Attachment 1

AUXILIARY FEEDWATER SYSTEM
RELIABILITY ANALYSIS
FOR THE
RANCHO SECO NUCLEAR GENERATING STATION
UNIT NO. 1

December 1979

1629 305

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EXECUTIVE SUMMARY

The NRC has requested all operating plants with Babcock & Wilcox (B&W) designed reactors to consider means for upgrading the reliability of their Auxiliary Feedwater Systems (AFWS). As a part of the response to this request, SMUD and the other B&W Owners Group utilities have requested B&W to perform a simplified reliability analysis of existing auxiliary feedwater systems. This draft report presents the results of that reliability study for the Rancho Seco AFWS.

The primary objective of this study was to evaluate Rancho Seco AFWS reliability (defined as "point unavailability") using an approach which would produce results comparable to those obtained by NRC staff analyses for Westinghouse and Combustion Engineering Plants. Another objective was to identify dominant failure contributors affecting system reliability.

AFWS reliability was assessed for three cases: Loss of Main Feedwater (LMFW) with reactor trip, LMFW with Loss of Offsite Power (LMFW/LOOP) and LMFW with Loss of all AC power (LMFW/LOAC). System reliability was assessed by the construction and analysis of fault trees.

The results of this study are on the following page. These results indicate the Rancho Seco AFWS reliability, based on the reliabilities obtained by the NRC for Westinghouse plants, is medium to high for LMFW, low to medium for LMFW/LOOP, and medium for LMFW/LOAC. AFWS reliability for the LMFW/LOAC case is better than the Westinghouse average, accounting for the lack of major AC dependencies and a continued capability for automatic AFW initiation.

Dominant failure contributors which were identified in this study include 1) a potential diverted flow path which can defeat system operation if a single valve is inadvertantly left open, and 2) system unavailability resulting from outages for preventive maintenance.

A similar study will be performed for each Owners Group utility and additional plant specific draft reports will be prepared. At the conclusion of the program, information contained in the plant specific reports will be collected and used to generate an AFWS reliability report comparing all B&W operating plants.

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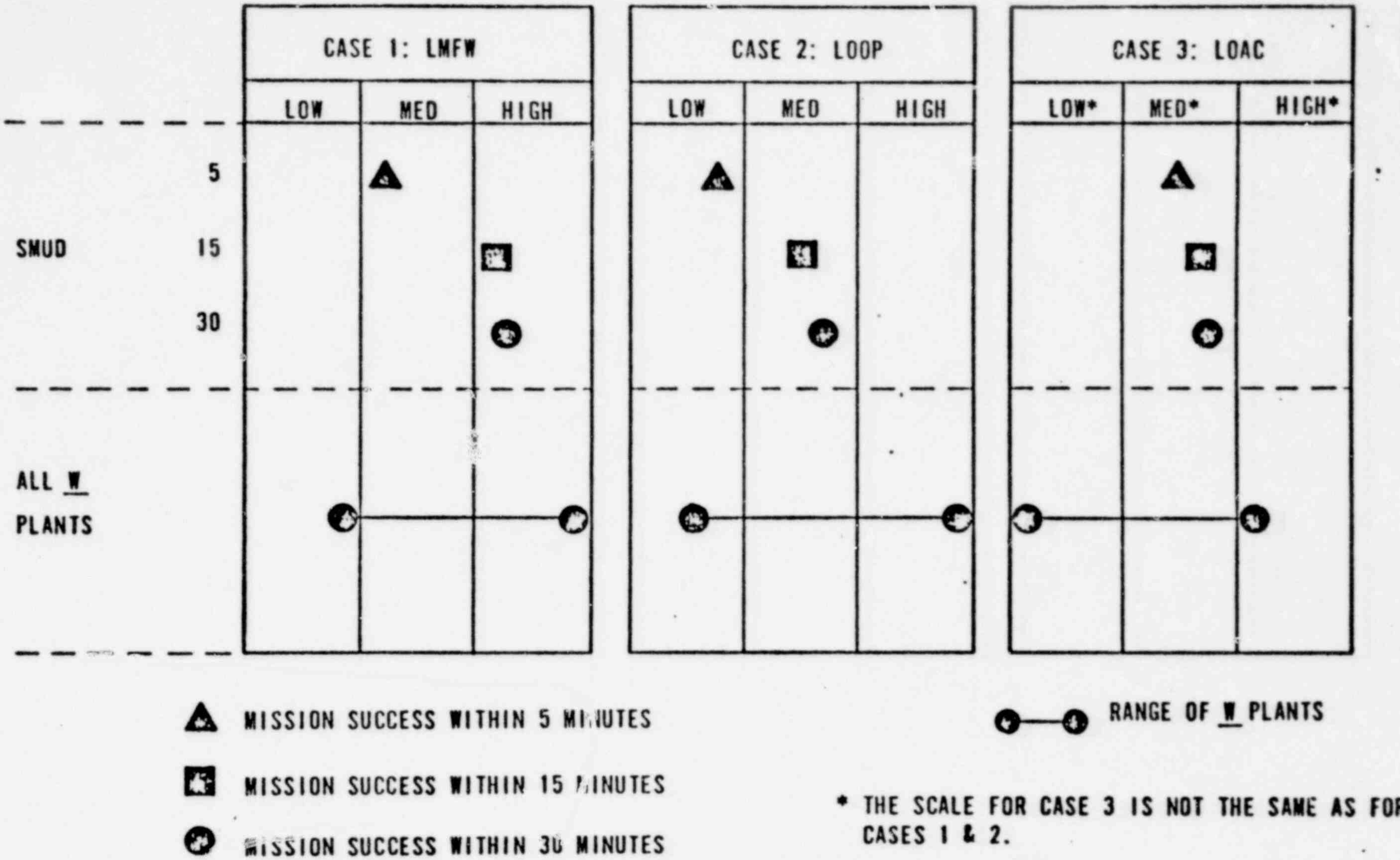

COMPARISON OF RANCHO SECO AFWS RELIABILITY WITH NRC RESULTS FOR W PLANTS

1.0 Introduction

1.1 Background

This report presents the results of a reliability study for the Rancho Seco Auxiliary Feedwater System (AFWS). The NRC is conducting similar analyses for Westinghouse and Combustion Engineering plants. Preliminary results of the NRC study are available (Reference 1) and have been included in this report for comparison with the Rancho Seco AFWS reliability. The approach employed in this study for Rancho Seco has been developed in close coordination with the NRC and is therefore expected to yield comparable results.

1.2 Objectives

The objectives of this study are:

- To perform a simplified analysis to assess the relative reliability of the Rancho Seco AFWS. It is intended that the results of this analysis be directly comparable to those obtained by the NRC for Westinghouse and Combustion Engineering plants. This is assured by the use of the same evaluative technique, event scenarios, assumptions and reliability data used by the NRC.
- To identify, through the development of reliability-based insight, dominant failure contributors to the Rancho Seco AFWS unreliability.

1.3 Scope

The Rancho Seco AFWS was analyzed as it existed on August 1, 1979. Three event scenarios were analyzed:

- Case 1 - Loss of Main Feedwater with Reactor Trip (LMFW).
- Case 2 - LMFW coincident with Loss of Offsite Power (LMFW/LOOP).
- Case 3 - LMFW coincident with Loss of all AC Power (LMFW/LOAC).

These event scenarios were taken as given; that is, postulated causes for these scenarios and the associated probabilities of their occurrence were not considered. Additionally, external common mode events (earthquakes, fires, etc.) and their effects were excluded from consideration.

For each of the three cases, system reliability as a function of time was evaluated.

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1.4 Analysis Technique

The evaluation of reliability for the Rancho Seco AFWS was based primarily on the construction and analysis of fault trees. This technique encourages the development of insights which permit identification of the primary contributors to system unreliability. Application of this technique is described in detail in Section 3.1.

1.5 Assumptions and Criteria

Assumptions and criteria were made in consultation with the NRC staff and were selected to assure that the Rancho Seco reliability evaluation results will be comparable to those obtained by the NRC for the Westinghouse and Combustion Engineering analyses.

1) Criterion for Mission Success - In order to evaluate the overall reliability contribution of system components, it is necessary to establish whether or not failure of those components will prevent successful accomplishment of the AFWS mission. Thus, it is necessary to explicitly define the criterion for mission success. The criterion adopted for this study was the attainment of flow from at least one pump to at least one steam generator. Mission success can be alternatively defined as at least one running pump with suction to a source of water and an open flow path to at least one generator without flow diversion.

   System reliability was calculated at times of 5, 15, and 30 minutes to allow for a range of operator action. These times were specifically chosen because NRC-supplied operator reliability data for these times was available; however, these times are reasonable and consistent with LMFW mitigation for B&W plants. In their study, the NRC staff has used steam generator dryout time as a criterion for successful AFWS initiation, and the 5 minute case represents a comparable result for B&W plants since auxiliary feedwater delivery within 5 minutes will prevent steam generator dryout. However, steam generator dryout itself does not imply serious consequences; a more appropriate criteria is the maintenance of adequate core cooling. Recent ECCS analyses (Reference 2) have shown that adequate core cooling can be maintained for times in excess of 20 minutes without AFWS operation, providing that at least one High Pressure Injection Pump is operated.

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2) Power Availability - The following assumptions were made regarding power availability:

LMFW - All AC and DC power was assumed available with a probability of 1.0.

LMFW/LOOP - The most limiting diesel generator was unavailable with a probability of 10^{-2}. The other generator was assumed available with a probability of 1.C. (The most limiting generator was DG-A (see Figure 3) except for the case in which motor-driven AFWS pump P-319 was in preventive maintenance.)

LMFW/LOAC - DC and battery-backed AC were assumed available with a probability of 1.0.

3) NRC-Supplied Data - NRC-supplied unreliability data for hardware, operator actions and preventive maintenance were assumed valid and directly applicable. These data are listed in Appendix B.

4) Small Lines Ignored - Lines on the order of 1-inch were ignored as possible flow diversion paths.

5) Coupled Manual Actions - Manual initiation of valves with identical function was considered coupled. Such valves were assumed to be both opened manually or both not opened. The case in which one valve was opened and the other valve was left closed was not considered.

6) Degraded Failures - Degraded failures were not considered; that is, components were assumed to operate properly or were treated as failed. The only exception to this assumption was the Electric/Pneumatic signal converters which result in a 50% flow control valve position on loss of power; this position was considered as not failed closed and, therefore, capable of passing adequate flow.

7) Condensate Storage Tank - The Condensate Storage Tank is a Seismic Category I structure and a failure probability of 5×10^{-6} was assigned to this tank.

8) ICS Reliability - Although separate control circuits are provided within the Integrated Control System (ICS) to control the flow of AFW to either of the steam generators, the ICS was assumed to consist of only a single control device with signals to both AFWS trains and a failure probability of 7×10^{-3} was assigned to ICS operation.

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2.0 System Descripti

2.1 Overall Configuration

A diagram of the Rancho Seco AFWS is presented in Figure 1. The system consists of two interconnected trains, capable of supplying auxiliary feedwater to either or both steam generators under automatic or manual initiation and control.

2.1.1 Suction

The primary water source for both trains of the Rancho Seco AFWS is the Seismic Category I Condensate Storage Tank, T-358. Separate 8-inch lines provide water to the pumps in both trains via locked open valves and check valves.

A reserve of 250,000 gallons is maintained within the tank for AFWS use. This reserve is physically assured by the use of internal standpipes which prevent draw-down of the tank level below the 250,000 gallon limit. In addition, the tank level is indicated in the control room.

An alternate supply of water is available for AFWS use from a connection on the transfer line between the Folsum South Canal and an on-site reservoir. This alternate water supply enters the suction cross-tie between two locked closed valves. Additional details on this water source are described in Section 2.2.

2.1.2 Pumps and Discharge Cross-Tie

The pumps in both trains are each rated at 840 gpm with a design recirculation flow of 60 gpm. Thus each pump is capable of delivering 780 gpm against maximum OTSG pressure to the discharge piping supplying both steam generators.

The Train A pump, P-318, (supplying Steam Generator A) is a combination turbine driven motor driven pump with both the turbine and electric motor on a common shaft. Either motive source can drive the pump at its rated capability. The Train B pump, P-319, is a motor driven pump only.

The pumps are interconnected at their discharge by a discharge cross-tie containing two normally open AC motor operated valves. This cross-tie permits either pump to feed either or both steam generators.

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2.1.3 Flow Control Valves

The flow of auxiliary feedwater to each steam generator is controlled by normally closed air operated flow control valves, FV-20527 and FV-20528. During automatic AFWS initiation and control, these valves are under control from the Integrated Control System via an Electric to Pneumatic signal converter. Control for these valves, including manual control, will be described in greater detail in Section 2.4.

2.1.4 Steam Supply for the AFWS Turbine

Steam to turbine K-308 (Figure 1) for turbine driven pump P-318 is extracted immediately downstream of both steam generators. This steam must pass through either or both of two normally open AC motor operated valves and a normally closed DC motor operated steam supply valve, FV-30801. Initiation of the turbine driven pump is accomplished by opening this steam supply valve. Opening of this valve can be initiated by several signals as described in Section 2.4.

