NEAR
VALVE) FAILS TO
OPEN
D20SV3
ETF LINE (COMMON
TO THROTTLE AND
REHEAT STOP VLV)
IS CLOGGED
CLOGGING OF
DRAIN LINES NO.1
AND NO 2 DUE TO
COMMON CAUSE
DUMP VALVE DRAIN
LINE FAILS TO
OPEN
D28SV3
DUMP VALVE
DRAIN LINE
IS CLOGGED
D27SV3
COMMON THROTTLE
VALVE DRAIN LINE
IS CLOGGED
PRIMARY DRAIN
LINE RETURN TO
127
I
128
Q
129
134
135
136
137

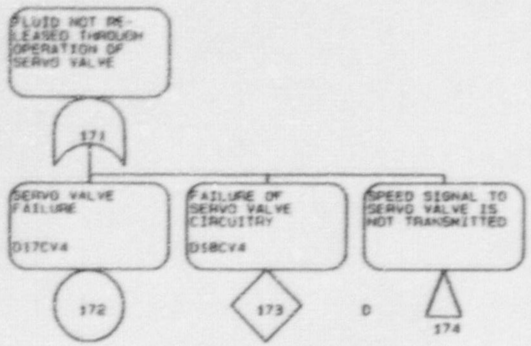

GOVERNOR VALVES GV2 AND GV4 FAIL TO CLOSE
139
GOVERNOR VALVE GV2 FAILS TO CLOSE
140
GOVERNOR VALVE GV4 FAILS TO CLOSE
165
VALVE FAILURES
141
HIGH PRESSURE FLUID UNDER OPERATING PISTON NOT RELEASED
144
VALVE FAILURES
166
HIGH PRESSURE FLUID UNDER OPERATING PISTON NOT RELEASED
169
GOVERNOR VALVE STICKS OPEN D19CV2
142
SERVOMOTOR PISTON STICKS OPEN D32CV2
143
SERVO AND DUMP VALVES FAIL TO RELEASE FLUID
145
DRAIN PATHS FOR EH FLUID ARE BLOCKED
158
GOVERNOR VALVE STICKS OPEN D19CV4
167
SERVOMOTOR PISTON STICKS OPEN D32CV4
168
SERVO AND DUMP VALVES FAIL TO RELEASE FLUID
170
DRAIN PATHS FOR EH FLUID ARE BLOCKED
SEE PAGE 16
FLUID NOT RELEASED THROUGH OPERATION OF SERVO VALVE
146
FLUID NOT DUMPED THROUGH DUMP VALVE
150
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14CV2
159
DRAIN PATH TO EH RESERVOIR IS BLOCKED
160
FLUID NOT RELEASED THROUGH OPERATION OF SERVO VALVE
SEE PAGE 14
FLUID NOT DUMPED THROUGH DUMP VALVE
SEE PAGE 15
SERVO VALVE FAILURE D17CV2
147
FAILURE OF SERVO VALVE CIRCUITRY D18CV2
148
D
SPEED SIGNAL TO SERVO VALVE IS NOT TRANSMITTED
149
DUMP VALVE IS STUCK CLOSED D11CV2
151
NO SIGNAL TO ACTUATE DUMP OF HP OIL FROM GOVERNOR VALVE
152
SERVO/DUMP VALVE DRAIN LINE IS CLOGGED D27CV2
161
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28CV2
162
E
COMMON GOVERNOR VALVE (SERVO) DRAIN LINE IS CLOGGED
163
B
PRIMARY DRAIN LINE RETURN TO EH RESERVOIR IS BLOCKED
164
ETF LINE FROM GOVERNOR VALVES IS BLOCKED
153
OPC AND EMERGENCY TRIPS FAIL TO DRAIN ETF FLUID FOR IV/GV
F
157
CHECK VALVE IN ETF LINE (REAR VALVE) FAILS TO OPEN D23CV2
154
G1
ETF LINE (COMMON TO GOVERNOR AND INTERCEPT VLVE) IS CLOGGED
155
O
CLOGGING OF DRAIN LINES NO.1 AND NO.2 DUE TO COMMON CAUSE
156

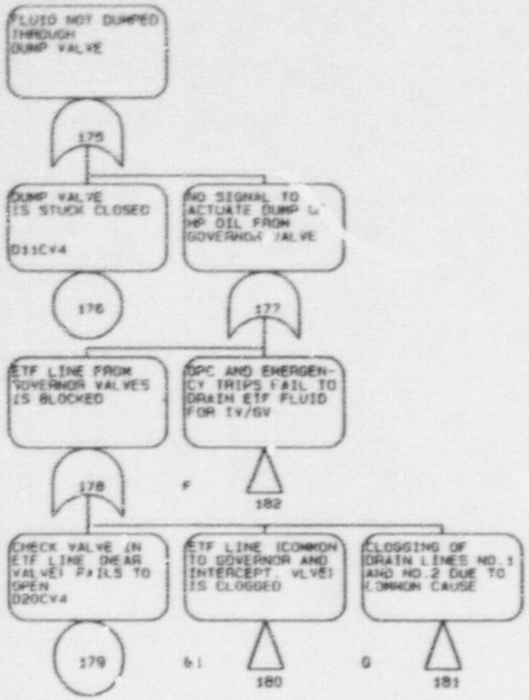

THROTTLE VALVE TV2 OR TV4 FAILS TO CLOSE
190
THROTTLE VALVE TV2 FAILS TO CLOSE
191
THROTTLE VALVE TV4 FAILS TO CLOSE
210
VALVE FAILURES
192
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
195
VALVE FAILURES
211
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
SEE PAGE 17
THROTTLE VALVE STICKS OPEN D15SV2
193
SERVOMOTOR PISTON STICKS OPEN D32SV2
194
DUMP VALVE IS STUCK CLOSED
196
NO SIGNAL TO ACTUATE DUMP OF HP FLUID FROM THROTTLE VALVE
197
DRAIN PATHS FOR EH FLUID ARE BLOCKED
203
THROTTLE VALVE STICKS OPEN D15SV4
212
SERVOMOTOR PISTON STICKS OPEN D32SV4
213
ETF LINE FROM THROTTLE VALVES IS BLOCKED
198
ETF NOT DRAINED VIA INTERFACE VALVE AND SOL. VALVE (20/ET)
K
202
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14SV2
204
DRAIN PATH TO EH RESERVOIR IS BLOCKED
205
CHECK VALVE IN ETF LINE (NEAR VALVE) FAILS TO OPEN D20SV2
199
ETF LINE (COMMON TO THROTTLE AND REHEAT STOP VLV) IS CLOGGED
I
200
CLOGGING OF DRAIN LINES NO.1 AND NO.2 DUE TO COMMON CAUSE
G
201
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28SV2
206
DUMP VALVE DRAIN LINE IS CLOGGED D27SV2
207
COMMON THROTTLE VALVE DRAIN LINE IS CLOGGED
208
PRIMARY DRAIN LINE RETURN TO EH RESERVOIR IS BLOCKED
B
209

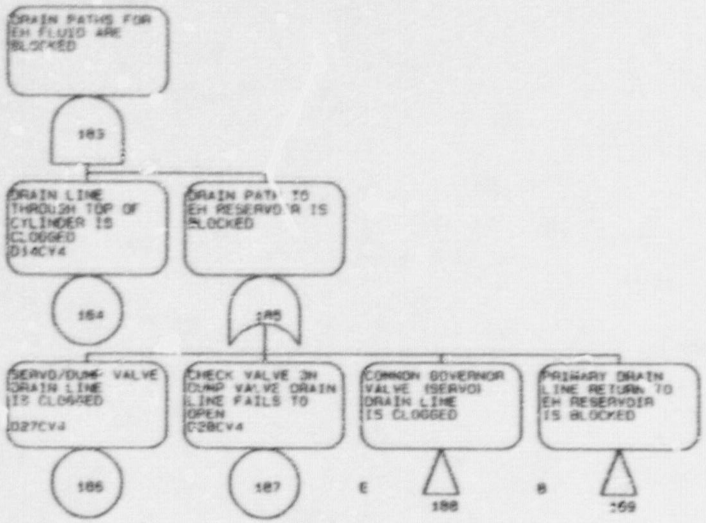

MECHANICAL TRIP FAILS TO ACTUATE
47
OVERSPEED TRIP MECHANISM (TRIGGER & WST.) FAILS TO OPERATE D01
48
CUP VALVE STICKS CLOSED D02
NO MECHANICAL TRIP AT THE TIME OF EXTENSION SHAFT FAILURE
50
EXTENSION SHAFT FAILS, DISABLING MAIN SPEED SENSING FUNCTION
F1
51
MECHANICAL TRIP NOT ACTIVATED BY EXTENSION SHAFT FAILURE D52
52


ELECTRICAL TRIP FAILS TO ACTUATE WITH LOSS OF LOAD
53
FAILURE OF 20/AST ACTUATION TRAIN
D04
FAILURE OF 20/AST-1 SOLENOID OR PLUNGER VALVE
D03
54
55


20/ET SOLENOID VALVE IS NOT OPEN
58
20/ET SOLENOID VALVE STUCK CLOSED D08
59
CCF OF 20-1/OPC, 20-2/OPC AND 20/ET SOLENOID VALVES
X
60
CCF OF 20-1/OPC AND 20/ET SOLENOID VALVES
Y
61
CCF OF 20-2/OPC AND 20/ET SOLENOID VALVES
Z
62
SIGNAL TO OPEN THE SOLENOID VALVE (20/ET) IS NOT TRANSMITTED
63
FAILURE OF THE PRESSURE SWITCH (63/AST) WHICH ACTUATES 20/ET D09
64
FAILURE TO DRAIN AUTOSTOP OIL
C
65


FLUID NOT RE-LEASED THROUGH OPERATION OF SERVO VALVE
171
SERVO VALVE FAILURE
D17CV4
172
FAILURE OF SERVO VALVE CIRCUITRY
D18CV4
173
D
SPEED SIGNAL TO SERVO VALVE IS NOT TRANSMITTED
174


FLUID NOT DUMPED THROUGH DUMP VALVE
175
DUMP VALVE IS STUCK CLOSED
D11CV4
NO SIGNAL TO ACTUATE DUMP HP OIL FROM GOVERNOR VALVE
176
177
ETF LINE FROM GOVERNOR VALVES IS BLOCKED
OPC AND EMERGENCY TRIPS FAIL TO DRAIN ETF FLUID FOR IV/GV
178
F
182
CHECK VALVE (IN ETF LINE NEAR VALVE) FAILS TO OPEN
D20CV4
ETF LINE (COMMON TO GOVERNOR AND INTERCEPT. VLVE) IS CLOGGED
CLOGGING OF DRAIN LINES NO.1 AND NO.2 DUE TO COMMON CAUSE
179
180
G
181


DRAIN PATHS FOR EH FLUID ARE BLOCKED
183
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14CV4
184
DRAIN PATH TO EH RESERVOIR IS BLOCKED
185
SERVO/DUMP VALVE DRAIN LINE IS CLOGGED D27CV4
186
CHECK VALVE IN DUMP VALVE DRAIN LINE FAILS TO OPEN D28CV4
187
COMMON GOVERNOR VALVE (SERVO) DRAIN LINE IS CLOGGED
E
188
PRIMARY DRAIN LINE RETURN TO EH RESERVOIR IS BLOCKED
B
259

Fault tree : p:\tvtf\bb29E\vbr-7.txt

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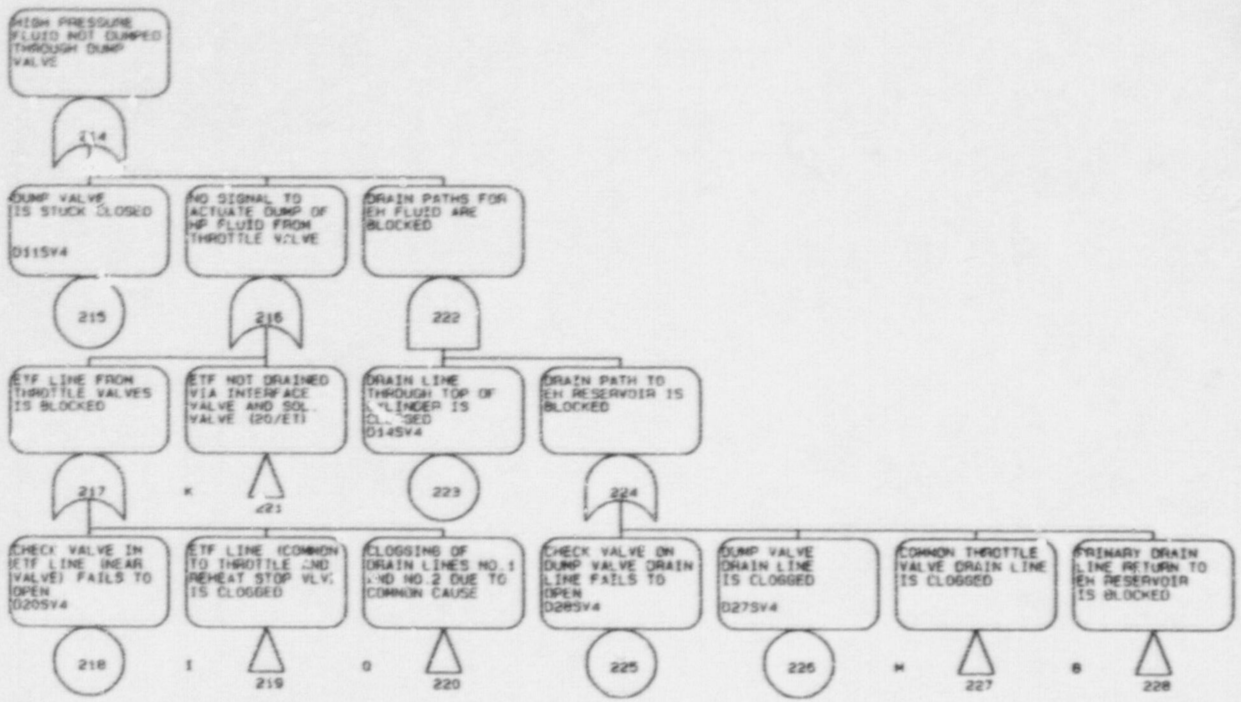
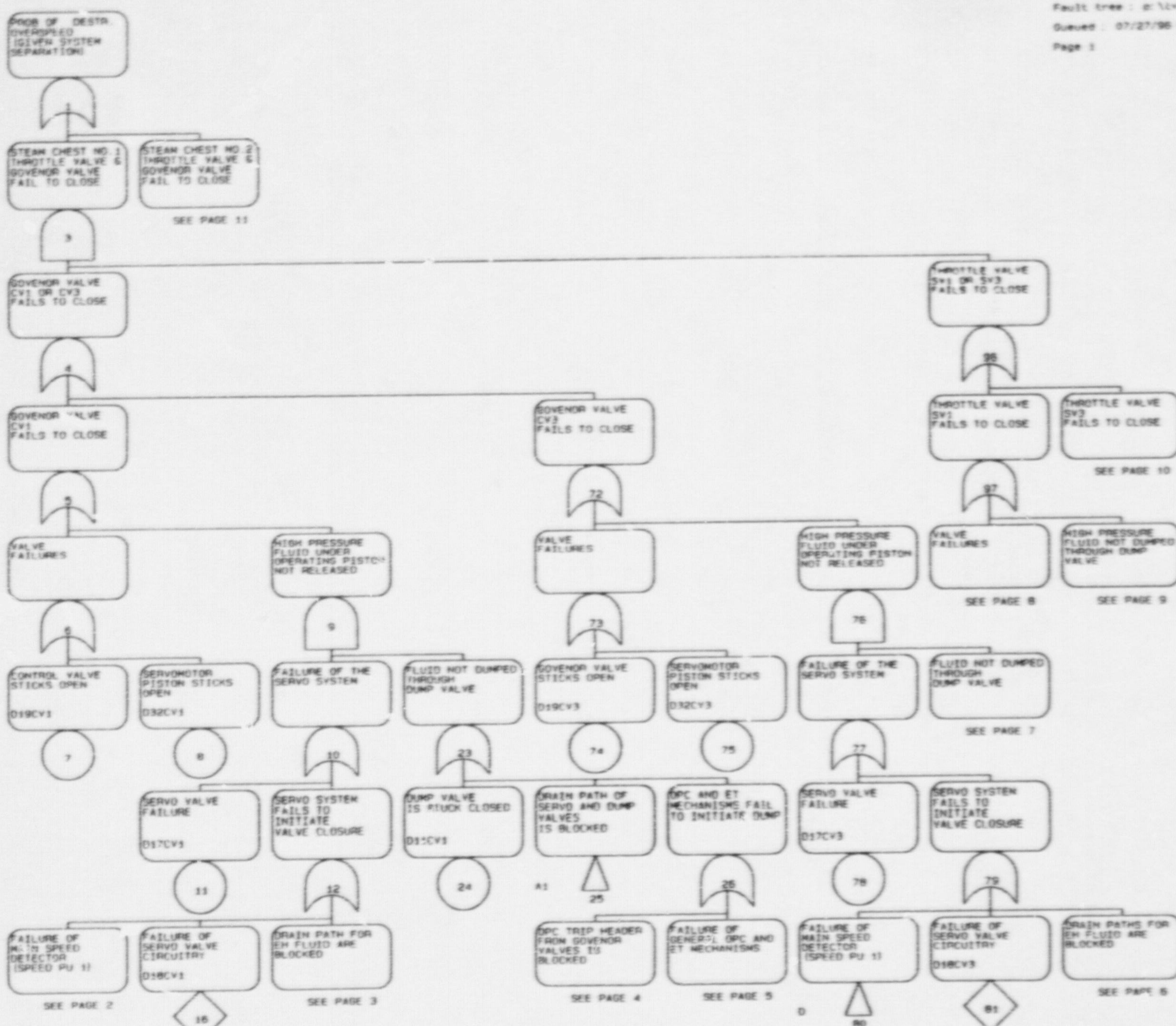
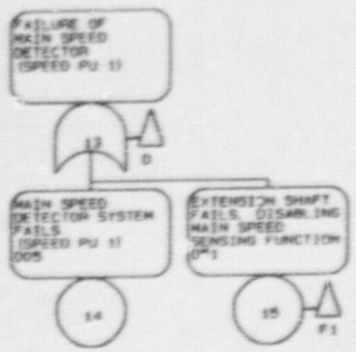


