Wood-Leaver and Associates, Inc.

WLA-1-R-82-02 Rev 1

RELIABILITY ANALYSIS OF THE EMERGENCY FEEDWATER SYSTEM AT THE SEABROOK NUCLEAR POWER STATION

FINAL REPORT

Prepared For:

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and
PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

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June, 1982

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1.0 INTRODUCTION

1.1 BACKGROUND

The action plan developed by the NRC in response to the accident at the Three Mile Island Unit-2, NUREG-0737, requires (Item II.E.1.1) that all operating nuclear power plants or plants applying for operating licenses conduct a reliability analysis of the auxiliary feedwater (AFW) system. The analysis is to be performed using event-tree and fault-tree logic techniques and is intended to evaluate the potential for system failure during a variety of loss of main feedwater transients. The primary purpose of the reliability evaluation is to identify potential failures resulting from human errors, common causes, single-point vulnerabilities, and outages due to test and maintenance.

The stated purpose of the recommendations associated with TMI Action Plan Item II.E.1.1 was to decrease the unreliability of AFW systems towards a goal of 10^{-4} to 10^{-5} per demand for loss of main feedwater and loss of offsite power transients. As a result of reliability evaluations performed both by the NRC staff (NUREG-0611) and various operating license applicants, it was deemed by the staff that three AFW pumps were necessary to achieve the desired unreliability goal assuming all other AFW system safety criteria are met. Therefore the current staff position is that applicants for operating licenses must include at least three AFW pumps in their plant design, and each pump must be capable of providing to the steam generators at least the minimum flow necessary for decay heat removal following a loss of offsite power. Also, a minimum of two of these pumps and their associated trains must be safety grade.

On October 30, 1981, the NRC staff informed the Public Service Company of New Hampshire, (PSNH) of the staff position regarding AFW system reliability, and questioned the ability of the Seabrook Nuclear Station auxiliary feedwater system to meet the specified reliability goals. The

Seabrook AFW system[1] consists of a two-pump safety grade emergency feedwater (EFW) system and a non-safety grade "startup feed pump" that may operate in parallel with the emergency feed pumps. The staff's concern, as stated in the October 30 letter, related primarily to the perceived inability to power the third "start-up" pump from the emergency AC buses.

PSNH replied to the staff's concerns by letter on December 4, 1981.[2] In this response it was noted that provisions were included in the Seabrook design to allow the startup feed pump to be powered from an emergency bus if necessary. With this provision it is the position of PSNH that the Seabrook EFW system design meets the requirements of the October 30 letter from the staff.

1.2 PURPOSE

The purpose of this study was to perform a reliability analysis of the Seabrook EFW system considering the use of the startup feed pump as a third source of emergency feed water and to demonstrate using the results of the study the validity of PSNH's position, i.e., that the required reliability goals as specified by the NRC staff are met by the existing Seabrook AFW system design. In addition, this study was intended to identify for PSNH and the NRC staff any dominant faults affecting the AFW system reliability under the loss of main feedwater/loss of power transient conditions specified by the staff in NUREG-0611. The techniques used to achieve these objectives were the logic modeling methods specified by NUREG-0737.

1.3 SCOPE

The EFW system design evaluated by this study is that described in section 6.8 of the Seabrook Nuclear Station Final Safety Analysis Report (FSAR) and further described in system description document SD-1M. The

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[1] In this report the term "auxiliary feedwater", or AFW, system as applied to Seabrook means the combined emergency feedwater and startup pump systems.

[2] Letter No. SBN 198, T.F. H4.4.98 to Mr. Frank J. Miraglia from Mr. John DeVincentis.

design of the startup feed pump system is described in system description document SD-1Q. The primary sources of specific design information about both the systems described in these documents were facility P and I drawings and logic diagrams. A listing of all drawings used in the course of this study is provided in Appendix C.

The transient conditions under which the AFW system reliability was determined are those outlined by the NRC staff in NUREG-0611, i.e.,

- Loss of main feedwater with reactor trip;
- Loss of main feedwater with coincident loss of offsite station power;
- Loss of main feedwater with coincident loss of all station AC power.

For each of the transient conditions analyzed, unreliability was defined as the probability of failure of the combined EFW and startup pump system to start and provide feedwater to at least two steam generators prior to the time that the steam generators would boil dry following a reactor trip from full power. The time required to boil away the water in the steam generators is determined by the initial mass of water contained in them at the time of trip and the amount of decay heat liberated from the core. For the Seabrook station this time would generally be in the range of 35 to 60 minutes following a trip from full power operation; therefore, 30 minutes was selected as a conservative mission time for this reliability study. The unreliabilities calculated exclude any consideration for the causes or probabilities of the specified transient conditions, nor do they consider external common mode failure initiators such as earthquakes, floods, etc.

2.0 SYSTEM DESCRIPTION

2.1 EMERGENCY FEEDWATER SYSTEM

A schematic of the emergency feedwater system at Seabrook is shown in Figure 1. The system consists of two pumps each supplied by individual suction lines from the condensate storage tank (CST). Each pump has a design flow of 710 gpm at a head of 3050 feet and is capable of providing full cooling of the reactor coolant system in emergency situations. One pump is driven by an AC motor which is powered by one of the 4160V plant emergency buses. The second pump is steam-turbine driven with steam being supplied from either of two steam generators. Take-off points for the turbine steam supply lines are upstream of the main steam isolation valves, thereby ensuring motive power to the turbine even in the event of steam line isolation. Both pumps are attached to a common return to the CST which is used for pump testing. This return line is isolated during normal operation.

During operation of the EFW system, both pumps discharge into a common header which in turn supplies four individual supply lines to each of the four steam generator main feed lines. Each emergency feed line joins its associated main feedwater header downstream of the feedwater isolation valve and outside of containment.

The emergency feedwater supply lines are each equipped with two motor-operated flow isolation valves and a flow limiting venturi. The valves are normally open and are designed to fail "as-is" on loss of power. The valve positions are set such that they assure a minimum of 235 gpm to each steam generator during normal operation with both EFW pumps running. The control systems for the valves are designed to isolate an emergency feed supply line if flow in the line exceeds a preset high flow value. This feature prevents diversion of EFW flow following a line break in any steam generator. A single flow orifice located between the isolation valves in each line provides differential pressure information to the control equipment for flow measurement. Two separate flow transmitters are used to provide independent high flow isolation signals to each of the isolation valves. The flow transmitters, control equipment, and motor-operators for the

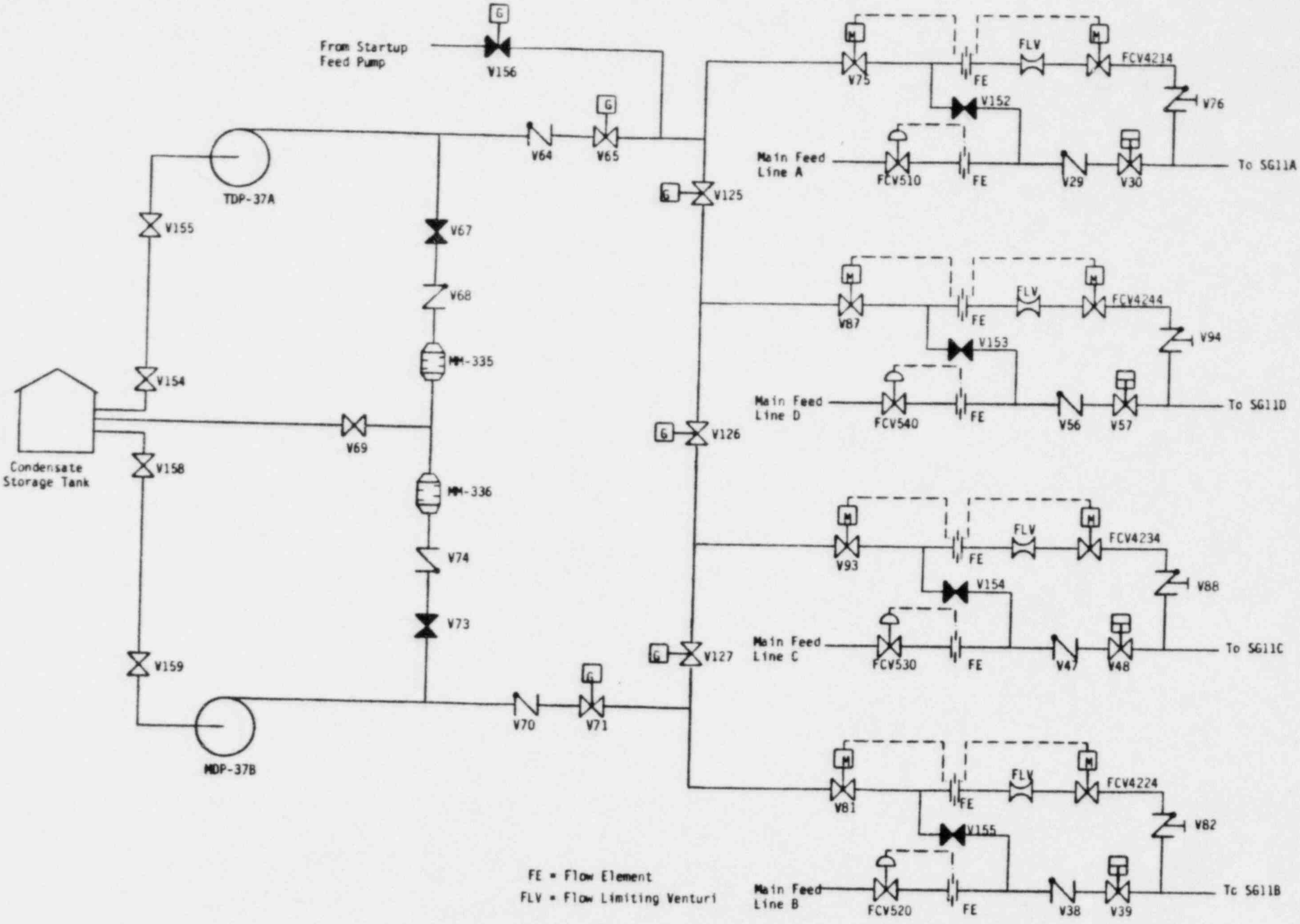

Figure 1. Seabrook Nuclear Station Emergency Feedwater System

valves upstream of the flow elements are powered by train B emergency electrical buses while those downstream of the flow elements are powered by train A buses.

Assuming both EFW pumps are running, flow through any EFW line is limited to a maximum of 750 gpm by a flow limiting venturi also located between the isolation valves. This flow limitation provides runout protection for the EFW pumps in the event of depressurization of any steam generator. The venturis provide an added benefit in that a pipe break in any steam generator along with failure of both isolation valves in the associated EFW line will not cause a complete loss of cooling water to the remaining steam generators.

Each supply line is also equipped with a non-return valve which prevents the EFW system from being subjected to normal steam generator pressures when the EFW system is not in use.

The pump discharge headers and the common emergency feedwater header are equipped with a total of five isolation valves that are used to segregate various parts of the system for testing and maintenance activities. These valves are all manual, gear-operated valves that are locked open when the system is in its normal readiness state. The pump discharge headers are also equipped with check valves to prevent reverse flow through a pump during operation with the pump out of service. Flow diversion through the pump recirculation lines is prevented during normal operation by normally closed manual valves in each recirculation header. The recirculation lines are also equipped with pressure reducing orifices that will limit flow should the manual valves be left open.

Each pump suction line to the CST contains two manual isolation valves, one in the tank yard and one in the emergency feed pump building. Both valves are normally open and locked in position.

The steam supply lines for the turbine-driven EFW pump are shown in Figure 2. Steam can be supplied to the turbine from either steam generator "A" or "B". Steam from either steam generator is supplied to a common header

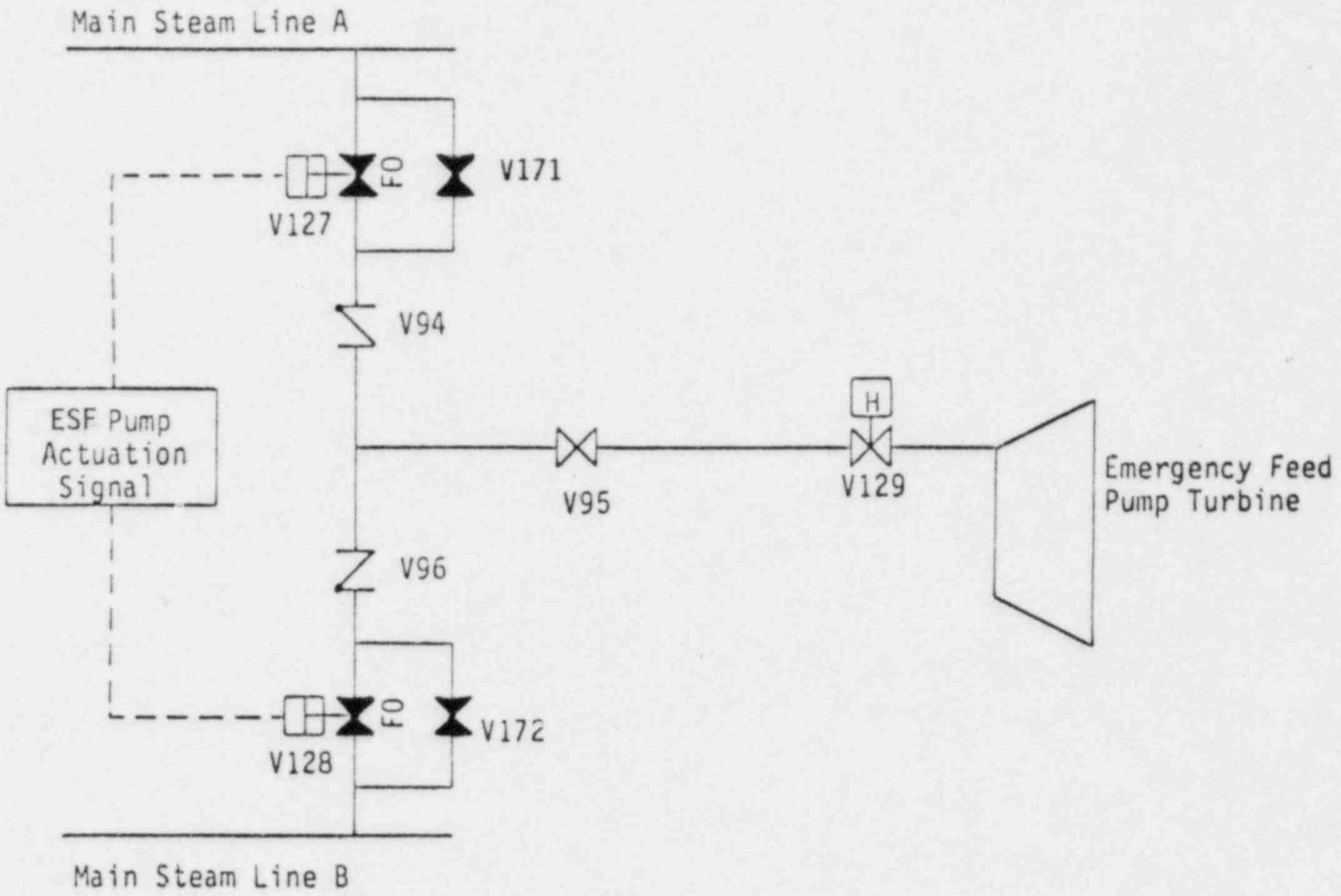

Figure 2. Steam Supply for Turbine-Driven EFW Pump

through air-operated, fail-open valves that are actuated by an engineered safety feature (ESF) actuation signal. Both valves will open as a result of a loss of offsite power, low-low level in any steam generator, or any safety injection signal.* Each steam supply line is equipped with a check valve to prevent diversion of steam from the turbine in the event of a pipe break in one of the steam lines. The common supply header to the turbine-driven pump contains a normally open manual isolation valve used during turbine maintenance and a spring-loaded mechanical trip valve that closes on turbine over-speed.

Oil cooling for the turbine-driven EFW pump bearings is provided by an oil cooler supplied directly from the discharge of the turbine-driven pump. The cooling flow is discharged to the common recirculation header.

2.2 STARTUP FEEDPUMP SYSTEM

The elements of the startup feedpump (SUF) system at Seabrook are shown in Figure 3. The system consists of a single motor-driven pump capable of supplying 1500 gpm at 3000 ft. of head. The pump takes suction from the CST via the main condensate makeup line. The suction line between the pump and CST is equipped with three normally open manual isolation valves. The discharge headers from the pump attaches to six other feedwater system headers, i.e., the main feedwater pump discharge header, the high-pressure feedwater heater outlet header, the condensate pump discharge header, the make-up header from the CST, the steam generator recirculation pump discharge header, and the EFW pump discharge header. The pump is also equipped with a recirculation line to the CST for pump protection and testing. Flow through the recirculation line is controlled by a pressure-controlled throttling valve that senses pressure at the pump discharge.

With the exception of the main feedwater pump discharge header, the discharge from the startup pump is isolated from all feed system headers by at least one normally closed valve. The supply path to the main feedwater pump discharge header is normally open but is equipped with a manual gear-operated

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* These same signals will also automatically start the motor-driven EFW pump.

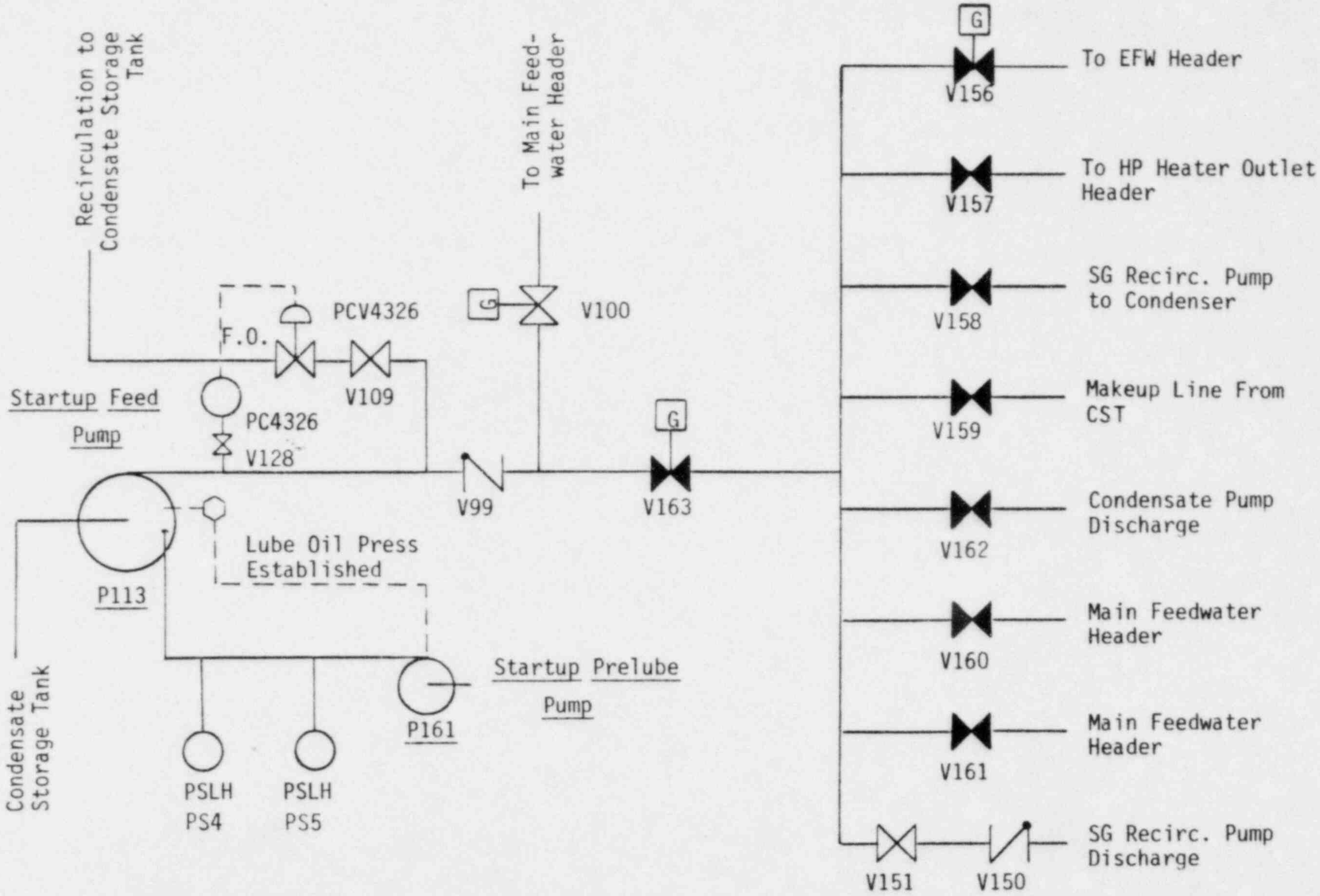

Figure 3. Seabrook Nuclear Station Startup Feed Pump System

valve to allow isolation if necessary. Flow to the EFW pump discharge header is prevented during normal operation by two normally closed manual gear-operated isolation valves.