2.1.5 Other Important System Features

The primary components for AFWS operation following LMFW are described above. There are additional system features, however, which affect overall system reliability. These features are described below:

Safety Features Bypass Valves - The main flow control valves are connected in parallel with two normally closed AC motor operated valves which automatically go to full open in the even of Safety Features Actuation. After these valves open, they may be manually controlled to throttle the flow of auxiliary feedwater to the steam generators.

Recirculation and Test Lines - A 2½-inch line with flow orifices is connected to the discharge of both pumps to provide normal (60 gpm) recirculation flow. This flow is discharged to the condenser hotwells. Of more significance to system reliability is a 6-inch recirculation test line connected to the discharge of the Train A pump, downstream of the discharge cross-tie. This

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line and the associated manual valve, FWS-055, are used to perform quarterly full-flow tests of both pumps. This line is capable of discharging full flow of both pumps to the condenser hotwells.

2.1.6 Valve Indications and Operability

All AC motor operated valves fail "as is" in the event of loss of AC power. All such valves are manually controllable and position indicated in the control room. Power for indication and control of these valves is derived from the AC power source for each valve.

The DC motor operated steam supply valve will fail "as is" in the unlikely event that battery-backed DC becomes unavailable. The valve is manually controllable and position indicated in the control room. Power for control and indication is also battery-backed DC.

The air operated flow control valves will fail to the full open position in the event control air is lost. Loss of power to the Electric/Pneumatic converters will result in the valves assuming a position of approximately 50% open. The control signal to the Electric/Pneumatic converters is indicated at the ICS manual controllers for the valves. Manual control of the valves can also be exercised using DC powered solenoid valves FV-20527A and FV-20528A which dump the air to the valve operators thereby causing the control valves to assume the full open position.

2.2 Supporting Systems and Backup Water Source

The pumps, motors and turbine are self-contained entities without dependencies on secondary support systems. This is illustrated by Figure 2(a) which shows the cooling water scheme for the turbine and turbine driven pump. Pump lube oil is circulated via a shaft powered oil slinger ring, and lube oil cooling is obtained by using the pumped fluid as shown.

The only support system of significance to the AFWS is the backup water supply source. A simplified diagram of this system is shown in Figure 2(b). Water can be made available to the AFWS suction cross-tie via locked open

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valve PCW-080 by either of two means: (1) operating the Folsum South Canal transfer pumps and valves or (2) opening valve HV-43011 to obtain gravity flow from the on-site reservoir. The pumps and valves in the transfer pump path are not in general controllable from the control room and are not on vital power.

HV-43011 is open at certain times of the year, but for this study was assumed normally closed as shown. This valve is controllable from the control room, but the valve operator is not powered from a vital AC power source.

2.3 Power Sources

A simplified diagram showing power distribution for the AFWS is provided in Figure 3. As shown, AC power for all AFWS components necessary to achieve auxiliary feedwater flow, is derived from diesel generator-backed nuclear service busses.

Normally power is supplied to these busses from the switchyard. However, in the event of LMFW/LOOP (case 2), the diesel generators are started automatically and all AFWS components will remain operable with the only manual action required being the loading of the Train B pump on its bus (loading of the Train A pump motor is also manual should the turbine fail to operate). This manual loading is performed by a key oeprated switch and is described further in Section 2.4.

In the event of LMFW/LOAC (Case 3) the AFWS flow will still be initiated through the DC battery-backed steam supply valve and controlled via the flow control valves under control from the ICS and Non-Nuclear Instrumentation which are on battery-backed vital AC. Loss of AC will ultimately result in the loss of control air to the flow control valves because the air compressors are on non-vital AC (refer to Figure 4). However, in this event the flow control valves will go full open and thus not prevent getting auxiliary feedwater to the steam generators.

2.4 Instrumentation and Control

2.4.1 Initiation and Control Logic

A logic diagram showing the means of AFWS initiation and control is provided in Figure 5. This diagram is simplified and does not show some redundancies which actually exist in the hardware.

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As stated earlier, the AFWS turbine can be initiated to feed auxiliary feedwater by a Safety Features Actuation signal. In this event the steam supply valve FV-30801 is opened, SFV-20577 is opened by Safety Features Actuation signal 1B, and SFV-20578 is opened by Safety Features Actuation signal 1A. Flow to the steam generators may be throttled by assuming manual control of these valves.

It is expected, however, that the AFWS initiation for the three cases analyzed in this study will not result from Safety Features Actuation but from another source. Three other such sources are available; (1) low main feedwater pump discharge pressure on both main feedwater pumps, (2) loss of all four reactor coolant pumps, and (3) manual initiation.

Loss of the reactor coolant pumps or low main feedwater discharge pressure will start both AFWS pumps by opening the turbine steam supply valve and starting the motor driven pump motor. However, the start signal to the motor driven pump (P-319) motor is interlocked to prevent it being automatically loaded onto the diesel. If diesel generator A is running, a key-operated bypass switch must be used to start the pump motor (or restart the motor if it had been running and normal bus power was lost). The pump motor for the turbine driven/motor driven pump (P-318) can only be initiated manually. It is interlocked with diesel generator B in a fashion similar to that described above for the motor for pump P-319.

Initiation of auxiliary feedwater flow will not be successful, however, until the flow control valves are opened. This is accomplished within the ICS based on steam generator level signals. If all four reactor coolant pumps are tripped the flow valves are directed to open and control steam generator level to the operate level. If the reactor coolant pumps are running but there is a loss of both main feedwater pumps, the flow control valves will open and control to the startup level. If neither situation exists and manual control of the controller has not been taken, the Integrated Control System directs the valves to remain closed. In any event, the control signals to the valves can be overriden by manually operated solenoid valves which exhaust the air to the flow control valves and, thereby, cause them to open fully.

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2.4.2 Instrumentation

An indication of auxiliary feedwater flow in either train is obtained from clamp-on ultrasonic flow meters which are located at the discharge of Train A (downstream of the 6-inch test line), and at the Train B inlet to the steam generator.

Pump suction and discharge pressures are provided in the control room. The condensate tank level and valve positions are indicated in the control room as described in Section 2.1.

2.5 Operator Actions

For Cases 1 and 2, all major components of the AFWS, excluding the locked valves, are operable from the control room. Operation of the alternate water supply may require operator action outside the control room depending on existing valve lineups.

For Case 3, manual initiation of the AFW turbine is available from the control room and manual control of the flow control valves is available as long as control air supply lasts. Thereafter, flow control will require manipulation of the valves locally.

Generally, only one non-dedicated operator is available in the control room to monitor and operate the AFWS.

2.6 Testing

Quarterly tests under full flow conditions are performed to confirm the operability of both AFWS pumps. The tests (which require less than an hour to perform) use the 6-inch recirculation line and valve FWS-055.

During testing the cross-tie valves are open and both trains are out-of-service. However, during all full flow tests an operator is stationed at valve FWS-055. This operator remains in communication with the control room and is ready to close the valve to restore operability to both trains should the need arise.

Monthly operability checks of both pumps are performed using the normal recirculation flow path. These checks confirm the pump and pump drive capability to operate and produce the required pump discharge pressure.

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Operability of all valves, in Figure 1, excluding the locked valves, is confirmed by quarterly tests. After valve manipulation, the positions of all affected valves is assured by use of a double check procedure. The proper status of all locked valves is assured by administrative procedure using a locked valve list and valve tags which are logged in at the control room whenever a valve is not in its usual configuration.

2.7 Technical Specification Limitations

An important Technical Specification Limitation applicable to the AFWS concerns availability of the AFWS pumps. One pump must be available any time reactor coolant temperature is above 280°F. To achieve criticality or to remain critical both AFWS pumps must be available. However, one pump is allowed to be out of service for a maximum of 48 hours for maintenance or repair.

Technical Specifications also require the availability of 250,000 gallons of water in the Condensate Storage Tank for AFWS use.

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3.0 Reliability Evaluation

3.1 Fault Tree Technique

The Rancho Seco AFWS reliability was evaluated by constructing and analyzing a fault tree. The fault tree developed during this study is contained in Appendix A. The top level event in this tree is failure to achieve mission success; from this point the tree branches downward to a level of detail corresponding to NRC-supplied data. This level is generally indicated by basic event circles.

For construction of the first tier of the tree (page A-1), the AFWS components in each train were grouped into three categories - Suction, Pump and Discharge. The suction cross-tie interconnects the trains between the categories Suction and Pump, and the discharge cross-tie interconnects the trains between categories Pump and Discharge. System failure can result from Suction-Suction, Pump-Pump and Discharge-Discharge failures or from failure combinations such as Pump(A)-Discharge(B) with the discharge cross-tie inoperable. The tree on page A-1 indicates all the combinations which were considered.

Hand calculations were performed to obtain system unavailability for 5, 15 and 30 minutes for each of the three event scenario cases.

3.2 Comparative Reliability Results

The results of the analysis are presented in Figure 6. Indicated in this figure are the system reliability results for each of the three cases and for each time 5, 15 and 30 minutes. The basic format for this figure, including the characterization of Low, Medium, and High reliability, was adopted from information presented by the NRC in Reference 1. Because the NRC-supplied input data were often unverified estimates of component and human reliability, absolute values of calculated system reliability must be de-emphasized; results have significance only when used on a relative basis for purposes of comparison. Accordingly, the intent of Figure 6 is to show the relative reliability standing of the Rancho Seco AFWS for each of the three cases and also to compare these results to the NRC results for Westinghouse plants. The Westinghouse results and numerical values permitting construction of Figure 6 were all obtained from Reference 1. It should be noted that there is a scale change for the Case 3 results; reliability results for Case 3 cannot be cross-compared with Cases 1 and 2.

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As indicated in Figure 6, relative to Westinghouse, Rancho Seco has medium to high reliability for Case 1, low to medium reliability for Case 2, and medium reliability for Case 3.

As the time for operator action increases from 5 to 30 minutes, the probability of mission success improves. Most of the improvement occurs between 5 and 15 minutes, reflecting a significant difference in the NRC-supplied operator reliability data for these times. On the other hand, there was little difference in the operator reliability data between 15 and 30 minutes and this is reflected in the system unavailability results.

The primary difference in AFWS unavailability between Case 1 and Case 2 is the requirement for manual loading of the pump onto the diesel (although inclusion of a failure probability for the limiting diesel also contributes to the overall result).

The favorable Case 3 result reflects the lack of AC dependencies coupled with a continued capability for automatic initiation of auxiliary feedwater.

3.3 Dominant Failure Contributors

3.3.1 Case 1 - LMFW

The dominant failure contributor in this analysis is diverted flow through the 6-inch test line which can defeat system operability even with two pumps running. The specific cause of this diverted flow is valve FWS-055 being left open. This valve could inadvertently be left open after test or preventive maintenance or (less likely) could be mistakenly opened during operations on adjacent or similar valves. The unavailability contribution of this event concurrent with pump testing was not significant because of the small time (tests require less than 1 hour per quarter) for occurrence plus the availability of a dedicated operator during the test. In the event that FWS-055 is left open, corrective actions include: closing FWS-055, manually closing FWS-120, or in the event that pump P-319 is operating, remotely closing either HV-31826 or HV-31827 on the cross-tie.

Other dominant failure contributors in this analysis include preventive maintenance on pumps and valve operators.

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3.3.2 Case 2 - LMFW/L(

Dominant contributors in this analysis are similar to those for Case 1. However, there is an added contributor which accounts for the major portion of the difference in the system reliability from Case 1 to Case 2 as shown in Figure 6. This difference is the requirement for manual loading of the AFWS pumps onto the diesel generators.

3.3.3 Case 3 - LMFW/LOAC

The dominant contribution for system unavailability in this analysis for the loss of all AC is the outage incurred by preventive maintenance activities. PM on the turbine driven pump P-318 and steam supply valves HV-20569, HV-20596 and FV-30801 account for one-half of AFW system unavailability. The assumptions used conservatively emphasized the effects of maintenance on the system availability; nonetheless, those assumptions were maintained to allow direct comparison with NRC's results for other plants.

3.3.4 Other Findings

Other concerns, expressed by the NRC, were investigated for the Rancho Seco AFWS and found to be insignificant contributors to system unreliability.

1) Actuation sub-systems were found to be adequate and did not limit system availability.
2) The alternate water supply, and procedures for placing it in operation, were identified as a potential area of concern; however, the excellent availability of the primary water source minimized the importance of this concern and it did not substantially impact system availability.
3) No major AC dependencies were identified.

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REFERENCES

1) "Auxiliary Feedwater Reliability Study", an NRC staff presentation to the ACRS at the ACRS meeting of July 26, 1979, 1717 "H" Street, Room 1046, Washington, D.C.

2) "Evaluation of Transient Behavior and Small Reactor Coolant System Breaks in the 177 Fuel Assembly Plant", 7 May 1979.