DESTRUCTIVE OVERSPEED FAULT TREE FOR VARIATION 8

Fault tree : c:\cvtf\eb298\var-8.dat

Queued : 07/27/98 09:14:14





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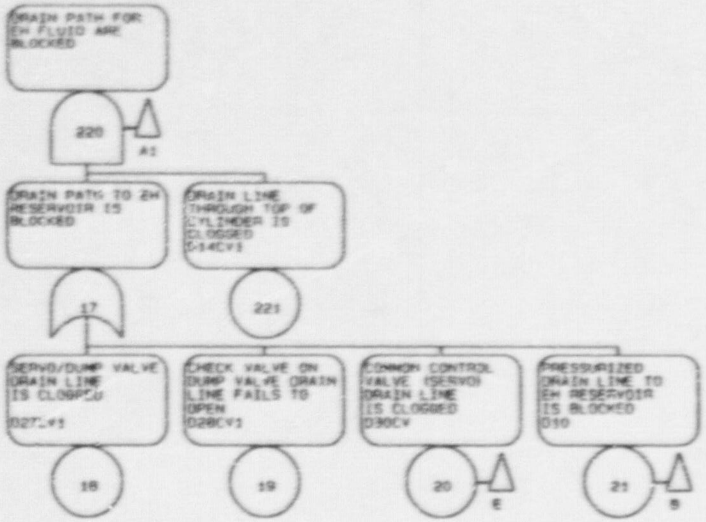
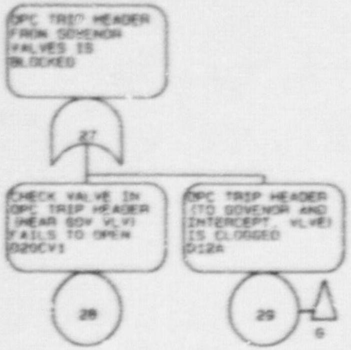
Page 2


DRAIN PATH FOR EH FLUID ARE BLOCKED
220
A1
DRAIN PATH TO EH RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14CV1
17
221
SERVO/DUMP VALVE DRAIN LINE IS CLOGGED D27CV1
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28CV1
COMMON CONTROL VALVE (SERVO) DRAIN LINE IS CLOGGED D30CV
PRESSURIZED DRAIN LINE TO EH RESERVOIR IS BLOCKED D10
18
19
20
E
21
B


OPC TRIP HEADER FROM GOVENOR VALVES IS BLOCKED
27
CHECK VALVE IN OPC TRIP HEADER (NEAR GOV VLV) FAILS TO OPEN D20CV1
OPC TRIP HEADER (TO GOVENOR AND INTERCEPT. VLVE) IS CLOGGED D12A
28
29
6

Fault tree : p:\tvtf\bb296\ver-8.dat

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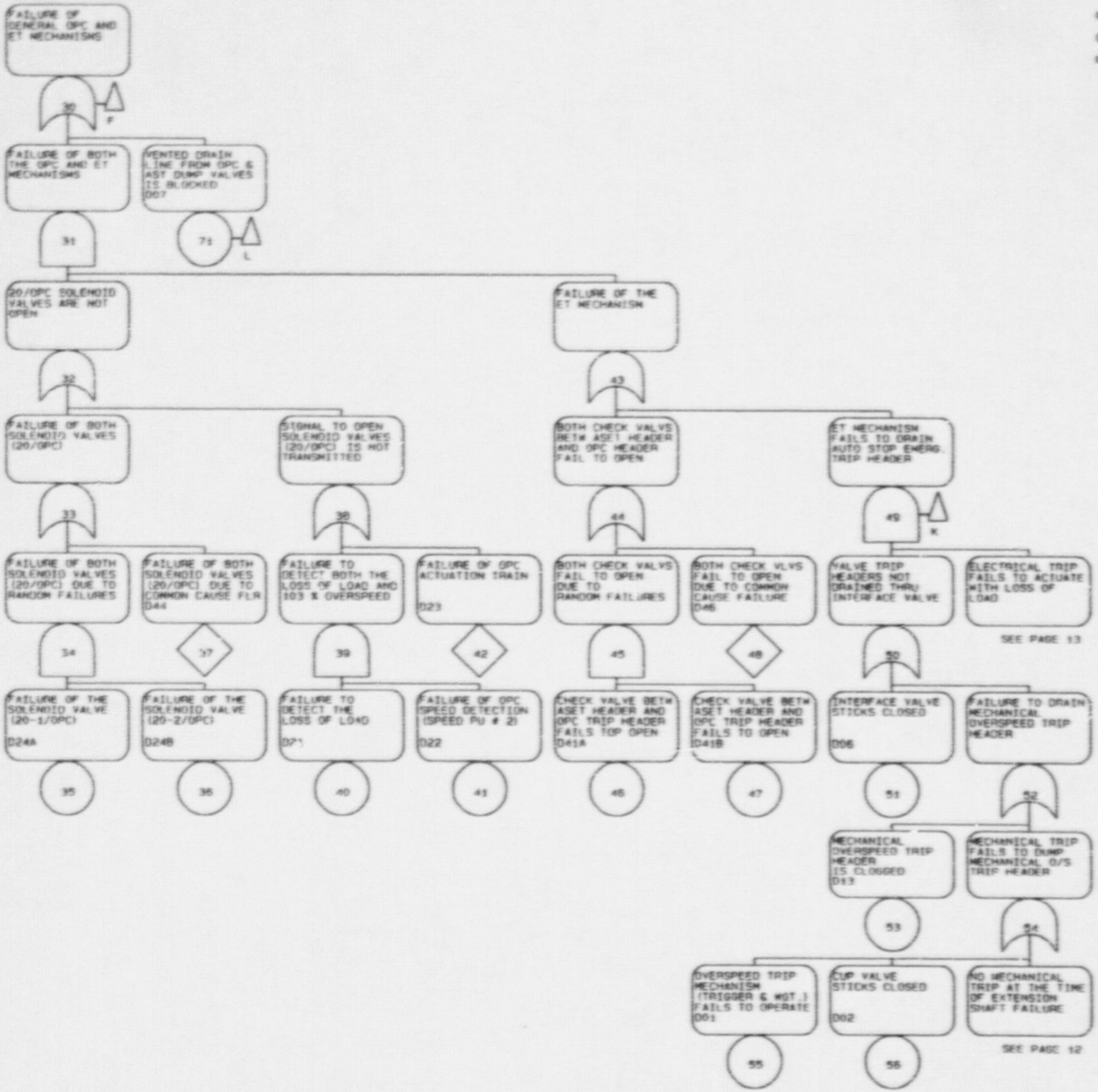

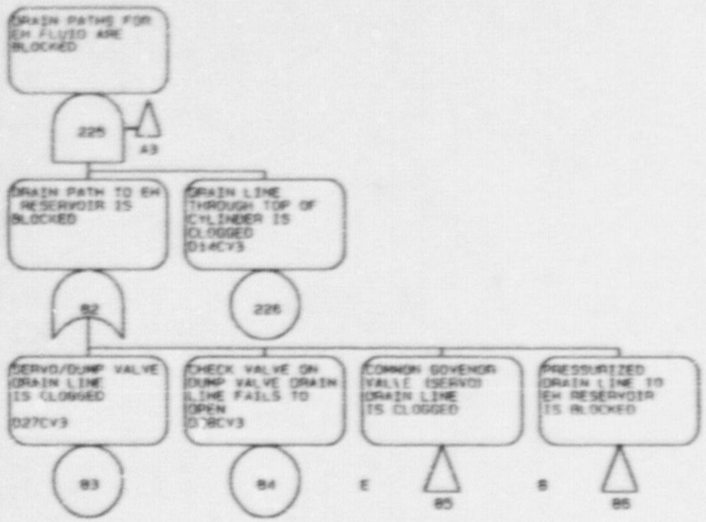

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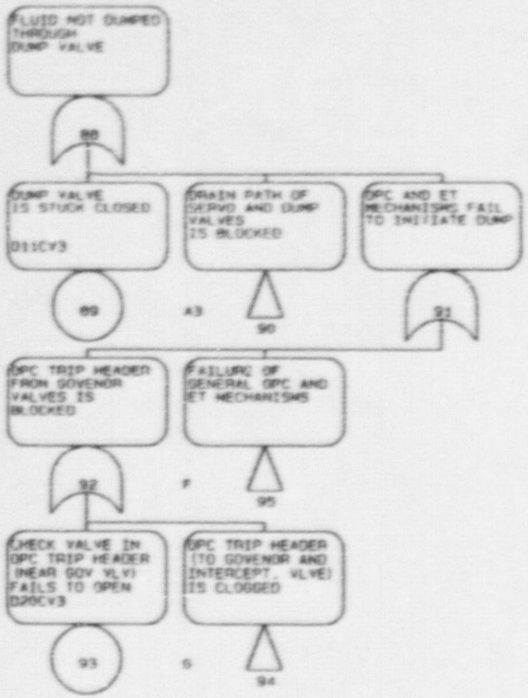

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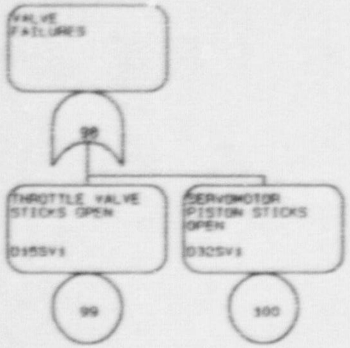

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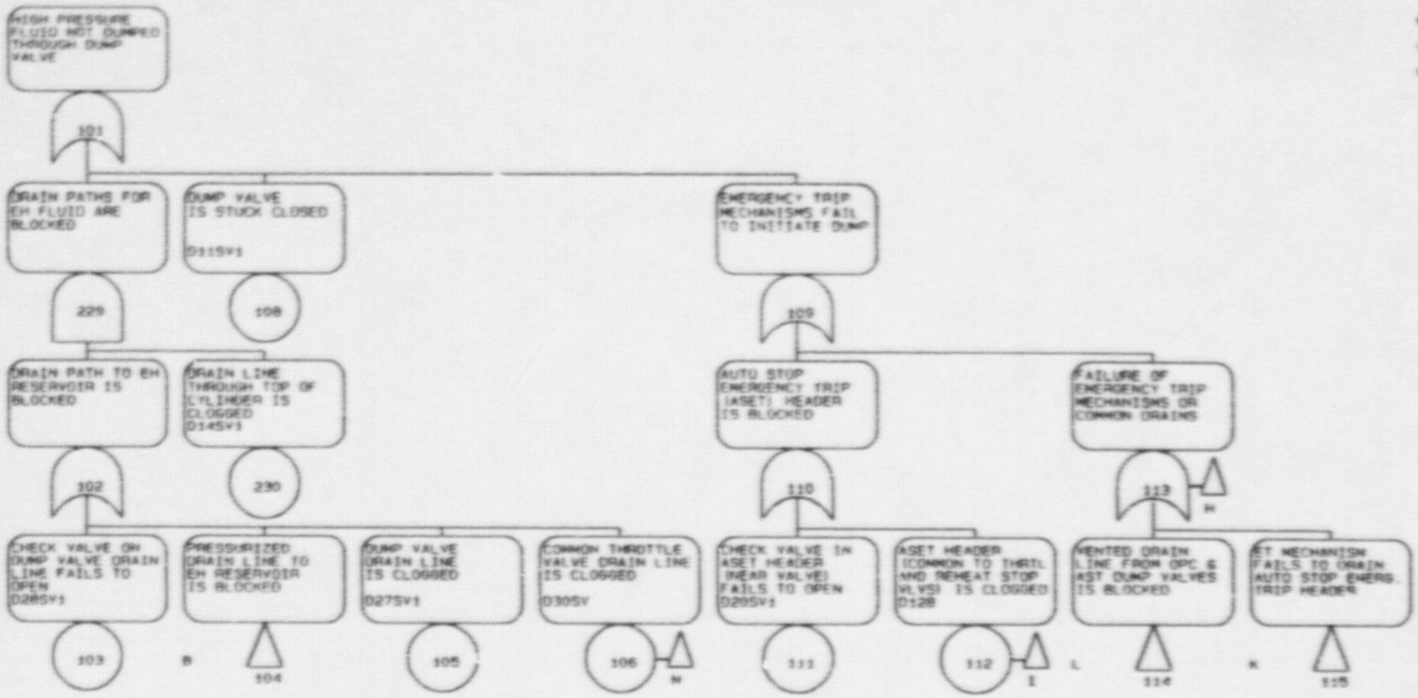
Page 8


HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
101
DRAIN PATHS FOR EH FLUID ARE BLOCKED
229
DUMP VALVE IS STUCK CLOSED
D11SV1
108
EMERGENCY TRIP MECHANISMS FAIL TO INITIATE DUMP
109
DRAIN PATH TO EH RESERVOIR IS BLOCKED
102
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED
D14SV1
230
AUTO STOP EMERGENCY TRIP (ASET) HEADER IS BLOCKED
110
FAILURE OF EMERGENCY TRIP MECHANISMS OR COMMON DRAINS
113
H
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN
D28SV1
103
B
PRESSURIZED DRAIN LINE TO EH RESERVOIR IS BLOCKED
104
DUMP VALVE DRAIN LINE IS CLOGGED
D27SV1
105
COMMON THROTTLE VALVE DRAIN LINE IS CLOGGED
D30SV
106
N
CHECK VALVE IN ASET HEADER (NEAR VALVE) FAILS TO OPEN
D20SV1
111
ASET HEADER (COMMON TO THRTL AND REHEAT STOP VLVS) IS CLOGGED
D128
112
I
L
VENTED DRAIN LINE FROM OPC & AST DUMP VALVES IS BLOCKED
114
K
ET MECHANISM FAILS TO DRAIN AUTO STOP EMERG. TRIP HEADER
115

Fault tree : p:\t-tf\bb296\ver-8.det

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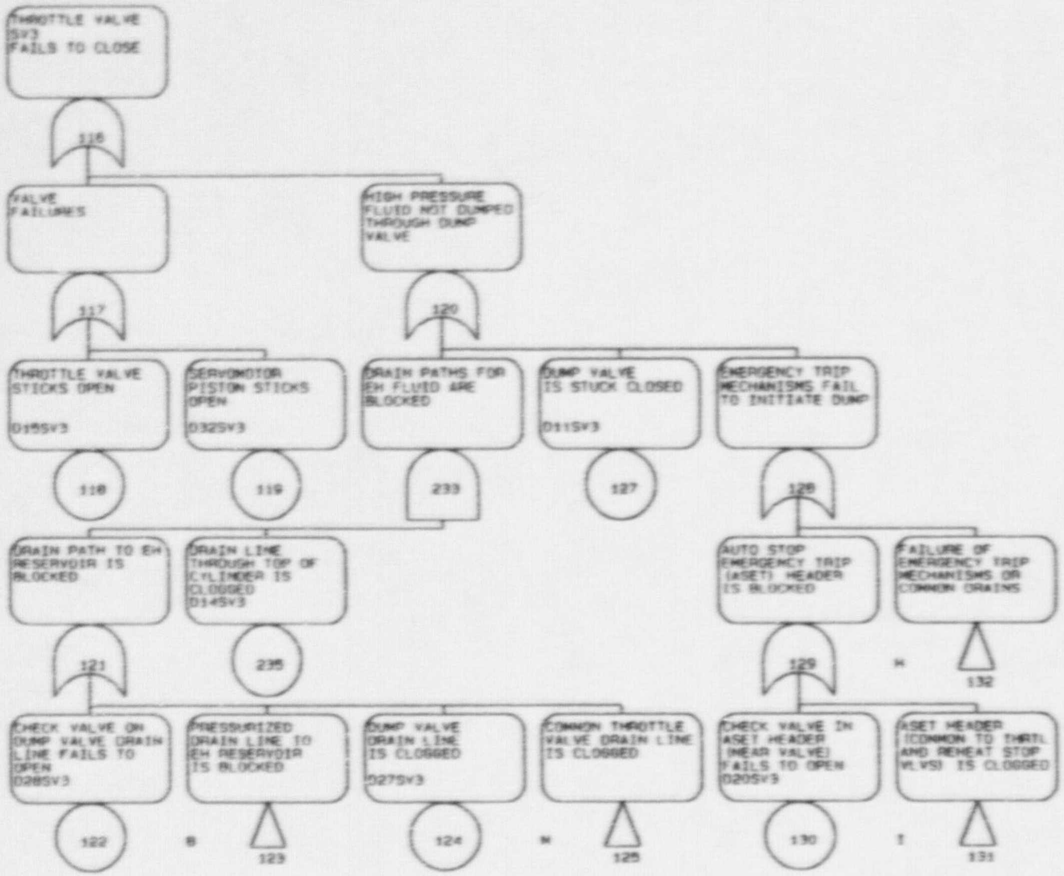

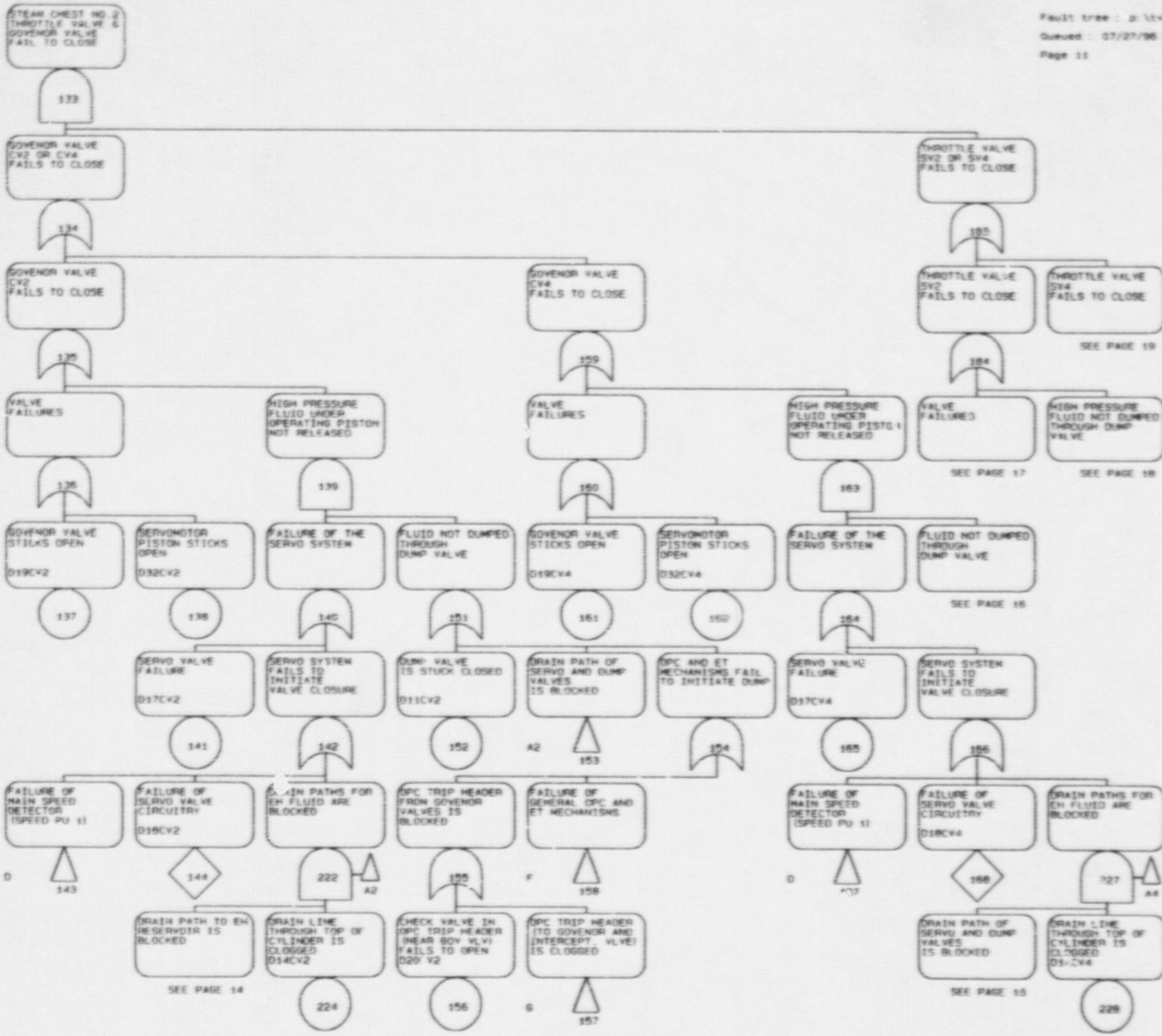
STEAM CHEST NO.2 THROTTLE VALVE & GOVENOR VALVE FAIL TO CLOSE
133
GOVENOR VALVE CV2 OR CV4 FAILS TO CLOSE
THROTTLE VALVE SV2 OR SV4 FAILS TO CLOSE
134
GOVENOR VALVE CV2 FAILS TO CLOSE
GOVENOR VALVE CV4 FAILS TO CLOSE
THROTTLE VALVE SV2 FAILS TO CLOSE
THROTTLE VALVE SV4 FAILS TO CLOSE
SEE PAGE 19
135
159
184
VALVE FAILURES
HIGH PRESSURE FLUID UNDER OPERATING PISTON NOT RELEASED
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
SEE PAGE 17
SEE PAGE 18
136
139
150
163
GOVENOR VALVE STICKS OPEN D19CV2
SERVOMOTOR PISTON STICKS OPEN D32CV2
FAILURE OF THE SERVO SYSTEM
FLUID NOT DUMPED THROUGH DUMP VALVE
GOVENOR VALVE STICKS OPEN D19CV4
SERVOMOTOR PISTON STICKS OPEN D32CV4
SEE PAGE 16
137
138
140
151
161
162
164
SERVO VALVE FAILURE D17CV2
SERVO SYSTEM FAILS TO INITIATE VALVE CLOSURE
DUMP VALVE IS STUCK CLOSED D11CV2
DRAIN PATH OF SERVO AND DUMP VALVES IS BLOCKED
OPC AND ET MECHANISMS FAIL TO INITIATE DUMP
SERVO VALVE FAILURE D17CV4
141
142
152
A2
153
154
165
166
FAILURE OF MAIN SPEED DETECTOR (SPEED PU 1)
FAILURE OF SERVO VALVE CIRCUITRY D18CV2
DRAIN PATHS FOR EH FLUID ARE BLOCKED
OPC TRIP HEADER FROM GOVENOR VALVES IS BLOCKED
FAILURE OF GENERAL OPC AND ET MECHANISMS
FAILURE OF SERVO VALVE CIRCUITRY D18CV4
D
143
144
222
A2
155
F
158
168
227
A4
DRAIN PATH TO EH RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14CV2
CHECK VALVE IN OPC TRIP HEADER (NEAR BDY VLV) FAILS TO OPEN D20 V2
OPC TRIP HEADER (TO GOVENOR AND INTERCEPT. VLVE) IS CLOGGED
DRAIN PATH OF SERVO AND DUMP VALVES IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED
SEE PAGE 14
224
156
G
157
SEE PAGE 15
228