During startup, lubrication of the SUF pump is provided by a motor driven auxiliary lube oil pump. Operation of the auxiliary lube oil pump is controlled by SUF pump lube oil pressure. When the SUF pump is in the AUTO control mode, startup of the lube oil pump will be followed by start of the SUF pump when sufficient oil pressure is established. Once started, a shaft-driven lube oil pump located on the SUF pump supplies lubrication and the auxiliary lube oil pump is stopped. Should the shaft-driven pump fail, the auxiliary oil pump will automatically restart.

In its normal operating mode the SUF pump will start automatically on a trip of both main feed pumps unless a safety injection or high-high steam generator level signal also occurs.

2.3 EMERGENCY ELECTRICAL POWER SOURCES

Emergency electrical power for the EFW and SUF systems is supplied from both 4160V emergency AC buses and both vital DC instrument buses. Power for the motor-driven EFW pump is taken from emergency AC bus E6 and diesel-generator 1B while the SUF pump, via operator action, can be powered from emergency AC bus E5 and diesel-generator 1A. The auxiliary lube oil pump used when starting the SUF pump is also supplied power by bus E5 through buses E52 and E523. Control power for the motor-driven EFW train is taken entirely from vital DC instrument bus 11B. Control power for the steam-turbine admission valves is supplied from both ESF trains, one valve receiving control power from DC bus 11A in train A and the other receiving power from DC bus 11B in train B. There are no AC power dependencies in the turbine-driven EFW pump train. As noted in Section 2.1, electrical power for the EFW isolation valves also comes from the emergency buses, and train separation criteria are met for each EFW supply line.

2.4 INSTRUMENTATION AND CONTROLS

The control room operator at Seabrook has available a variety of instrumentation and controls that allow him to monitor and direct operation of both the emergency feedwater system and the startup feed pump. The important equipment relative to EFW and SUF system operation are listed below:

Instrumentation	Location
o Operating status lights for the motor-driven EFW pump	Control room/remote safe shutdown panel
o Position indication lights for both steam admission valves to the turbine-driven EFW pump	Control room/remote safe shutdown panel *
o Suction and discharge pressures for both EFW pumps	Control room/local
o Flow indication for each emergency feedwater supply line	Control room/remote safe shutdown panel
o Three narrow-range and one wide-range level transmitter in each steam generator	Control room/remote safe shutdown panel
o Steam pressure in each steam generator	Control room
o Dual CST level transmitters	Control room

Alarms	Location
o Trip alarm for motor-driven EFW pump	Control room
o Alarms indicating local operation of either EFW pump	Control room
o Low suction pressure alarms for both EFW pumps	Control room
o Startup feed pump trip alarm	Control room
o Startup feed pump pre-lube pump running alarm	Control room

* Position indication is available at the remote shutdown panel only for valve V-127.

o Low and low-low level alarms in each steam generator	Control room
o CST low level alarms	Control room
o SI actuation alarm	Control room
o Pump motor bearing and winding temperature alarms	Control room
o Emergency feed pump valves misaligned	Control room
o SUF pump powered from bus E5	Control room

Controls	Location
o Manual/auto controller for motor-driven EFW pump	Control room/ switchgear room
o Manual/auto controller for turbine-driven EFW pump steam admission valve	Control room/remote safe shutdown panel *
o Manual/auto controller for each EFW flow limiting valve	Control room/remote safe shutdown panel
o Manual/auto controller for startup feed pump	Control room
o Manual/auto controller for startup feed pump prelube pump	Control room

Automatic Actuation Signals	EFW Function
o Safety injection signal	Starts both EFW pumps
o High flow to one S/G	Close both EFW isolation valves in line with high flow
o Low-low level in any steam generator	Starts both EFW pumps
o Loss-of-offsite power signal	Starts both EFW pumps

* Only steam-admission valve V-127 can be controlled at the remote shutdown panel.

o Trip of both main feed pumps	Starts SUF pump *
o Low bearing oil pressure at SUF pump	Starts SUF prelube pump

* This signal is prohibited if either a safety injection or steam generator high-high level signal is present.

3.0 RELIABILITY ANALYSIS

3.1 FAULT TREE MODEL

The fault tree model used for this study was developed from an existing fault tree created several years ago as part of a "mini WASH-1400" review of the Seabrook station. In its original form the tree considered the two-pump emergency feedwater system but did not include modeling of the startup feed pump. In the initial phases of this study the old fault tree model was reviewed for accuracy and revised as necessary to properly reflect the current EFW system design at Seabrook. In addition, the logic necessary to model the impact of the SUF system on AFW system reliability was incorporated into the trees. As a result, the fault tree now models the entire "three pump" AFW system as it currently exists in the Seabrook design. In essence, failures of all components shown in Figures 1 through 3 of this report are now considered by the fault tree model. A logic diagram of the complete fault tree is provided in Appendix A.

In addition to component failures, the fault tree also includes logic to consider the effects of failures in interfacing systems on AFW system reliability. Examples are failures of the electrical power sources for the EFW and SUF pump and controls, failures of reactor protection system actuation signals, failures at piping interfaces with the main feedwater/condensate systems, failures in the steam generators, and errors by plant personnel while maintaining and operating the system.

The handling of operator errors by the Seabrook EFW system fault tree requires some discussion because of the potentially large impact such errors might have on the capability of the startup feed pump to function as a backup to the safety grade EFW system. As was noted in Section 1.0, the primary reason for conducting the reliability analysis reported here was to demonstrate this backup capability. To do this, two key concerns had to be addressed: the ability to provide emergency AC power to the SUF system and the ability to align the SUF system with the EFW system. In the current Seabrook design these two functions can be accomplished only through a specific set of operator actions at locations other than the control room.

In order to provide power to the SUF pump from an emergency AC bus, an operator must manually "rack out" the SUF pump breaker from bus 4 located in the non-essential switchgear room, move it to the essential switchgear room, and manually "rack in" the breaker to emergency bus E5. He must also change the bus transfer switch to the E5 bus position. The breaker has been equipped with built-in rollers to facilitate moving it from room to room. In addition, the two switchgear rooms are adjacent to each other minimizing the distance that the breaker must be moved.

Aligning of the SUF pump with the EFW systems also requires an operator (or operators) to change the position of three manual isolation valves. One of the valves (V-109) must be closed to prevent possible flow diversion of the SUF pump discharge to the condensate tank via the SUF recirculation line should power be lost to the SUF pump recirculation valve (PCV-4326). The remaining two valves (V-156 and V163) must be opened to connect the SUF pump discharge header to the EFW system header. Valves V-109 and V-163 are located in the turbine hall. Valve V-156 is in the emergency feed pump room.

The approach used in this analysis to correctly depict the operator actions outlined above was to consider alignment of the SUF pump for emergency operation to be four distinct actions rather than just one. Failure to perform any one of the four can prevent the SUF pump from performing the desired function under the appropriate set of conditions.

The first three actions relate to operation of the three manual valves in the cross-tie and pump discharge headers. Failure to change the position of any valve was assumed to prevent flow from the SUF reaching the EFW header. Each operation was considered to be a separate event because of the different valve locations, and because more than one operator might be sent to perform the required actions.

The fourth action considered in the fault tree was the loading of the startup pump system onto an emergency bus. In reality this action represents multiple operations (viz. starting the prelube oil pump, moving the pump circuit breaker to the essential switchgear room, starting the SUF pump, etc.). In this case, however, all the controls necessary to start both the

SUF prelube pump and the SUF pump are available on the main control board. The only actions required outside the control room are moving of the pump breaker and changing of the bus transfer switch as described earlier. This is likely to be done by one operator following well defined procedures. Therefore, for the purpose of this study, it was judged that a single operator error event could adequately represent failures in the pump loading process.

In addition to using four operator errors that could result in failure of the SUF pump system, special consideration was also given to the failure rates applied to these actions. Even though it is assumed that specific emergency procedures and operator training will be used at Seabrook to ensure proper utilization of the SUF pump during emergencies, the failure rates used in this study for these operator errors is significantly higher (.01/demand)* than would normally be expected for situations where well developed procedures are in place and special operator training is provided. Again use of the higher values was felt to be necessary to reflect the disparity in locations where actions must be performed and because of the short time (≅ 30 minutes) available for the actions to be completed. Further discussion of these and other operator error rates is provided in the following section.

3.2 DATA USED IN FAULT TREE QUANTIFICATION

Previous analyses similar to the one presented here that have been conducted by other utilities owning plants designed by Westinghouse have generally had as an objective a comparative evaluation of the reliability of a specific emergency feedwater system with generic reliability analyses reported by the NRC staff in NUREG-0611. However, as noted in Section 1.0 of this report, the October 30th, 1981 letter to Seabrook specified a quantitative reliability goal for emergency feedwater system performance. For that reason the component failure data presented in NUREG-0611 was considered to be too

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* The error associated with isolating the SUF pump recirculation line was assigned a value of 10^{-3}/d because it was assumed to be coupled with opening one of the cross-tie isolation valves. See Section 3.2 for further discussion.

general to allow an accurate fault tree analysis of system unreliability to be performed. Therefore, it was decided that the best failure information available to date would be incorporated in this study. The following section presents that data and the sources from which it was taken.

3.2.1 Failure Data - General

Table B.1 (Appendix B) presents a compilation of data for various failure modes of different power plant components, both mechanical and electrical. The data was extracted from the following sources:

1) The Reactor Safety Study (WASH-1400)
2) GE-22A2589, Recommended Component Failure Rates, May 1974
3) IEEE-Std 500-1977, Nuclear Reliability Data Manual.

and the following reports from the Licensee Event Report (LER) evaluation program:

1) NUREG/CR-1205, Data Summaries of LER's of Pumps
2) NUREG/CR-1362, Data Summaries of LER's of Diesel Generators
3) NUREG/CR-1740, Data Summaries of LER's of Selected Instrumentation and Control Components
4) NUREG/CR-1363, Data Summaries of LER's of Valves.

The data values obtained from the above references are presented in Table B.1 for each failure mode for which data from that reference was applicable. To avoid ambiguity where multiple values are presented for a single failure mode, Table B.1 indicates the recommended value that was used in the fault tree analysis. In the cases where multiple data values exist, engineering judgement was used to determine the most appropriate data based on similarity of the plant component, function and environment to the equipment represented by the data.

In some instances the data presented in the referenced sources were either too general or the component data were obtained on like components having dissimilar functions. In particular, NUREG/CR-1205 presents component failure data for pumps by generic classification, namely, running, alternating and standby. However, review of the LERs revealed that sufficient data was available to extract specific component data for motor and turbine driven auxiliary feedwater pumps.

Similarly, the generic values presented in NUREG/CR-1363 for safety/relief valve failure rates were calculated using primary side components (i.e., pressurizer relief valves, pump relief valves, etc.) only. The components of interest in the Seabrook fault tree were the steam generator safety/relief valves. A limited amount of data existed in the LERs on secondary safety/relief valve failures. Also, it was noted that licensees do not always report relief valve failures since no credit is taken for them in accident analyses. To compensate for these facts, the values presented in Table B.1 for safety and relief valve premature opening were calculated using the information available in NUREG/CR-1363 and applying a factor of 5 to the safety valve failure rate and a factor of 10 to the relief valve failure rate.

One further point should be mentioned as to the conservative bias built into some of the data. In particular, the failure rates of the diesel generator, as taken from NUREG/CR-1362 for weekly testing, are 1.0×10^{-2}/d for the failure to start mode and 6.0×10^{-3}/hr for the failure to run mode. These failure rates are calculated assuming that all plant diesel generators are tested weekly. However, this does not account for the many starts of the diesel generators which occur outside of normal testing periods. Therefore, the number of demands on the diesel generators are underestimated while, conversely, the number of failures reflects diesel generator failures which occur during all phases of operations. For those reasons, the failure rates from NUREG/CR-1362 associated with weekly testing were considered to be most representative of the diesel failure frequencies to be expected at the Seabrook station.

3.2.2 Treatment of Time Dependent Failures

Failure rates used in the fault tree analysis are either demand dependent or time dependent. Demand dependent failure rates are applied to static components which are required to change position or state to perform their required function. Examples are the auxiliary feedwater pumps which are required to start on demand and certain valves, such as the steam turbine inlet valves (V-127 and V-128), which are required to change state upon receipt of the appropriate actuation signal.

Time dependent failures are characterized by the necessity of a component to maintain condition, position or status in order to perform its required function. Examples are the auxiliary feedwater pumps which must continue to run once started, valves which must maintain their position (e.g., remain open), and electrical components which must maintain their status (e.g., pump breakers do not trip) for the entire mission time prescribed for a particular transient. Time dependent failures are also characteristic of components which are in a standby condition and which could fail prior to operation.

The unavailability of a time dependent component is calculated from the hourly failure rate and a mission time for operating components, or a testing interval for standby components. The time interval used is dependent on the testing frequency, the actuation circuitry employed, and the operational requirements of a component for the transient being considered. For example, consider the actuation circuit of the motor- driven emergency feedwater pump shown in Figure 4. This pump can be started automatically on receipt of either a safety injection signal, a loss of offsite power signal, or on a low-low steam generator water level signal. It can also be started manually from the control room by the operator using manual/auto control station CS-4255-1. The Technical Specifications require that the motor-driven EFW pump be tested every month. During these tests the pump will be started manually from the control room using CS-4255-1. This procedure will also test the integrity of the control circuit from CS-4255-1 to the pump. Therefore, for certain failure modes of the control circuits, the proper testing frequency would be calculated from the one month testing interval, i.e.:

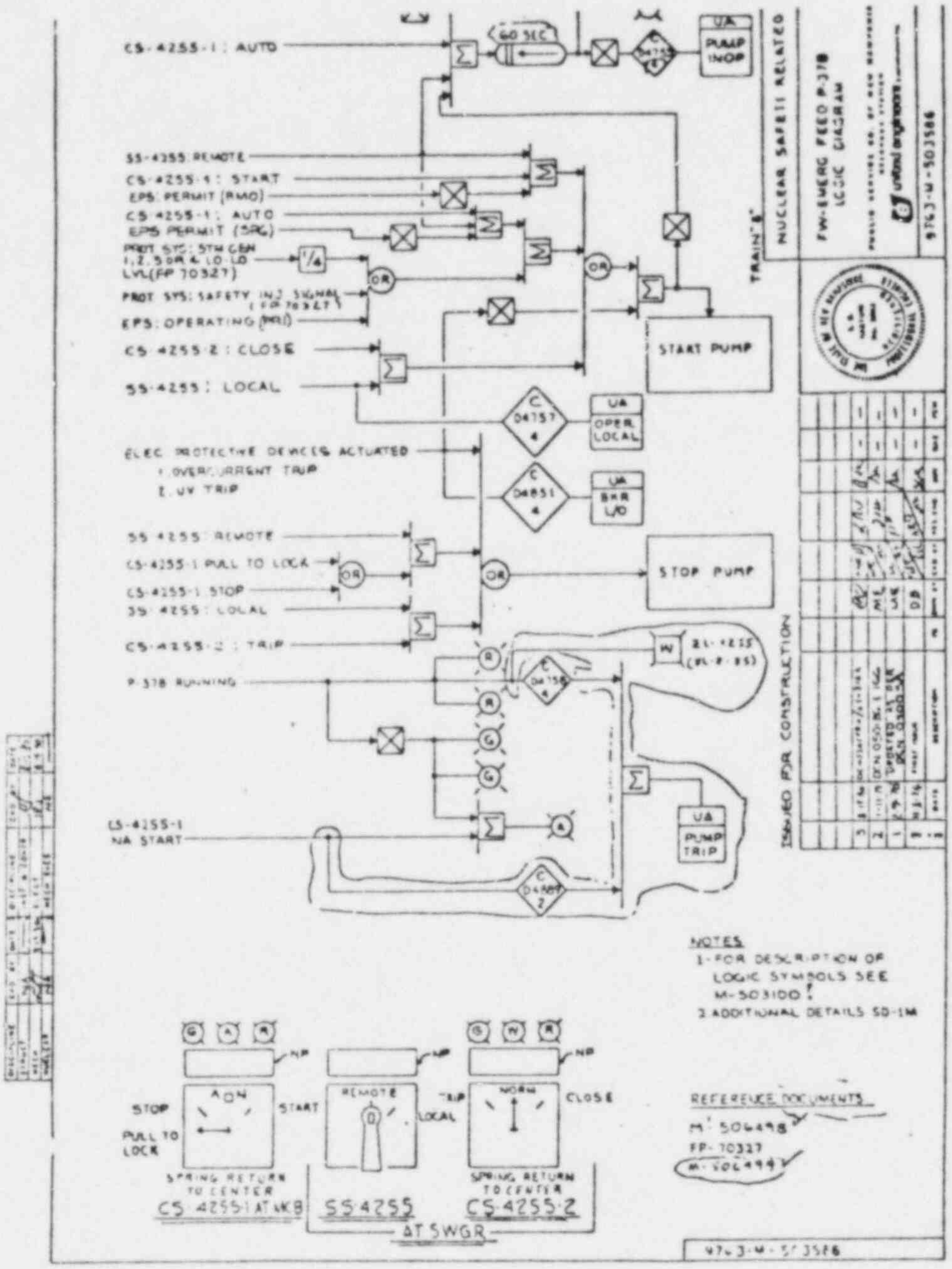

Figure 4. Motor-Driven EFW Pump Control Logic

t = [30 days x 24 hours/day] /2 = 360 hours.

In comparison, the tests of EFW system components to actuate on an automatic signal will be performed only every 18 months. The unavailability of a component due to failure to receive an automatic actuation signal therefore would be calculated on the basis of the following time interval:

t = (18 months x 720 hours/month) /2 = 6480 hours.

It is assumed that for the monthly test of the turbine-driven emergency feed pump only one of the two steam admission valves is opened and that these valves are used alternately from one test to the next. Therefore, the control circuitry to the steam inlet valves V-127 and V-128 would each be tested on a bi-monthly interval, and the unavailability of these valves due to failures of the control system are calculated using the following interval:

t = [60 days x 24 hours/day] /2 = 720 hours.

The unavailability of components which are required to operate or maintain condition are calculated using the mission time. In the study presented here the mission time is the time in which the steam generators would boil dry given an insufficient supply of water from the emergency feedwater system.

The unavailability of each failure event used in the Seabrook fault tree analysis, defined using the criteria discussed above, is presented in Table B-2 (Appendix B).