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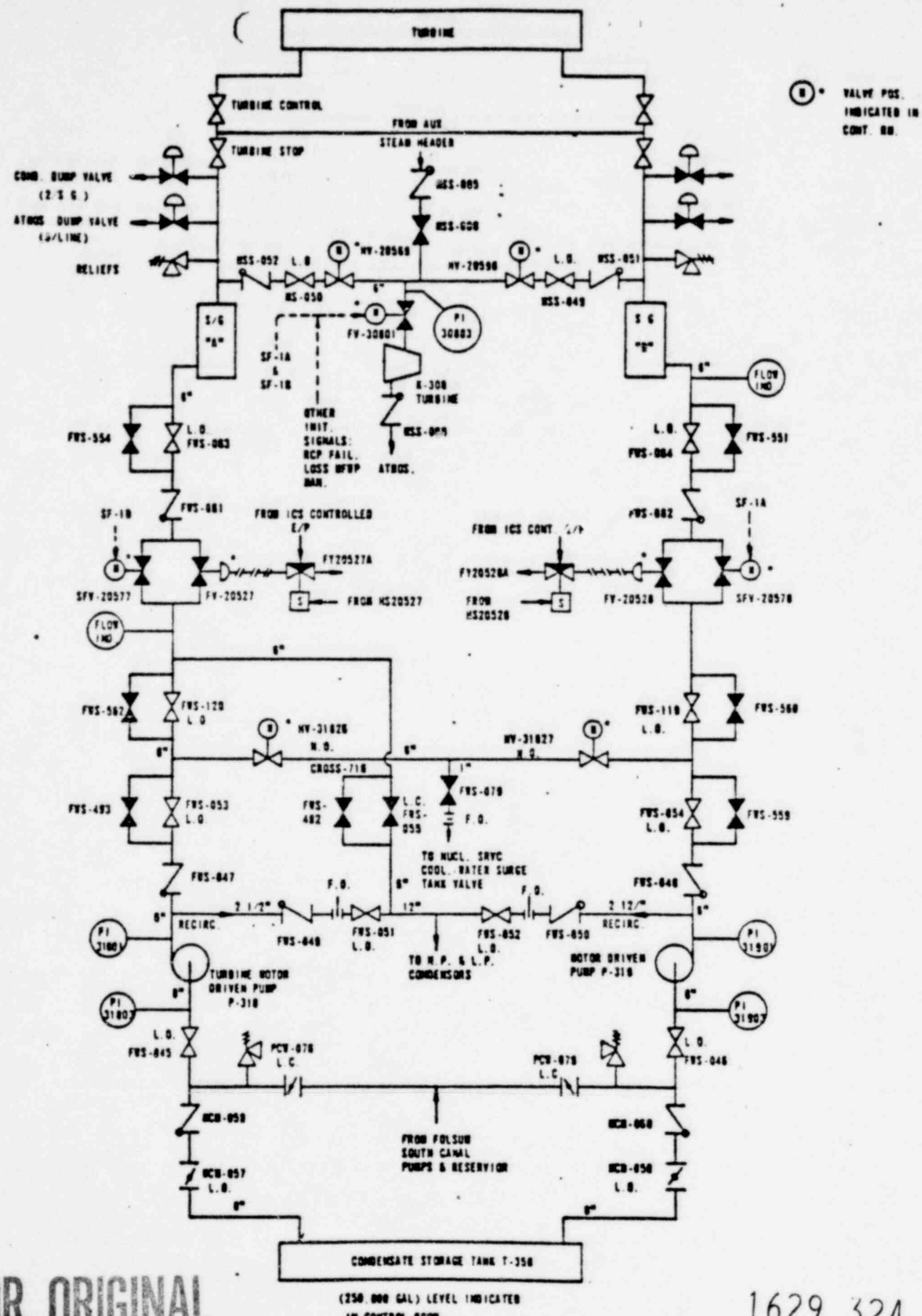

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FIG. 1. RANCHO SECO AFWS

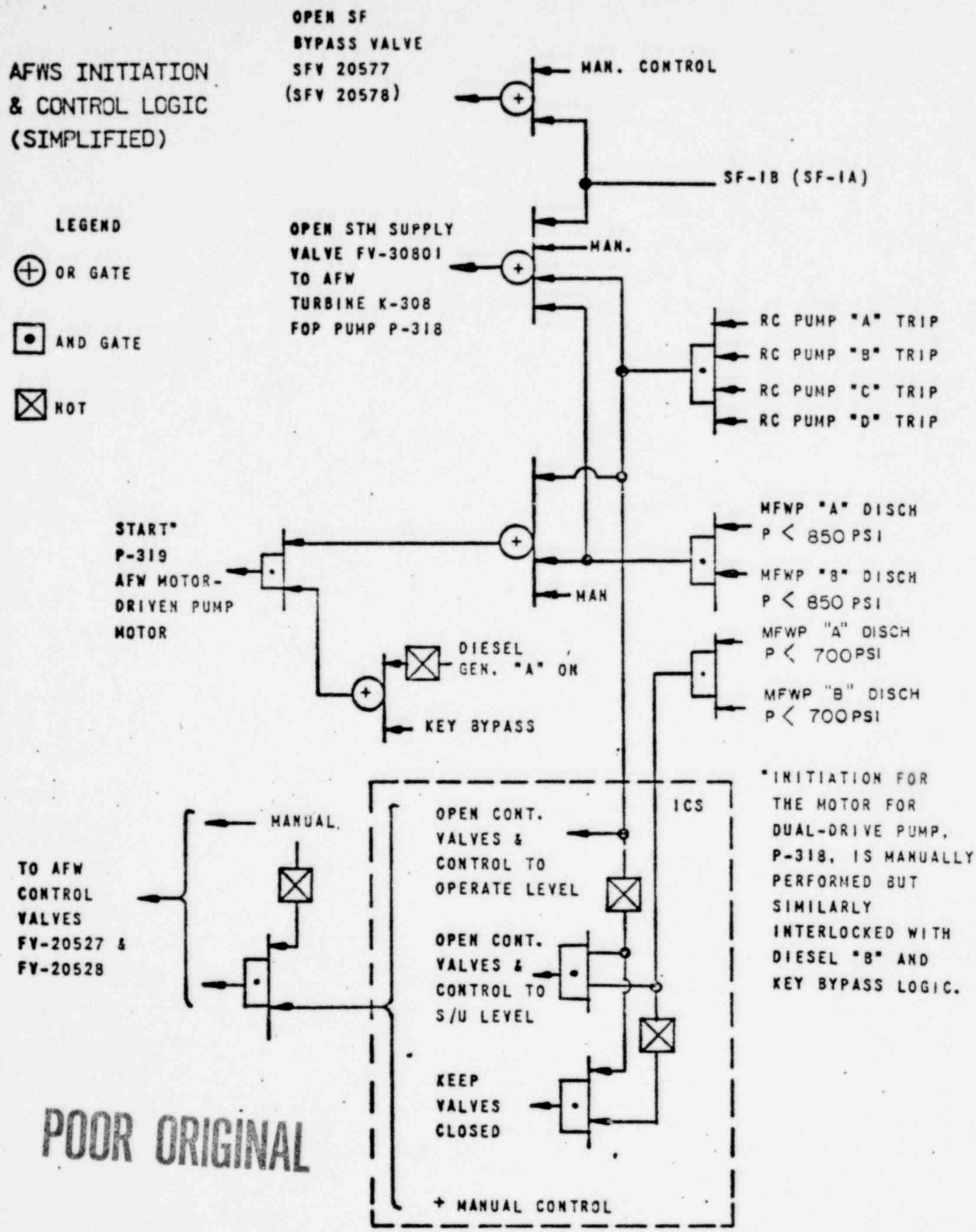

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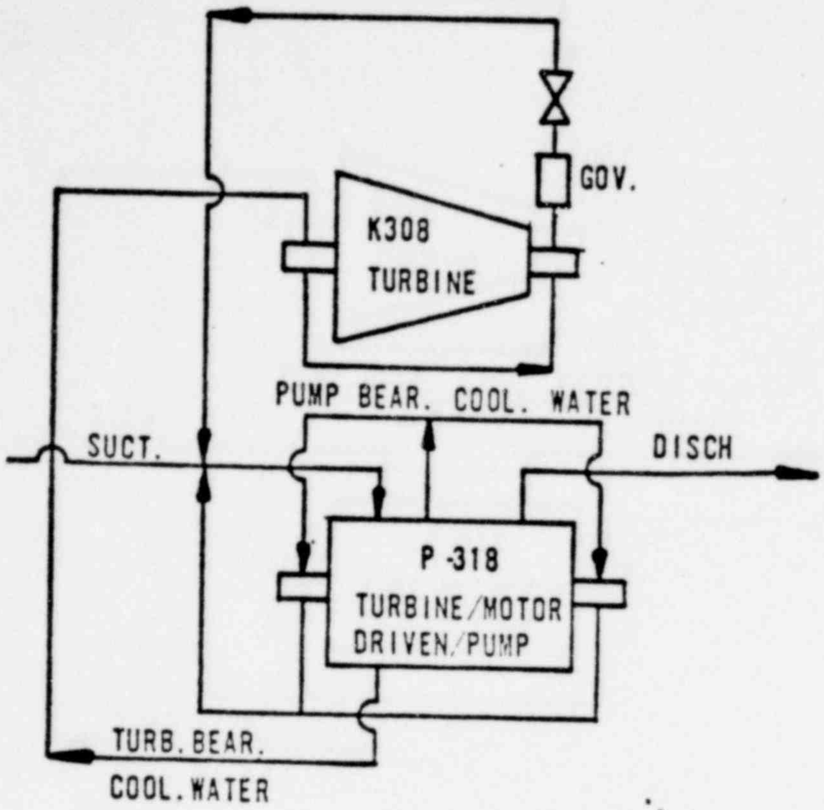
FIG. 5. RANCHO SECO AFWS INITIATION AND CONTROL