Fault tree : p \t\tf\bb295\ver-8.dat

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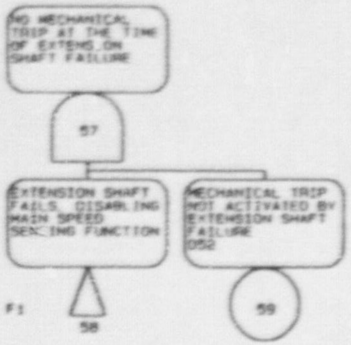
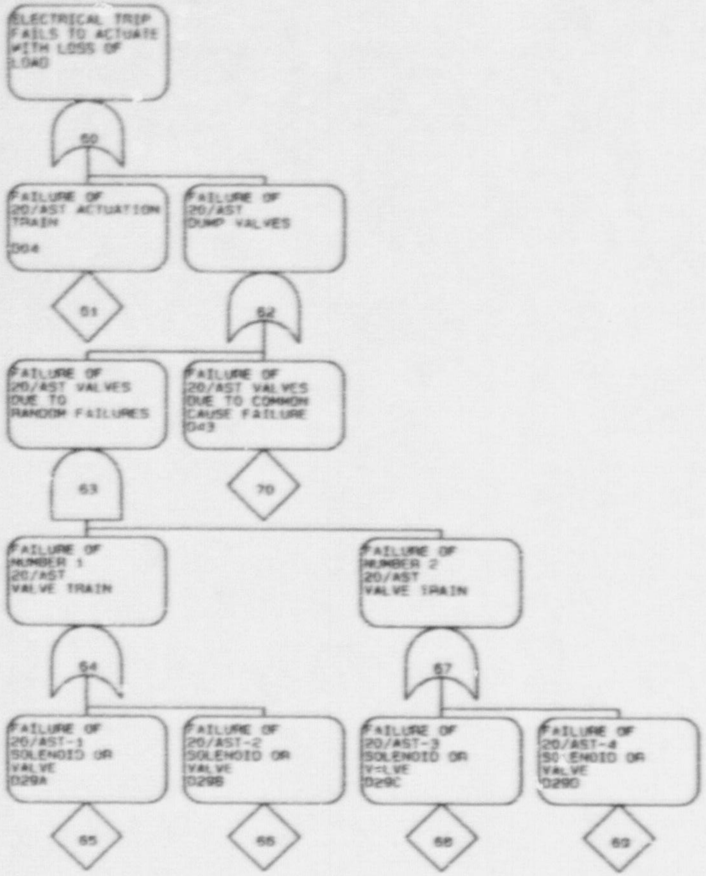
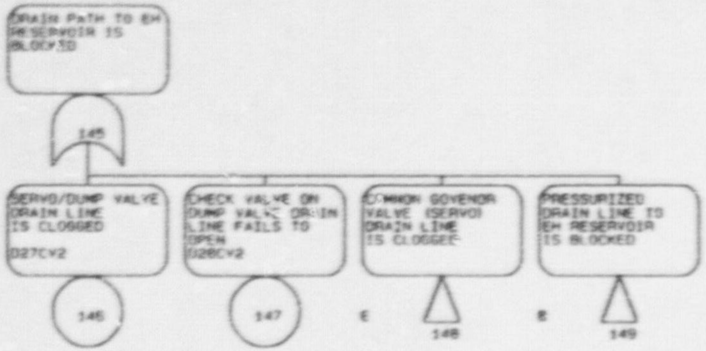
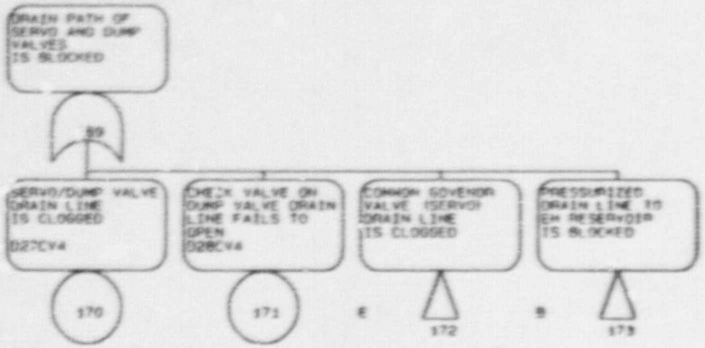
Page 12

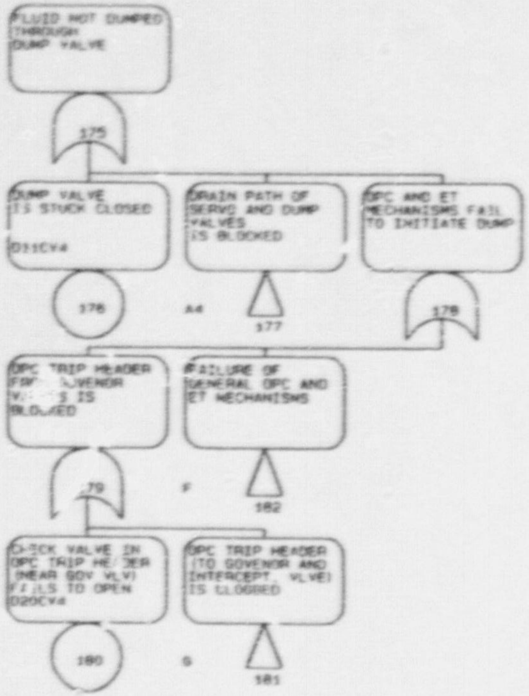


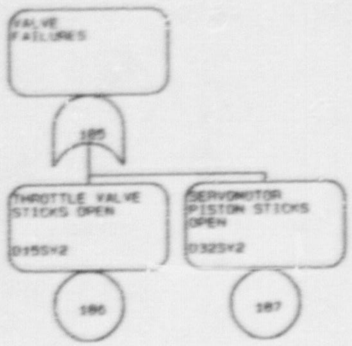

ELECTRICAL TRIP FAILS TO ACTUATE WITH LOSS OF LOAD
50
FAILURE OF 20/AST ACTUATION TRAIN D04
51
FAILURE OF 20/AST DUMP VALVES
52
FAILURE OF 20/AST VALVES DUE TO RANDOM FAILURES
FAILURE OF 20/AST VALVES DUE TO COMMON CAUSE FAILURE D43
63
70
FAILURE OF NUMBER 1 20/AST VALVE TRAIN
FAILURE OF NUMBER 2 20/AST VALVE TRAIN
64
67
FAILURE OF 20/AST-1 SOLENOID OR VALVE D29A
FAILURE OF 20/AST-2 SOLENOID OR VALVE D29B
FAILURE OF 20/AST-3 SOLENOID OR VALVE D29C
FAILURE OF 20/AST-4 SOLENOID OR VALVE D29D
65
66
68
69

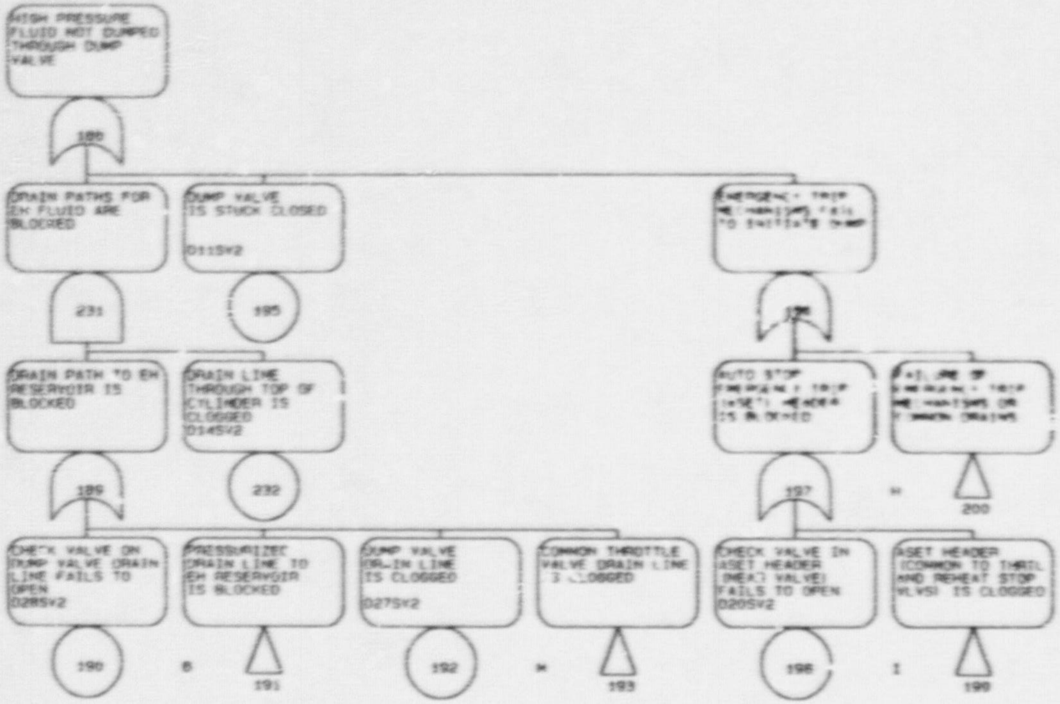


DRAIN PATH TO EH RESERVOIR IS BLOCKED
145
SERVO/DUMP VALVE DRAIN LINE IS CLOGGED
D27CV2
146
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN
D28CV2
147
COMMON GOVENOR VALVE (SERVO) DRAIN LINE IS CLOGGED
148
PRESSURIZED DRAIN LINE TO EH RESERVOIR IS BLOCKED
149


DRAIN PATH OF SERVO AND DUMP VALVES IS BLOCKED
89
SERVO/DUMP VALVE DRAIN LINE IS CLOGGED
D27CV4
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN
D28CV4
COMMON GOVENOR VALVE (SERVO) DRAIN LINE IS CLOGGED
PRESSURIZED DRAIN LINE TO EH RESERVOIR IS BLOCKED
170
171
E
172
B
173


FLUID NOT DUMPED THROUGH DUMP VALVE
175
DUMP VALVE IS STUCK CLOSED
D11CV4
DRAIN PATH OF SERVO AND DUMP VALVES IS BLOCKED
OPC AND ET MECHANISMS FAIL TO INITIATE DUMP
176
A4
177
178
OPC TRIP HEADER
IS
FAILURE OF GENERAL OPC AND ET MECHANISMS
F
182
CHECK VALVE IN OPC TRIP HEADER (NEAR GOV VLV)
D20CV4
OPC TRIP HEADER (TO GOVENOR AND INTERCEPT. VLVE) IS CLOGGED
180
G
181


VALVE
FAILURES
185
THROTTLE VALVE
STICKS OPEN
D155V2
SERVOMOTOR
PISTON STICKS
OPEN
D325V2
186
187


HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
188
DRAIN PATHS FOR EH FLUID ARE BLOCKED
DUMP VALVE IS STUCK CLOSED D11SV2
231
195
DRAIN PATH TO EH RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14SV2
189
232
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28SV2
PRESSURIZED DRAIN LINE TO EH RESERVOIR IS BLOCKED
DUMP VALVE DRAIN LINE IS CLOGGED D27SV2
COMMON THROTTLE VALVE DRAIN LINE IS CLOGGED
190
191
192
193
197
200
CHECK VALVE IN ASET HEADER (MEA) VALVE) FAILS TO OPEN D20SV2
ASET HEADER (COMMON TO THRTL AND REHEAT STOP VLVS) IS CLOGGED
198
199

Fault tree : p:\tvtf\bb298\var-8.dat

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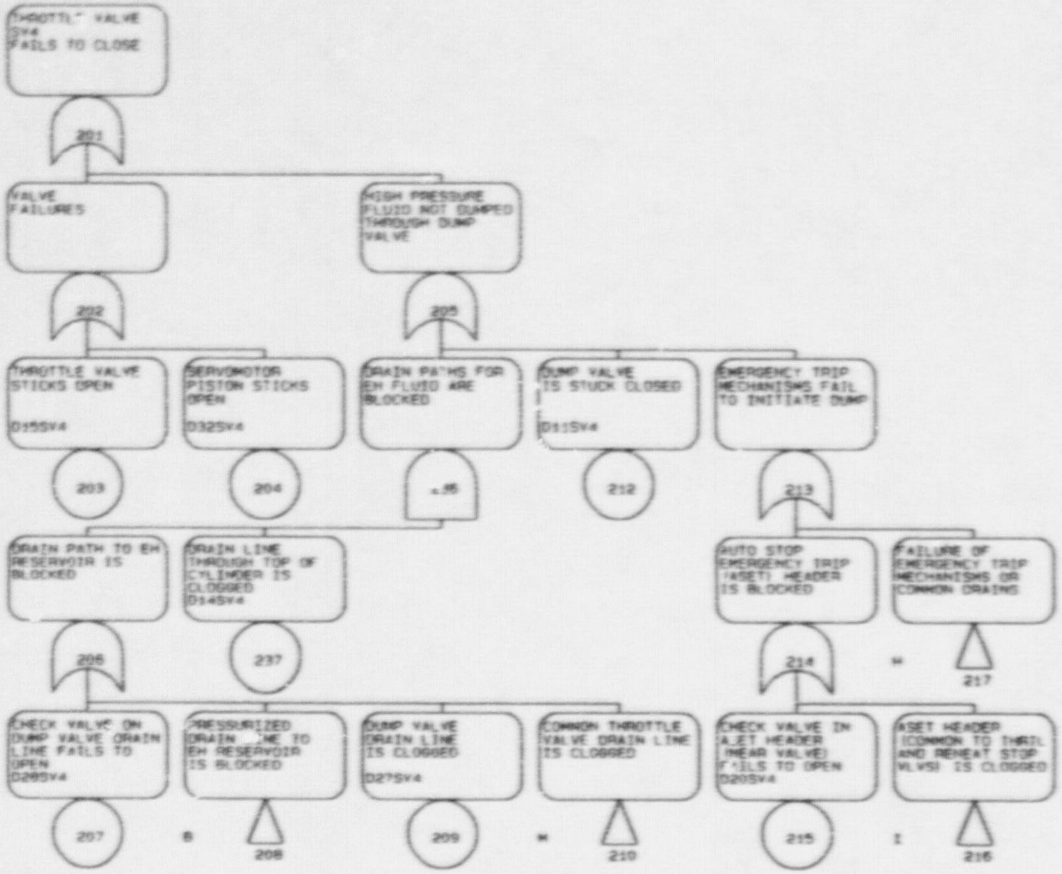
Page 19 (LAST)



APPENDIX C

VANDELLOS 2 LDK ROTOR ASSESSMENT

The evaluation of the generic allowance for design and intermediate overspeed missile ejection probabilities, presented in Sections 4 and 7, was based on heavy disc keyplate low pressure rotors. Vandellos 2 has three light disc keyway (LDK) rotors which have higher missile ejection probabilities given an overspeed condition. This appendix presents the assessment performed to determine the design and intermediate overspeed missile ejection probabilities, and the total annual missile ejection frequency, for Vandellos 2.

As described in WCAP-11525 (Reference 1), the total missile ejection probability is the sum of the design, intermediate, and destructive overspeed missile ejection probabilities. The annual missile ejection frequency is the sum of the missile ejection probabilities multiplied by the system separation frequency (see Section 6 of this report). The design and intermediate missile ejection probabilities are composed of: 1) the conditional probability of the overspeed event and, 2) the conditional missile ejection probability given the overspeed event. Destructive overspeed is assumed to always lead to missile ejection.

Table 8.2-2 in WCAP-11525 lists the type of low pressure rotor for each plant at the time the WCAP was written. Included in Table 8.2-3 of WCAP-11525 are the conditional probabilities of missile ejection for the LDK rotors. These probabilities were based on turbine missile reports referenced in WCAP-11525. The LDK probabilities are very high and, when multiplied by the probabilities of design and intermediate overspeed, may not support longer test intervals. Therefore, to more accurately calculate missile ejection probabilities, this assessment uses plant specific conditional missile ejection probabilities from Turbine Missile Report CT-24926 for Vandellos 2 (Reference 8).