3.2.3 Test and Maintenance Outages

In addition to a component being unable to accomplish its function due to mechanical or electrical faults, a component may be unable to respond to a system demand because that component is out of service due to maintenance or testing. Technical Specifications limit the time during which some components can be unavailable and the plant still maintained at full power conditions. At Seabrook one such limit applies to the EFW system. In the event that an emergency feedwater pump is disabled, restoration must occur within 72 hours or the plant must be placed in a hot standby condition. This 72 hour limit is assumed to apply also to pump discharge isolation valves if they require servicing.

All other components within the emergency feedwater system at Seabrook are assumed to have no time restrictions in relation to plant operation. However, the assumption was made that combinations of components which disable more than one emergency feedwater supply line could not be taken out of service simultaneously. No maintenance requirements were considered for manually operated valves within the emergency feedwater system since these valves are located in low energy lines and position changes, other than those required for testing, do not routinely occur between scheduled outages. Unavailabilities of these valves due to maintenance errors during scheduled outages have been considered and will be described in a later section.

Maintenance unavailabilities were calculated from data presented in NUREG/CR-1635, Nuclear Plant Reliability Data System 1979 Annual Reports of Cumulative System and Component Reliability. This source presents average restoration times for various components and failure modes. For those components whose outage times are limited by the Technical Specifications, the average restoration time was assumed equal to 72 hours if the average time specified by NUREG/CR-1635 was greater than 72 hours. The maintenance unavailability for a component was then calculated as follows:

$$Q_{maint} = N \times t_{/T}$$

where:

N = number of maintenance acts
t = average component restoration time
T = total component calendar hours.

Note that this calculation introduces additional conservatism because it assumes all maintenance acts are performed while the plant is operating at power. A list of maintenance unavailabilities is presented in Table 1.

Additional unavailabilities can be assigned to emergency feedwater system components due to periodic testing. In particular, the Technical Specifications require that the emergency feedwater pumps be started every month. Referring to Figure 1, the procedure for testing pump P-37A or 37B is to close either manual isolation valve V-65 or V-71 and open manual valve V-67 or V-73 to recirculate emergency feedwater to the condensate storage tank.

The startup feed pump can be tested in several ways. One method would be through the normally open manual valve V-100 in the line which connects the startup pump discharge to the discharge line of the main feedwater pumps. Another would be to close V-100 and recirculate water to the condensate storage tank through PCV-4326 which will open automatically on high pump discharge pressure. However, if the startup pump is needed, PCV-4326 will automatically close as pump discharge pressure decreases thereby eliminating possible flow diversion. Neither of these test methods change the configuration of the startup feed pump; therefore, no test outage was applied to the startup feed system. One exception to this assumption is discussed in the section on operator actions.

The test frequency for the emergency system is once per month and the time interval of the test was assumed to be the average test time for pumps of 1.4 hours found in Table III 5-1 of WASH-1400. The unavailability due to testing therefore is:

$$Q_{test} = {}^{1.4}/720 = 2 \times 10^{-3}$$

The test unavailabilities and the components to which they apply are shown in Table 1.

TABLE 1

SUMMARY OF MAINTENANCE AND TEST UNAVAILABILITIES

Components	Maintenance	Test	Total
1) Motor Driven EFP-37B	4.2×10^{-4}	N/A	4.2×10^{-4}
2) Turbine Driven EFP-37A		N/A	9.4×10^{-4}
Pump contribution	4.2×10^{-4}		
Turbine contribution	5.2×10^{-4}		
3) Startup Feed Pump P-113	7.0×10^{-4}	N/A	7.0×10^{-4}
4) Lube Oil Pump P-161	5.0×10^{-4}	N/A	5.0×10^{-4}
5) Diesel Generator	7.0×10^{-4}	N/A	7.0×10^{-4}
6) Valves			
a) Emerg Feed Flow Isolation Valves (4214,4224,4234, 4244,75,87,93 81)	8.5×10^{-4}	N/A	8.5×10^{-4}
b) Steam Supply Valves V-127, V-128	8.7×10^{-4}	N/A	8.7×10^{-4}
c) Steam Supply Valve V-129	1.0×10^{-4}	N/A	1.0×10^{-4}
d) Manual Isolation Valve V-65,V-71	9.3×10^{-6}	2.0×10^{-3}	2.0×10^{-3}

3.2.4 Operator Errors

Operator errors can be divided into two basic types, 1) errors of commission and 2) errors of omission. Errors of commission occur when the operator performs an action which terminates or reverses the normal operation or condition of a component. Examples would be the operator shutting off a running pump or changing the position of a valve.

Errors of omission occur when the operator fails to perform an action which would initiate component operation or place it in its proper operating condition given that these actions have not occurred automatically. Errors of omission also occur when the operator is the prime mover causing a system to function, such as in the proper alignment of the startup feedwater system to provide backup emergency feedwater flow. This type of error also includes failure to restore valves to their proper position following maintenance test acts.

A description of all operator actions used in the fault tree analysis and their associated unavailabilities are shown in Table 2. The guidelines of NUREG/CR-1278, Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, and NUREG-0611 were used in formulating the unavailabilities.

As a general rule, errors of commission are assigned a probability of 1×10^{-4} and errors of omission a probability of 1×10^{-3}. These probabilities are adjusted for abnormal circumstances. For instance, a probability of 1×10^{-3} would normally be assigned both to errors of omission by the operator for actions which can be performed from the control room and to maintenance restoration acts. However, if the operation must be performed locally (outside of the control room) or under potentially adverse conditions, the failure probability is increased accordingly.

Except for automatic actuation of the lube oil pump (P-161), the startup feed water system requires manual operation outside of the control room for alignment to the emergency feedwater system. (Refer to Section 3.1 for a discussion of the assumptions used to model the startup feed pump for the Loss of Main Feedwater transient.) In the event of Loss of Station Power the operator must manually transfer the startup pump breaker from Bus 4 in the non-essential switchgear room to Bus E5 in the essential switchgear room, change the bus transfer switch to the E5 bus position, open discharge isolation valve V-156 in the emergency feed pump building, open discharge isolation V-163 and close condensate storage tank recirculation line isolation valve V-109 in the turbine hall. This last action (closing V-109) is necessary to prevent a diversion of flow from the startup system because a Loss of Station Power could result in PCV-4326 opening due to loss of air. The operator failure rates for the first three actions are assumed to be 1 x 10^{-2}/demand because these actions, even though assumed to be covered by emergency procedures, may include multiple steps and must be done at different locations. In contrast, the failure probability assigned to the closing of V-109 is assumed to be only 1 x 10^{-3}. Since both V-163 and V-109 are located in the same vicinity, it was assumed that a single operator would be assigned the task of changing the position of both valves. Therefore, the failure to complete both actions will be dominated by the failure to perform the first, and the failure probability for the second action is more appropriately represented by the standard failure rate for errors of omission. Thus, the total failure probability for completing both actions is 1.1 x 10^{-2}.

TABLE 2

SUMMARY OF OPERATOR ACTIONS/FAILURE PROBABILITIES

	Operator Action/Error	Failure Probability
1)	Operator fails to open either Steam Supply Valve V127 or V128 given failure to open automatically.	5×10^{-3}
2)	Operator fails to close an isolation valve which fails to close automatically	5×10^{-3}
3)	Operator fails to close Emergency Feedwater System manual isolation valve to isolate rupture in header	9×10^{-1}
4)	Operator fails to restore valve to normal position after maintenance	1×10^{-3}
5)	Operator inadvertently blocks actuation signal, turns off running pump, shuts an isolation valve or fails to restore valve given indication of improper positioning.	1×10^{-4}
6)	Operator fails to open V-156 in startup feed pump discharge line and align pump to emergency power within 30 minutes	1×10^{-2}
7)	Operator fails to open V-163 in startup feed pump discharge line and close V-109 in recirculation line to the CST	1.1×10^{-2}
8)	Operator fails to start the startup feed pump (P-113) from the control room given no automatic actuation signal and existence of emergency procedure	1×10^{-3}
9)	Operator fails to properly transfer breaker for SUF pump to bus E5	1×10^{-2}

3.3 RESULTS FROM FAULT TREE ANALYSES

3.3.1 Computer Codes

All qualitative cut-set analyses and numerical evaluations of unreliability made using the Seabrook AFW system fault tree model were performed by the WAMBAM(1) and WAMCUT(2) computer codes. Versions of these codes were obtained from the Electric Power Research Institute (EPRI) by PSNH and its service organization, Yankee Atomic Electric Co. (YAEC) for the purpose of conducting this study. Some modifications were required to the codes to reduce their memory requirements during execution so that they could be run on the CDC-7600 computer at YAEC; however, the modifications only affected the size of the fault tree that could be analyzed and not the numerical probability calculations or cut-set evaluations performed by the code.

3.3.2 Events Analyzed

Three specific events were analyzed using the Seabrook fault tree. They were:

- A loss of main feedwater transient with reactor trip (LMFW)
- A loss of main feedwater transient with coincident loss of offsite power (LMFW/LOSP)
- A loss of main feedwater transient with coincident loss of offsite power and both onsite emergency diesel-generators (LMFW/LOAC).

In all cases, successful operation of the AFW system required that at least two of the four plant steam generators be supplied with cooling flow from the AFW system.

In a general sense, a loss of main feedwater event is the transient for which the auxiliary feedwater system is intended to provide protection. Therefore the reliability of the AFW system for the LMFW transient can be viewed as a reference against which reliability calculations for the other transients may be compared. The fault tree described in the previous sections and presented in Appendix A was designed specifically for the LMFW event. Evaluations of the other transients were made by modifying this baseline fault tree as described later.

Before discussing the modifications necessary to model these other events, one point of conservatism regarding LMFW events that has been included into the fault tree should be reiterated. As was noted in Section 3.1, fault tree modeling of the effects of the startup feed pump on AFW system reliability assumed in all cases that the SUF pump was successful only when supplying the emergency feedwater header. As a result all the operator actions required to achieve this goal must be successful. This includes manually starting the SUF pump and, if necessary, loading it on an emergency bus. It also requires the necessary actions to change the positions of the three valves in the startup pump discharge and cross-tie headers as was described in Section 3.2.4. In many LMFW transients, however, none of these actions will be required. In those transients which result in a trip of the main feed pumps but do not result in either a high steam generator level or a safety injection signal, the SUF pump will be automatically started and will deliver flow to the steam generators by way of the main feed lines. Therefore no operator actions are necessary to receive the benefit of cooling from the SUF pump. Similarly, if these same transients are accompanied by a loss of the normal SUF pump power source, only the actions to load the SUF pump on the emergency bus and isolate its recirculation line are necessary. Flow can still be provided to the steam generators through the main feedwater lines without additional valve manipulations.* Thus the fault tree model, by requiring the SUF pump to supply cooling water via the EFW headers in all cases, provides conservative estimates of reliability for these transients where main feedwater flow paths are still available and in which a safety injection or high steam generator level signal is not generated.

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* Note that if the cause of the power loss is a loss of offsite power, the main feedwater lines will not be open because of closure of the main feedwater isolation valves on loss of power.

The LMFW/LOSP transients impact the EFW system in only one way. They eliminate the redundant electrical power sources for both the motor-driven EFW pump and the motor-driven SUF pump. As a result the reliability of both pumps is reduced because all single point failures causing loss of the emergency bus supplying the pump will also result in loss of the pump. In the case of the startup pump, the necessity of an operator action to load the pump on the emergency bus is also introduced into the system.

Modeling the loss of offsite power in the fault tree was done by converting gates EP 21 (pg. A-38 of Appendix A) and SUP 21 (pg. A-43 of Appendix A) to AND gates, converting gates EPE6 (pg. A-38 of Appendix A) and SUP 19 (pg. A-43 of Appendix A), and MOD4 (pg. A-45 of Appendix A) to OR gates, and inputting an LOSP frequency of 0. This has the same effect as inputting an LOSP frequency of 1.0 in the reference tree but greatly reduces the computer calculations required to evaluate the tree. All cut-sets and failure probabilities determined for the modified tree will be conditional on the LOSP event even though the code cut-set output will not include specific indication of that fact.

The total loss of AC power events have a much more drastic effect on AFW system reliability. In essence the system is reduced to a single pump system because both motor-driven pumps become unavailable. Thus, all single point failures disabling the turbine-driven EFW pump result in loss of system function.

For the total loss of AC power events, the fault tree modifications were also more extensive. All tree structure below gates AF127, SUP1, and MOD4 (pgs. A-30, A-41, and A-45 of Appendix A) was eliminated. The net effect is the same as inputting frequency values of 1.0 for both the LOSP event and failure of both diesel generators in that both motor-driven pumps are eliminated from the system. Again code results are conditional on these failures although the conditionality is not reflected specifically in the output.

3.3.3 Numerical Reliability Results

A total of five cases were analyzed with the Seabrook AFW system fault tree model. They were the LMFW, LMFW/LOSP, and LMFW/LOAC events assuming all three pumps are part of the EFW system, and the LMFW and LMFW/LOSP events assuming only the two-train emergency feedwater system is used to provide steam generator cooling. The latter two cases were done to provide a reference for evaluating the effect of the SUF pump on overall system reliability. The results of the five cases are shown in Table 3.

TABLE 3

AFW SYSTEM UNRELIABILITY

TRANSIENT	3-PUMP AFW SYSTEM	2-PUMP EFW SYSTEM
LMFW	2.1×10^{-5}	2.8×10^{-4}
LMFW/LOSP	5.6×10^{-5}	5.8×10^{-4}
LMFW/LOAC	2.1×10^{-2}	2.1×10^{-2}

It is clear from these results that the Seabrook AFW system easily meets the NRC specified reliability goals when use of the SUF pump is considered for the LMFW transient. Even with a coincident loss of offsite power, the system exhibits an unreliability of better than 10^{-4}/demand. In terms of the results published by the NRC in NUREG-0611 for other Westinghouse plants, the Seabrook AFW system would fall into the high, high, and medium categories respectively for the LMFW, LMFW/LOSP and LMFW/LOAC transients.

3.3.4 Dominant Failures for Three Pump AFW System

Dominant contributors to availability of the AFW system at Seabrook for the three loss of main feedwater/loss of power events are shown in Tables 4, 5, and 6. Events are ranked by the magnitude of their contribution to system unavailability. It should be noted that no single point failures* were found in either the LMFW or LMFW/LOSP events that would disable the entire AFW system, although, as should be expected, a number of single failures will disable the turbine-driven pump train during a LMFW/LOAC event.

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* One single failure exists that will disable the AFW system under any circumstance. That is a failure of the condensate storage tank such that no water is available to the suction of any of the pumps. The probability of such a failure was assumed negligible for the purposes of this study.

TABLE 4

DOMINANT CONTRIBUTORS TO CONDITIONAL UNAVAILABILITY LOSS OF MAIN FEEDWATER EVENT

EVENT	CONTRIBUTION TO UNAVAILABILITY
1. Equipment and maintenance faults: Failures preventing motor-driven EFW pump from functioning coupled with maintenance errors causing isolation valve V125 to be closed.	7.0×10^{-6}
2. Maintenance faults: Maintenance outage of motor-driven EFW pump train coupled with maintenance errors causing isolation valve V125 to be closed.	3.0×10^{-6}
3. Maintenance faults: Maintenance errors causing isolation valve V125 to be closed and the motor-driven EFW train to be inoperable.	2.0×10^{-6}
4. Equipment and operator faults: Equipment failures in both EFW trains coupled with failure of operator to properly align SUF pump with EFW system.	1.9×10^{-6}
5. Equipment faults: Equipment failures disabling motor-driven EFW pump train and isolation valve V125.	9.0×10^{-7}
6. Equipment faults: Equipment failures disable all three pump trains.	7.3×10^{-7}
7. Equipment, maintenance and operator faults: Equipment failure in one EFW train while other EFW train out of service coupled with failure of operator to properly align SUF pump with EFW system.	5.9×10^{-7}
8. Cut-sets with unavailability values less than 1×10^{-7}	4.4×10^{-6}
Total unavailability (all cut-sets) =	2.1×10^{-5}

TABLE 5

DOMINANT CONTRIBUTORS TO CONDITIONAL UNAVAILABILITY LOSS OF MAIN FEEDWATER/LOSS OF OFFSITE POWER EVENT

EVENT	CONTRIBUTION TO UNAVAILABILITY
1. Equipment and maintenance faults: Failures preventing either diesel generator 1B or motor-driven EFW pump from functioning coupled with maintenance errors causing isolation valve V125 to be closed.	2.1×10^{-5}
2. Equipment and operator faults: Equipment failures disabling both EFW trains coupled with failure of operator to properly align SUF pump with EFW system.	8.5×10^{-6}
3. Maintenance faults: Maintenance outages or errors disabling motor-driven EFW pump train coupled with maintenance errors causing isolation valve V125 to be closed.	5.6×10^{-6}
4. Equipment faults (triples): Equipment failures disable all three pump trains.	7.0×10^{-6}
5. Equipment faults (doubles): Equipment failures disabling motor-driven EFW pump train coupled with failure of valve V125 to remain open.	2.0×10^{-6}
6. Maintenance, equipment, and operator faults: Maintenance outage of one EFW pump train coupled with equipment and operator errors that disable both the remaining EFW pump train and the SUF pumps.	2.2×10^{-6}
7. Maintenance, equipment, and operator faults: Maintenance errors that disable turbine-driven EFW pump train coupled with failures of diesel-generator 1B and failure of operator to properly align SUF pump with EFW system.	3.3×10^{-7}
8. Cut-sets with unavailability values less than 10^{-7}.	9.4×10^{-6}
Total unavailability (all cut-sets) =	5.6×10^{-5}

TABLE 6

DOMINANT CONTRIBUTORS TO CONDITIONAL UNAVAILABILITY LOSS OF MAIN FEEDWATER/LOSS OF ALL AC POWER

	EVENT	CONTRIBUTION TO UNAVAILABILITY
1.	Equipment faults: Failure of turbine-driven EFW pump to start or continue running once started.	1.4×10^{-2}
2.	Maintenance faults: Maintenance errors causing turbine-driven EFW train to be inoperable.	4.1×10^{-3}
3.	Maintenance faults: Turbine-driven EFW train out of service for maintenance.	2.5×10^{-3}
4.	Equipment faults: Miscellaneous single valve failures.	7.0×10^{-4}
5.	Maintenance faults: Miscellaneous multiple maintenance errors causing turbine-driven EFW train to be inoperable.	8.5×10^{-5}
6.	Cut-sets with unavailability values less than 10^{-5}	1.1×10^{-5}
	Total unavailability (all cut-sets) =	2.1×10^{-2}

3.3.5 Potential Common Cause Failures

The cut-set results from the reliability analysis were also used in conjunction with the system engineering drawings to conduct a qualitative review of potential common-cause failure modes of the Seabrook AFW system. During the review, consideration was given to potential dependencies resulting from common location, environment, human interactions, and support equipment for all three AFW pump trains. As a result of this investigation, two potential susceptibilities were identified.

The first of the common-cause susceptibilities results from a combined location and environmental dependency. Because both emergency feedwater pumps are located in the same pump room, conditions which result in an extreme environment in that room can adversely affect both pumps. An obvious potential source for such an environmental upset are failures associated with the steam turbine-driven pump that cause steam to escape into the pump room. The resultant high temperatures and high humidity might result in consequential failure of the motor-driven pump. Failure of the two EFW pumps alone are not sufficient to fail the AFW system because of the availability of the SUF pump which is located in the turbine building. However, for the SUF pump to be able to supply cooling to the steam generators via the EFW piping requires that manual isolation valve V156 be opened. This valve is located in the emergency feed pump room and would be inaccessible in the event of extreme environments in the room.