(a)
TURBINE/MOTOR DRIVEN
PUMP BEARING COOLING
WATER SCHEME



(b)
ALTERNATE WATER SOURCE

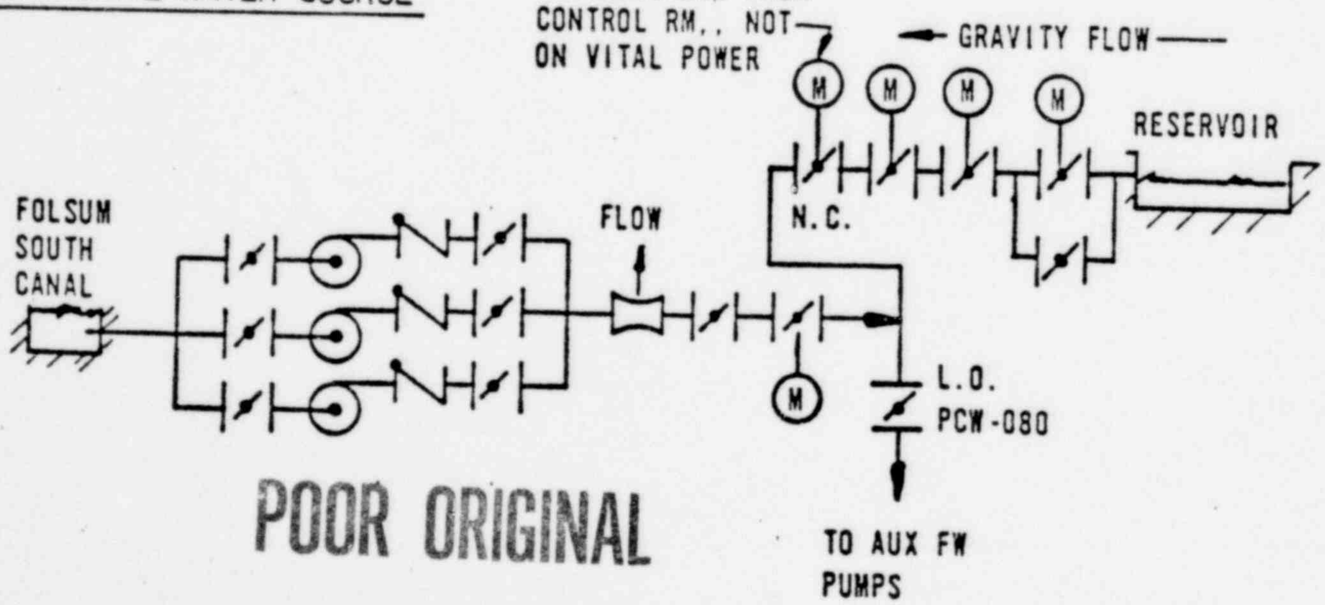


FIG. 2. AFWS SUPPORT

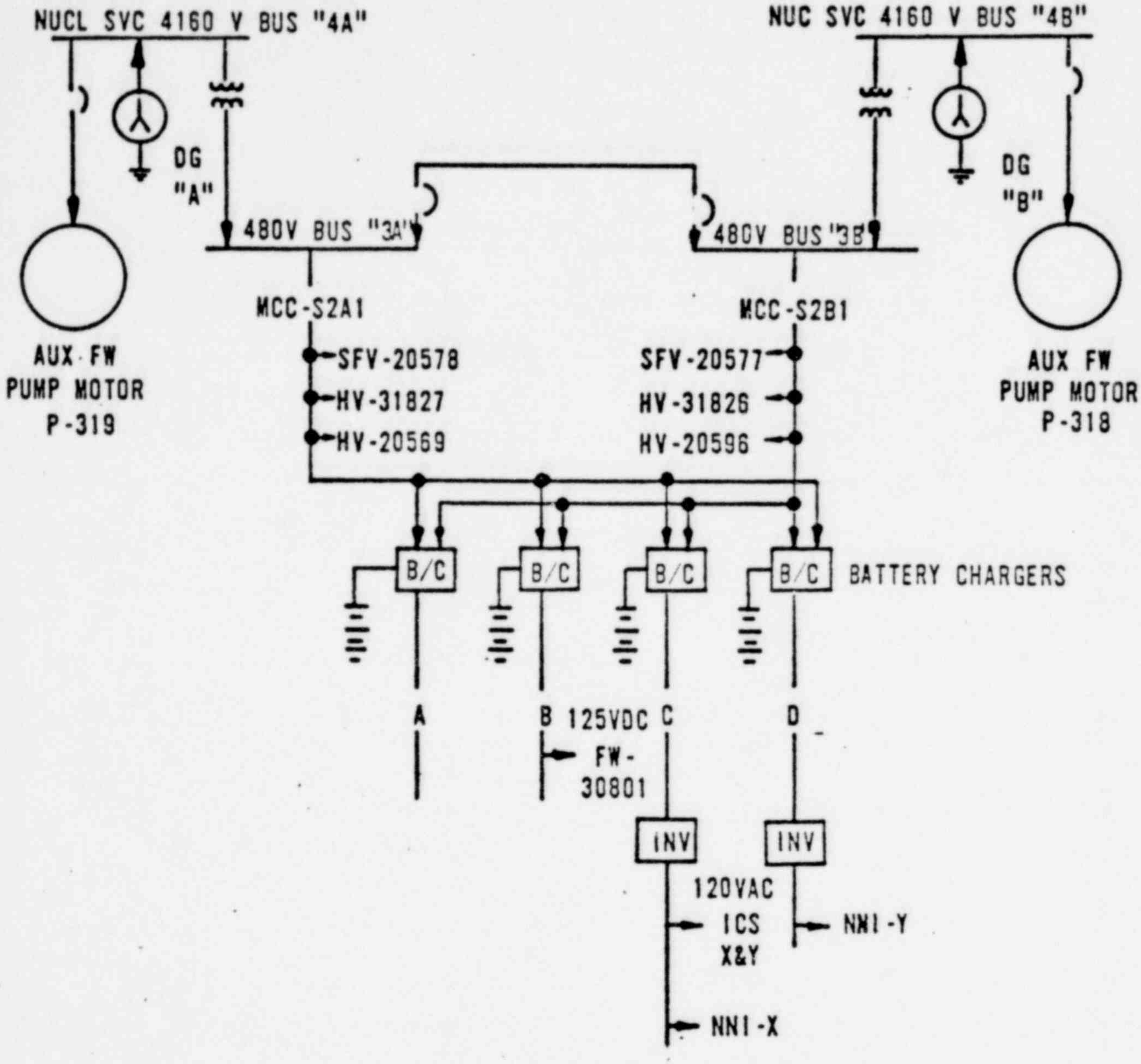


FIG.3. SIMPLIFIED POWER DISTRIBUTION FOR DG AND BATTERY-BACKED AFWS COMPONENTS

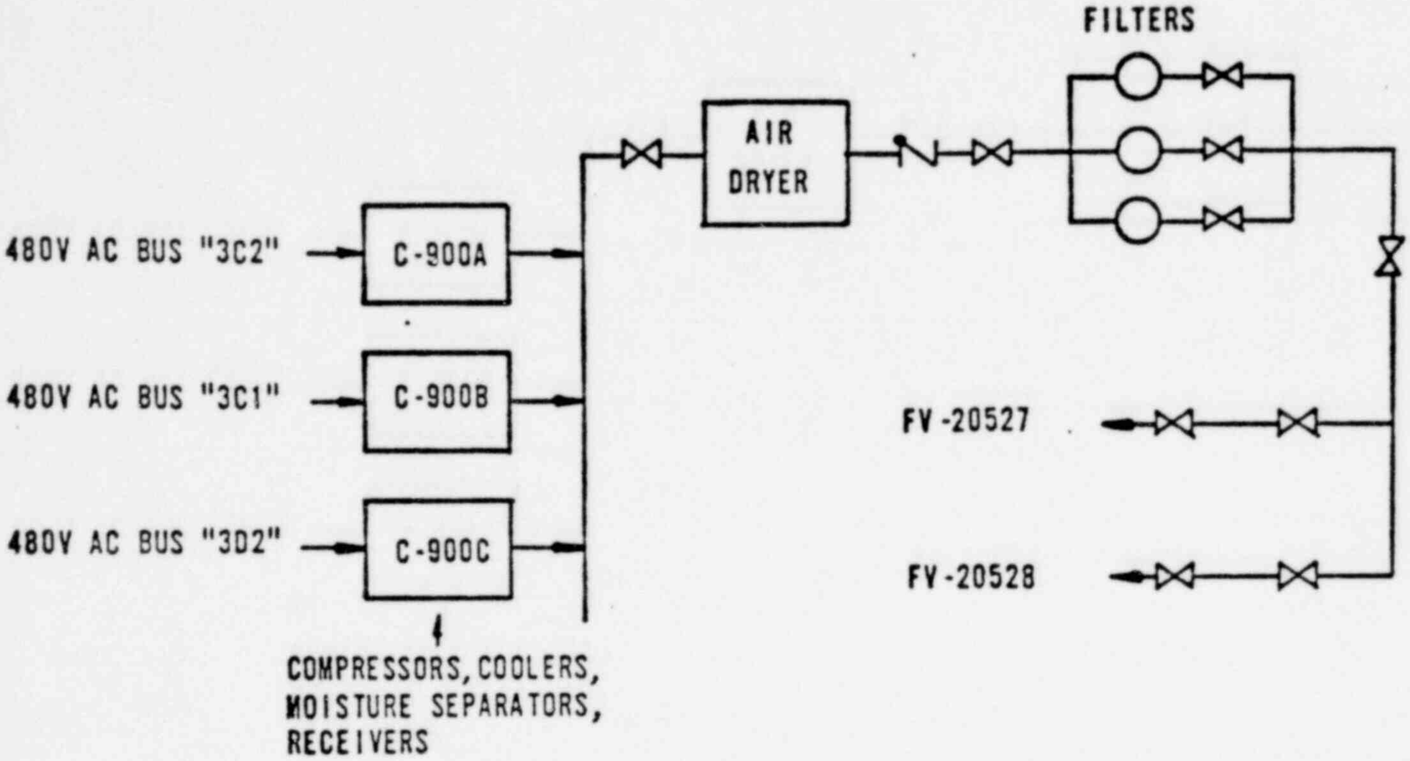


FIG.4. AIR SUPPLY TO AFWS CONTROL VALVES

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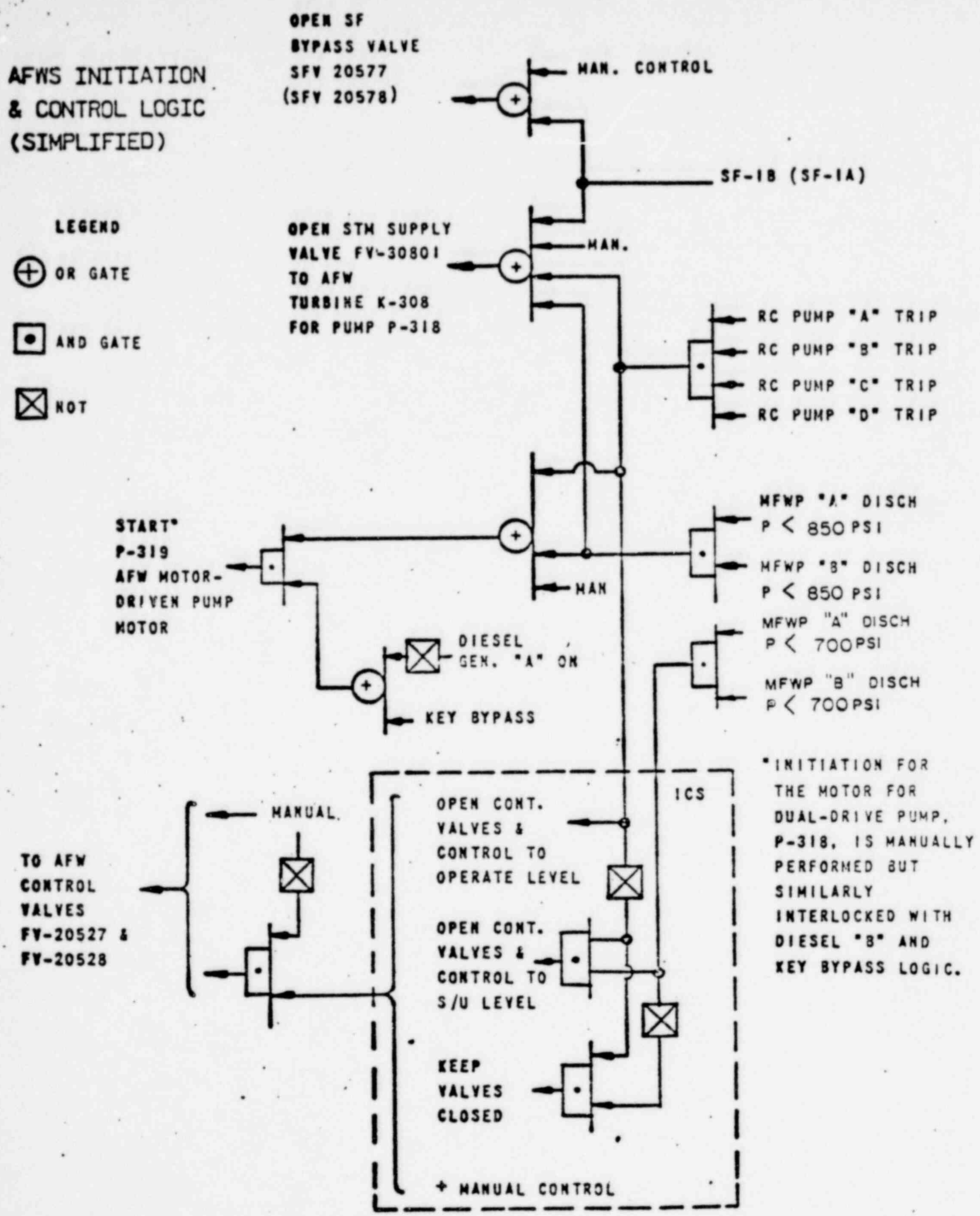