Because design and intermediate overspeed probabilities were not specifically calculated for the generic BB-296 TVTF program, a fault tree analysis was performed for the design and intermediate overspeed events for Vandellos 2. The Variation 8 design and intermediate overspeed fault trees from WCAP-11525 were modified to incorporate six reheat stop and six reheat interceptor valves. The system separation frequency was removed. It is now applied outside of the fault trees as described in Section 7. To more accurately model the drain paths, the logic was revised to model valve closure on the dump of EH fluid through the drain path from the valves to the top of the cylinder. This is the same change discussed in Section 5. For the design and intermediate overspeed fault trees, the drain path revisions also included removing basic event D07 (vented drain line from OPC is blocked) and adding basic event D10 (primary drain line return is blocked). These are the only differences between the Variation 8 design and intermediate overspeed fault trees in WCAP-11525 and the Vandellos fault trees. The design and intermediate overspeed fault trees used for the

Vandellos 2 analysis are included at the end of this Appendix C. The fault tree analyses included changing the valve failure rates discussed in Section 3. Table C-1 shows the conditional design and intermediate overspeed probabilities calculated for various test intervals.

Destructive overspeed is assumed to occur when there is a system separation and at least one governor valve and one throttle valve in the same steam chest fail to close. Destructive overspeed is independent of the number of reheat stop and reheat interceptor valves. Therefore, the Variation 8 destructive overspeed results are applicable to Vandellos 2. Table C-1 also shows the conditional destructive overspeed probabilities for Vandellos 2, which are summarized in Table 5-1.

(+a,c)

Table C-1 Conditional Probability of Overspeed for Vandellos 2

The conditional missile ejection probabilities for the design and intermediate overspeed events were derived from Reference 8. WCAP-11525, Section 8.2 discusses the relationship between design and intermediate overspeed conditional missile ejection probabilities. The conditional intermediate overspeed missile ejection probabilities were a factor of 5 to 15 times greater than design overspeed. A factor of 100 was used for this assessment for conservatism. The conditional missile ejection probability for destructive overspeed is 1.0. The resulting conditional missile ejection probabilities for Vandellos 2 are shown in Table C-2.

(+a,c)

Table C-2 Conditional Missile Ejection Probabilities

For a given test interval, the total missile ejection frequency is:

$$0.4*[P(A)*P(M/A) + P(B) * P(M/B) + P(C)],$$

where 0.4 is the system separation frequency per year (see Section 6),
P(A), P(B), P(C) are from Table C-1 and,
P(M/A) and P(M/B) are from Table C-2.

The annual missile ejection frequencies, for various test intervals, are shown in Table C-3 for Vandellos 2.

(+a,c)

Table C-3 Annual Frequency of Missile Ejection for Vandellos 2

Due to the high conditional missile ejection probabilities for the LDK rotors, the generic allowance discussed in Sections 4 and 7 does not apply to Vandellos 2. The Vandellos 2 turbine orientation is discussed in Section 3.5.1.3 of the Vandellos 2 Final Safety Analysis Report (FSAR). The FSAR evaluation concludes that the turbine is favorably oriented. Table 1 of Reference 6 shows that the annual missile ejection probability criterion for a favorably-oriented turbine is 1.0E-4 per year. The Vandellos 2 missile ejection frequency results, for a 3-month test interval, show a large margin to the limit. Therefore, the Vandellos 2 results support the conclusions of Section 7, which conservatively interpret the generic missile ejection frequency results as supporting a quarterly testing interval until reasonable failure rate data can be accumulated based on quarterly testing.

VANDELLOS 2

DESIGN AND INTERMEDIATE OVERSPEED FAULT TREES

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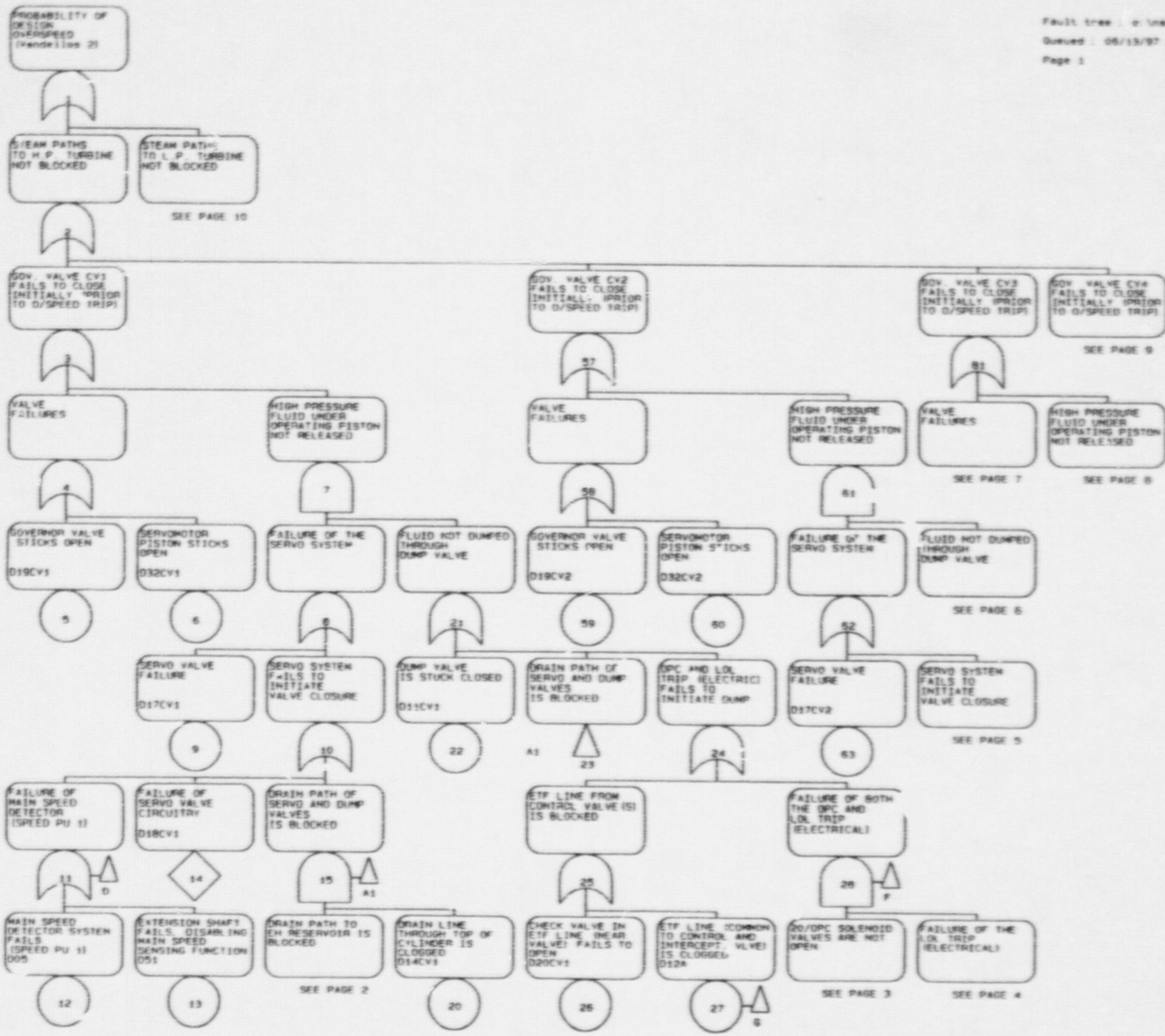
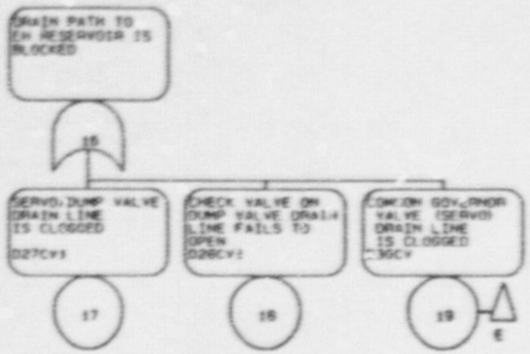
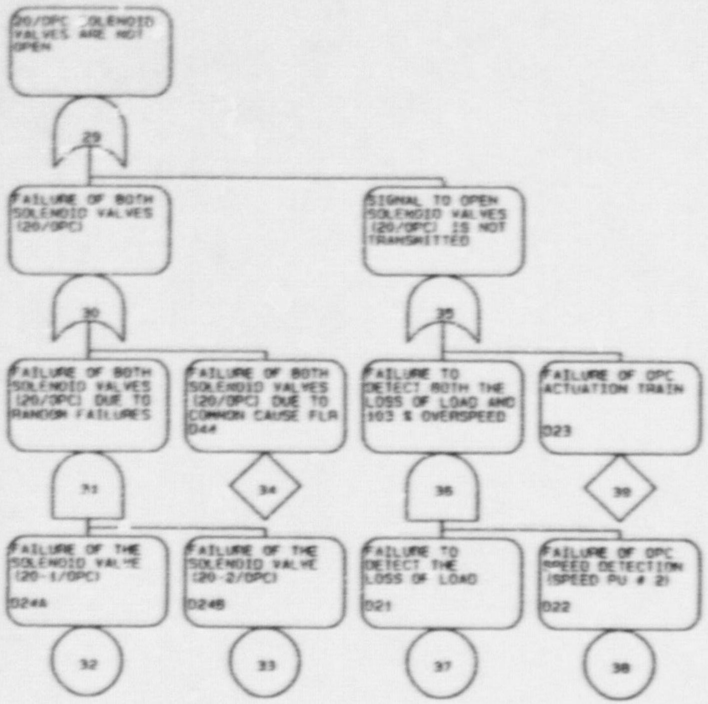
Page 1




DRAIN PATH TO EH RESERVOIR IS BLOCKED
15
SERVO/DUMP VALVE DRAIN LINE IS CLOGGED
D27CV1
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN
D28CV1
COMMON GOVERNOR VALVE (SERVO) DRAIN LINE IS CLOGGED
-30CV
17
18
19
E



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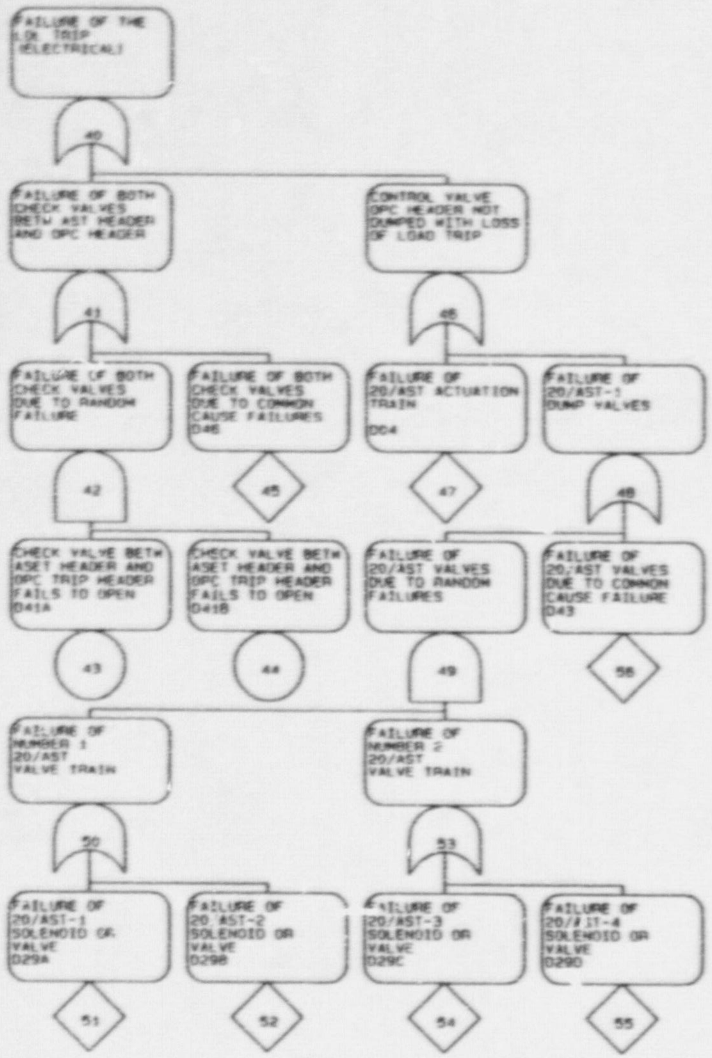
FAILURE OF THE LOL TRIP (ELECTRICAL)
40
FAILURE OF BOTH CHECK VALVES BETW AST HEADER AND OPC HEADER
CONTROL VALVE OPC HEADER NOT DUMPED WITH LOSS OF LOAD TRIP
41
46
FAILURE OF BOTH CHECK VALVES DUE TO RANDOM FAILURE
FAILURE OF BOTH CHECK VALVES DUE TO COMMON CAUSE FAILURES D46
FAILURE OF 20/AST ACTUATION TRAIN D04
FAILURE OF 20/AST-1 DUMP VALVES
42
45
47
48
CHECK VALVE BETW ASET HEADER AND OPC TRIP HEADER FAILS TO OPEN D41A
CHECK VALVE BETW ASET HEADER AND OPC TRIP HEADER FAILS TO OPEN D41B
FAILURE OF 20/AST VALVES DUE TO RANDOM FAILURES
FAILURE OF 20/AST VALVES DUE TO COMMON CAUSE FAILURE D43
43
44
49
56
FAILURE OF NUMBER 1 20/AST VALVE TRAIN
FAILURE OF NUMBER 2 20/AST VALVE TRAIN
50
53
FAILURE OF 20/AST-1 SOLENOID OR VALVE D29A
FAILURE OF 20/AST-2 SOLENOID OR VALVE D29B
FAILURE OF 20/AST-3 SOLENOID OR VALVE D29C
FAILURE OF 20/AST-4 SOLENOID OR VALVE D29D
51
52
54
55

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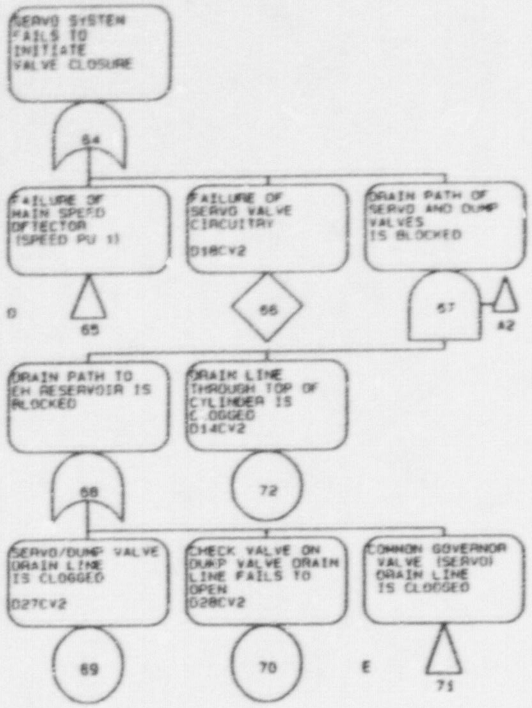

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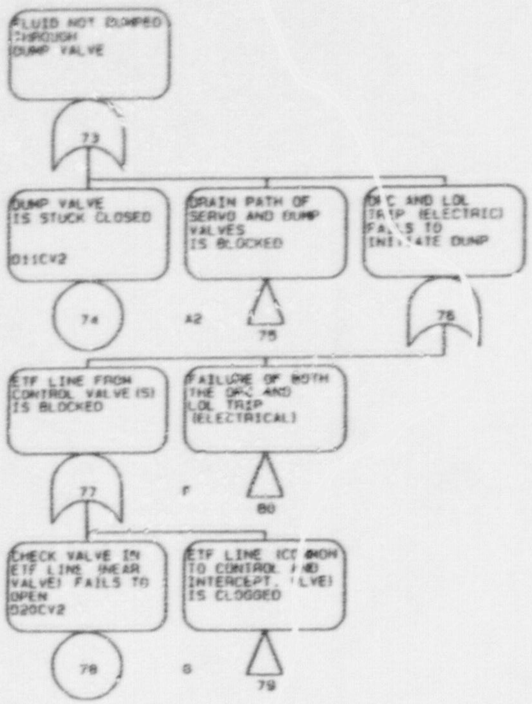
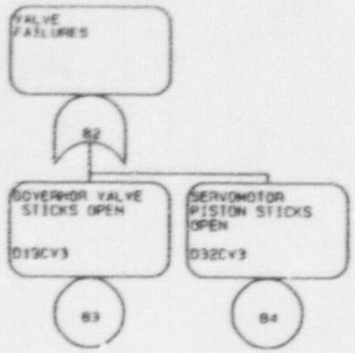
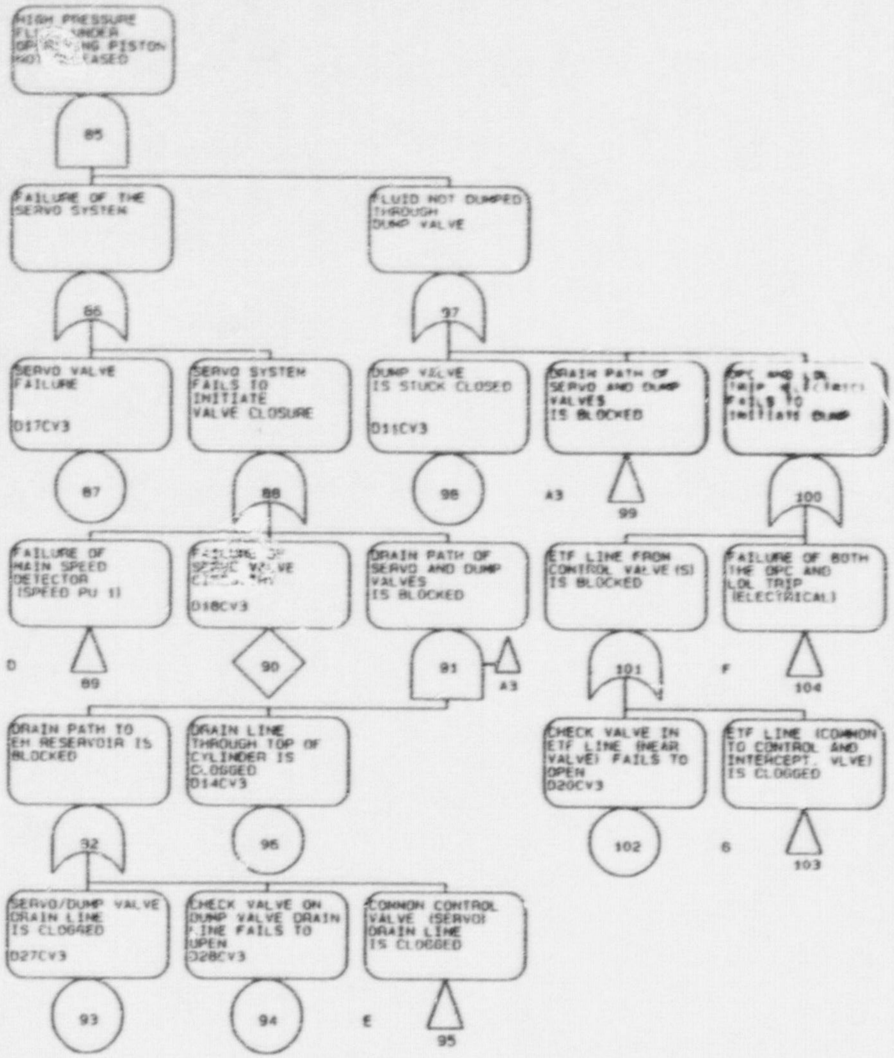