As was noted in Section 3.3.2, in many situations it will not be necessary to align the SUF pump with the EFW system in order to use it for plant cooling. Only in circumstances where the normal flow path through the main feedwater lines is unavailable will this be required. Therefore, even should both EFW pumps fail due to a pump room steam leak and valve V156 also be inaccessible, the ability to cool the plant will still exist in most circumstances.

Most probable causes for steam leaks in the pump room of sufficient severity to cause environmental problems are associated with cracks in the pump turbine casing or breaks in the steam supply lines to the turbine. The most likely cause of the main feedwater lines being unavailable for supplying cooling to the steam generators is a safety injection signal which will cause closure of the main feed isolation valves. The probability of simultaneous occurrence of these events is small compared to the overall system unavailability predicted by the fault tree analyses. Therefore this common-cause susceptibility has a negligible effect on the system.

A common-cause failure potential often present in systems that incorporate automatic feedwater line isolation features is the possibility of a faulty calibration procedure causing all isolation setpoints to be improperly adjusted. As a result, inadvertent closure of all isolation valves can occur during system startup or following system flow perturbations. The design of the Seabrook system avoids this problem by incorporating control logic to inhibit isolation of more than a single EFW line. Signals denoting the closure of EFW isolation valve in any EFW line will inhibit closure of additional valves in the remaining lines.

No other common-cause susceptibilities were identified which might adversely impact the Seabrook AFW design. Electrical power sources were found to be sufficiently separated and diverse to prevent dependencies due to power failures. With one exception,* all powered valves critical to system operation are of a fail-safe design such that loss of air or loss of power events do not pose threats to system function. With the exception of the location dependency noted above, separation of the SUF pump from the EFW pumps provides protection from location dependent effects such as vibration, grit, temperature, impact, explosions, etc. Separation of the SUF and EFW pumps also provides protection from electrical train common-cause failures due to localized grounding of power supplies.

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* Recirculation valve PCV-4326 on the SUF pump discharge.

4.0 CONCLUSIONS

The results presented in this report lead to the following conclusions:

1. The Seabrook combined auxiliary feedwater system consisting of the two-train emergency feedwater system and the single-train startup feedwater system has an unreliability of 2.1×10^{-5} for a loss of main feedwater event and is well within the range of unreliability specified by the NRC staff in their October 30, 1981 letter to the Public Service Company of New Hampshire.

2. The unreliability of the Seabrook combined AFW system during combined loss of main feedwater/loss of offsite power events is 5.6×10^{-5}, and for a combined loss of main feedwater/loss of all AC power event is 2.1×10^{-2}. These values compare favorably with analyses done for auxiliary feedwater systems at other plants of Westinghouse design.

3. Major contributors to system unreliability generally relate to failures of pumps and to maintenance errors causing pump trains to be inadvertently disabled.

4. No severe common-cause failure susceptibilities were identified for the Seabrook auxiliary feedwater system.

5.0 REFERENCES

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6.0 BIBLIOGRAPHY

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6. NUREG/CR-1635, "Nuclear Plant Reliability Data System 1979 Annual Reports of Cumulative System and Component Reliability," Southwest Research Institute, September 1980.

7. ANSI/IEEE Std 500-1977, "IEEE Guide to the Collection and Presentation of Electrical, Electronic, and Sensing Component Reliability Data for Nuclear Power Generating Stations."

8. NUREG-0611, "Generic Evaluation of Feedwater Transients and Small Break Loss-of-Coolant Accidents," January 1980.

9. NUREG-0737, "Clarification of TMI Action Plan Requirements," November, 1980.

APPENDIX A

SEABROOK EFW SYSTEM FAULT TREE

APPENDIX A

The following is a guideline for interpreting the basic fault identifiers used in the attached Seabrook EFW fault tree and in fault identifier Table B-2.

Each fault identifier consists of 10 alphanumeric characters of the form:

X-XX-1-XXXX-XX

The first character identifies the system to which the component belongs (see Table A.1). The second and third characters identify the component type (Table A.2). The fifth through eighth characters are for component identification and the last two characters identify the fault codes (Table A.3).

TABLE A.1

SYSTEM IDENTIFICATION CODE

C - Condensate System

M - Emergency Feedwater System

Q - Steam Supply System

R - Electrical Distribution System

5 - Condensate Storage System

6 - Control/Protection System

TABLE A.2

COMPONENT TYPES

BA - Batteries
BC - Battery Chargers
CA - Circuit Breaker
CB - Contactor
CC - Controller
CD - Starter
CE - Switch
EC - Electrical Conductors
GD - Diesel Generator
HX - Heat Exchanger
IC - Instrument Controller
ID - Sensor/Detector/Element - Pressure
IE - Sensor/Detector/Element - Temperature
IF - Sensor/Detector/Element - Flow
IG - Sensor/Detector/Element - Level
IH - Sensor/Detector/Element - Radiation
IP - Power Supply
IX - Instrument Error
MA - AC Motor
MD - DC Motor
OA - Piping less than 1 inch in diameter
OB - Piping greater than 1 inch but less than 2 inch
OC - Piping greater than 2 inch but less than 3 inch
OD - Piping greater than 3 inch but less than 4 inch
OE - Piping greater than 4 inch but less than 6 inch
OF - Piping greater than 6 inch but less than 8 inch
OG - Piping greater than 8 inch but less than 10 inch
OH - Piping greater than 10 inch but less than 12 inch
OI - Piping greater than 12 inch but less than 16 inch
OJ - Piping greater than 16 inch but less than 24 inch
OK - Piping greater than 24 inch but less than 36 inch
OL - Piping greater than 36 inch

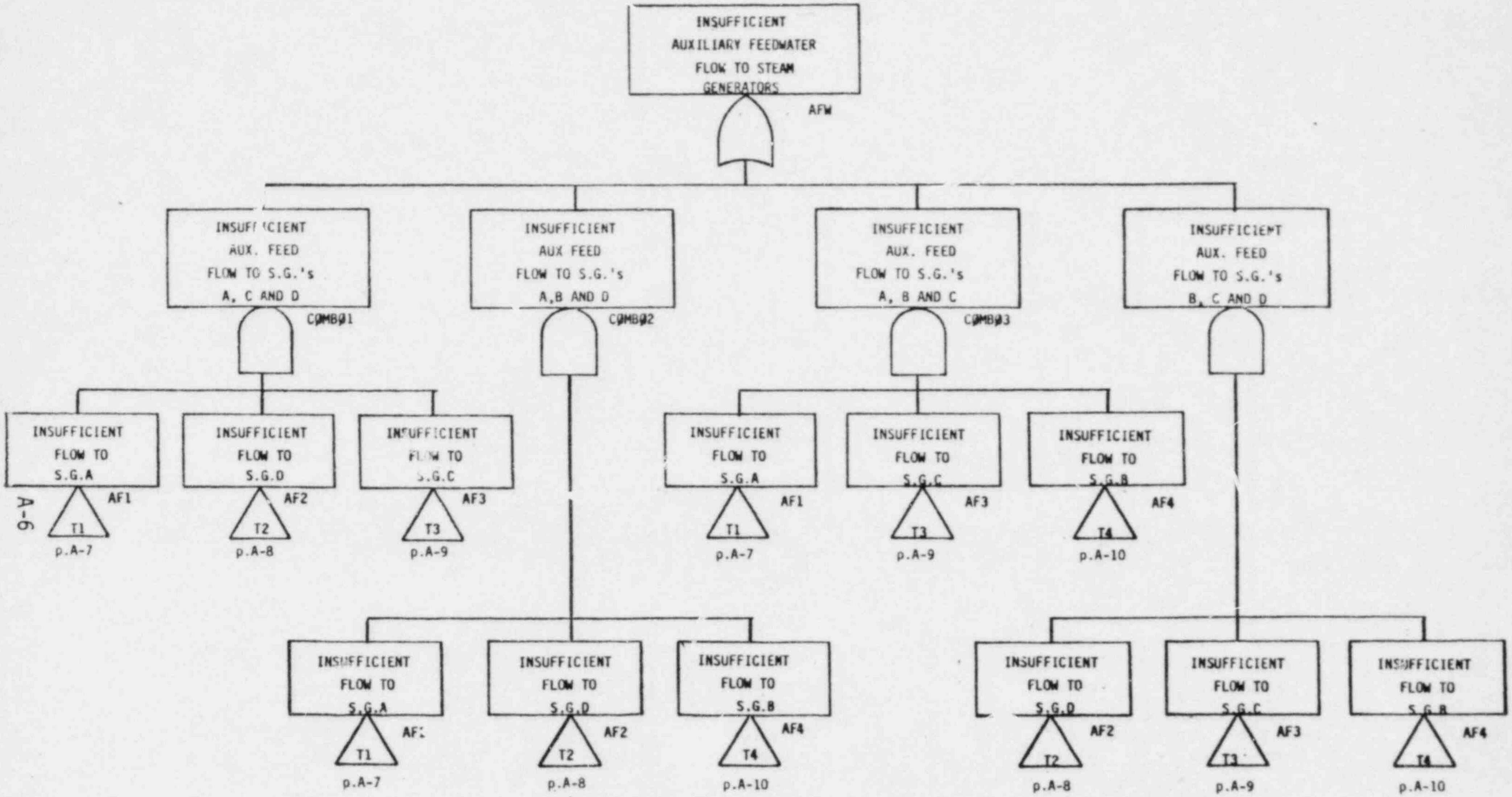
TABLE A.2 (CONT'D.)

PB - Centrifugal Pump
RA - Control, General Purpose
TR - Transformer
TU - Turbine
VA - Check Valve
VB - Relief Valve
VC - Vacuum Relief
VD - Isolation, Shutoff Valve
VG - Flow Control

TABLE A.3

FAULT CODES

CL - Cooling Failure
LB - Lubrication Failure
MA - Fails to Open/De-energize/Disengage
MB - Fails to Close/Energize/Engage
MC - Fails to Remain Closed/De-energize/Disengaged
MD - Fails to Remain Open/Energized/Engaged
ME - Fail to Start
MG - Fail to Run
MJ - Leak/Rupture/Electrical Short Circuit
MK - Open Circuit
ML - Overload
MM - Underload
MN - No Signal/No Input
MO - Spurious Signal
OA - Operator Fails to Open/De-energize/Disengage
OB - Operator Fails to Close/Energize/Engage
OC - Operator Inadvertently Opens/De-energizes/Disengages/Leaves Open
OD - Operator Inadvertently Closes/Energizes/Engages/Leaves Closed
OE - Operator Fails to Start
OG - Operator Fails to Leave Running
OH - Calibration Error
OO - Out of Service


INSUFFICIENT AUXILIARY FEEDWATER FLOW TO STEAM GENERATORS
AFW
INSUFFICIENT AUX. FEED FLOW TO S.G.'s A, C AND D
CØMBØ1
INSUFFICIENT AUX FEED FLOW TO S.G.'s A,B AND D
CØMBØ2
INSUFFICIENT AUX. FEED FLOW TO S.G.'s A, B AND C
CØMBØ3
INSUFFICIENT AUX. FEED FLOW TO S.G.'s B, C AND D
INSUFFICIENT FLOW TO S.G.A
AF1
T1
p.A-7
INSUFFICIENT FLOW TO S.G.D
AF2
T2
p.A-8
INSUFFICIENT FLOW TO S.G.C
AF3
T3
p.A-9
INSUFFICIENT FLOW TO S.G.A
AF1
T1
p.A-7
INSUFFICIENT FLOW TO S.G.C
AF3
T3
p.A-9
INSUFFICIENT FLOW TO S.G.B
AF4
T4
p.A-10
INSUFFICIENT FLOW TO S.G.A
AF1
T1
p.A-7
INSUFFICIENT FLOW TO S.G.D
AF2
T2
p.A-8
INSUFFICIENT FLOW TO S.G.B
AF4
T4
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INSUFFICIENT FLOW TO S.G.D
AF2
T2
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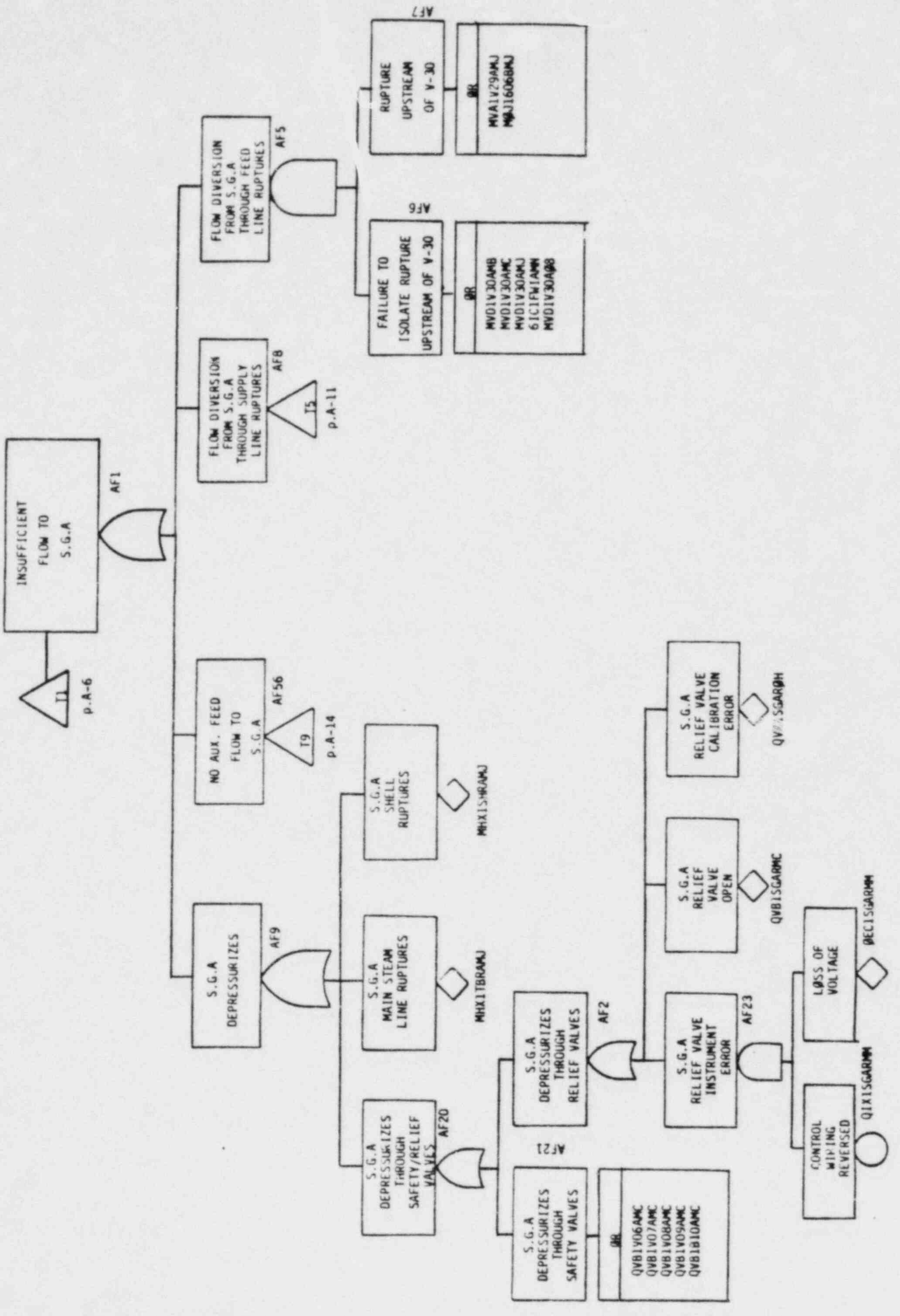
INSUFFICIENT FLOW TO S.G.B
AF4
T4
p.A-10