FIG. 5. RANCHO SECO AFWS INITIATION AND CONTROL

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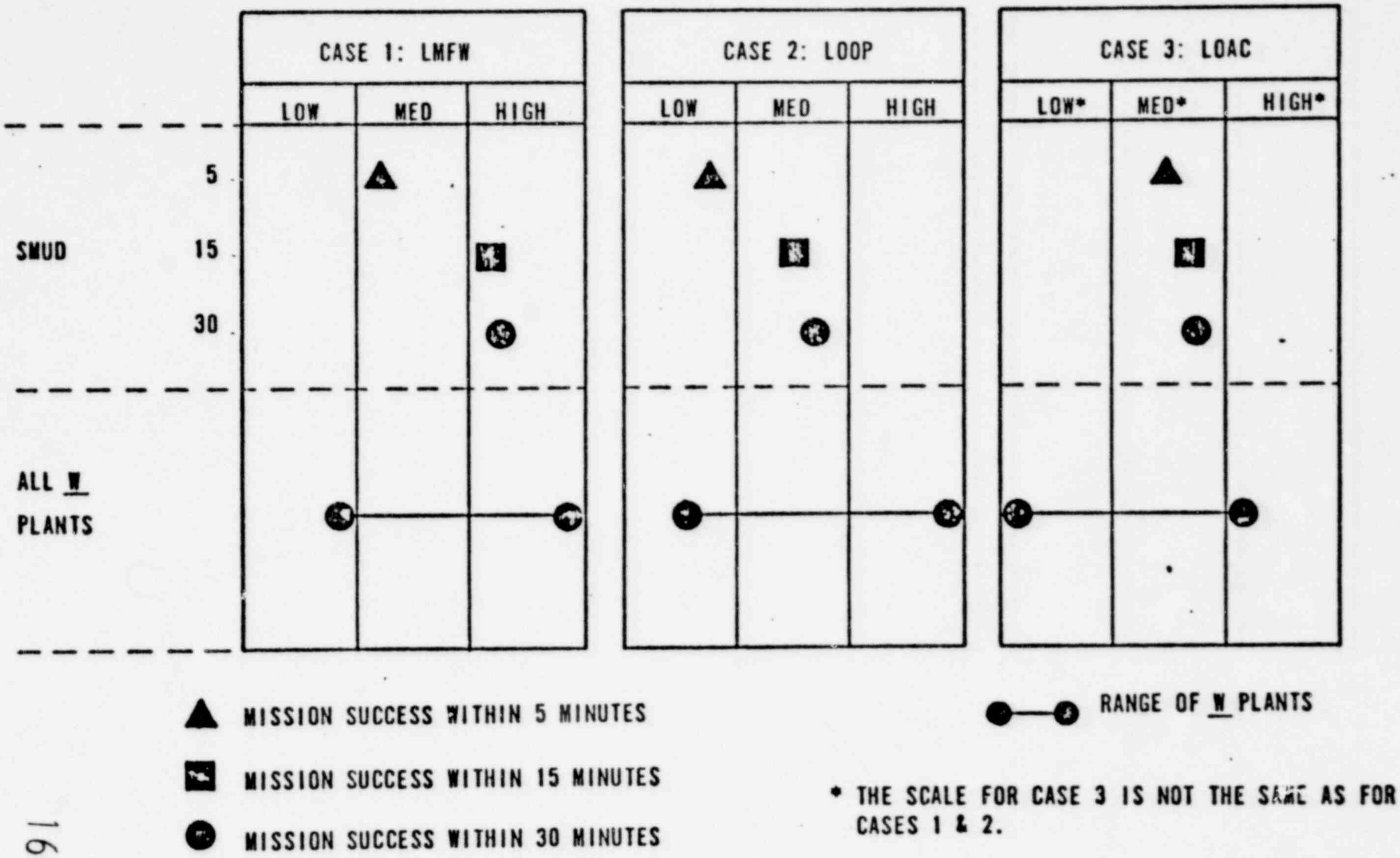

FIG. 6

COMPARISON OF RANCHO SECO AFWS RELIABILITY WITH NRC RESULTS FOR W PLANTS

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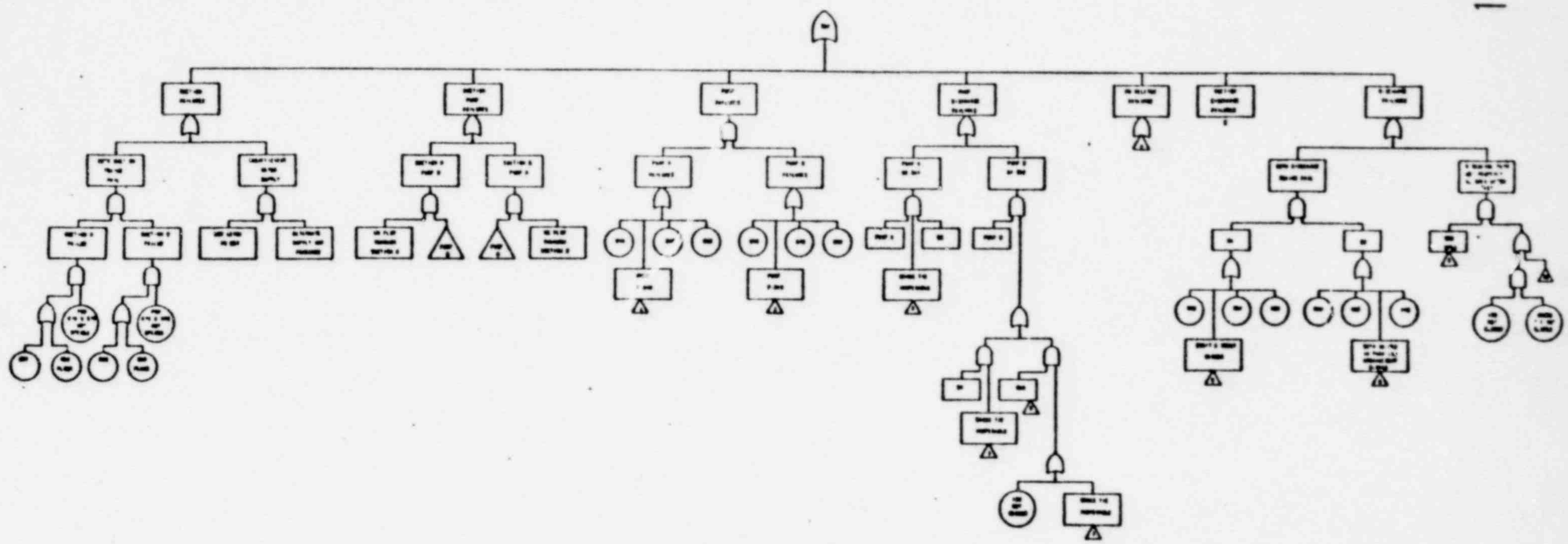

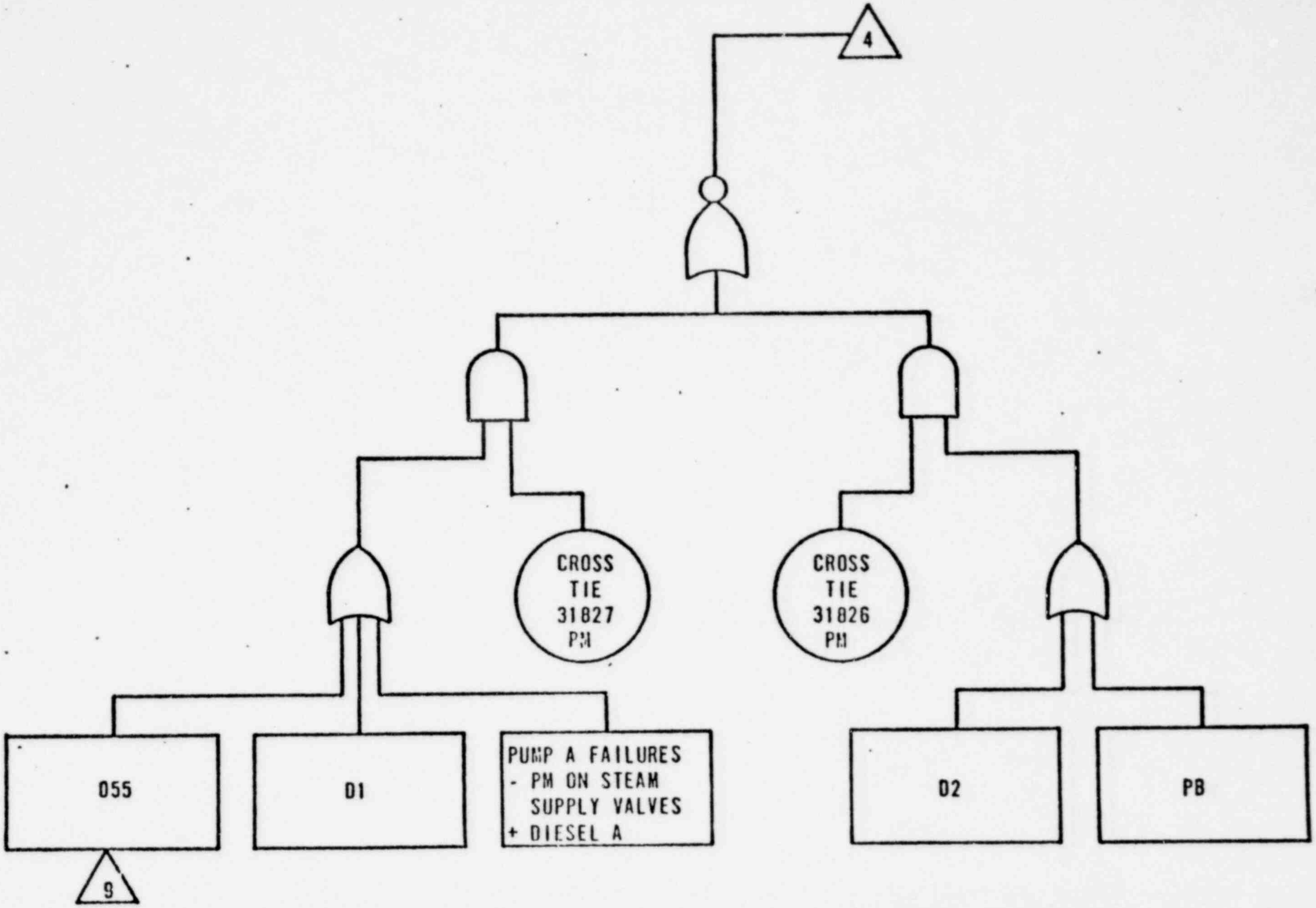
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+ DIESEL A
D2
PB
9

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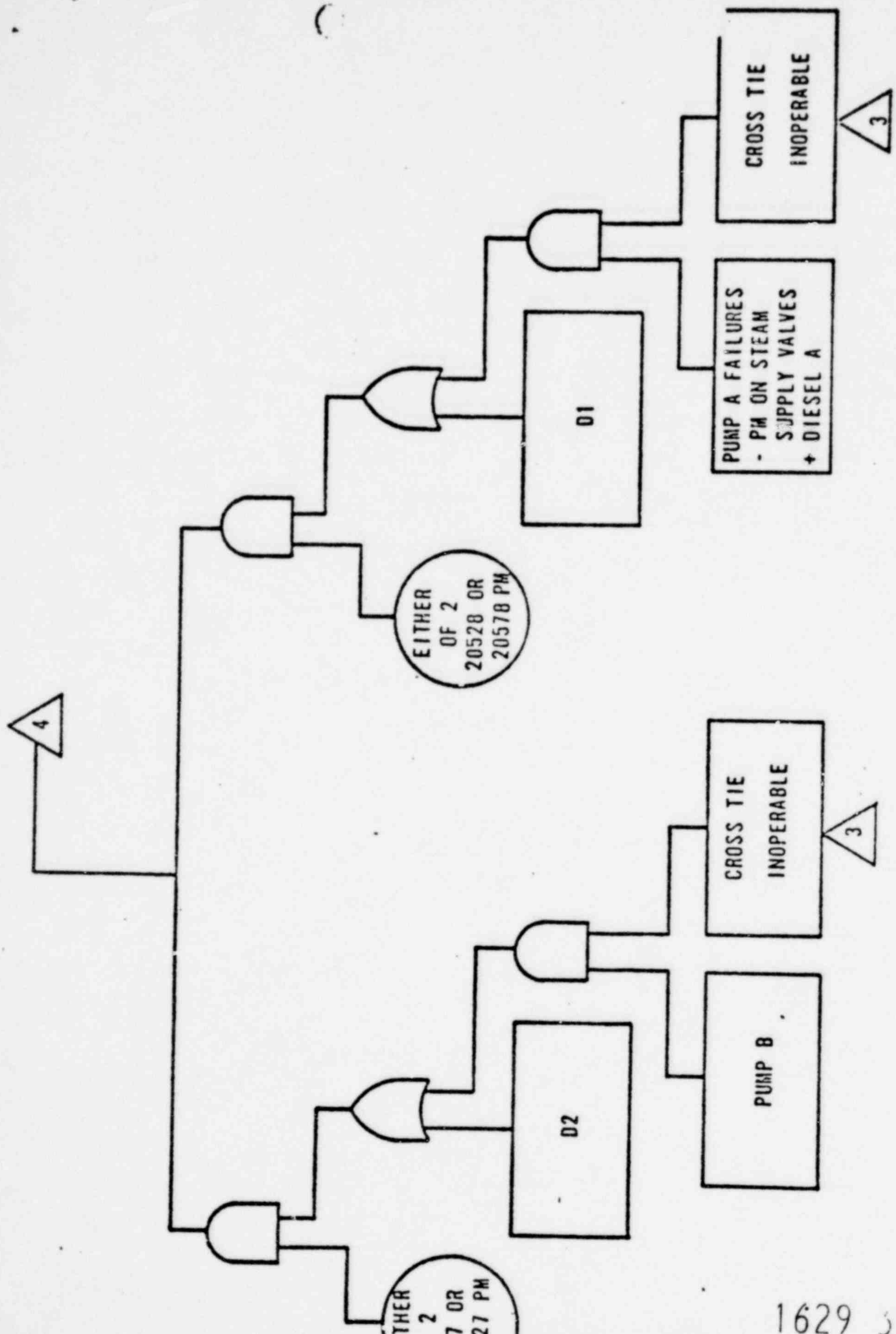