VALVE FAILURES
B2
GOVERNOR VALVE STICKS OPEN
D13CV3
SERVOMOTOR PISTON STICKS OPEN
D32CV3
B3
B4


FAILURE OF THE SERVO SYSTEM
FLUID NOT DUMPED THROUGH DUMP VALVE
85
86
97
SERVO VALVE FAILURE D17CV3
SERVO SYSTEM FAILS TO INITIATE VALVE CLOSURE
DUMP VALVE IS STUCK CLOSED D11CV3
DRAIN PATH OF SERVO AND DUMP VALVES IS BLOCKED
87
88
98
A3
99
100
FAILURE OF MAIN SPEED DETECTOR (SPEED PU 1)
D18CV3
DRAIN PATH OF SERVO AND DUMP VALVES IS BLOCKED
ETF LINE FROM CONTROL VALVE (S) IS BLOCKED
FAILURE OF BOTH THE OPC AND LDL TRIP (ELECTRICAL)
D
89
90
91
A3
101
F
104
DRAIN PATH TO EH RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14CV3
CHECK VALVE IN ETF LINE (NEAR VALVE) FAILS TO OPEN D20CV3
ETF LINE (COMMON TO CONTROL AND INTERCEPT. VLVE) IS CLOGGED
92
96
102
G
103
SERVO/DUMP VALVE DRAIN LINE IS CLOGGED D27CV3
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28CV3
COMMON CONTROL VALVE (SERVO) DRAIN LINE IS CLOGGED
93
94
E
95

Fault tree : o:\ns04\proj\tvtf\vand2d-

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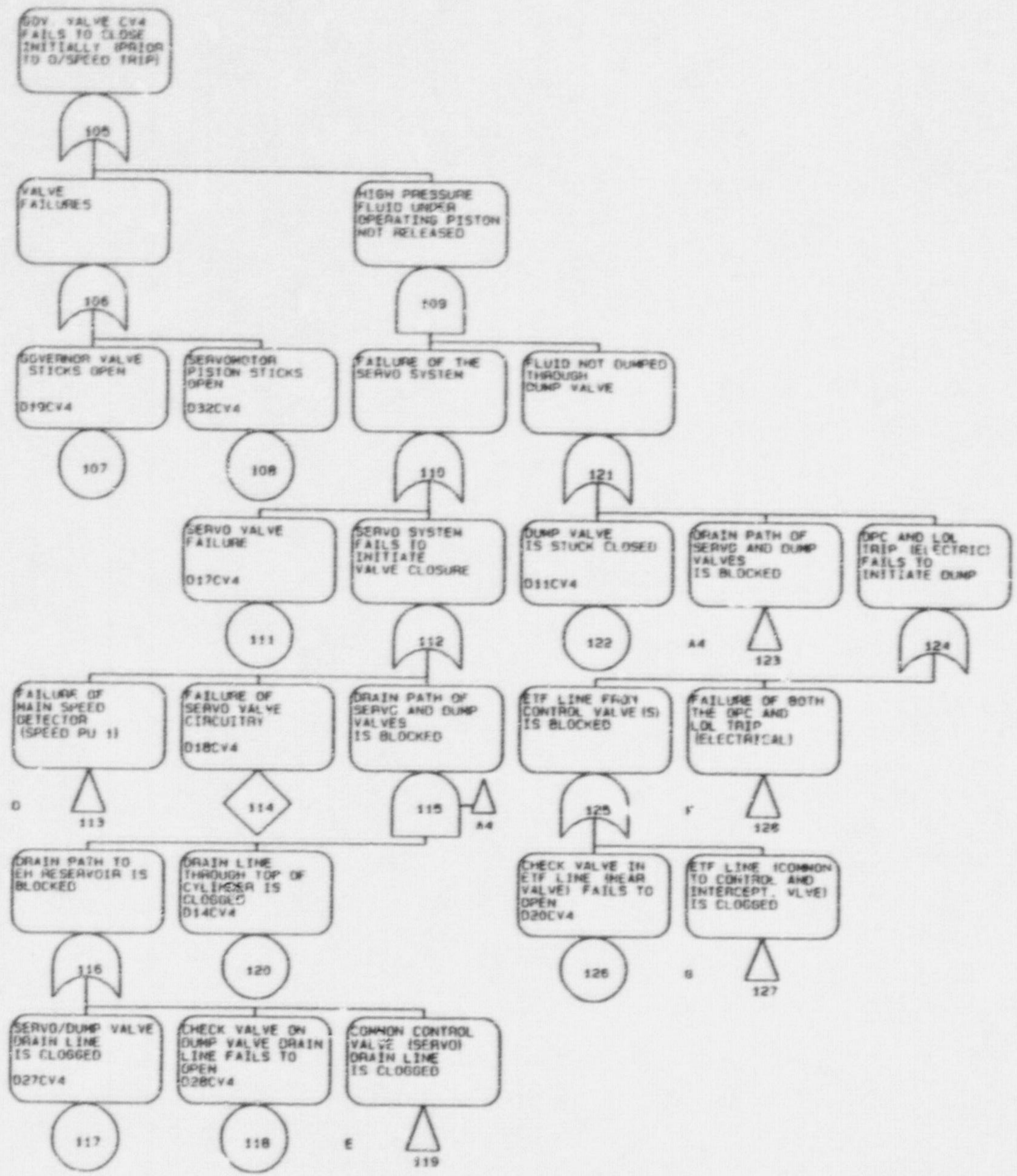
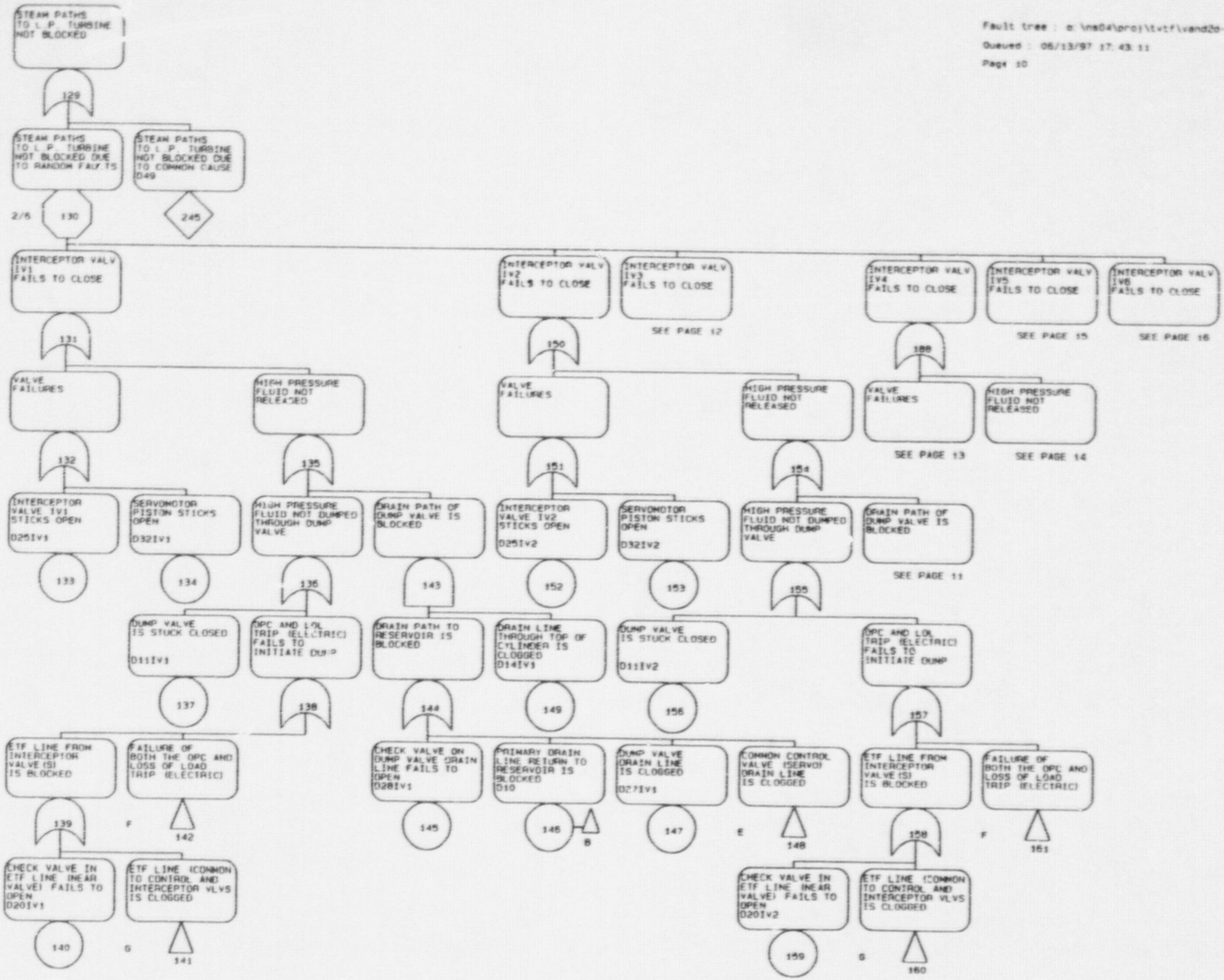
Page 9




STEAM PATHS TO L.P. TURBINE NOT BLOCKED
129
STEAM PATHS TO L.P. TURBINE NOT BLOCKED DUE TO RANDOM FAULTS
STEAM PATHS TO L.P. TURBINE NOT BLOCKED DUE TO COMMON CAUSE D49
2/6
130
245
INTERCEPTOR VALV IV1 FAILS TO CLOSE
INTERCEPTOR VALV IV2 FAILS TO CLOSE
INTERCEPTOR VALV IV3 FAILS TO CLOSE
SEE PAGE 12
INTERCEPTOR VALV IV4 FAILS TO CLOSE
INTERCEPTOR VALV IV5 FAILS TO CLOSE
SEE PAGE 15
INTERCEPTOR VALV IV6 FAILS TO CLOSE
SEE PAGE 16
131
VALVE FAILURES
HIGH PRESSURE FLUID NOT RELEASED
132
INTERCEPTOR VALVE IV1 STICKS OPEN D25IV1
133
SERVOMOTOR PISTON STICKS OPEN D32IV1
134
135
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
DRAIN PATH OF DUMP VALVE IS BLOCKED
136
DUMP VALVE IS STUCK CLOSED D11IV1
137
OPC AND LOL TRIP (ELECTRIC) FAILS TO INITIATE DUMP
138
ETF LINE FROM INTERCEPTOR VALVE(S) IS BLOCKED
FAILURE OF BOTH THE OPC AND LOSS OF LOAD TRIP (ELECTRIC)
F
142
139
CHECK VALVE IN ETF LINE (NEAR VALVE) FAILS TO OPEN D20IV1
140
G
ETF LINE (COMMON TO CONTROL AND INTERCEPTOR VLVS IS CLOGGED
141
143
DRAIN PATH TO RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14IV1
149
144
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28IV1
145
PRIMARY DRAIN LINE RETURN TO RESERVOIR IS BLOCKED D10
146
B
DUMP VALVE DRAIN LINE IS CLOGGED D27IV1
147
COMMON CONTROL VALVE (SERVO) DRAIN LINE IS CLOGGED
E
148
150
VALVE FAILURES
HIGH PRESSURE FLUID NOT RELEASED
151
INTERCEPTOR VALVE IV2 STICKS OPEN D25IV2
152
SERVOMOTOR PISTON STICKS OPEN D32IV2
153
154
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
DRAIN PATH OF DUMP VALVE IS BLOCKED
SEE PAGE 11
155
DUMP VALVE IS STUCK CLOSED D11IV2
156
OPC AND LOL TRIP (ELECTRIC) FAILS TO INITIATE DUMP
157
ETF LINE FROM INTERCEPTOR VALVE(S) IS BLOCKED
FAILURE OF BOTH THE OPC AND LOSS OF LOAD TRIP (ELECTRIC)
F
161
158
CHECK VALVE IN ETF LINE (NEAR VALVE) FAILS TO OPEN D20IV2
159
G
ETF LINE (COMMON TO CONTROL AND INTERCEPTOR VLVS IS CLOGGED
160
188
VALVE FAILURES
SEE PAGE 13
HIGH PRESSURE FLUID NOT RELEASED
SEE PAGE 14

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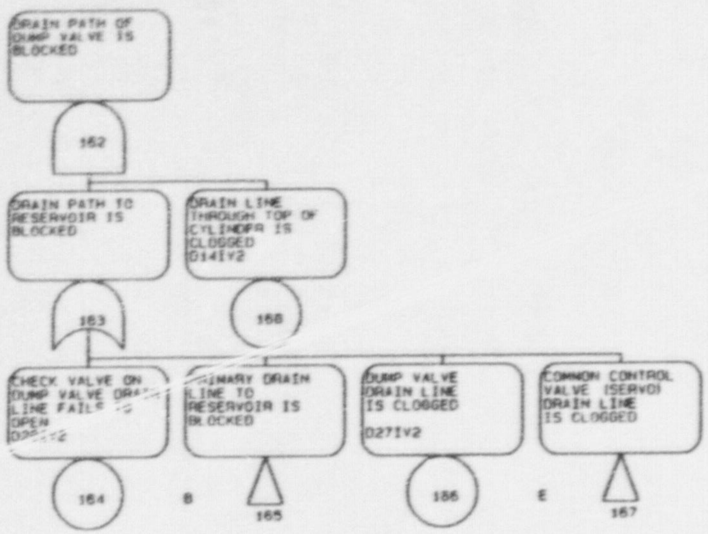
Page 11



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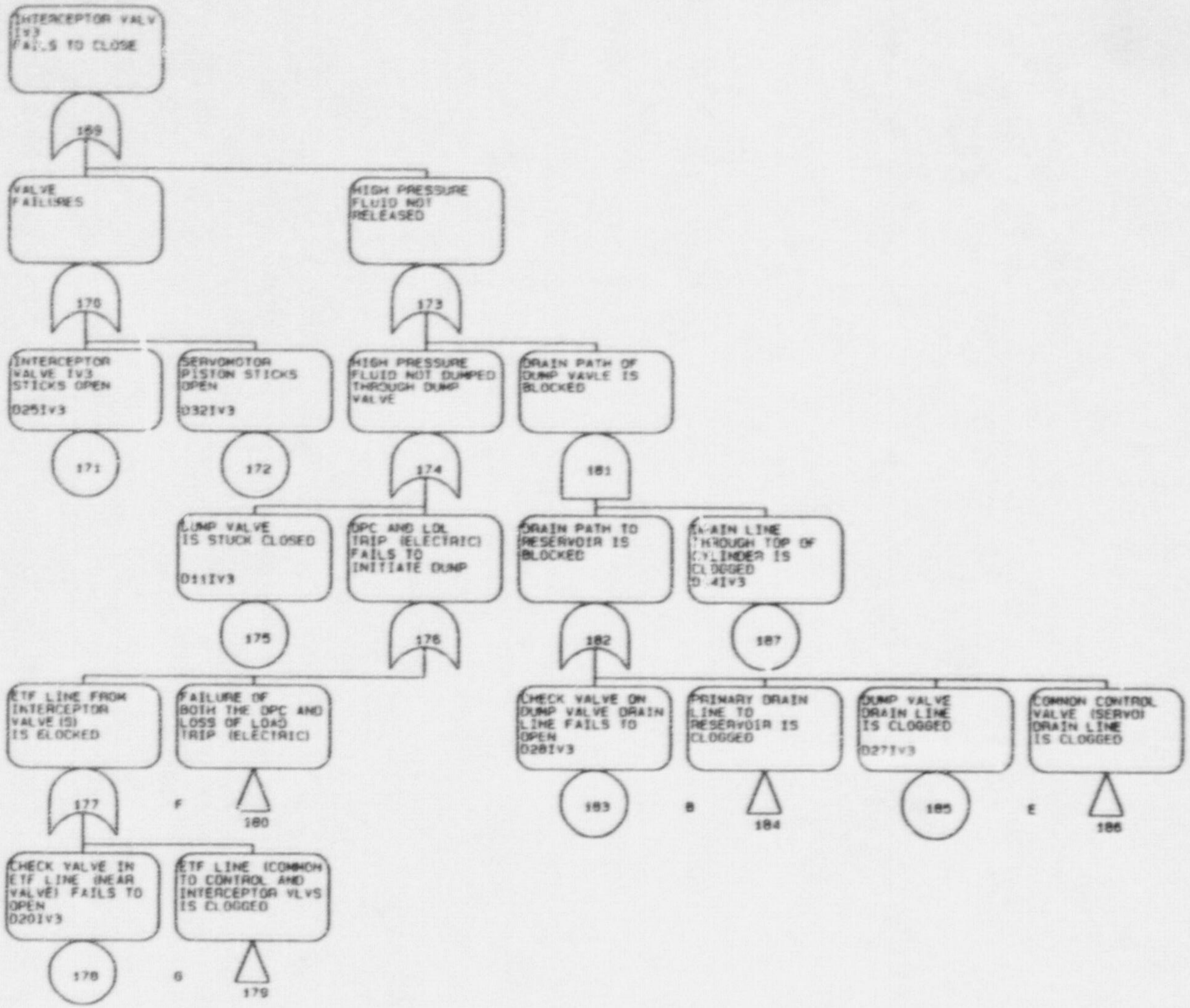
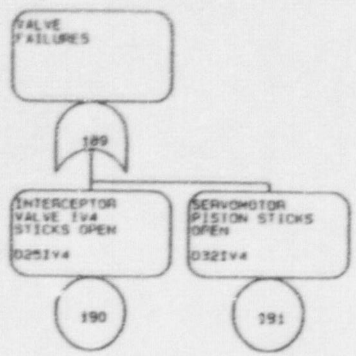
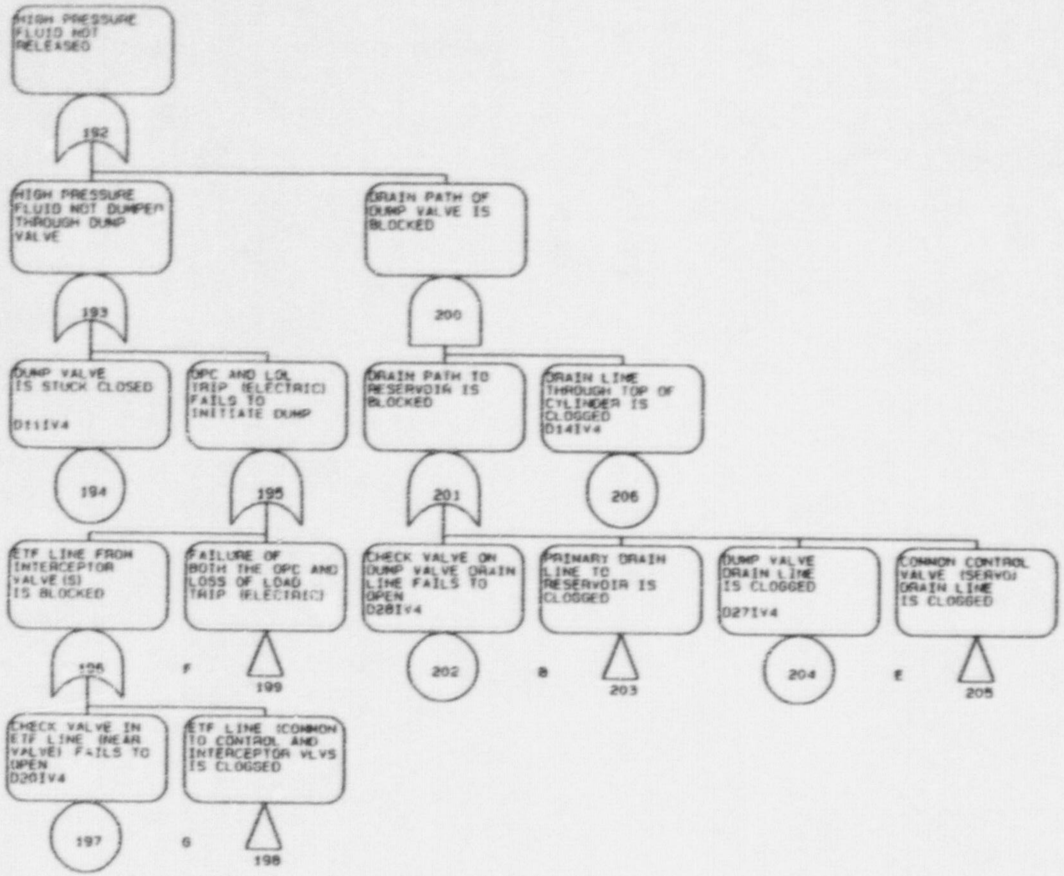