T1
p.A-6
INSUFFICIENT FLOW TO S.G.A
AF1
NO AUX. FEED FLOW TO S.G.A
AF56
T9
p.A-14
FLOW DIVERSION FROM S.G.A THROUGH SUPPLY LINE RUPTURES
AF8
T5
p.A-11
FLOW DIVERSION FROM S.G.A THROUGH FEED LINE RUPTURES
AF5
FAILURE TO ISOLATE RUPTURE UPSTREAM OF V-30
AF6
OR
MVD1V30AMB
MVD1V30AMC
MVD1V30AMJ
6IC1FW1AMM
MVD1V30AQ8
RUPTURE UPSTREAM OF V-30
AF7
OR
MVA1V29AMJ
MAJ1606BMJ
S.G.A DEPRESSURIZES
AF9
S.G.A DEPRESSURIZES THROUGH SAFETY/RELIEF VALVES
AF20
S.G.A MAIN STEAM LINE RUPTURES
MHX1TBRAMJ
S.G.A SHELL RUPTURES
MHX1SHRAMJ
S.G.A DEPRESSURIZES THROUGH SAFETY VALVES
AF21
OR
QVB1V06AMC
QVB1V07AMC
QVB1V08AMC
QVB1V09AMC
QVB1B10AMC
S.G.A DEPRESSURIZES THROUGH RELIEF VALVES
AF2
S.G.A RELIEF VALVE INSTRUMENT ERROR
AF23
S.G.A RELIEF VALVE OPEN
QVB1SGARMC
S.G.A RELIEF VALVE CALIBRATION ERROR
QV‹‹1SGARØH
CONTROL WIRING REVERSED
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LØSS OF VOLTAGE
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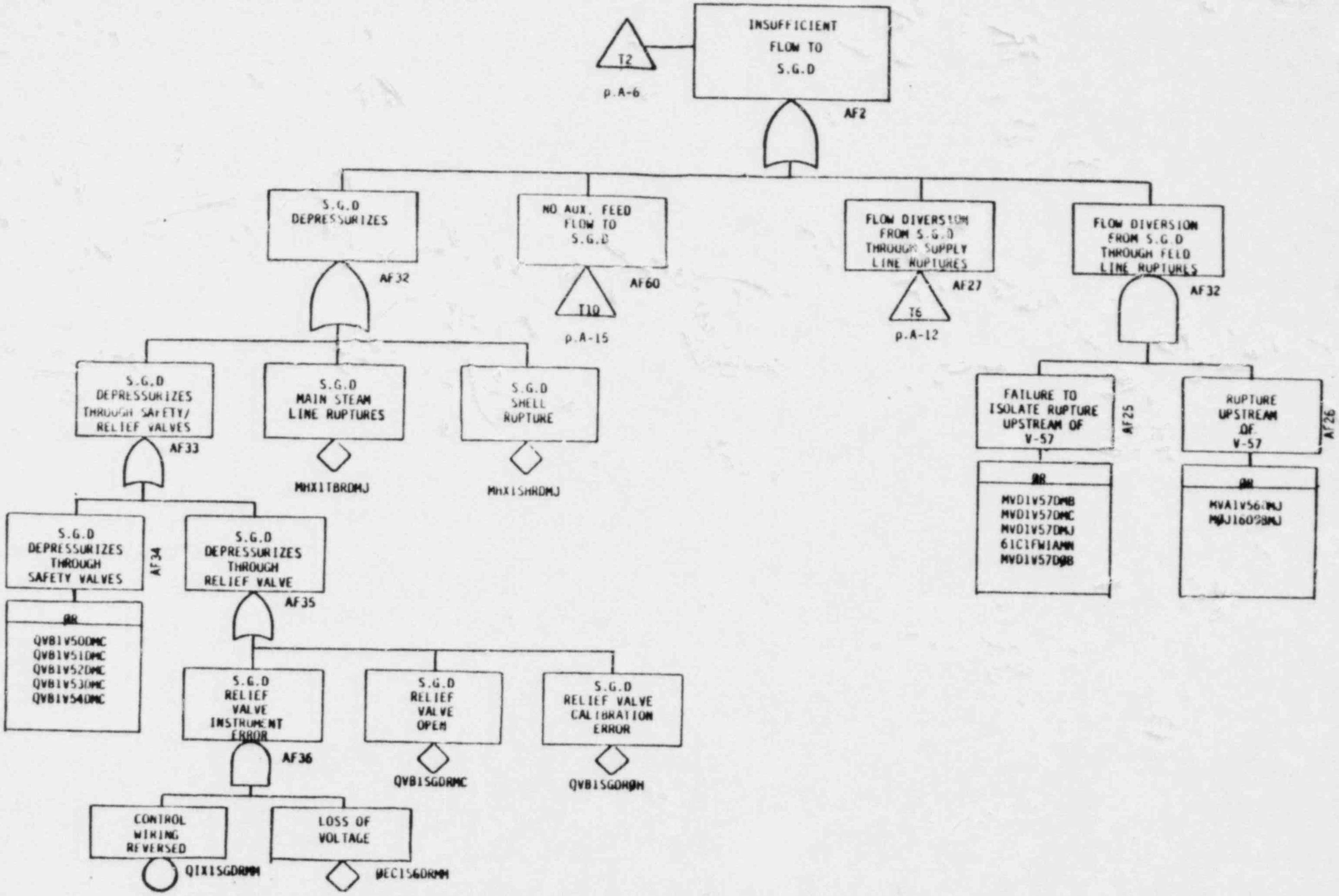
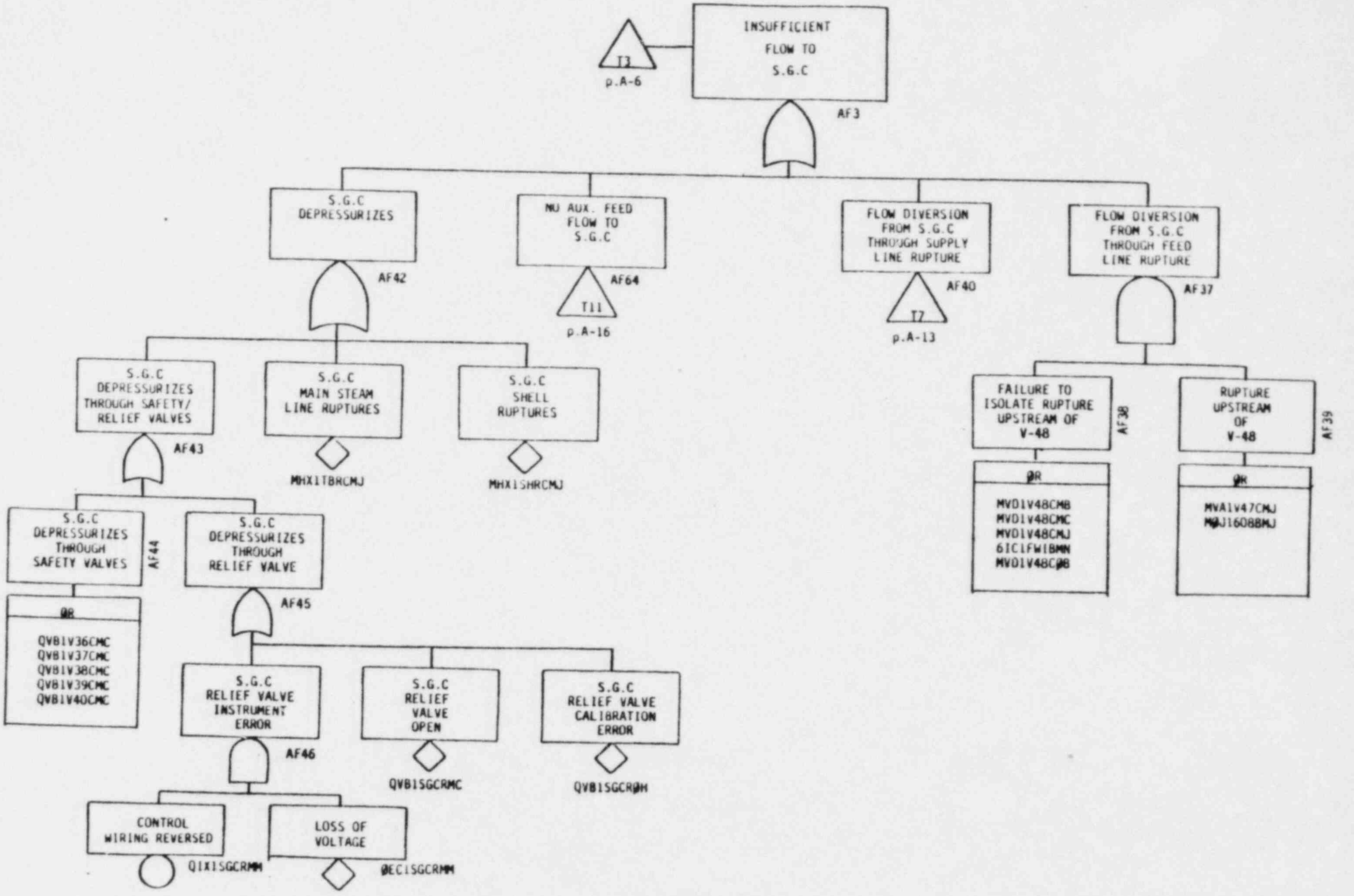
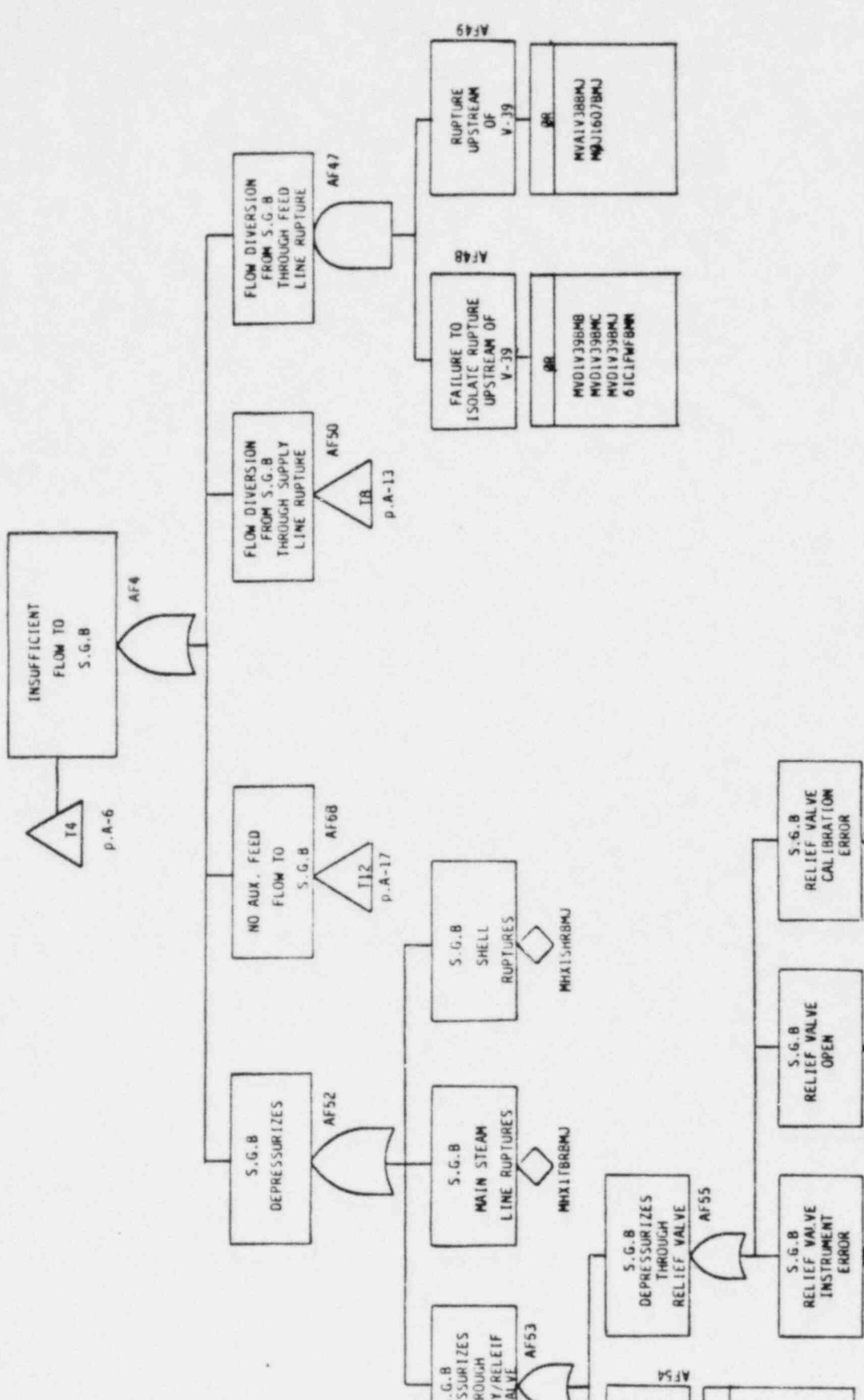
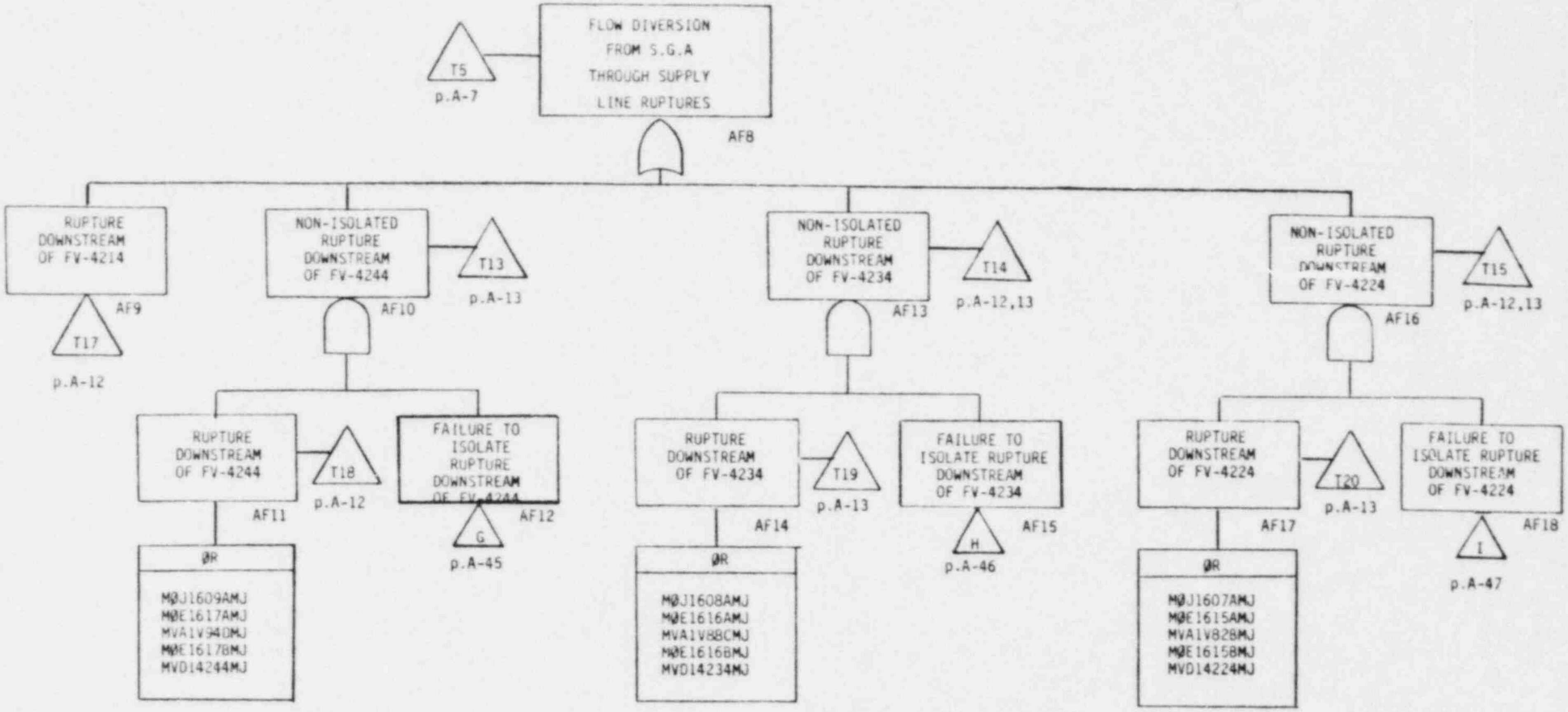
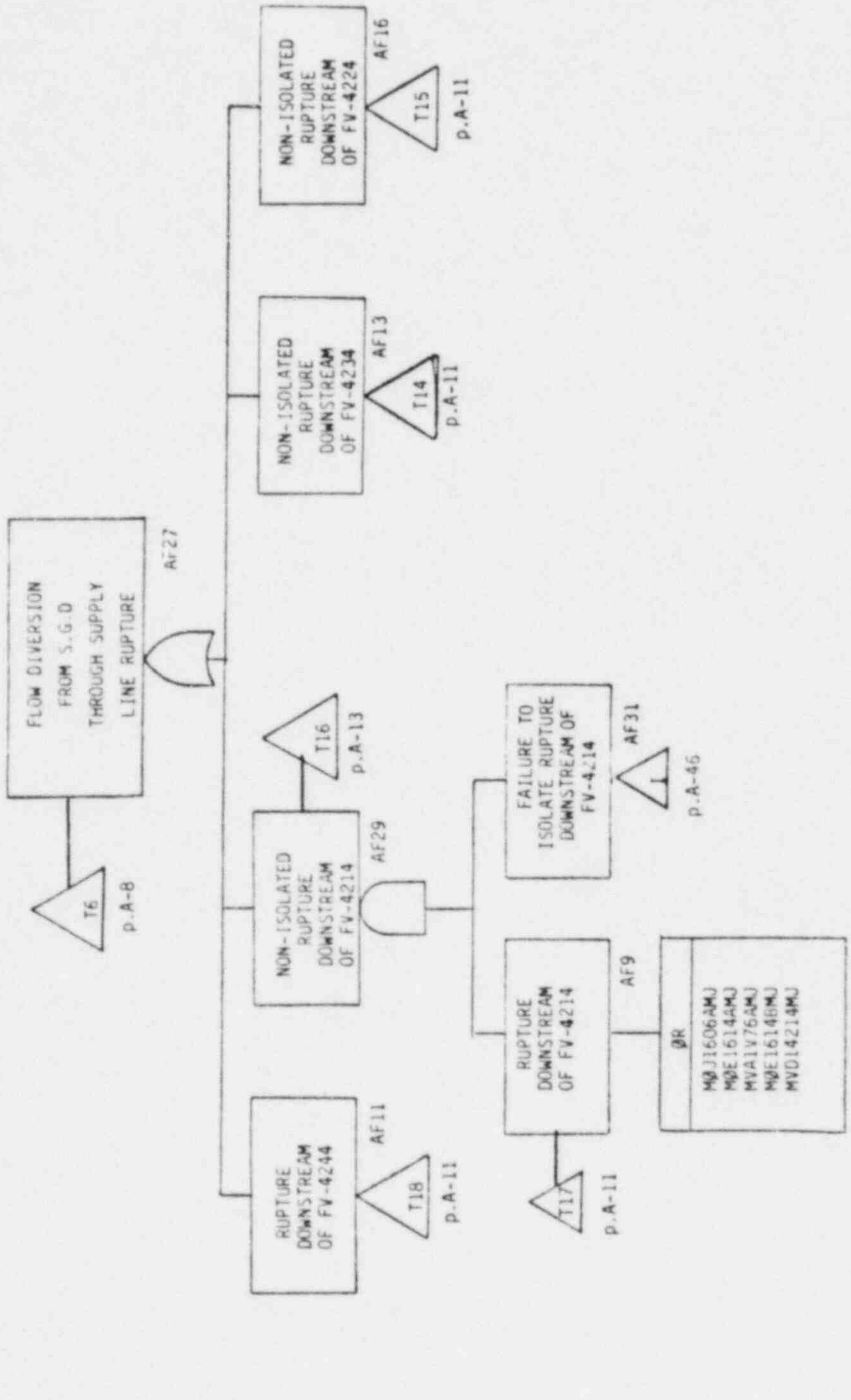
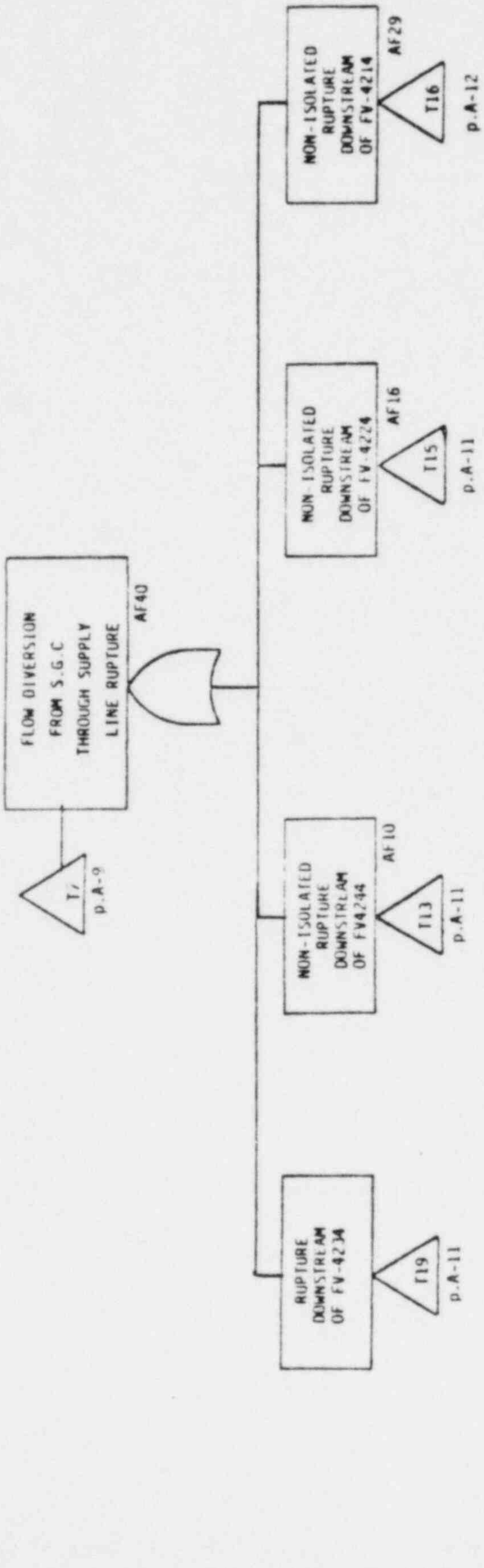

INSUFFICIENT FLOW TO S.G.D
T2
p.A-6
AF2
S.G.D DEPRESSURIZES
AF32
NO AUX. FEED FLOW TO S.G.D
T10
AF60
p.A-15
FLOW DIVERSION FROM S.G.D THROUGH SUPPLY LINE RUPTURES
T6
AF27
p.A-12
FLOW DIVERSION FROM S.G.D THROUGH FEED LINE RUPTURES
AF32
S.G.D DEPRESSURIZES THROUGH SAFETY/ RELIEF VALVES
AF33
S.G.D MAIN STEAM LINE RUPTURES
MHX1TBRDMJ
S.G.D SHELL RUPTURE
MHX1SHRDMJ
FAILURE TO ISOLATE RUPTURE UPSTREAM OF V-57
AF25
ØR
MVD1V57DMB
MVD1V57DMC
MVD1V57DMJ
61C1FW1AMM
MVD1V57DØB
RUPTURE UPSTREAM OF V-57
AF26
ØR
MVA1V560MJ
MØJ1609BMJ
S.G.D DEPRESSURIZES THROUGH SAFETY VALVES
AF34
ØR
QVB1V50DMC
QVB1V51DMC
QVB1V52DMC
QVB1V53DMC
QVB1V54DMC
S.G.D DEPRESSURIZES THROUGH RELIEF VALVE
AF35
S.G.D RELIEF VALVE INSTRUMENT ERROR
AF36
S.G.D RELIEF VALVE OPEN
QVB1SGDRMC
S.G.D RELIEF VALVE CALIBRATION ERROR
QVB1SGDRØM
CONTROL WIRING REVERSED
QIX1SGDRMM
LOSS OF VOLTAGE
ØEC1SGDRMM