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D2
PUMP B
CROSS TIE INOPERABLE
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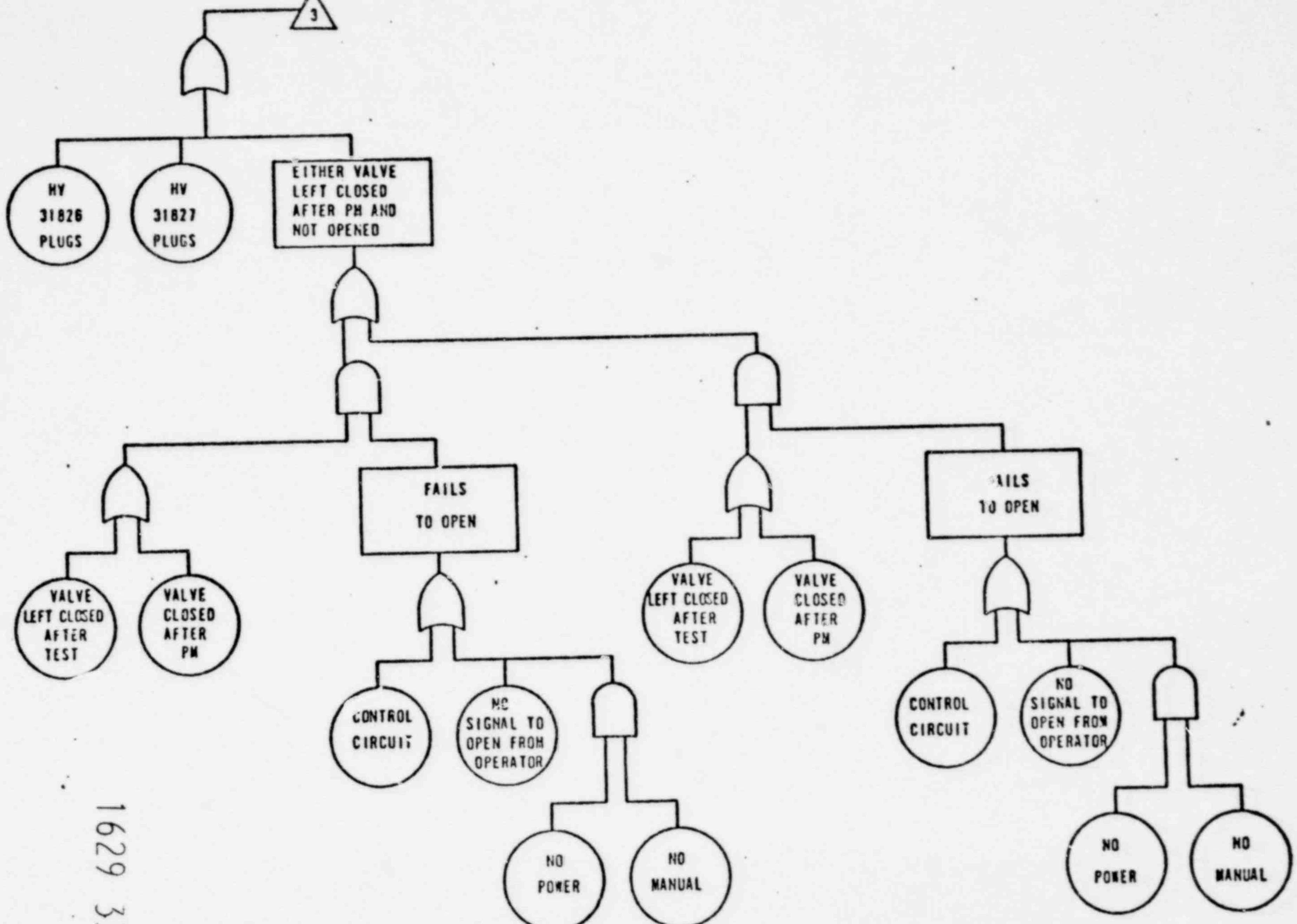
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HV 31827 PLUGS
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NO POWER
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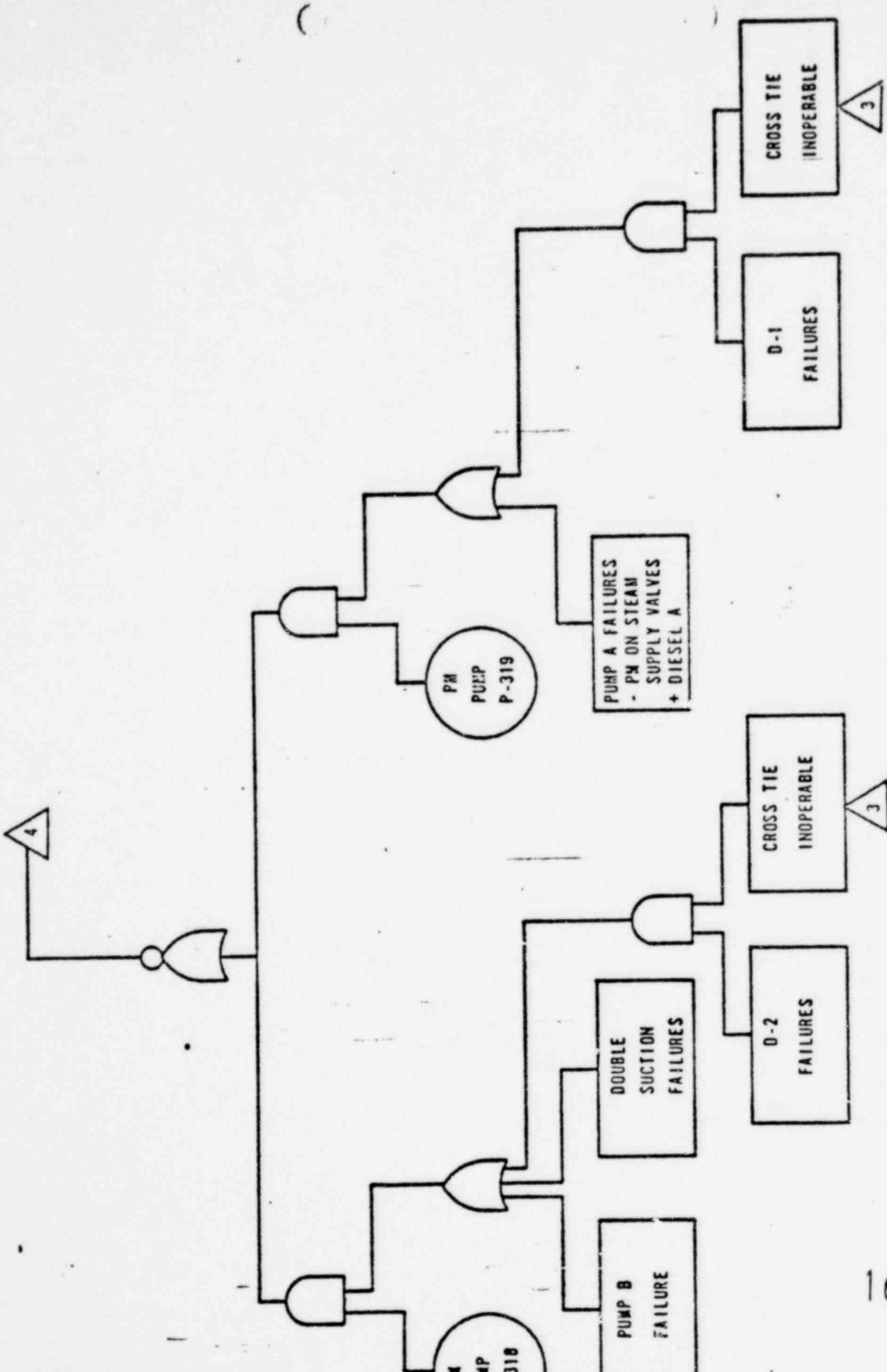
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+ DIESEL A
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3