VALVE
FAILURES
189
INTERCEPTOR
VALVE IV4
STICKS OPEN
D25IV4
SERVOMOTOR
PISION STICKS
OPEN
D32IV4
190
191


HIGH PRESSURE FLUID NOT RELEASED
192
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
DRAIN PATH OF DUMP VALVE IS BLOCKED
193
200
DUMP VALVE IS STUCK CLOSED D11IV4
OPC AND LOL TRIP (ELECTRIC) FAILS TO INITIATE DUMP
DRAIN PATH TO RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14IV4
194
195
201
206
ETF LINE FROM INTERCEPTOR VALVE(S) IS BLOCKED
FAILURE OF BOTH THE OPC AND LOSS OF LOAD TRIP (ELECTRIC)
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28IV4
PRIMARY DRAIN LINE TO RESERVOIR IS CLOGGED
DUMP VALVE DRAIN LINE IS CLOGGED D27IV4
COMMON CONTROL VALVE (SERVO) DRAIN LINE IS CLOGGED
196
F
199
202
B
203
204
E
205
CHECK VALVE IN ETF LINE (NEAR VALVE) FAILS TO OPEN D20IV4
ETF LINE (COMMON TO CONTROL AND INTERCEPTOR VLVS IS CLOGGED
197
G
198

Fault tree : o:\ns04\proj\tvtf\vand20-
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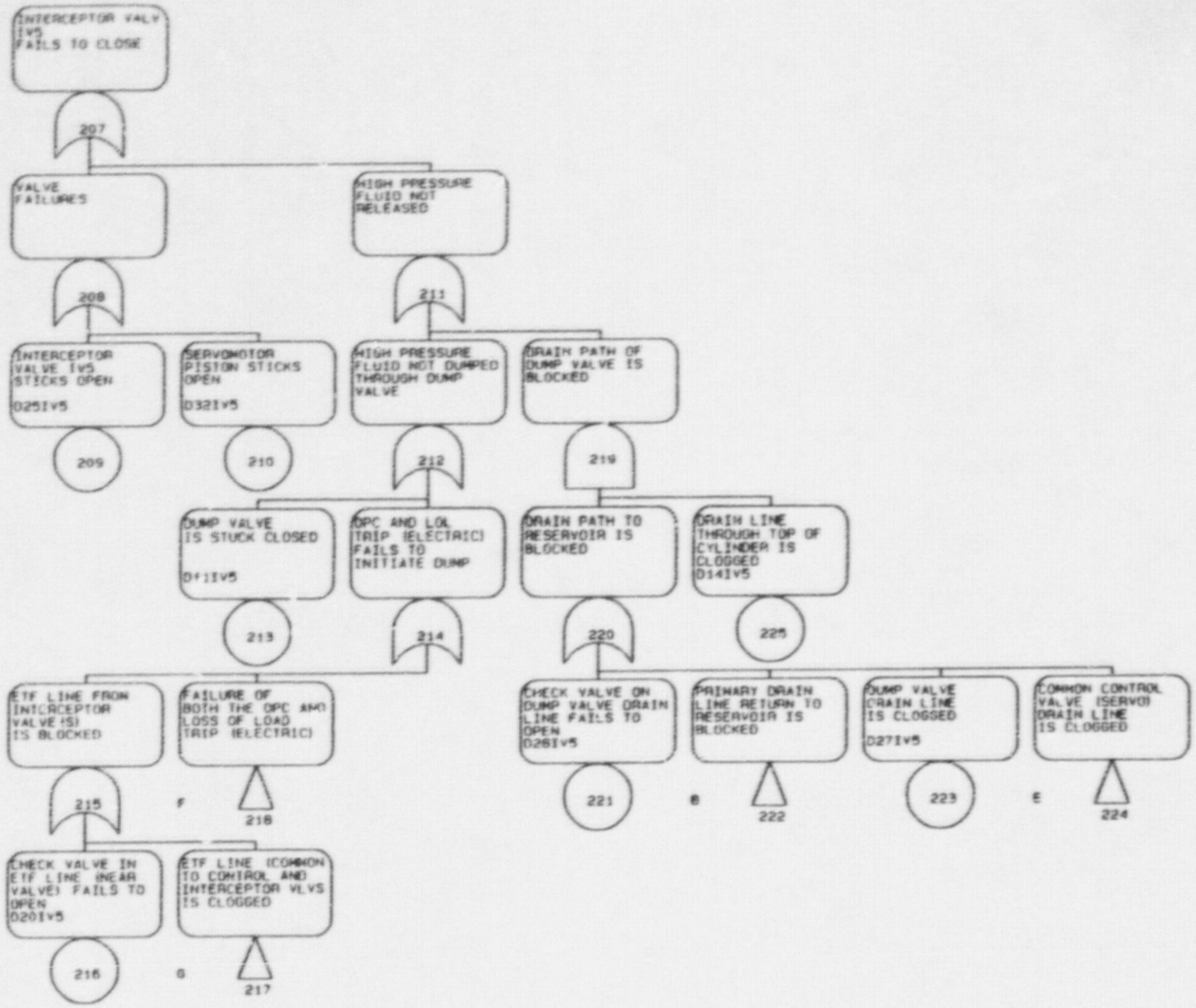
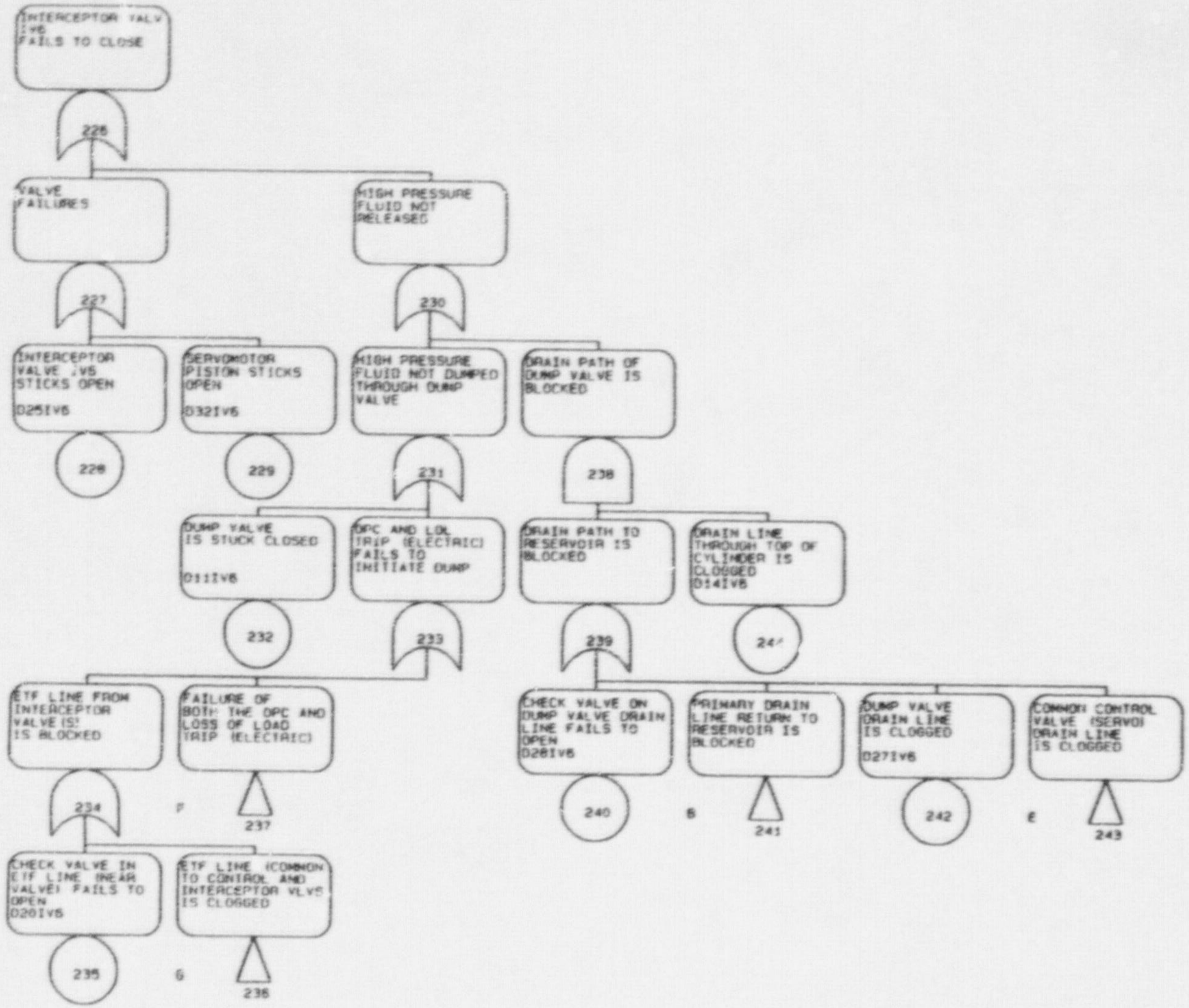
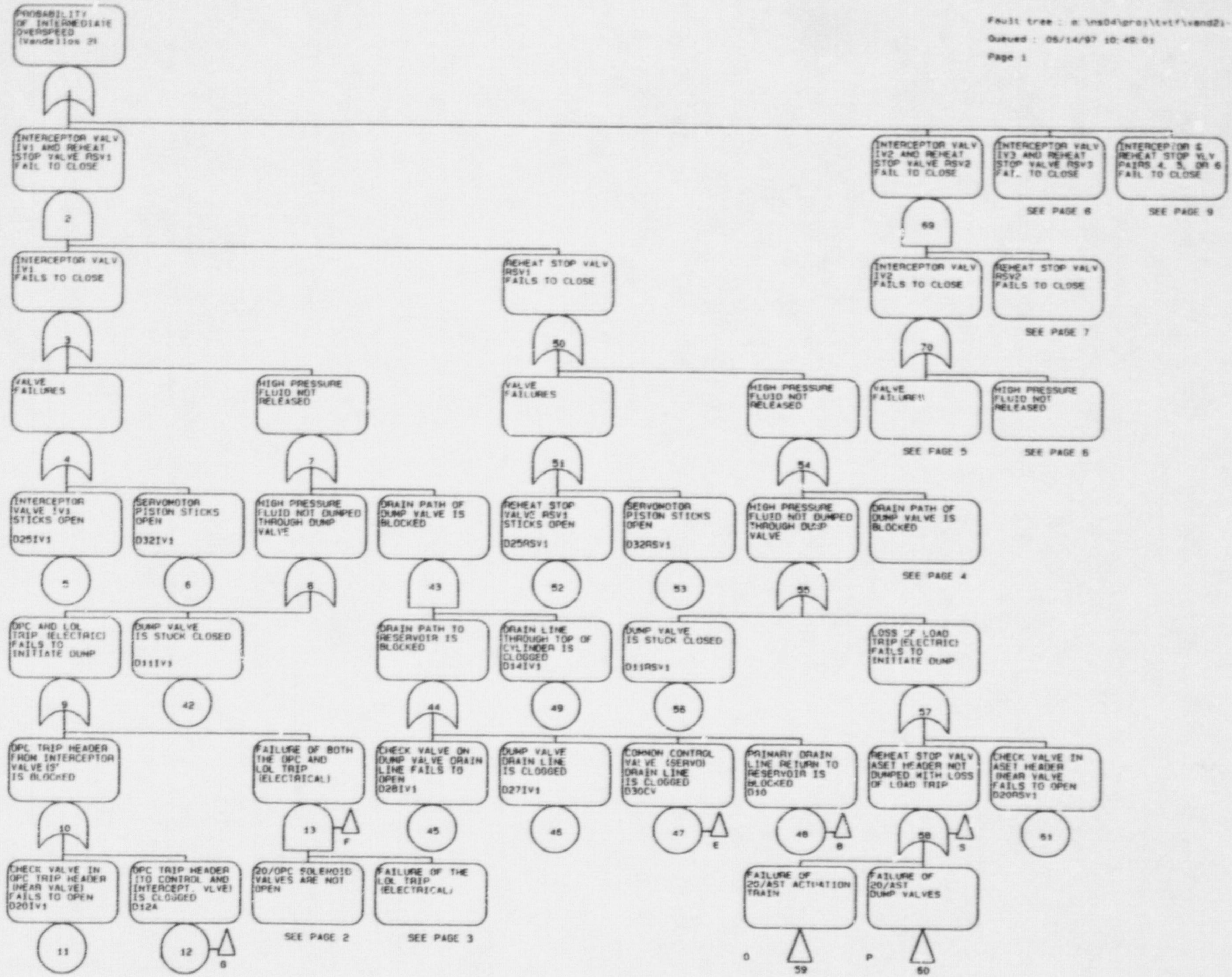
Page 15




INTERCEPTOR VALV IV6 FAILS TO CLOSE
226
VALVE FAILURES
HIGH PRESSURE FLUID NOT RELEASED
227
230
INTERCEPTOR VALVE IV6 STICKS OPEN
D25IV6
SERVOMOTOR PISTON STICKS OPEN
D32IV6
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
DRAIN PATH OF DUMP VALVE IS BLOCKED
228
229
231
238
DUMP VALVE IS STUCK CLOSED
D11IV6
OPC AND LDL TRIP (ELECTRIC) FAILS TO INITIATE DUMP
DRAIN PATH TO RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED
D14IV6
232
233
239
24?
ETF LINE FROM INTERCEPTOR VALVE(S) IS BLOCKED
FAILURE OF BOTH THE OPC AND LOSS OF LOAD TRIP (ELECTRIC)
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN
D28IV6
PRIMARY DRAIN LINE RETURN TO RESERVOIR IS BLOCKED
DUMP VALVE DRAIN LINE IS CLOGGED
D27IV6
COMMON CONTROL VALVE (SERVO) DRAIN LINE IS CLOGGED
234
F
237
240
B
241
242
E
243
CHECK VALVE IN ETF LINE (NEAR VALVE) FAILS TO OPEN
D20IV6
ETF LINE (COMMON TO CONTROL AND INTERCEPTOR VLVS IS CLOGGED
235
G
236


PROBABILITY OF INTERMEDIATE OVERSPEED (Vandellos 2)
INTERCEPTOR VALV IV1 AND REHEAT STOP VALVE RSV1 FAIL TO CLOSE
INTERCEPTOR VALV IV2 AND REHEAT STOP VALVE RSV2 FAIL TO CLOSE
INTERCEPTOR VALV IV3 AND REHEAT STOP VALVE RSV3 FAIL TO CLOSE
SEE PAGE 6
INTERCEPTOR & REHEAT STOP VLV PAIRS 4, 5, OR 6 FAIL TO CLOSE
SEE PAGE 9
2
69
INTERCEPTOR VALV IV1 FAILS TO CLOSE
REHEAT STOP VALV RSV1 FAILS TO CLOSE
INTERCEPTOR VALV IV2 FAILS TO CLOSE
REHEAT STOP VALV RSV2 FAILS TO CLOSE
SEE PAGE 7
3
50
70
VALVE FAILURES
HIGH PRESSURE FLUID NOT RELEASED
VALVE FAILURES
HIGH PRESSURE FLUID NOT RELEASED
VALVE FAILURES
HIGH PRESSURE FLUID NOT RELEASED
SEE PAGE 5
SEE PAGE 6
4
7
51
54
INTERCEPTOR VALVE IV1 STICKS OPEN D25IV1
SERVOMOTOR PISTON STICKS OPEN D32IV1
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
DRAIN PATH OF DUMP VALVE IS BLOCKED
REHEAT STOP VALVE RSV1 STICKS OPEN D25RSV1
SERVOMOTOR PISTON STICKS OPEN D32RSV1
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
DRAIN PATH OF DUMP VALVE IS BLOCKED
SEE PAGE 4
5
6
8
43
52
53
55
OPC AND LOL TRIP (ELECTRIC) FAILS TO INITIATE DUMP
DUMP VALVE IS STUCK CLOSED D11IV1
DRAIN PATH TO RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14IV1
DUMP VALVE IS STUCK CLOSED D11RSV1
LOSS OF LOAD TRIP (ELECTRIC) FAILS TO INITIATE DUMP
9
42
44
49
56
57
OPC TRIP HEADER FROM INTERCEPTOR VALVE(S) IS BLOCKED
FAILURE OF BOTH THE OPC AND LOL TRIP (ELECTRICAL)
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28IV1
DUMP VALVE DRAIN LINE IS CLOGGED D27IV1
COMMON CONTROL VALVE (SERVO) DRAIN LINE IS CLOGGED D30CV
PRIMARY DRAIN LINE RETURN TO RESERVOIR IS BLOCKED D10
REHEAT STOP VALV ASET HEADER NOT DUMPED WITH LOSS OF LOAD TRIP
CHECK VALVE IN ASET HEADER (NEAR VALVE) FAILS TO OPEN D20RSV1
10
13
F
45
46
47
E
48
B
58
S
61
CHECK VALVE IN OPC TRIP HEADER (NEAR VALVE) FAILS TO OPEN D20IV1
OPC TRIP HEADER (TO CONTROL AND INTERCEPT. VLVE) IS CLOGGED D12A
20/OPC SOLENOID VALVES ARE NOT OPEN
FAILURE OF THE LOL TRIP (ELECTRICAL)
FAILURE OF 20/AST ACTUATION TRAIN
FAILURE OF 20/AST DUMP VALVES
SEE PAGE 2
SEE PAGE 3
11
12
B
O
59
P
60