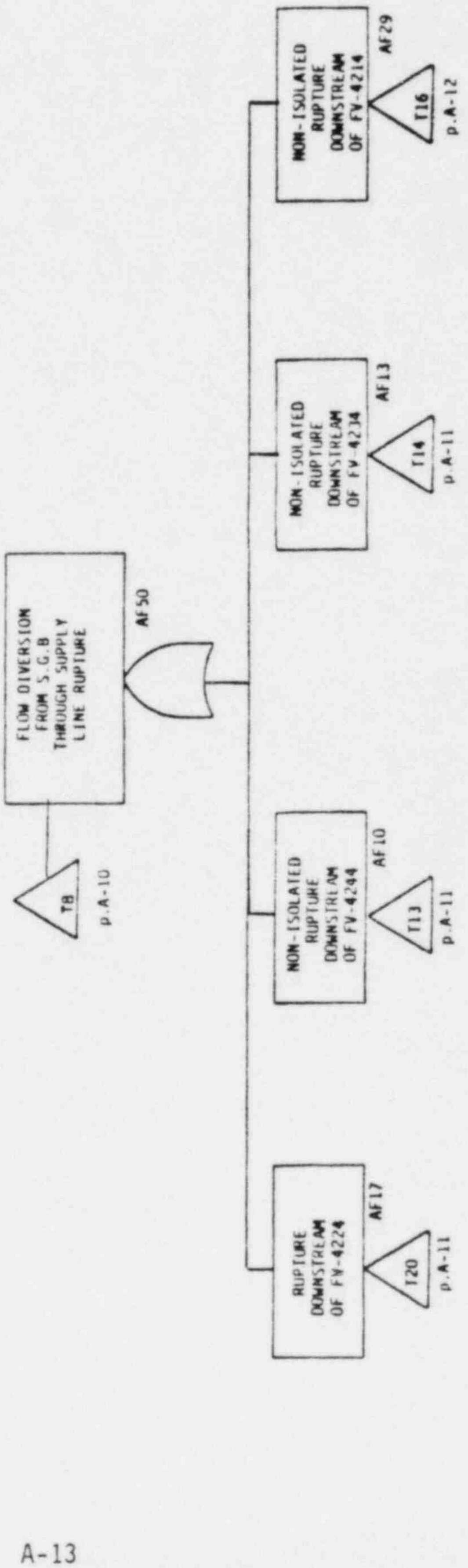

INSUFFICIENT FLOW TO S.G.C
AF3
T3
p.A-6
S.G.C DEPRESSURIZES
AF42
NU AUX. FEED FLOW TO S.G.C
AF64
T11
p.A-16
FLOW DIVERSION FROM S.G.C THROUGH SUPPLY LINE RUPTURE
AF40
T7
p.A-13
FLOW DIVERSION FROM S.G.C THROUGH FEED LINE RUPTURE
AF37
S.G.C DEPRESSURIZES THROUGH SAFETY/ RELIEF VALVES
AF43
S.G.C MAIN STEAM LINE RUPTURES
MHX1TBRCMJ
S.G.C SHELL RUPTURES
MHX1SHRCMJ
FAILURE TO ISOLATE RUPTURE UPSTREAM OF V-48
AF38
0R
MVD1V48CMB
MVD1V48CMC
MVD1V48CMJ
6IC1FW1BMN
MVD1V48C08
RUPTURE UPSTREAM OF V-48
AF39
0R
MVA1V47CMJ
M0J1608BMJ
S.G.C DEPRESSURIZES THROUGH SAFETY VALVES
AF44
0R
QVB1V36CMC
QVB1V37CMC
QVB1V38CMC
QVB1V39CMC
QVB1V40CMC
S.G.C DEPRESSURIZES THROUGH RELIEF VALVE
AF45
S.G.C RELIEF VALVE INSTRUMENT ERROR
AF46
S.G.C RELIEF VALVE OPEN
QVB1SGCRMC
S.G.C RELIEF VALVE CALIBRATION ERROR
QVB1SGCR0H
CONTROL WIRING REVERSED
QIX1SGCRMM
LOSS OF VOLTAGE
0EC1SGCRMM

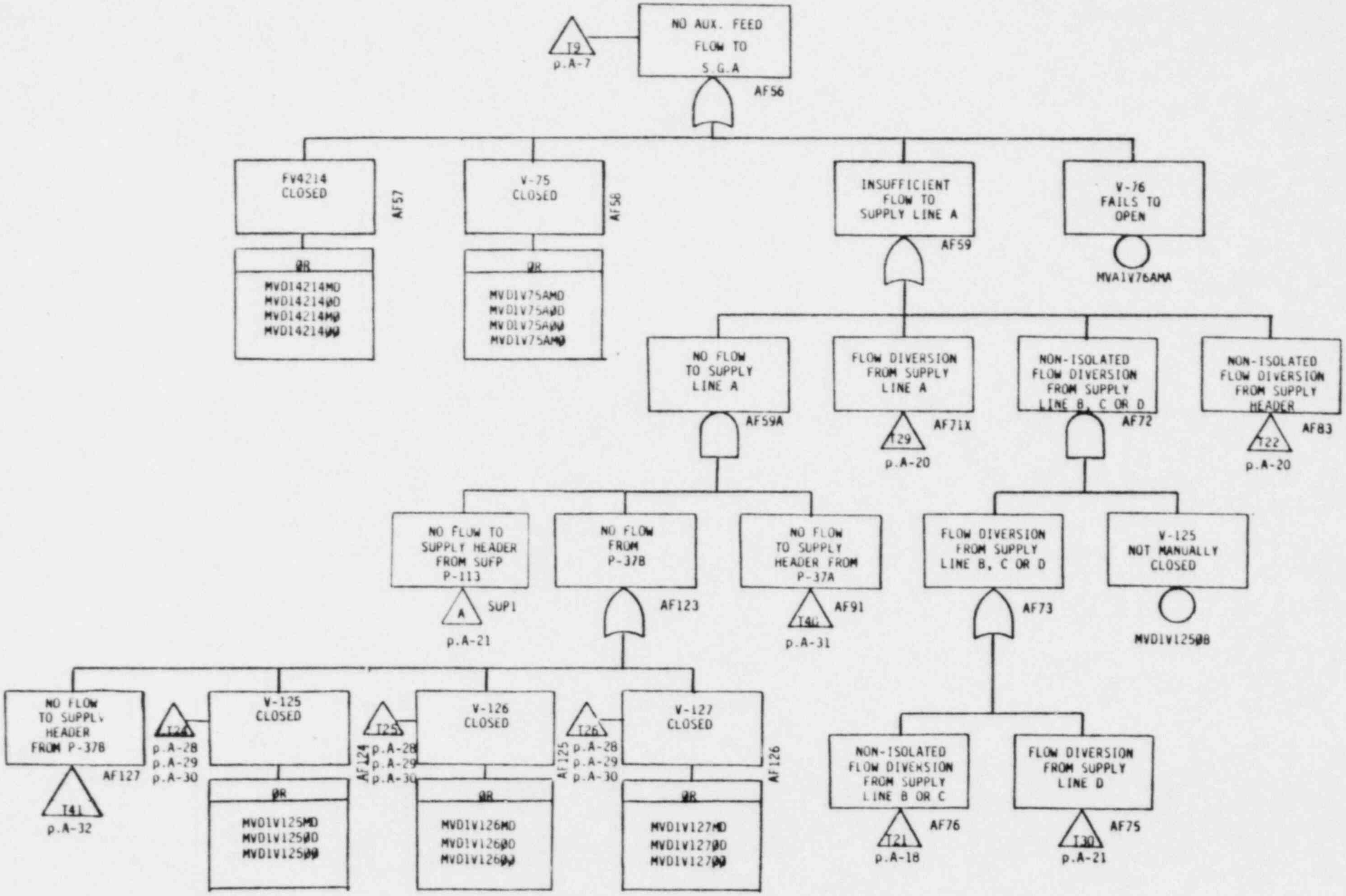

T4
p.A-6
INSUFFICIENT FLOW TO S.G.B
AF4
NO AUX. FEED FLOW TO S.G.B
AF68
T12
p.A-17
FLOW DIVERSION FROM S.G.B THROUGH SUPPLY LINE RUPTURE
AF50
T8
p.A-13
FLOW DIVERSION FROM S.G.B THROUGH FEED LINE RUPTURE
AF47
FAILURE TO ISOLATE RUPTURE UPSTREAM OF V-39
AF48
OR
MVD1V39BMB
MVD1V39BMC
MVD1V39BMJ
6IC1FWFBMM
RUPTURE UPSTREAM OF V-39
AF49
OR
MVA1V38BMJ
M0J1607BMJ
S.G.B DEPRESSURIZES
AF52
S.G.B SHELL RUPTURES
MHX1SHRBMJ
S.G.B MAIN STEAM LINE RUPTURES
MHX1TBRBMJ
S.G.B DEPRESSURIZES THROUGH SAFETY/RELEIF VALVE
AF53
S.G.B DEPRESSURIZES THROUGH SAFETY VALVES
AF54
OR
QVB1V36BMC
QVB1V37BMC
QVB1V38BMC
QVB1V39BMC
QVC1V40BMC
S.G.B DEPRESSURIZES THROUGH RELIEF VALVE
AF55
S.G.B RELIEF VALVE CALIBRATION ERROR
QVB1SGBR0H
S.G.B RELIEF VALVE OPEN
QVB1SGBRMC
S.G.B RELIEF VALVE INSTRUMENT ERROR
AF56A
LOSS OF VOLTAGE
0EC1SGBRMM
CONTROL WIRING REVERSED
QIX1SGBRMM


FLOW DIVERSION
FROM S.G.A
THROUGH SUPPLY
LINE RUPTURES
AF8
T5
p.A-7
RUPTURE
DOWNSTREAM
OF FV-4214
AF9
T17
p.A-12
NON-ISOLATED
RUPTURE
DOWNSTREAM
OF FV-4244
AF10
T13
p.A-13
RUPTURE
DOWNSTREAM
OF FV-4244
AF11
T18
p.A-12
FAILURE TO
ISOLATE
RUPTURE
DOWNSTREAM
OF FV-4244
AF12
G
p.A-45
0R
M0J1609AMJ
M0E1617AMJ
MVA1V94DMJ
M0E1617BMJ
MVD14244MJ
NON-ISOLATED
RUPTURE
DOWNSTREAM
OF FV-4234
AF13
T14
p.A-12,13
RUPTURE
DOWNSTREAM
OF FV-4234
AF14
T19
p.A-13
FAILURE TO
ISOLATE RUPTURE
DOWNSTREAM
OF FV-4234
AF15
H
p.A-46
0R
M0J1608AMJ
M0E1616AMJ
MVA1V88CMJ
M0E1616BMJ
MVD14234MJ
NON-ISOLATED
RUPTURE
DOWNSTREAM
OF FV-4224
AF16
T15
p.A-12,13
RUPTURE
DOWNSTREAM
OF FV-4224
AF17
T20
p.A-13
FAILURE TO
ISOLATE RUPTURE
DOWNSTREAM
OF FV-4224
AF18
I
p.A-47
0R
M0J1607AMJ
M0E1615AMJ
MVA1V82BMJ
M0E1615BMJ
MVD14224MJ

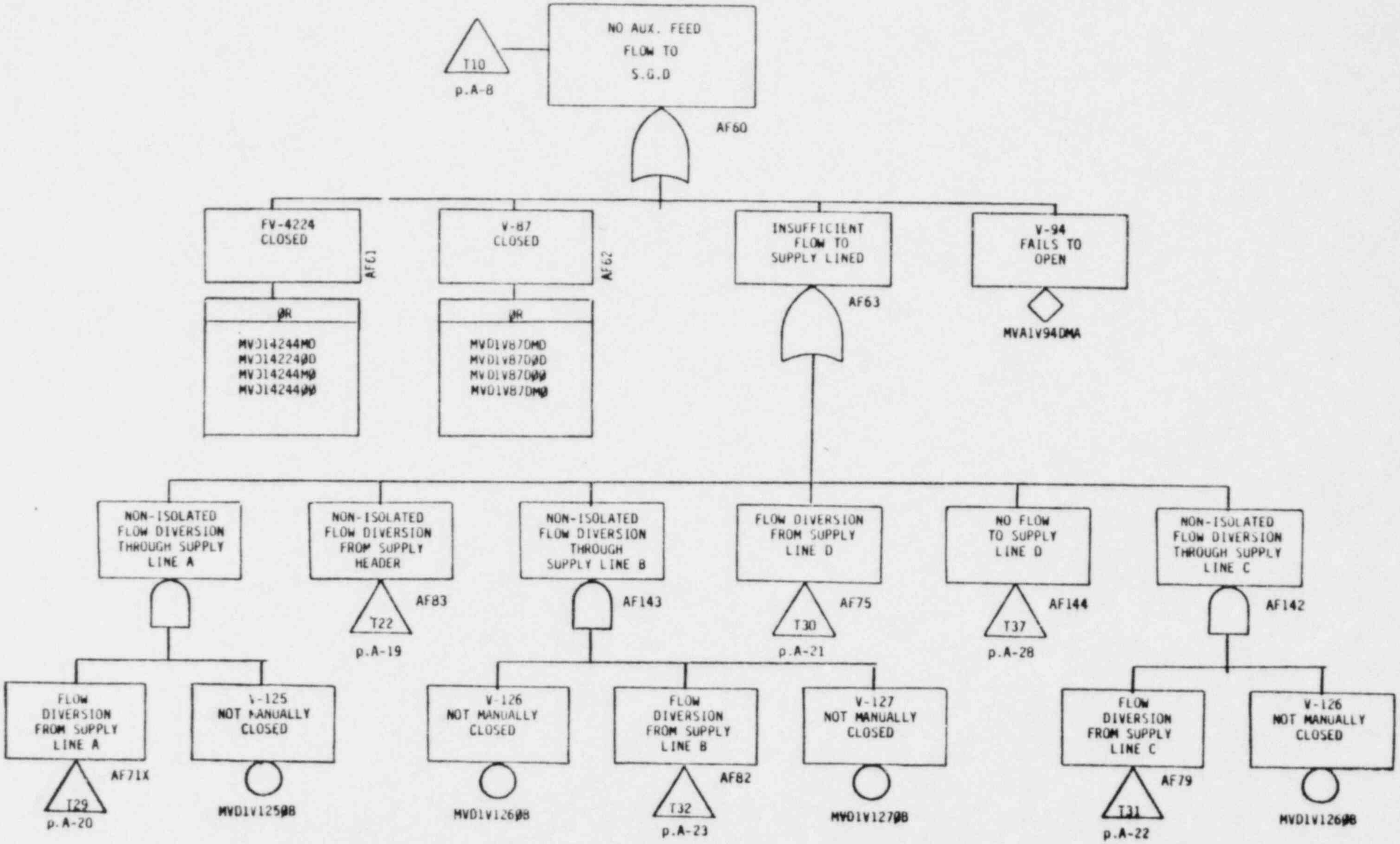

FLOW DIVERSION FROM S.G.D THROUGH SUPPLY LINE RUPTURE
AF27
T6
p.A-8
NON-ISOLATED RUPTURE DOWNSTREAM OF FV-4224
AF16
T15
p.A-11
NON-ISOLATED RUPTURE DOWNSTREAM OF FV-4234
AF13
T14
p.A-11
NON-ISOLATED RUPTURE DOWNSTREAM OF FV-4214
AF29
T16
p.A-13
FAILURE TO ISOLATE RUPTURE DOWNSTREAM OF FV-4214
AF31
I
p.A-46
RUPTURE DOWNSTREAM OF FV-4214
AF9
T17
p.A-11
ØR
MØJ1606AMJ
MØE1614AMJ
MVA1V76AMJ
MØE1614BMJ
MVD14214MJ
RUPTURE DOWNSTREAM OF FV-4244
AF11
T18
p.A-11


FLOW DIVERSION FROM S.G.C THROUGH SUPPLY LINE RUPTURE
AF40
T7
p.A-9
RUPTURE DOWNSTREAM OF FV-4234
T19
p.A-11
NON-ISOLATED RUPTURE DOWNSTREAM OF FV4244
AF10
T13
p.A-11
NON-ISOLATED RUPTURE DOWNSTREAM OF FV-4224
AF16
T15
p.A-11
NON-ISOLATED RUPTURE DOWNSTREAM OF FV-4214
AF29
T16
p.A-12

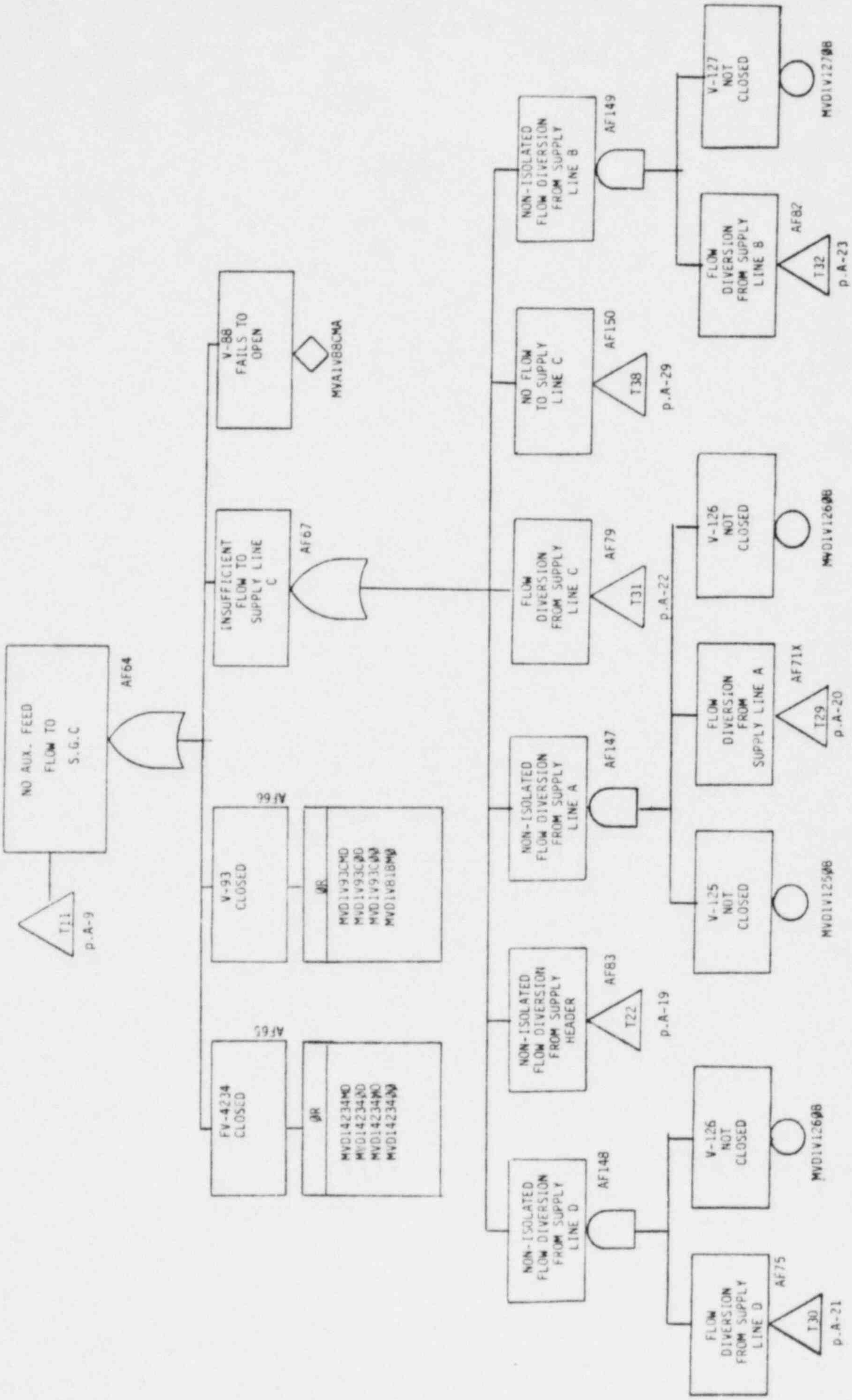

FLOW DIVERSION FROM S.G.B THROUGH SUPPLY LINE RUPTURE
AF50
T8
p.A-10
RUPTURE DOWNSTREAM OF FV-4224
AF17
T20
p.A-11
NON-ISOLATED RUPTURE DOWNSTREAM OF FV-4244
AF10
T13
p.A-11
NON-ISOLATED RUPTURE DOWNSTREAM OF FV-4234
AF13
T14
p.A-11
NON-ISOLATED RUPTURE DOWNSTREAM OF FV-4214
AF29
T16
p.A-12