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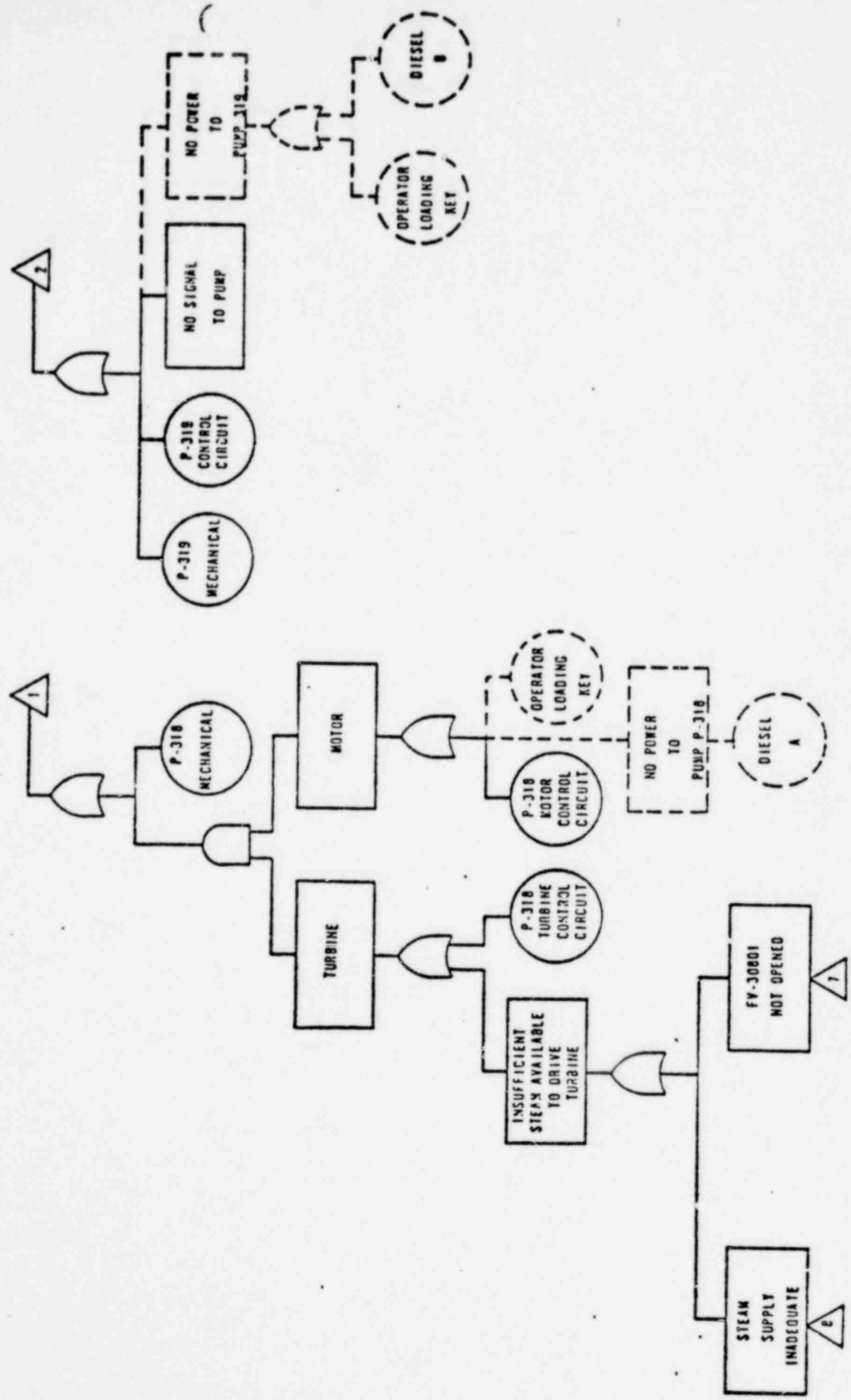
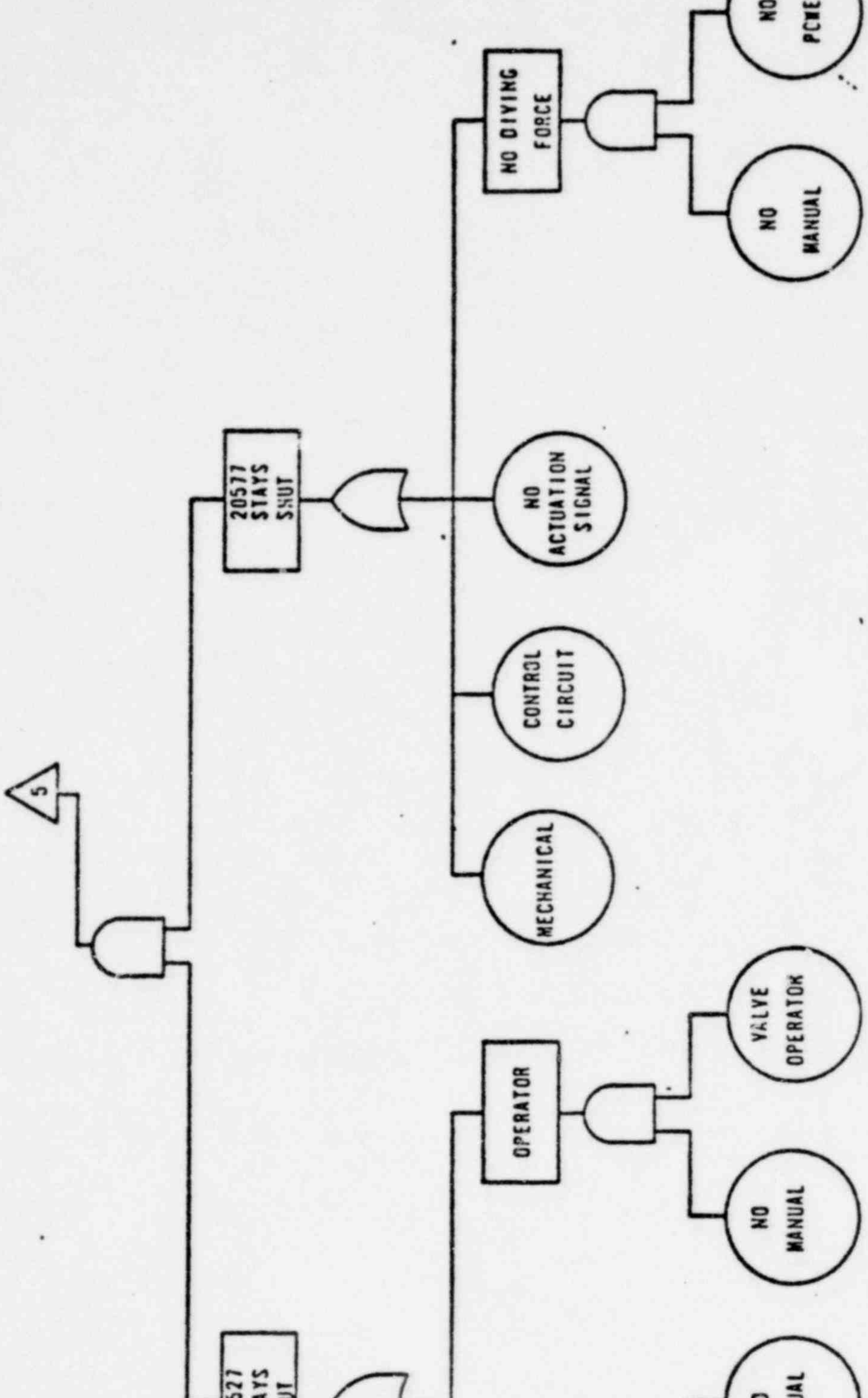
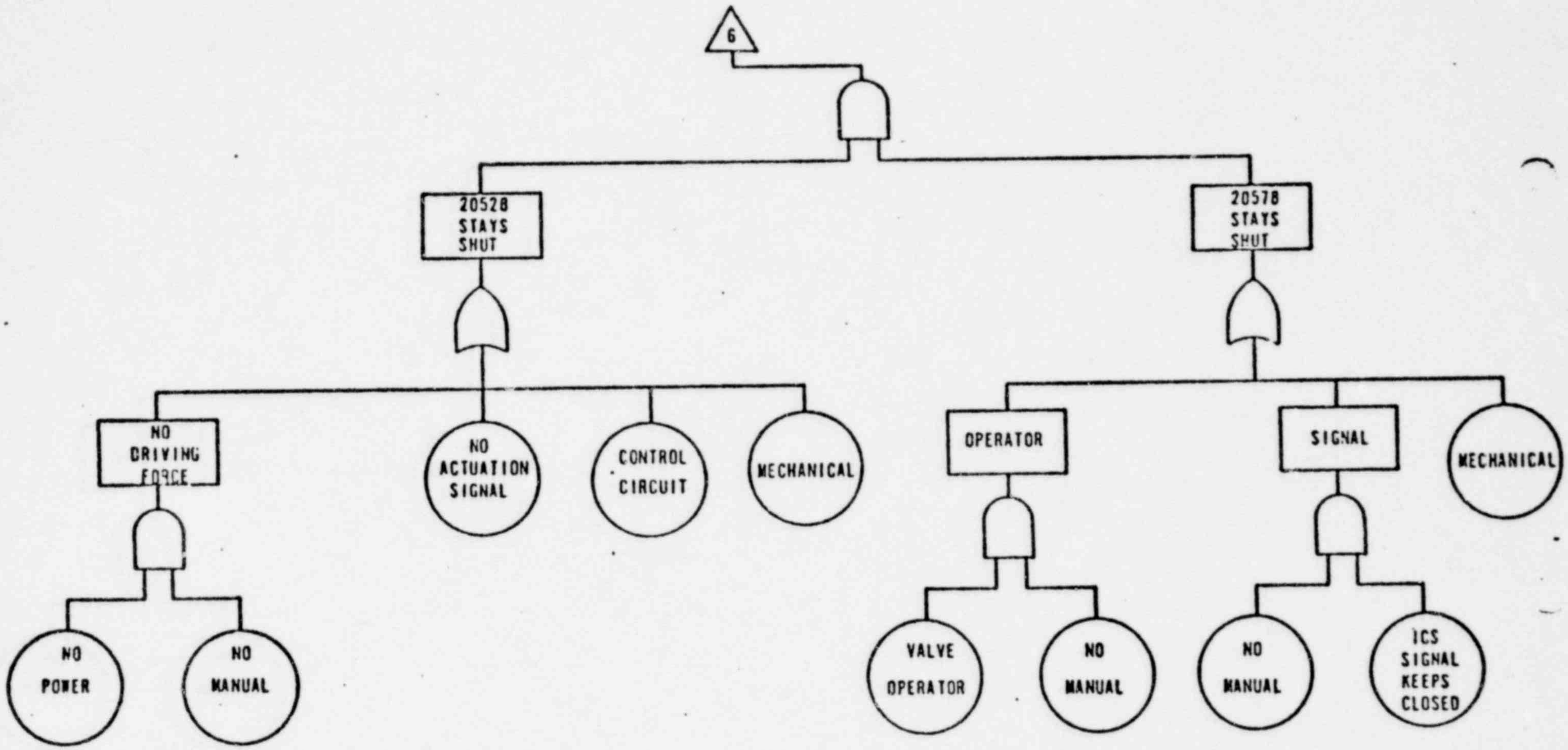
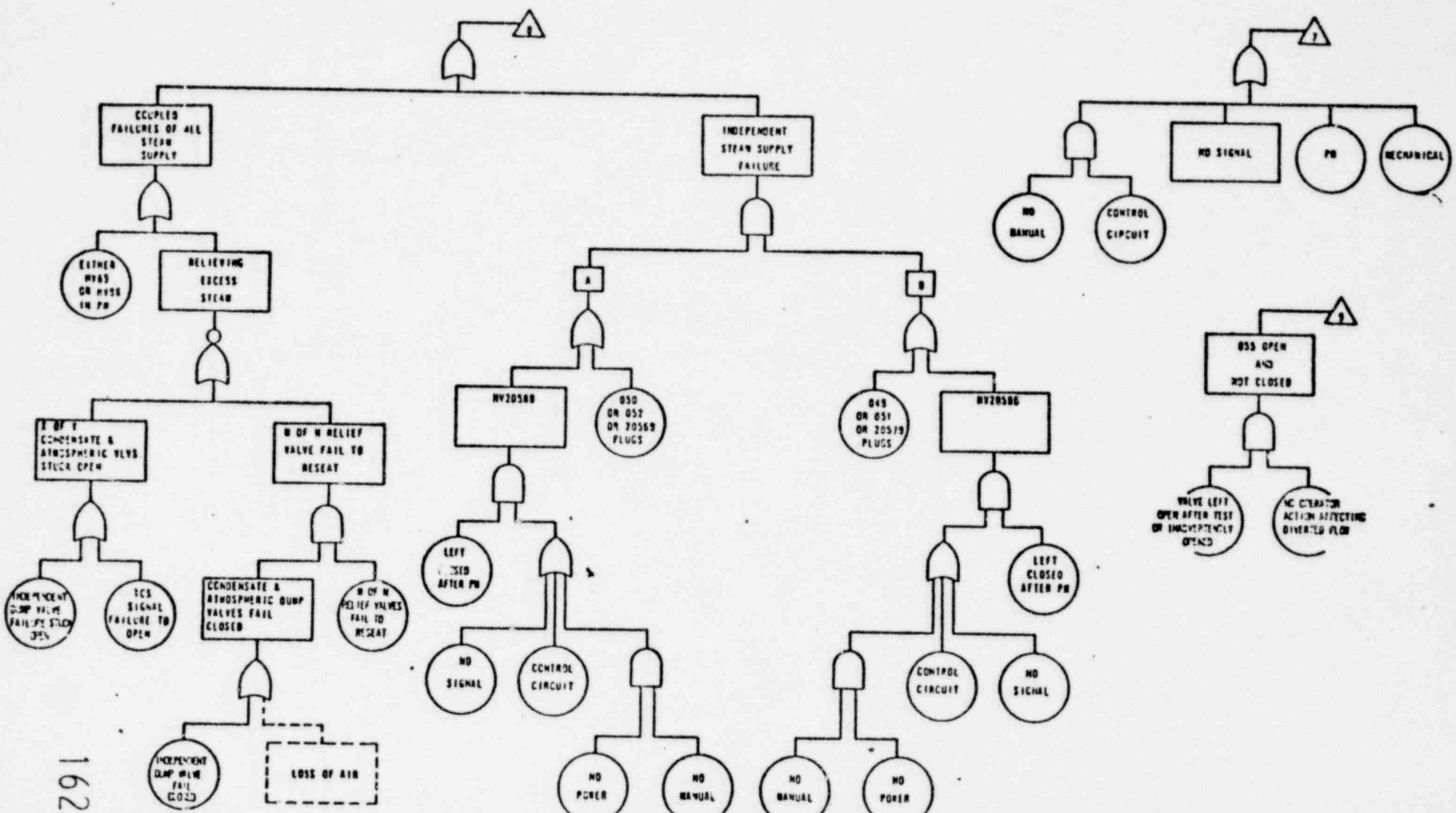

P-319 MECHANICAL
P-319 CONTROL CIRCUIT
NO SIGNAL TO PUMP
NO POWER TO PUMP 319
OPERATOR LOADING KEY
DIESEL B
P-318 MECHANICAL
MOTOR
TURBINE
P-318 MOTOR CONTROL CIRCUIT
OPERATOR LOADING KEY
NO POWER TO PUMP P-318
DIESEL A
P-318 TURBINE CONTROL CIRCUIT
INSUFFICIENT STEAM AVAILABLE TO DRIVE TURBINE
FV-30801 NOT OPENED
STEAM SUPPLY INADEQUATE


5
20527 STAYS SHUT
20577 STAYS SHUT
MECHANICAL
SIGNAL
OPERATOR
ICS SIGNAL KEEPS CLOSED
NO MANUAL
NO MANUAL
VALVE OPERATOR
MECHANICAL
CONTROL CIRCUIT
NO ACTUATION SIGNAL
NO DIYING FORCE
NO MANUAL
NO POWER

1629 337


6
20528
STAYS
SHUT
20578
STAYS
SHUT
NO
DRIVING
FORCE
NO
ACTUATION
SIGNAL
CONTROL
CIRCUIT
MECHANICAL
OPERATOR
SIGNAL
MECHANICAL
NO
POWER
NO
MANUAL
VALVE
OPERATOR
NO
MANUAL
NO
MANUAL
ICS
SIGNAL
KEEPS
CLOSED

1629 338


COUPLED FAILURES OF ALL STEAM SUPPLY
EITHER HV65 OR HV56 IN PM
RELIEVING EXCESS STEAM
1 OF 1 CONDENSATE & ATMOSPHERIC VLVS STUCK OPEN
N OF N RELIEF VALVE FAIL TO RESEAT
TCS SIGNAL FAILURE TO OPEN
CONDENSATE & ATMOSPHERIC DUMP VALVES FAIL CLOSED
N OF N RELIEF VALVES FAIL TO RESEAT
LOSS OF AIR
INDEPENDENT STEAM SUPPLY FAILURE
A
B
HV20588
050 OR 052 OR 20569 PLUGS
049 OR 051 OR 20579 PLUGS
HV20586
LEFT CLOSED AFTER PM
NO SIGNAL
CONTROL CIRCUIT
NO POWER
NO MANUAL
NO SIGNAL
PM
MECHANICAL
055 OPEN AND NOT CLOSED
VALVE LEFT OPEN AFTER TEST OR INADVERTENTLY OPENED

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APPENDIX B

NRC-SUPPLIED DATA USED FOR PURPOSES OF CONDUCTING A COMPARATIVE ASSESSMENT OF EXISTING AFWS DESIGNS & THEIR POTENTIAL RELIABILITIES

	Point Value Estimate of Probability of* Failure on Demand
I. Component (Hardware) Failure Data	
a. Valves:	
Manual Valves (Plugged)	$\sim 1 \times 10^{-4}$
Check Valves	$\sim 1 \times 10^{-4}$
Motor Operated Valves	
• Mechanical Components	$\sim 1 \times 10^{-3}$
• Plugging Contribution	$\sim 1 \times 10^{-4}$
• Control Circuit (Local to Valve)	
w/Quarterly Tests	$\sim 6 \times 10^{-3}$
w/Monthly Tests	$\sim 2 \times 10^{-3}$
b. Pumps: (1 Pump)	
Mechanical Components	$\sim 1 \times 10^{-3}$
Control Circuit	
• w/Quarterly Tests	$\sim 7 \times 10^{-3}$
• w/Monthly Tests	$\sim 4 \times 10^{-3}$
c. Actuation Logic	$\sim 7 \times 10^{-3}$

- - - - -

*Error factors of 3-10 (up and down) about such values are not unexpected for basic data uncertainties.