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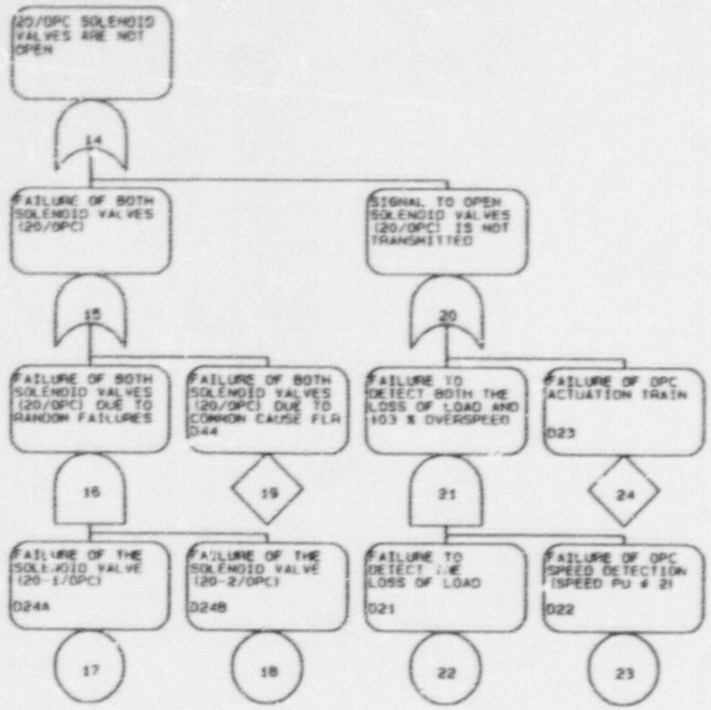

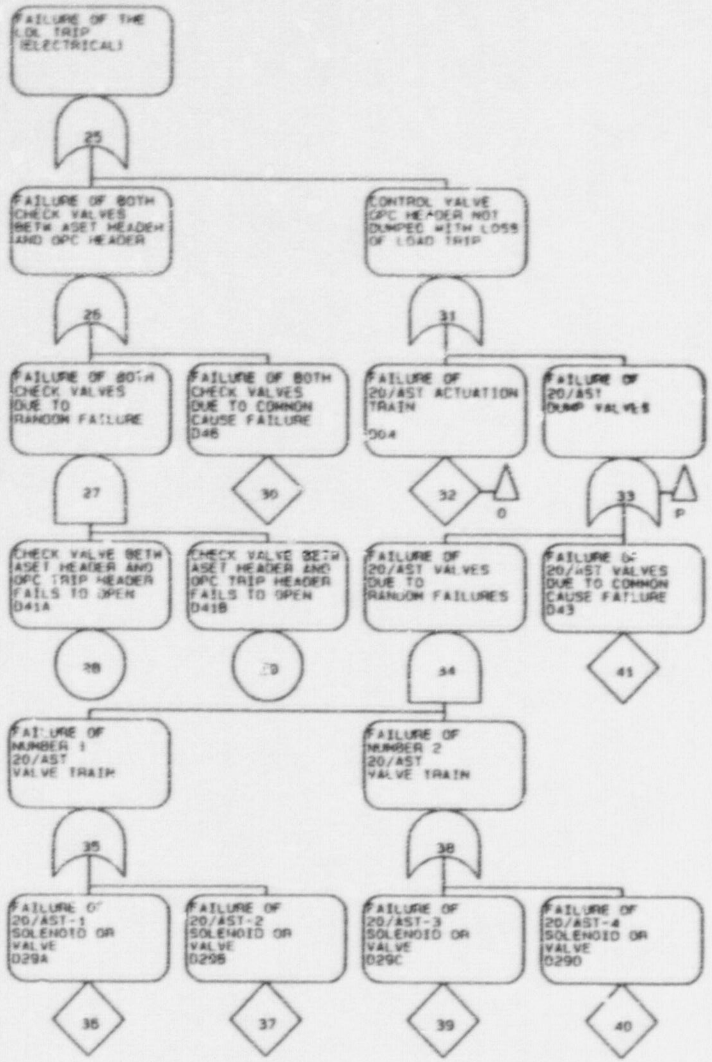

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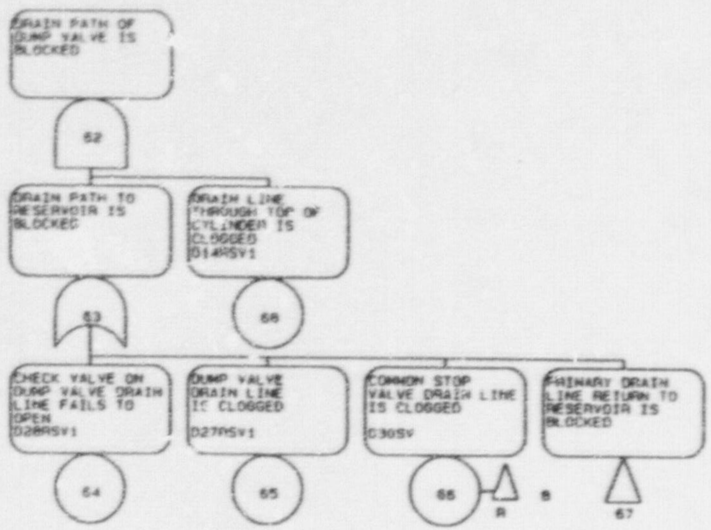

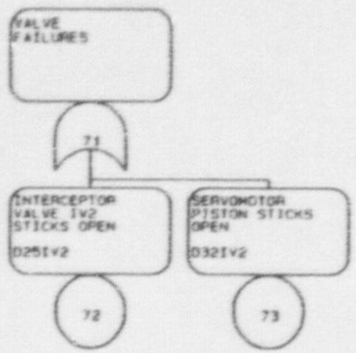
VALVE
FAILURES
71
INTERCEPTOR
VALVE IV2
STICKS OPEN
D25IV2
SERVOMOTOR
PISTON STICKS
OPEN
D32IV2
72
73

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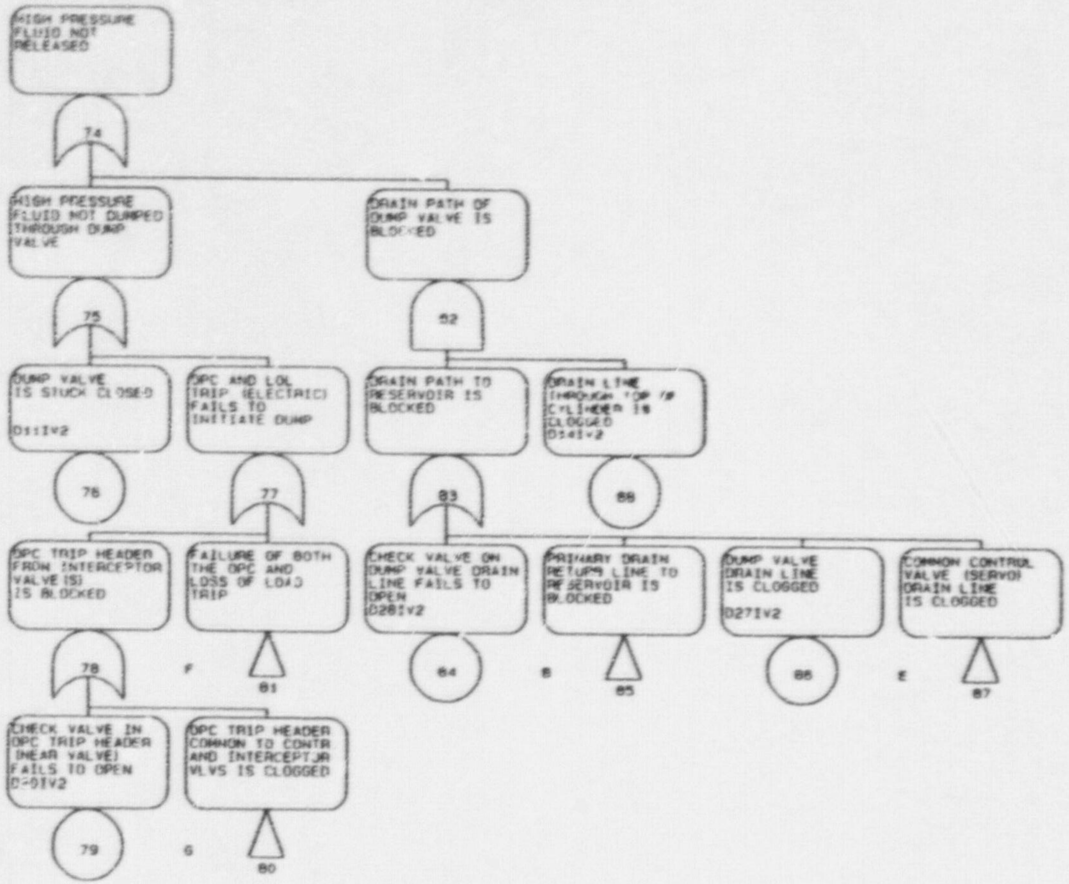

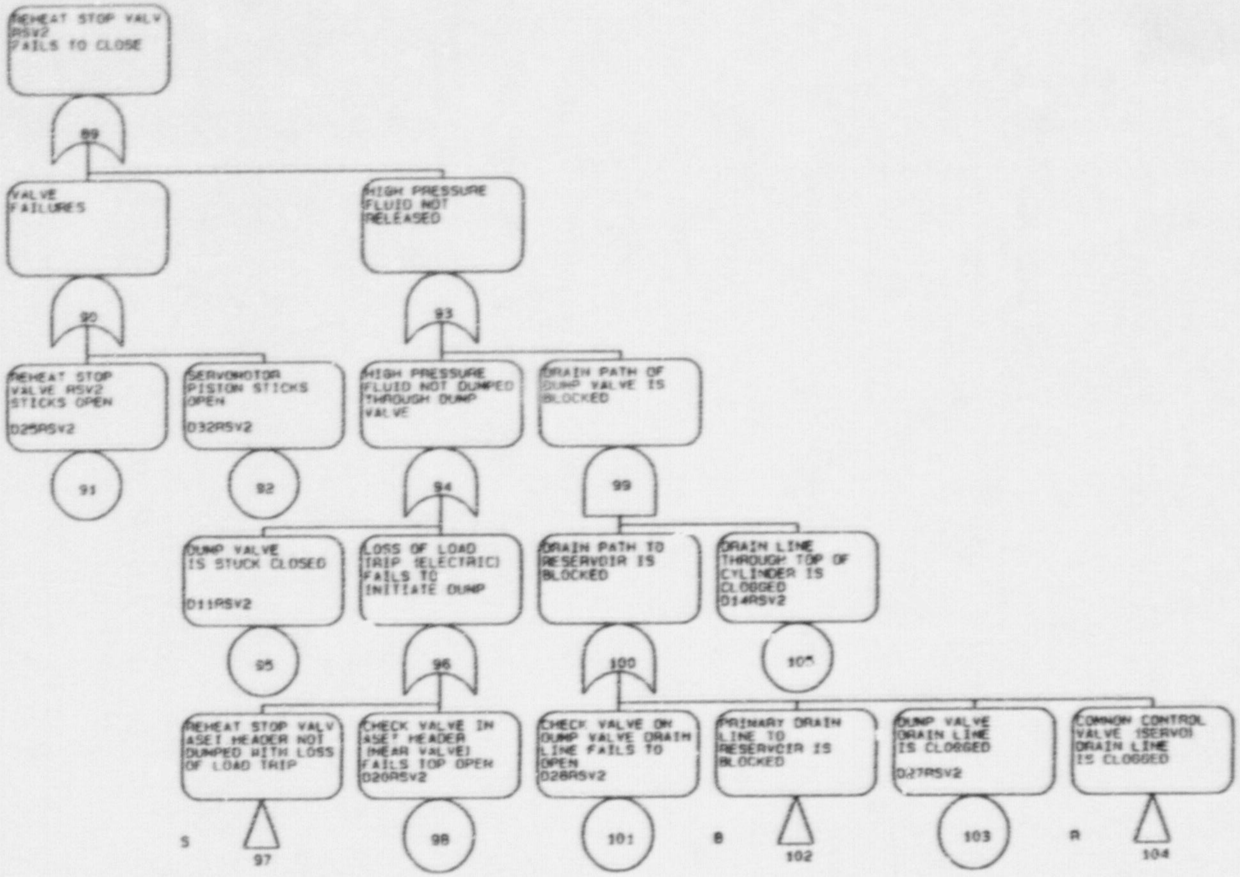
REHEAT STOP VALV RSV2 FAILS TO CLOSE
89
VALVE FAILURES
HIGH PRESSURE FLUID NOT RELEASED
90
93
REHEAT STOP VALVE RSV2 STICKS OPEN D25RSV2
SERVOMOTOR PISTON STICKS OPEN D32RSV2
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
DRAIN PATH OF DUMP VALVE IS BLOCKED
91
92
94
99
DUMP VALVE IS STUCK CLOSED D11RSV2
LOSS OF LOAD TRIP (ELECTRIC) FAILS TO INITIATE DUMP
DRAIN PATH TO RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14RSV2
95
96
100
REHEAT STOP VALV ASEI HEADER NOT DUMPED WITH LOSS OF LOAD TRIP
CHECK VALVE IN ASEI HEADER (NEAR VALVE) FAILS TOP OPEN D20RSV2
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28RSV2
PRIMARY DRAIN LINE TO RESERVOIR IS BLOCKED
DUMP VALVE DRAIN LINE IS CLOGGED D27RSV2
COMMON CONTROL VALVE (SERVO) DRAIN LINE IS CLOGGED
5
97
98
101
8
102
103
R
104

Fault tree : o:\ns04\proj\tvtf\vand2

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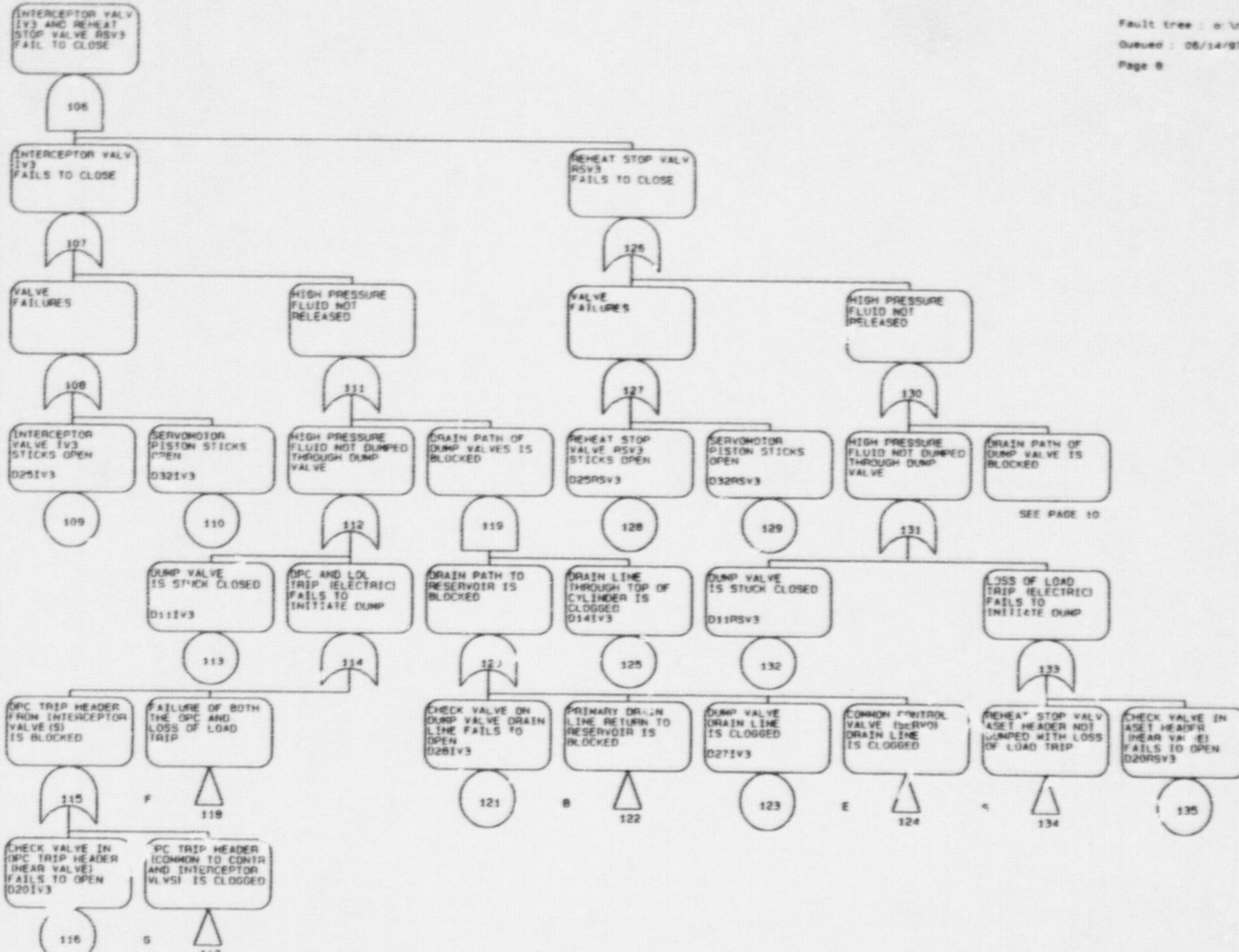