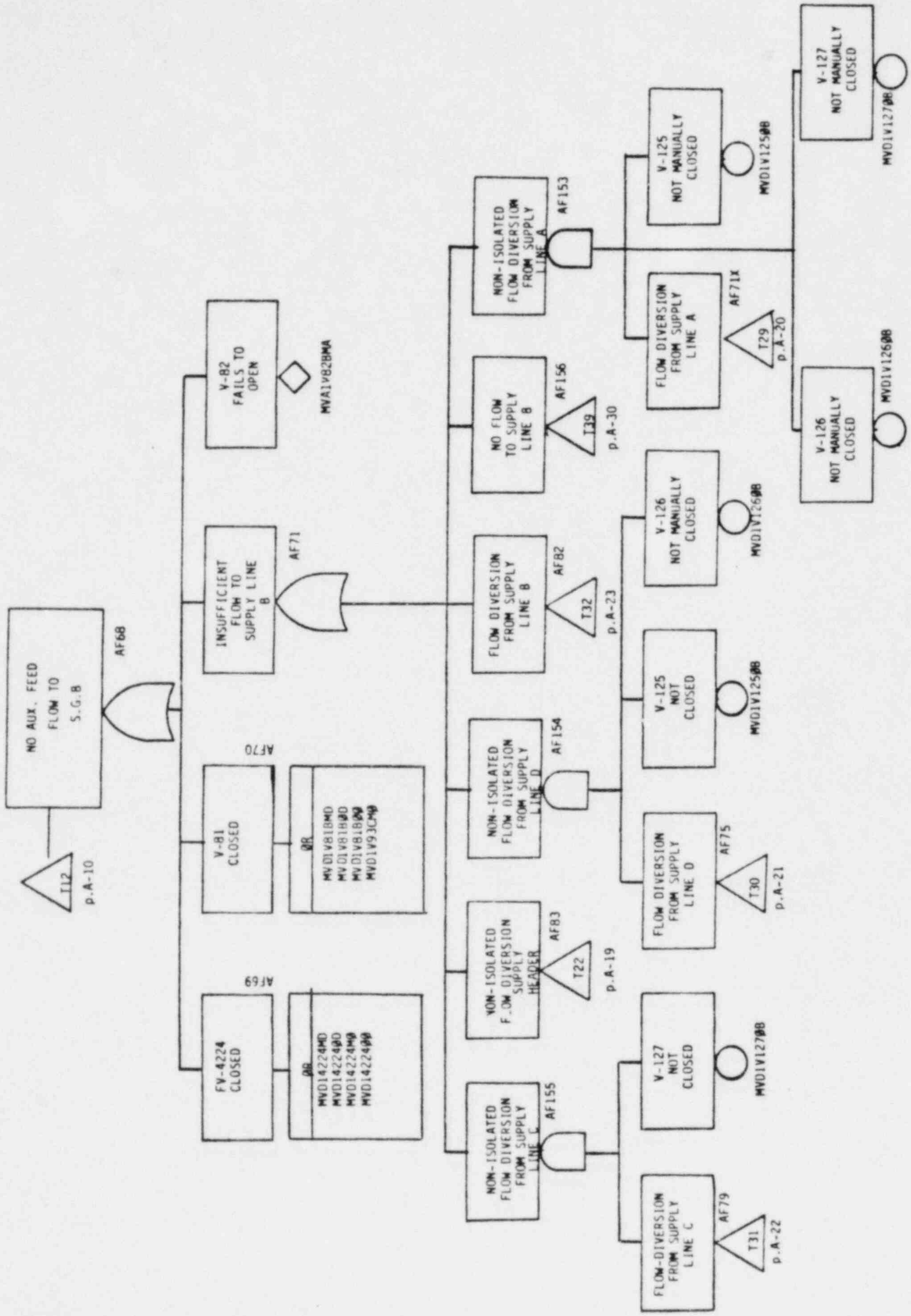


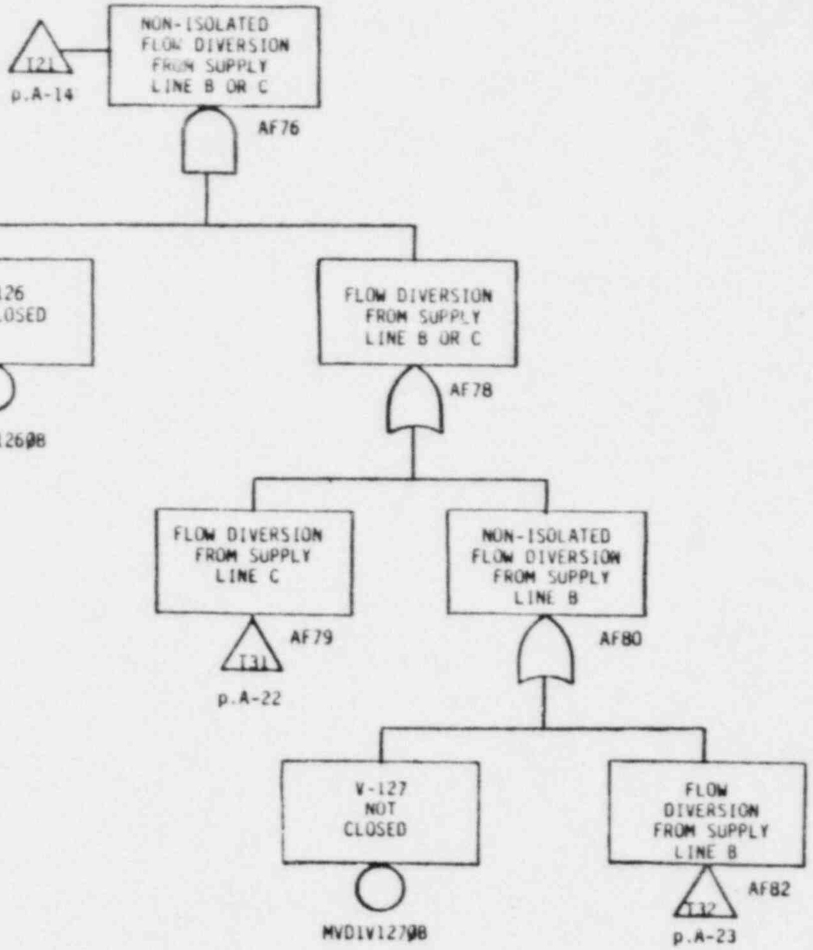
NO AUX. FEED FLOW TO S.G.A
AF56
T9
p.A-7
FV4214 CLOSED
AF57
ØR
MVD14214MD
MVD14214ØD
MVD14214MØ
MVD14214ØØ
V-75 CLOSED
AF58
ØR
MVD1V75AMD
MVD1V75AØD
MVD1V75AØØ
MVD1V75AMØ
INSUFFICIENT FLOW TO SUPPLY LINE A
AF59
V-76 FAILS TO OPEN
MVA1V76AMA
NO FLOW TO SUPPLY LINE A
AF59A
FLOW DIVERSION FROM SUPPLY LINE A
AF71X
T29
p.A-20
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE B, C OR D
AF72
NON-ISOLATED FLOW DIVERSION FROM SUPPLY HEADER
AF83
T22
p.A-20
NO FLOW TO SUPPLY HEADER FROM SUFP P-113
A
SUP1
p.A-21
NO FLOW FROM P-37B
AF123
NO FLOW TO SUPPLY HEADER FROM P-37A
AF91
T40
p.A-31
FLOW DIVERSION FROM SUPPLY LINE B, C OR D
AF73
V-125 NOT MANUALLY CLOSED
MVD1V125ØB
NO FLOW TO SUPPLY HEADER FROM P-37B
AF127
T41
p.A-32
T24
p.A-28
p.A-29
p.A-30
V-125 CLOSED
AF124
ØR
MVD1V125MD
MVD1V125ØD
MVD1V125ØØ
T25
p.A-28
p.A-29
p.A-30
V-126 CLOSED
AF125
ØR
MVD1V126MD
MVD1V126ØD
MVD1V126ØØ
T26
p.A-28
p.A-29
p.A-30
V-127 CLOSED
AF126
ØR
MVD1V127MD
MVD1V127ØD
MVD1V127ØØ
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE B OR C
AF76
T21
p.A-18
FLOW DIVERSION FROM SUPPLY LINE D
AF75
T30
p.A-21

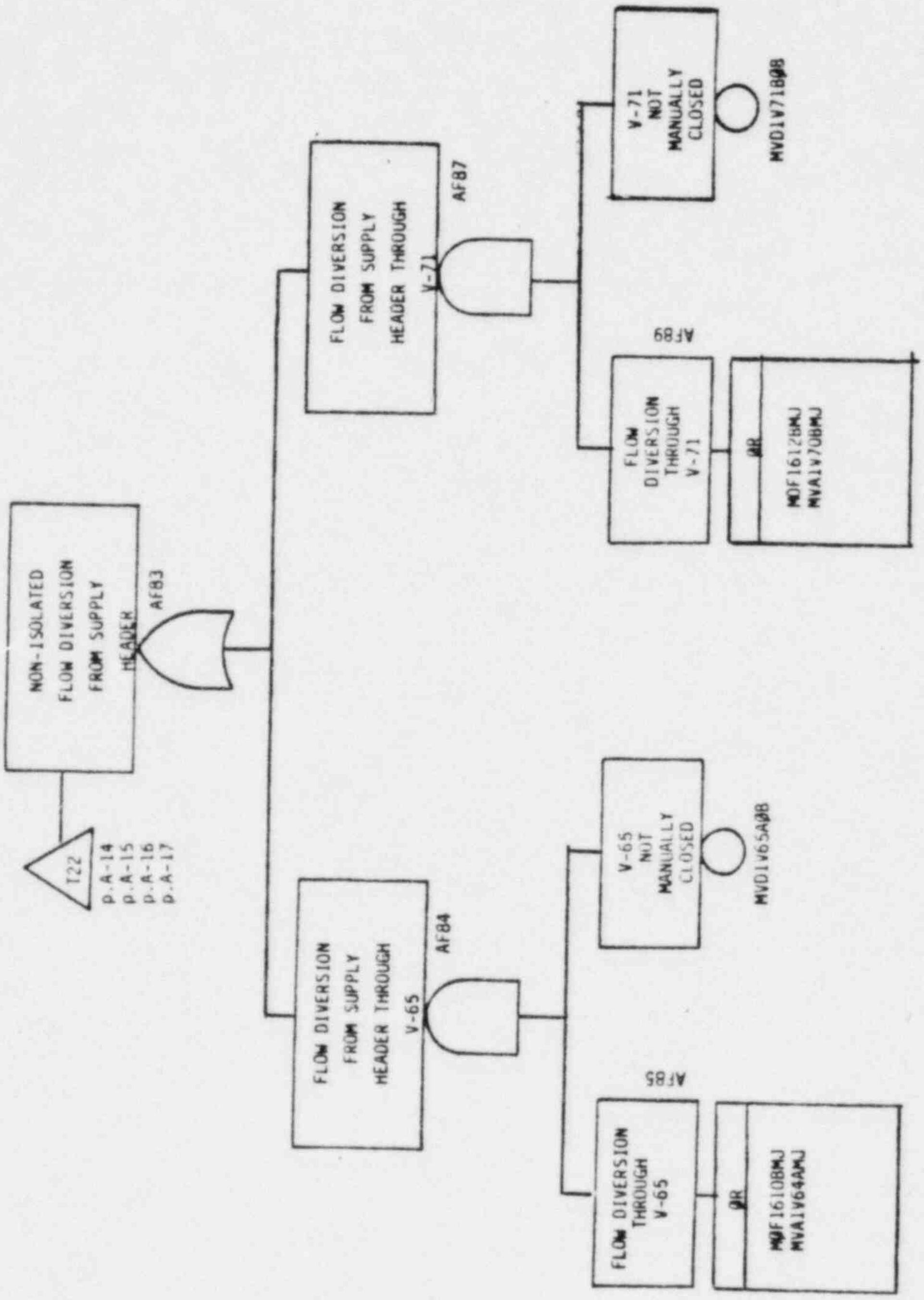


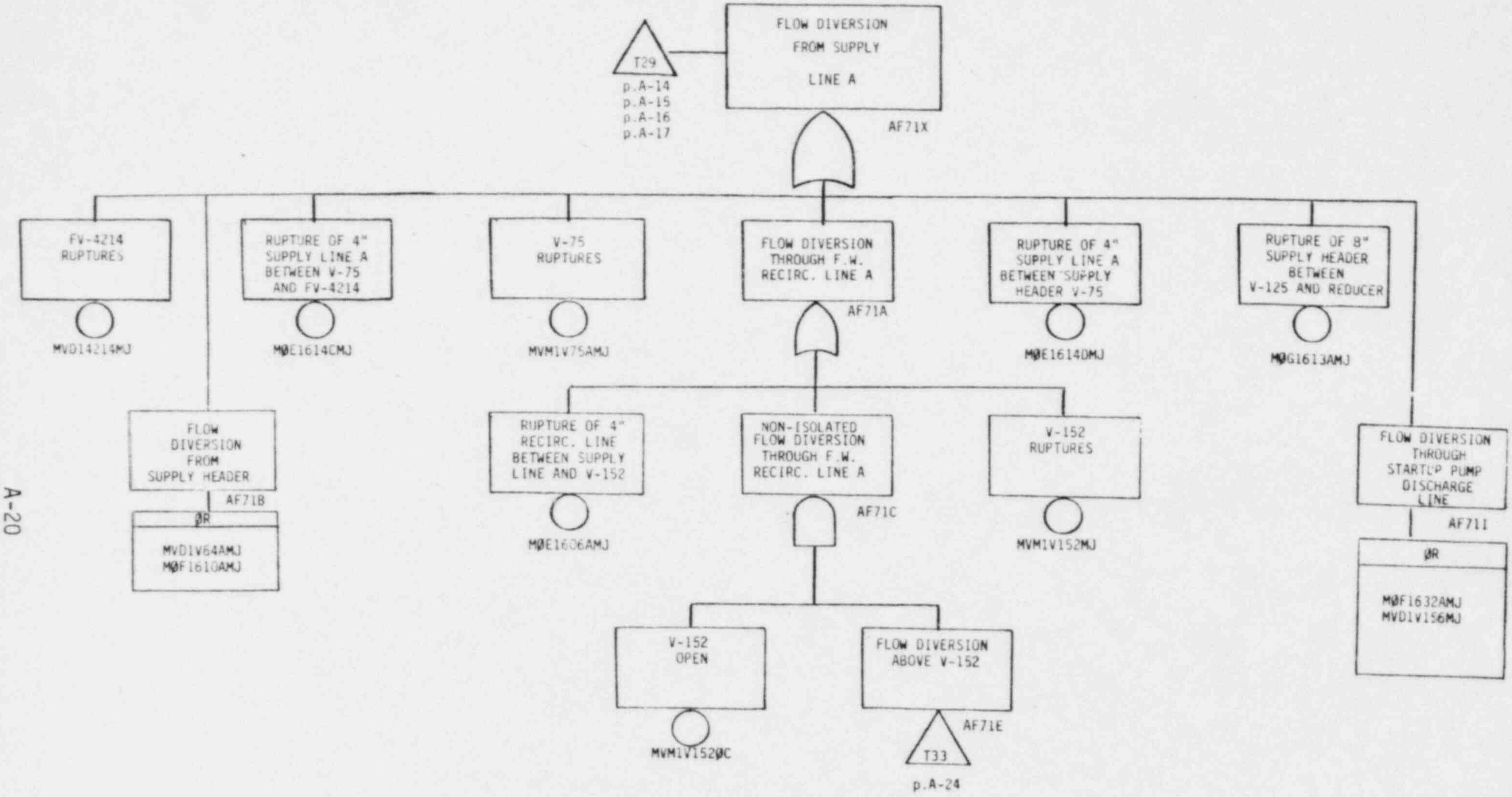
T10
p.A-8
NO AUX. FEED FLOW TO S.G.D
AF60
FV-4224 CLOSED
AF61
0R
MVD14244MD
MVD142240D
MVD14244M0
MVD1424400
V-87 CLOSED
AF62
0R
MVD1V87DMD
MVD1V87D0D
MVD1V87D00
MVD1V87DM0
INSUFFICIENT FLOW TO SUPPLY LINED
AF63
V-94 FAILS TO OPEN
MVA1V94DMA
NON-ISOLATED FLOW DIVERSION THROUGH SUPPLY LINE A
NON-ISOLATED FLOW DIVERSION FROM SUPPLY HEADER
AF83
T22
p.A-19
NON-ISOLATED FLOW DIVERSION THROUGH SUPPLY LINE B
AF143
FLOW DIVERSION FROM SUPPLY LINE D
AF75
T30
p.A-21
NO FLOW TO SUPPLY LINE D
AF144
T37
p.A-28
NON-ISOLATED FLOW DIVERSION THROUGH SUPPLY LINE C
AF142
FLOW DIVERSION FROM SUPPLY LINE A
AF71X
T29
p.A-20
V-125 NOT MANUALLY CLOSED
MVD1V1250B
V-126 NOT MANUALLY CLOSED
MVD1V1260B
FLOW DIVERSION FROM SUPPLY LINE B
AF82
T32
p.A-23
V-127 NOT MANUALLY CLOSED
MVD1V1270B
FLOW DIVERSION FROM SUPPLY LINE C
AF79
T31
p.A-22
V-126 NOT MANUALLY CLOSED
MVD1V1260B