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II. Human Acts & Errors - Failure Data:

← Estimated Human Error/Failure Probabilities →
← Modifying Factors & Situations →

	With Valve Position Indication in Control Room		With Local Walk-Around & Double Check Procedures		w/o Either	
	Point Value Estimate	Est on Error Factor	Point Value Estimate	Est on Error Factor	Point Value Estimate	Est on Error Factor
A) Acts & Errors of a Pre-Accident Nature						
1. Valves mispositioned during test/maintenance.						
a) Specific single valve wrongly selected out of a population of valves during conduct of a test or maintenance act ("X" no. of valves in population at choice).	$\frac{1}{20} \times 10^{-2} \times \frac{1}{X}$	20	$\frac{1}{20} \times 10^{-2} \times \frac{1}{X}$	10	$10^{-2} \times \frac{1}{X}$	10
b) Inadvertently leaves correct valve in wrong position.	$\sim 5 \times 10^{-4}$	20	$\sim 5 \times 10^{-3}$	10	$\sim 10^{-2}$	10
2. More than one valve is affected (coupled errors).	$\sim 1 \times 10^{-4}$	20	$\sim 1 \times 10^{-3}$	10	$\sim 3 \times 10^{-3}$	10

Appendix B

II. Human Acts & Errors - Failure Data (Cont'd):

← Estimated Human Error/Failure Probabilities →

	Time Actuation Needed	Estimated Failure Prob. for Primary Operator to Actuate AFWS Components
B) Acts & Errors of a Post-Accident Nature		
1. Manual actuation of AFWS from Control Room. Considering "non-dedicated" operator to actuate AFWS and possible backup actuation of AFWS.	~5 min. ~15 min. ~30 min.	$\sim 5 \times 10^{-2}$ $\sim 1 \times 10^{-2}$ $\sim 5 \times 10^{-3}$

III. Maintenance Outage Contribution

Maintenance outage for pumps and EMOVS:

$$Q_{Maintenance} \approx \frac{0.22\ (\#hours/maintenance\ act)}{720}$$

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Attachment 2

OUTSTANDING NUREG-0578 ITEMS

Item 2.1.7.a-2 Single Failure Criteria for Initiation System

The District once again states its position that if the NRC staff desires a dependable auxiliary feedwater system, the existing system satisfies that desire. The history of the system from both the surveillance and the operational demand perspectives verifies this statement. The Integrated Control System (ICS) Failure Modes and Effects Analysis did not determine any concerns with respect to auxiliary feedwater control. The auxiliary feedwater section of the ICS exhibits a significant degree of channelization with few single failure possibilities.

The existing auxiliary feedwater system has multiple manual backup capabilities which can be exercised from the control room. The results of the Auxiliary Feedwater System Reliability Analysis acknowledge some of the multiple backup capabilities of the Rancho Seco auxiliary feedwater system. Even though the analysis neglects other of the systems backup capabilities, it shows that the system is very reliable.

The District can install a carefully designed and tested single failure proof initiation system by extending the 1880 refueling outage. We can not install a system which is proven by five years of commercial operation.

Item 2.1.7.a-3 Testability

Auxiliary feedwater pump initiation can be tested from the initiating device to the pump starting device during normal operation. Auxiliary feedwater flow control valves can be tested from the initiating device to the valve operator during cold shutdown.

Item 2.1.7.a-6 Vital Power

The District will automatically load auxiliary feedwater pump P-319 onto its associated nuclear service bus on loss of offsite power. Previous testing shows that the requirements of Regulatory Guide 1.9 may not be fully satisfied with respect to minimum voltage and frequency during pump start. The same tests showed that the pump can be safety and successfully loaded onto the nuclear service bus.

As a result of the District meeting with the NRC Staff on November 29, 1979, we understand that an exemption will be granted to Regulatory Guide 1.9 to allow interim automatic loading of Auxiliary Pump P-319 onto its associated nuclear service bus. At the meeting the NRC staff requested information on two items:

1. Are low voltage trips bypassed on nuclear service bus loads when the nuclear service bus is being supplied by the diesel generator? ANSWER - Low voltage trips on nuclear service bus loads are bypassed when the bus is being supplied by the diesel generator.

2. Provide test results showing nuclear service bus voltage and frequency when an auxiliary feedwater pump is loaded onto a nuclear service bus being supplied by its associated diesel generator with a full safety features system load. A plot showing the information will be forwarded by a separate letter.

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OUTSTANDING ITEM FROM THE DISTRICTS LETTER OF SEPTEMBER 17, 1979

In a letter dated September 19, 1979 the District committed to alter auxiliary feedwater system configuration to improve reliability associated with system testing. Potential for improvement in this area is suggested by the results of the Auxiliary Feedwater System Reliability Analysis. The District intends to alter the existing auxiliary feedwater system at Rancho Seco as shown in the following figure. The District intends to install this change during the 1981 refueling outage. The exact configuration in the area of the throttle valve has not been determined. It may be a manually operated globe valve preceded by a motor operated gate valve or it may be a motor operated globe valve. In either case, the motor operated valve will be operable from the control room.

(SEE FOLLOWING FIGURE)

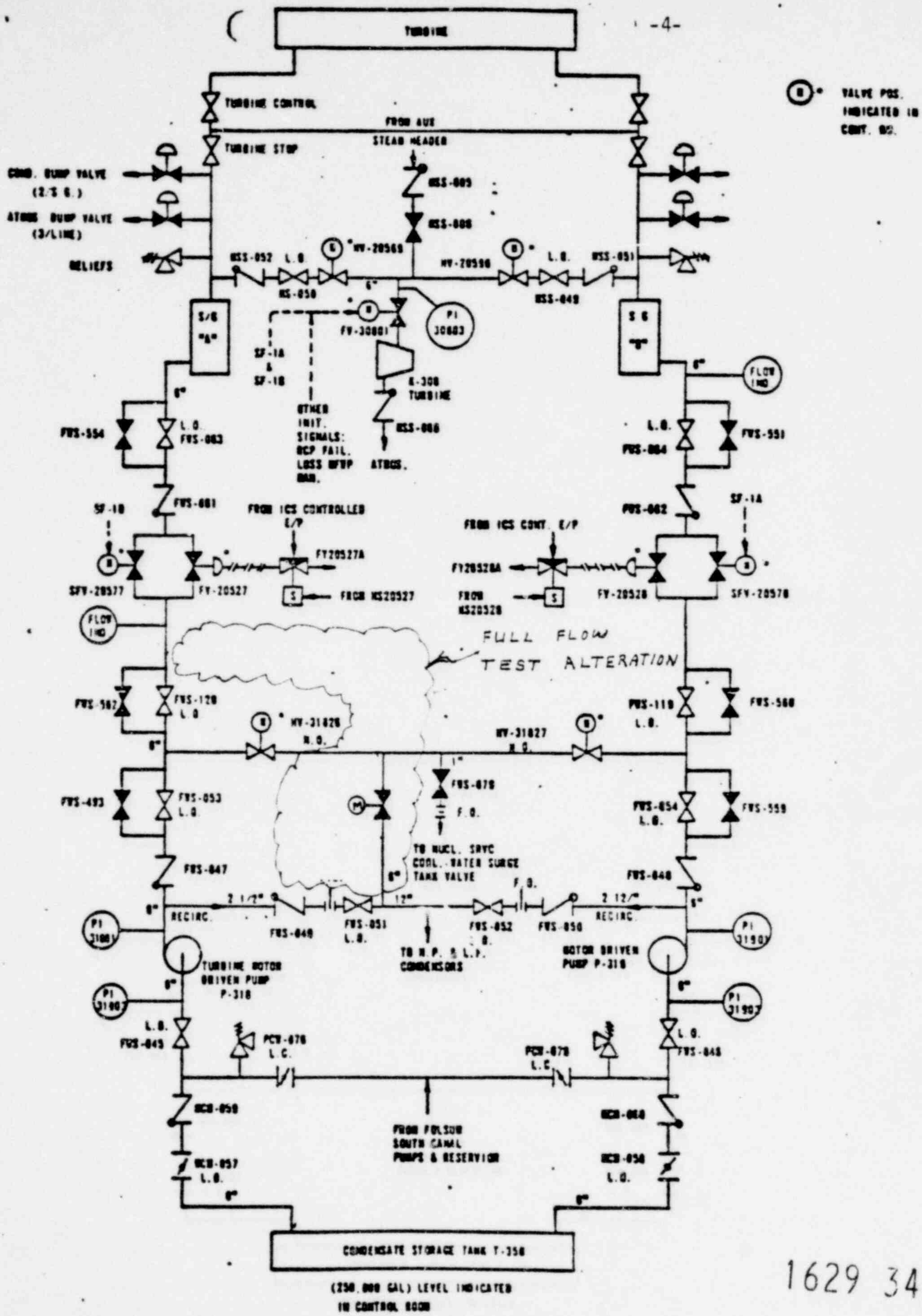

FIG. 1. RANCHO SECO AFWS

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ADDITIONAL ITEMS RECENTLY ADDED AFTER NRC STAFF REVIEW OF WESTINGHOUSE AND COMBUSTION ENGINEERING PLANTS

Item 1 Emergency procedure For Alternate Source of Water

Prior to startup at the end of the 1980 refueling outage Rancho Seco Emergency Procedures will reference standard operating procedures which in turn will describe how to obtain water for the auxiliary feedwater system from sources other than the condensate storage tank.

Item 2 Confirmation of Auxiliary Feedwater System Flow Path

The District committed to test the auxiliary feedwater system in accordance wth the ASME Code Section XI. A technical specification change letter dated March 16, 1979 made the commitment. On a quarterly basis, the ASME Code requires full flow capability verification of flow path check valves. The test will check full flow capability to the OTSG's when the plant is cooled down for an extended period.

Item 3 Redundant Level and Alarms For The Condensate Storage Tank

The District will install safety grade condensate storage tank level and level alarms during the 1981 refueling outage.

Item 4 Seventy-Two Hour Endurance Test

In June of this year at NRC request the District completed a 40 hour operational test on Auxiliary Feedwater Motor Driven Pump P-319 and on the Dual Drive Pump P-318 using the turbine drive. The results of this test were supplied to the NRC staff at a meeting on November 29, 1979.

The District strongly believes the 40 hour test verified the operability of the Rancho Seco auxiliary feedwater system and hopes the NRC staff would have specified a 72 hour test if they felt that only a test of 72 hours duration would suffice. In addition we question the necessity of a full flow test out to 72 hours. The Rancho Seco auxiliary feedwater system is sized for 4-1/2% FP decay heat. At 72 hours after a worst case history plant trip the decay heat rate is considerably less than 1% FP.

ADDITIONAL PLANT SPECIFIC ITEMS RECENTLY ADDED AFTER REVIEW OF THE RANCHO SECO AUXILIARY FEEDWATER SYSTEM

Item 1 Technical Specification on Operator Stationed at Auxiliary Feedwater Valve FWS-055 During Testing

The District does not commit to addition of Technical Specifications related to our commitment to station an operator at FWS-055 during testing. There are two reasons for this position.

First, the District is concerned that an addition to Technical Specifications of this acknowledged commitment excalates a procedural commitment to a Technical Specification commitment. A commitment such as this in a step in the direction of having plant procedures included in Technical Specifications.

The District satisfies the commitment to have an operator at FWS-055 by having the requirements in the surveillance procedure which uses FWS-055.

A second reason is that soon valve FWS-055 will not be required for surveillance testing for two separate reasons. The District Technical Specification change dated March 16, 1979 states that pump testing will be done in accordance with the ASME Code, Section XI. The ASME Code will not require use of FWS-055. In addition, another commitment made in this attachment says that the line containing FWS-055 will be removed and another test line with a motor operated valve will be added during the 1981 refueling outage.

Item 2 Monthly Stroking of Motor Operated Auxiliary Feedwater Valves

The District Technical Specification letter of March 16, 1979 says that safety system valve testing will be done in accordance with the ASME Code, Section XI. The ASME Code requires valve quarterly stroking. Standard Technical Specification accept this test frequency. Auxiliary feedwater valves are no more significant than other safety system valves. As such, the District intends to continue quarterly testing.

Item 3 Auxiliary Feedwater Flow Control During Loss of All AC Power

On loss of all AC power, the auxiliary feedwater pump DC steam inlet valve opens to start Pump - 318. Auxiliary feedwater flow control valves are then throttled to control flow to the OTSG's. Auxiliary Feedwater System operating procedure A.51 addresses local control of auxiliary feedwater flow control valves. Therefore, the capability currently exists to operate the auxiliary feedwater system on loss of all AC power.