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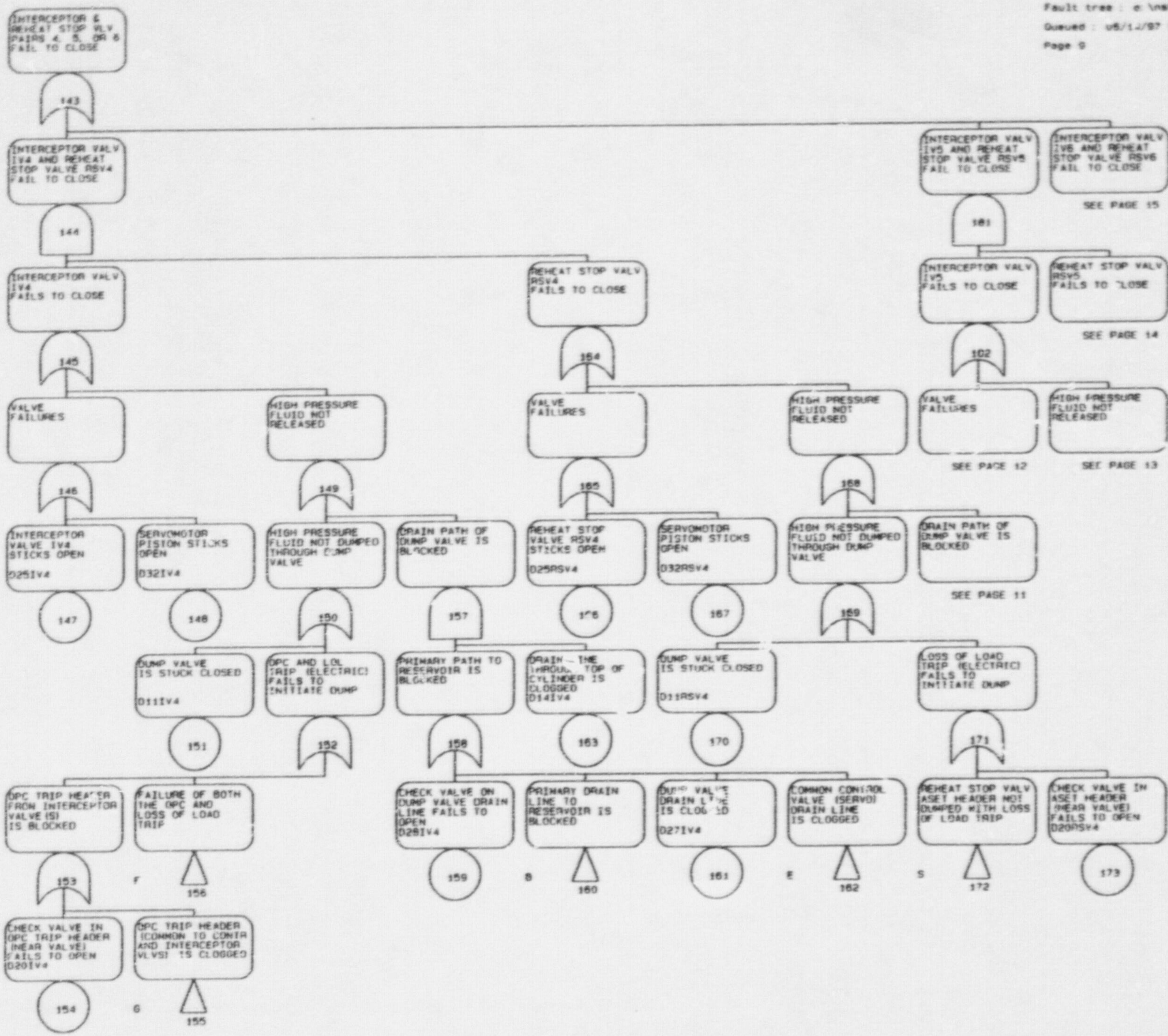
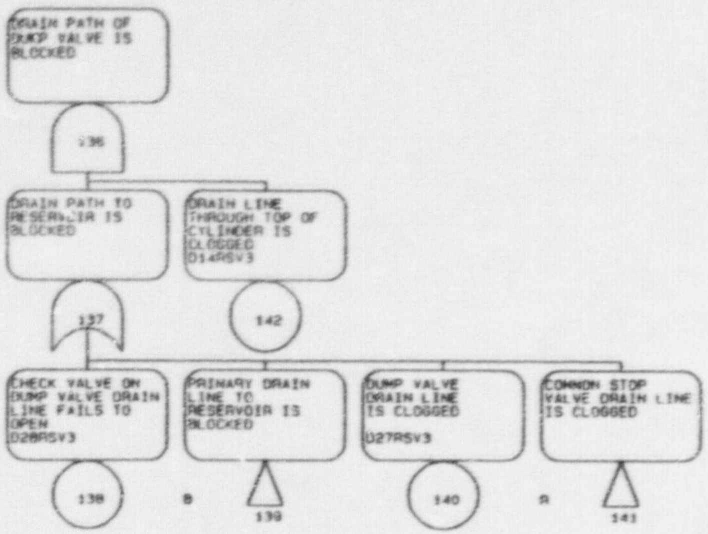
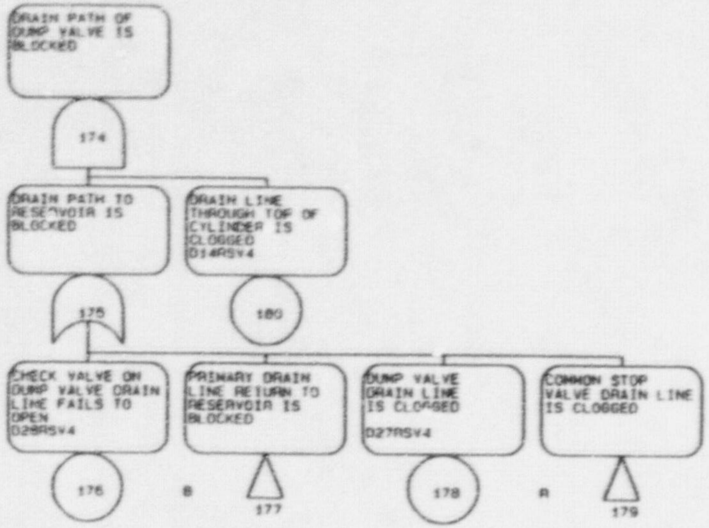
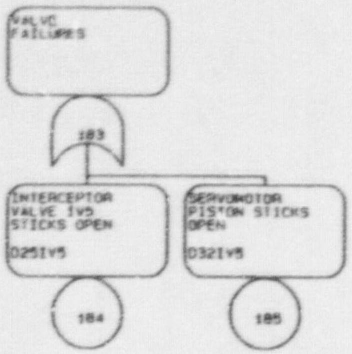



DRAIN PATH OF DUMP VALVE IS BLOCKED
136
DRAIN PATH TO RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14RSV3
137
142
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28RSV3
PRIMARY DRAIN LINE TO RESERVOIR IS BLOCKED
DUMP VALVE DRAIN LINE IS CLOGGED
D27RSV3
COMMON STOP VALVE DRAIN LINE IS CLOGGED
138
B
139
140
A
141


DRAIN PATH OF DUMP VALVE IS BLOCKED
174
DRAIN PATH TO RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14RSV4
175
180
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28RSV4
PRIMARY DRAIN LINE RETURN TO RESERVOIR IS BLOCKED
DUMP VALVE DRAIN LINE IS CLOGGED D27RSV4
COMMON STOP VALVE DRAIN LINE IS CLOGGED
176
B
177
178
A
179


VALVE
FAILURES
183
INTERCEPTOR
VALVE IV5
STICKS OPEN
D25IV5
SERVOMOTOR
PISTON STICKS
OPEN
D32IV5
184
185

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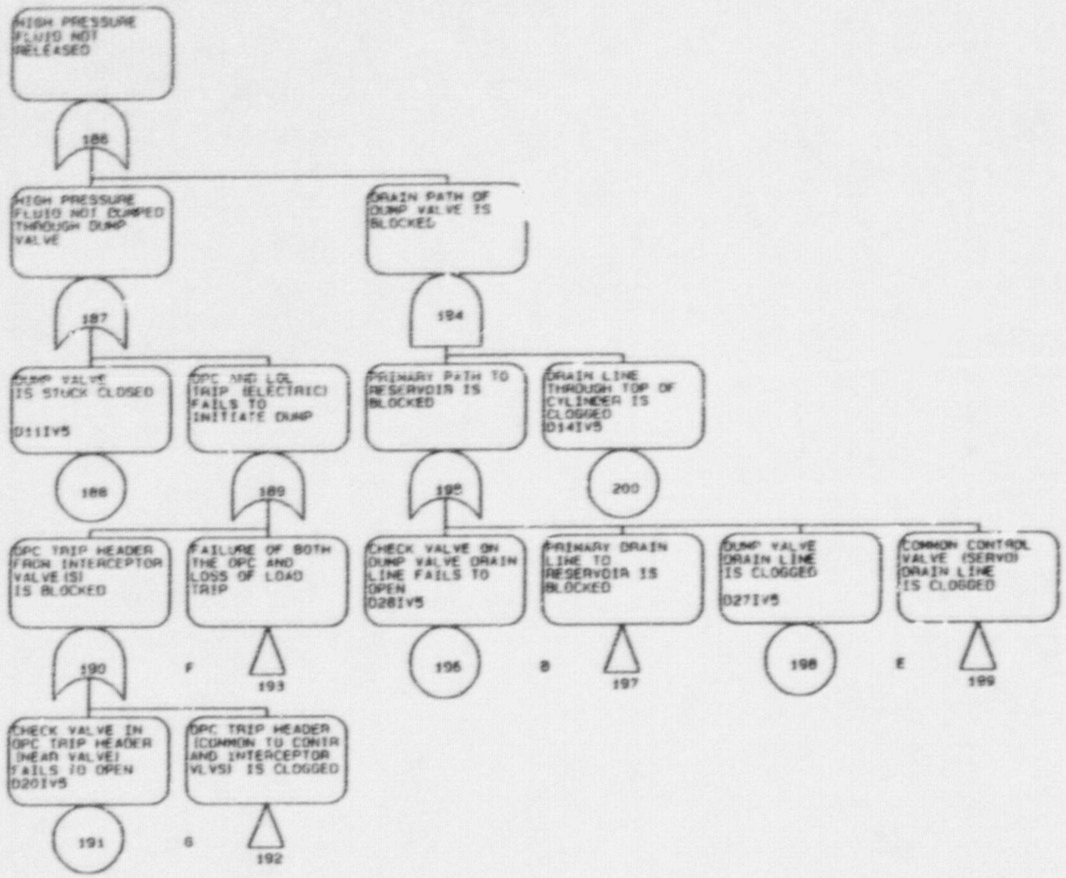
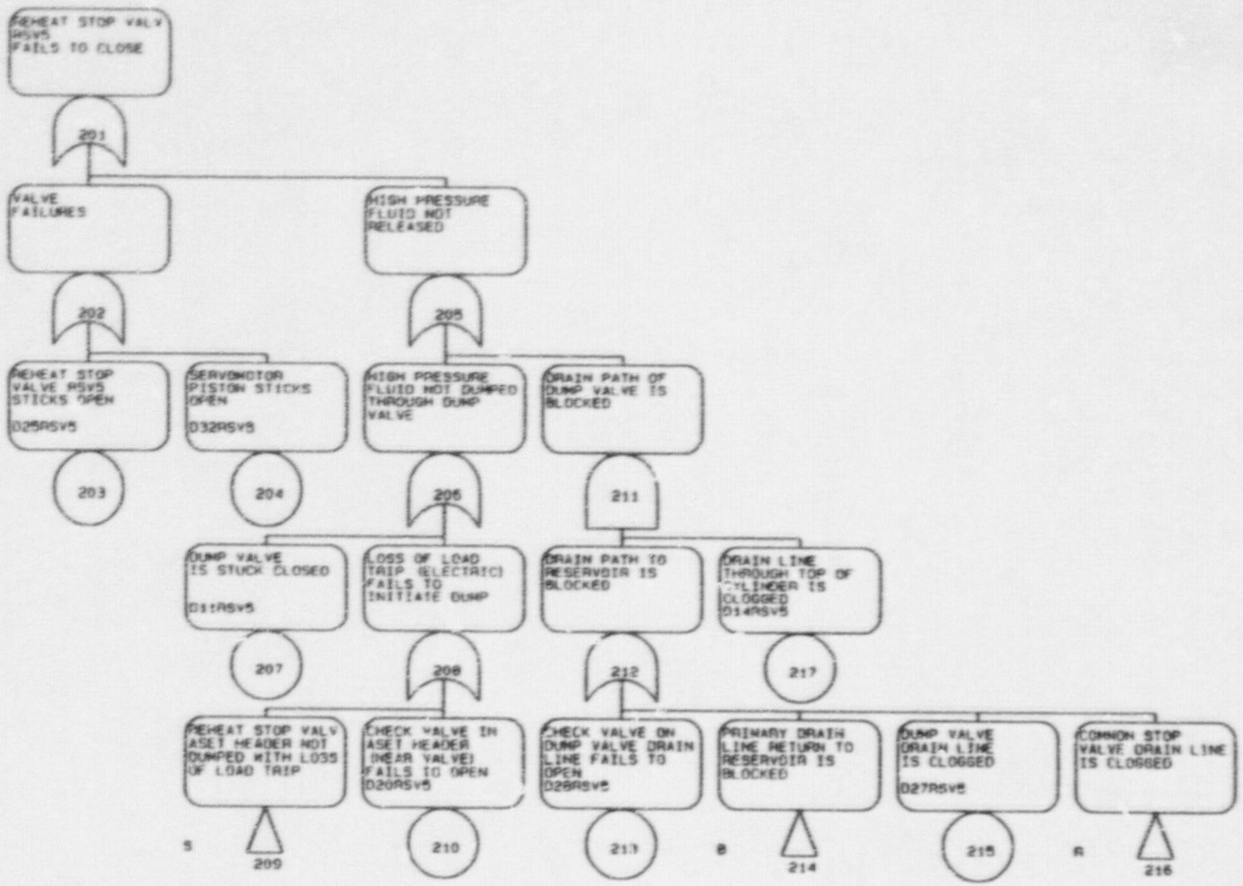
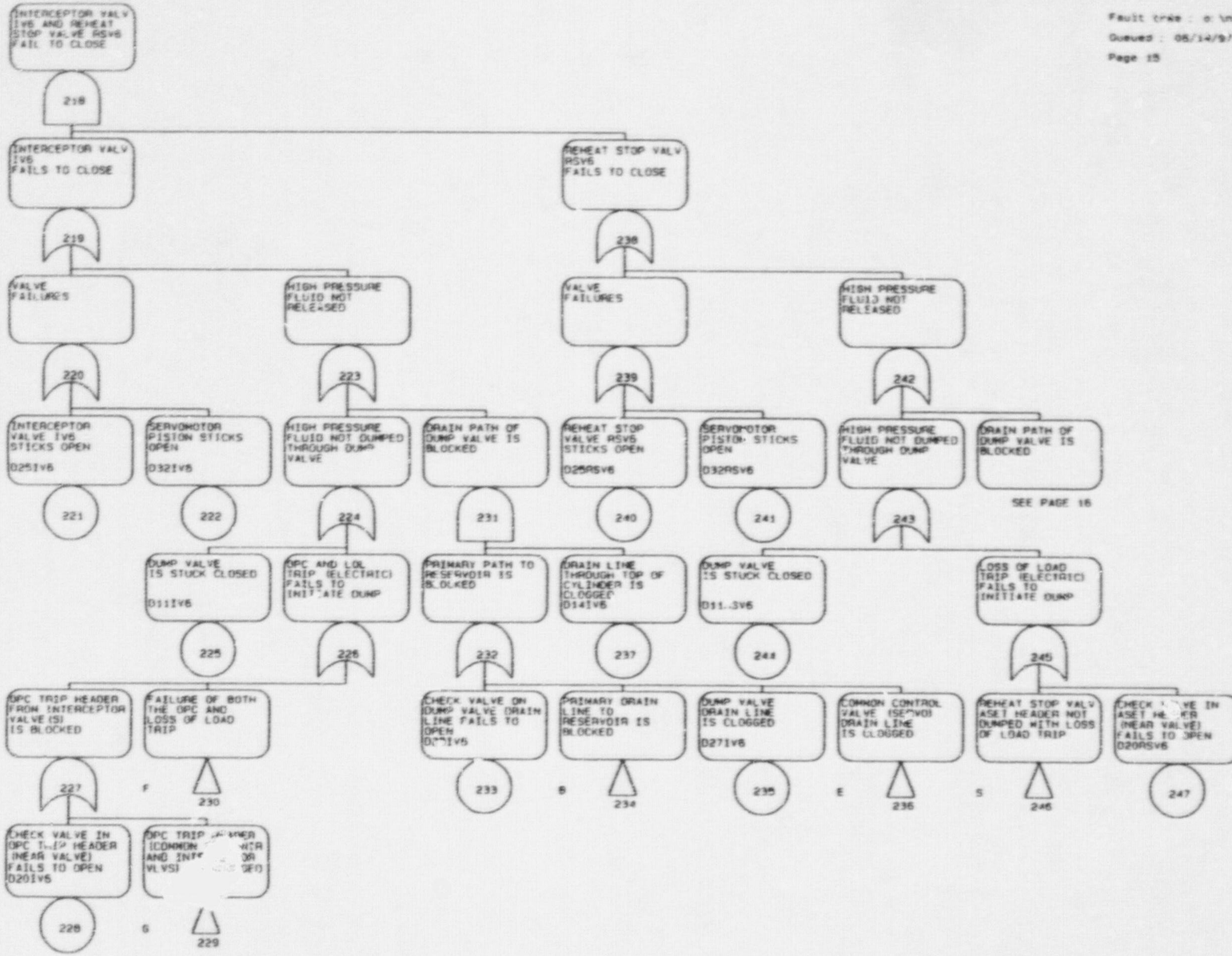



REHEAT STOP VALV RSV5 FAILS TO CLOSE
201
VALVE FAILURES
HIGH PRESSURE FLUID NOT RELEASED
202
205
REHEAT STOP VALVE RSV5 STICKS OPEN D25RSV5
SERVOMOTOR PISTON STICKS OPEN D32RSV5
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
DRAIN PATH OF DUMP VALVE IS BLOCKED
203
204
206
211
DUMP VALVE IS STUCK CLOSED D11RSV5
LOSS OF LOAD TRIP (ELECTRIC) FAILS TO INITIATE DUMP
DRAIN PATH TO RESERVOIR IS BLOCKED
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14RSV5
207
208
212
217
REHEAT STOP VALV ASET HEADER NOT DUMPED WITH LOSS OF LOAD TRIP
CHECK VALVE IN ASET HEADER (NEAR VALVE) FAILS TO OPEN D20RSV5
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN D28RSV5
PRIMARY DRAIN LINE RETURN TO RESERVOIR IS BLOCKED
DUMP VALVE DRAIN LINE IS CLOGGED D27RSV5
COMMON STOP VALVE DRAIN LINE IS CLOGGED
5
209
210
213
8
214
215
6
216


INTERCEPTOR VALV IV6 AND REHEAT STOP VALVE RSV6 FAIL TO CLOSE
218
INTERCEPTOR VALV IV6 FAILS TO CLOSE
219
REHEAT STOP VALV RSV6 FAILS TO CLOSE
238
VALVE FAILURES
220
HIGH PRESSURE FLUID NOT RELEASED
223
VALVE FAILURES
239
HIGH PRESSURE FLUID NOT RELEASED
242
INTERCEPTOR VALVE IV6 STICKS OPEN D25IV6
221
SERVOMOTOR PISTON STICKS OPEN D32IV6
222
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
224
DRAIN PATH OF DUMP VALVE IS BLOCKED
231
REHEAT STOP VALVE RSV6 STICKS OPEN D25RSV6
240
SERVOMOTOR PISTON STICKS OPEN D32RSV6
241
HIGH PRESSURE FLUID NOT DUMPED THROUGH DUMP VALVE
243
DRAIN PATH OF DUMP VALVE IS BLOCKED
SEE PAGE 16
DUMP VALVE IS STUCK CLOSED D11IV6
225
OPC AND LOL TRIP (ELECTRIC) FAILS TO INITIATE DUMP
226
PRIMARY PATH TO RESERVOIR IS BLOCKED
232
DRAIN LINE THROUGH TOP OF CYLINDER IS CLOGGED D14IV6
237
DUMP VALVE IS STUCK CLOSED
244
LOSS OF LOAD TRIP (ELECTRIC) FAILS TO INITIATE DUMP
245
OPC TRIP HEADER FROM INTERCEPTOR VALVE(S) IS BLOCKED
227
FAILURE OF BOTH THE OPC AND LOSS OF LOAD TRIP
F
230
CHECK VALVE ON DUMP VALVE DRAIN LINE FAILS TO OPEN
233
PRIMARY DRAIN LINE TO RESERVOIR IS BLOCKED
B
234
DUMP VALVE DRAIN LINE IS CLOGGED D27IV6
235
COMMON CONTROL VALVE DRAIN LINE IS CLOGGED
E
236
REHEAT STOP VALV ASET HEADER NOT DUMPED WITH LOSS OF LOAD TRIP
S
246
ASET HEADER (NEAR VALVE) FAILS TO OPEN D20RSV6
247
CHECK VALVE IN OPC TRIP HEADER (NEAR VALVE) FAILS TO OPEN D20IV6
228
OPC TRIP
G
229

Fault tree : a:\ne04\proj\tvtf\vand21-

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