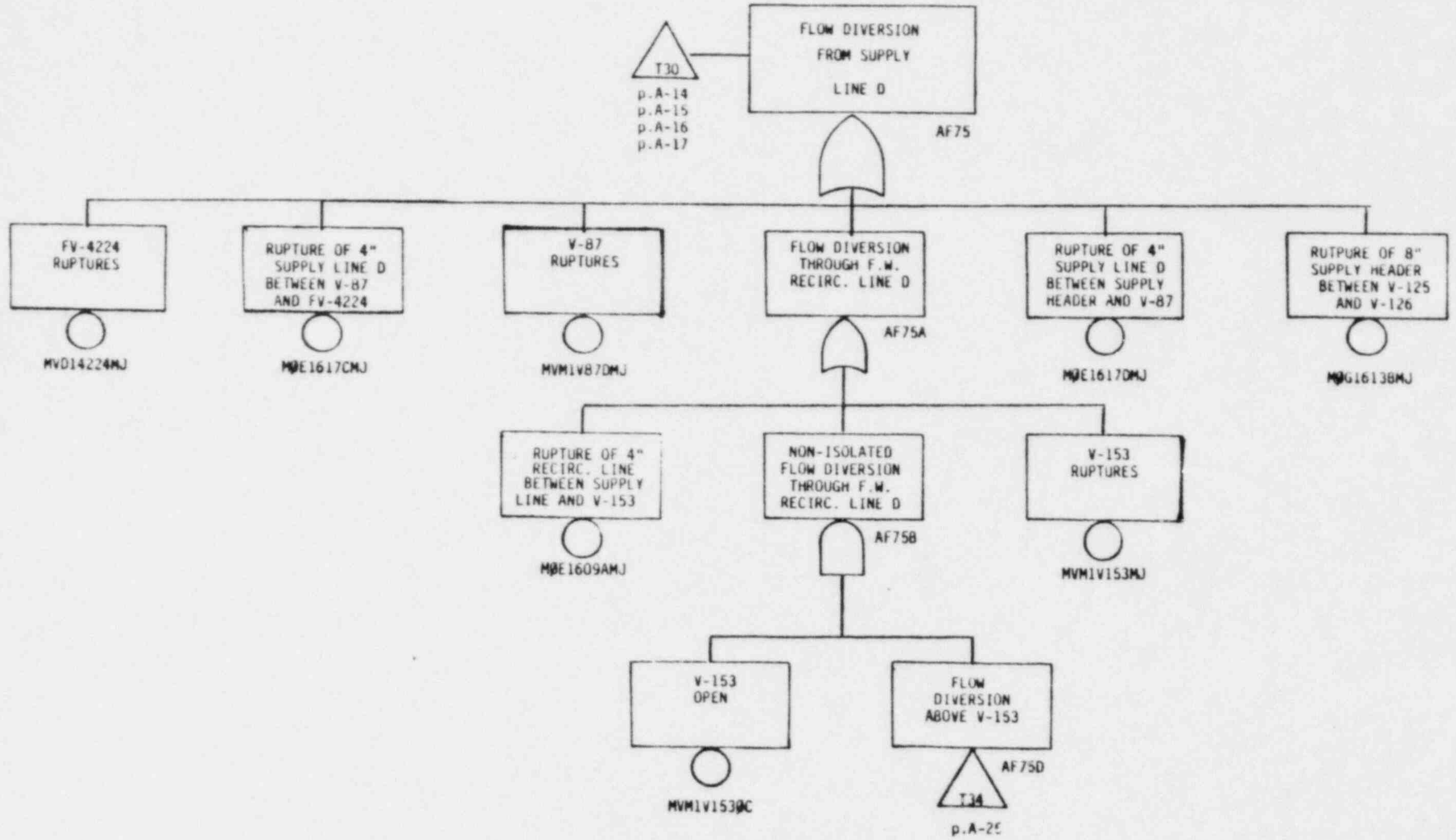

NO AUX. FEED FLOW TO S.G.C
AF64
T11
p.A-9
FV-4234 CLOSED
AF65
OR
MVD14234MO
MVD14234OD
MVD14234MO
MVD14234ØW
V-93 CLOSED
AF66
OR
MVD1V93CMO
MVD1V93COD
MVD1V93CØW
MVD1V81BMO
INSUFFICIENT FLOW TO SUPPLY LINE C
AF67
V-88 FAILS TO OPEN
MVA1V88CMA
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE D
AF148
NON-ISOLATED FLOW DIVERSION FROM SUPPLY HEADER
AF83
T22
p.A-19
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE A
AF147
FLOW DIVERSION FROM SUPPLY LINE C
AF79
T31
p.A-22
NO FLOW TO SUPPLY LINE C
AF150
T38
p.A-29
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE B
AF149
FLOW DIVERSION FROM SUPPLY LINE D
AF75
T30
p.A-21
V-126 NOT CLOSED
MVD1V126ØB
V-125 NOT CLOSED
MVD1V125ØB
FLOW DIVERSION FROM SUPPLY LINE A
AF71X
T29
p.A-20
V-126 NOT CLOSED
MVD1V126ØB
FLOW DIVERSION FROM SUPPLY LINE B
AF82
T32
p.A-23
V-127 NOT CLOSED
MVD1V127ØB

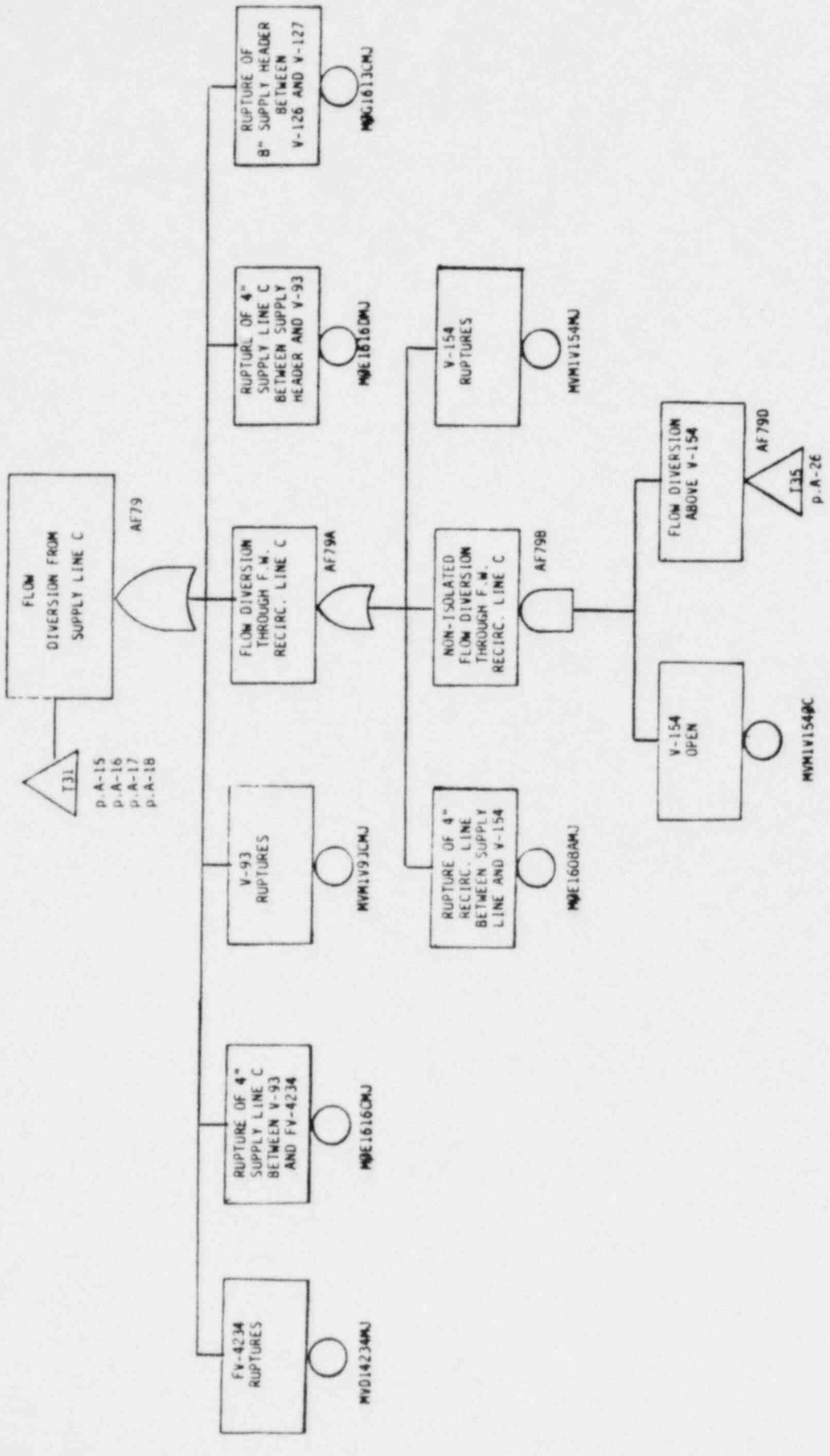

T12
p.A-10
NO AUX. FEED FLOW TO S.G.B
AF68
FV-4224 CLOSED
AF69
OR
MVD14224MD
MVD142240D
MVD14224M0
MVD1422400
V-81 CLOSED
AF70
OR
MVD1V81BMD
MVD1V81B0D
MVD1V81B00
MVD1V93CM0
INSUFFICIENT FLOW TO SUPPLY LINE B
AF71
V-82 FAILS TO OPEN
MVA1V82BMA
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE C
AF155
NON-ISOLATED FLOW DIVERSION SUPPLY HEADER
AF83
T22
p.A-19
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE D
AF154
FLOW DIVERSION FROM SUPPLY LINE B
AF82
T32
p.A-23
NO FLOW TO SUPPLY LINE B
AF156
T39
p.A-30
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE A
AF153
FLOW-DIVERSION FROM SUPPLY LINE C
AF79
T31
p.A-22
V-127 NOT CLOSED
MVD1V12700B
FLOW DIVERSION FROM SUPPLY LINE D
AF75
T30
p.A-21
V-125 NOT CLOSED
MVD1V12500B
V-126 NOT MANUALLY CLOSED
MVD1V12600B
FLOW DIVERSION FROM SUPPLY LINE A
AF71X
T29
p.A-20
V-125 NOT MANUALLY CLOSED
MVD1V12500B
V-126 NOT MANUALLY CLOSED
MVD1V12600B
V-127 NOT MANUALLY CLOSED
MVD1V12700B

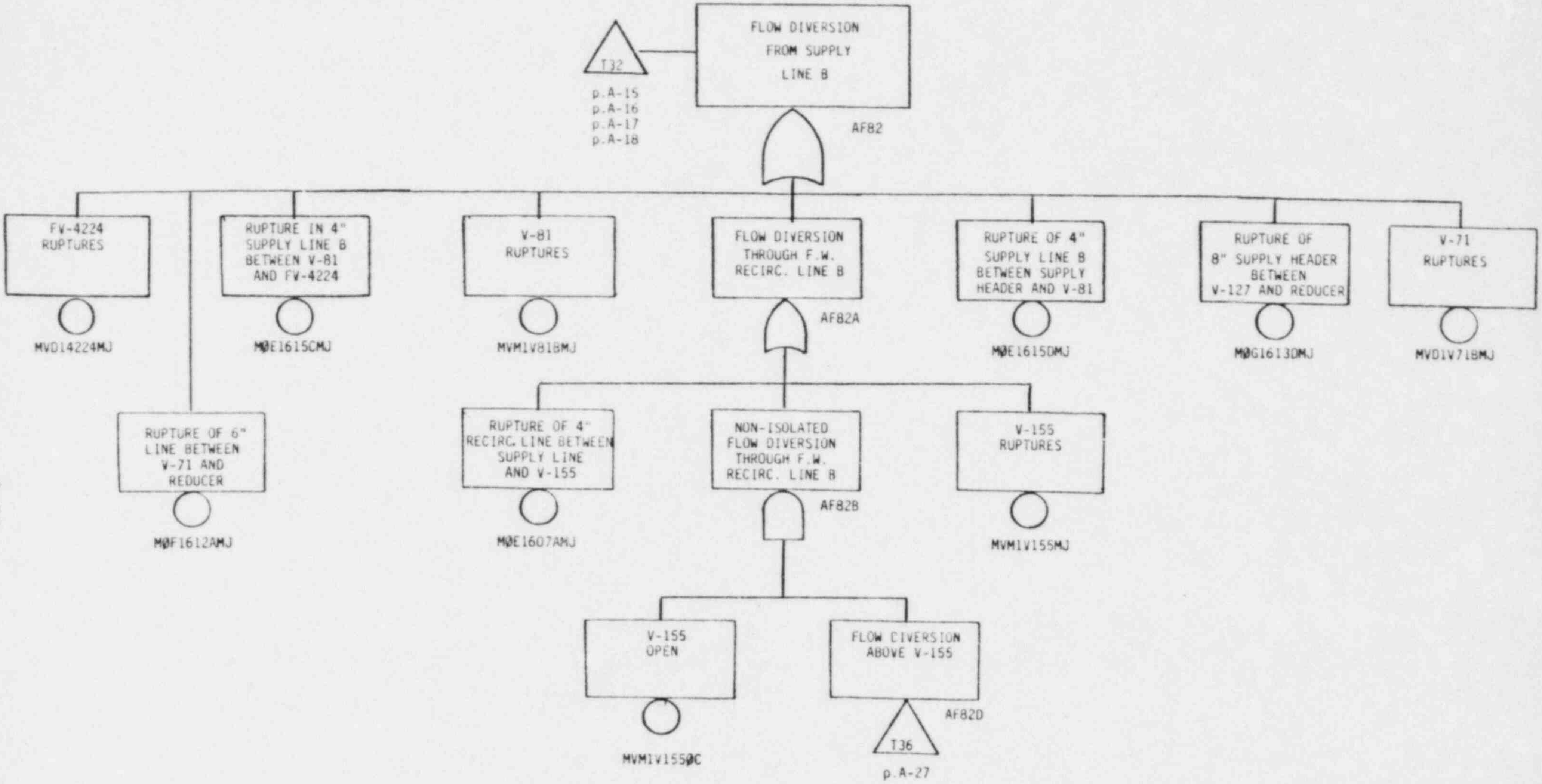

T21
p.A-14
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE B OR C
AF76
V-126 NOT CLOSED
MVD1V1260B
FLOW DIVERSION FROM SUPPLY LINE B OR C
AF78
FLOW DIVERSION FROM SUPPLY LINE C
AF79
T31
p.A-22
NON-ISOLATED FLOW DIVERSION FROM SUPPLY LINE B
AF80
V-127 NOT CLOSED
MVD1V1270B
FLOW DIVERSION FROM SUPPLY LINE B
AF82
T32
p.A-23

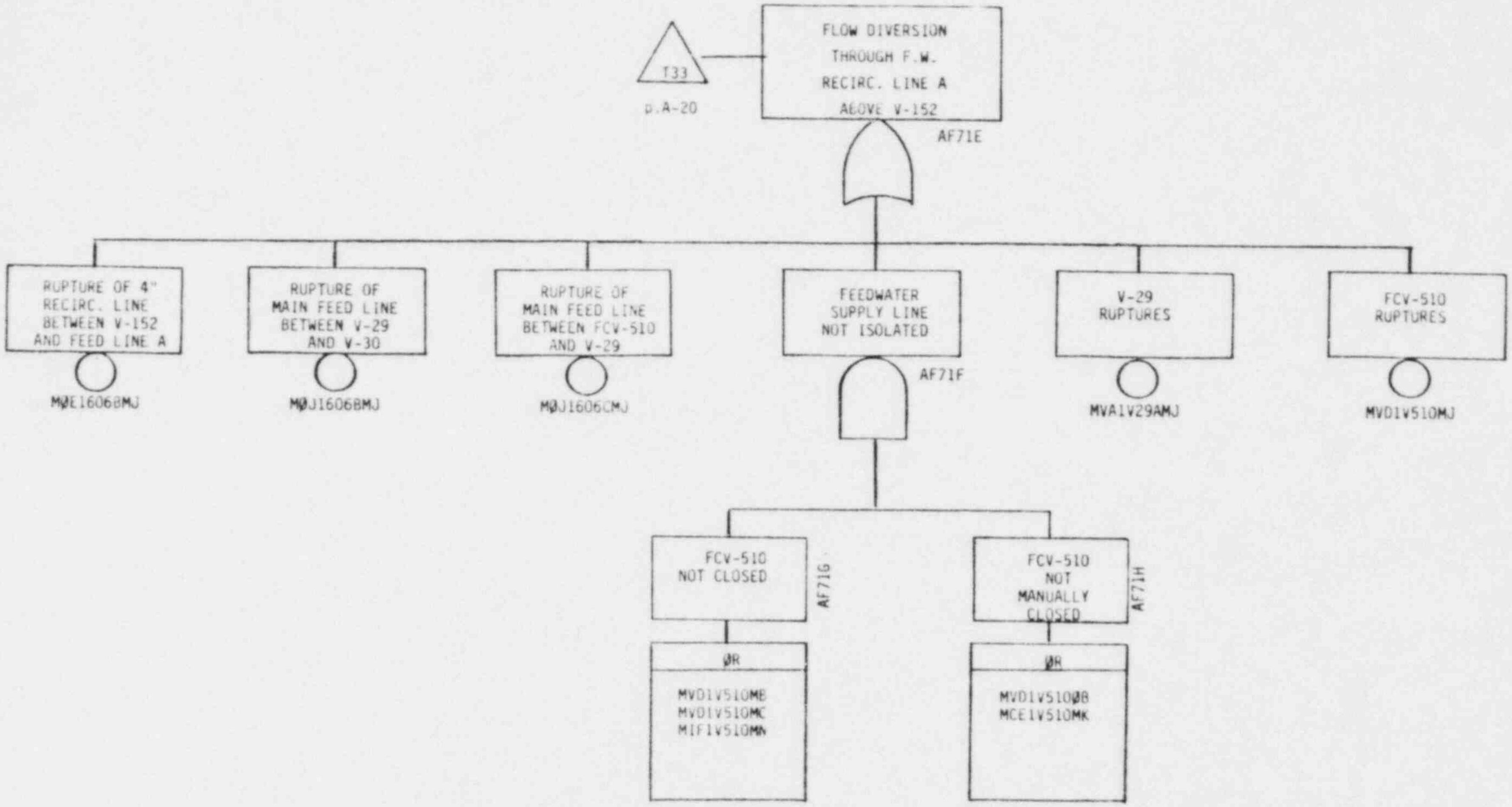

T22
p.A-14
p.A-15
p.A-16
p.A-17
NON-ISOLATED FLOW DIVERSION FROM SUPPLY HEADER
AF83
FLOW DIVERSION FROM SUPPLY HEADER THROUGH V-65
AF84
FLOW DIVERSION FROM SUPPLY HEADER THROUGH V-71
AF87
FLOW DIVERSION THROUGH V-65
AF85
OR
MDF1610BMJ
MVA1V64AMJ
V-65 NOT MANUALLY CLOSED
MVD1V65A0B
FLOW DIVERSION THROUGH V-71
AF89
OR
MDF1612BMJ
MVA1V70BMJ
V-71 NOT MANUALLY CLOSED
MVD1V71B0B


T29
p.A-14
p.A-15
p.A-16
p.A-17
FLOW DIVERSION FROM SUPPLY LINE A
AF71X
FV-4214 RUPTURES
MVD14214MJ
RUPTURE OF 4" SUPPLY LINE A BETWEEN V-75 AND FV-4214
M0E1614CMJ
V-75 RUPTURES
MVM1V75AMJ
FLOW DIVERSION THROUGH F.W. RECIRC. LINE A
AF71A
RUPTURE OF 4" SUPPLY LINE A BETWEEN SUPPLY HEADER V-75
M0E1614DMJ
RUPTURE OF 8" SUPPLY HEADER BETWEEN V-125 AND REDUCER
M0G1613AMJ
FLOW DIVERSION FROM SUPPLY HEADER
AF71B
0R
MVD1V64AMJ
M0F1610AMJ
RUPTURE OF 4" RECIRC. LINE BETWEEN SUPPLY LINE AND V-152
M0E1606AMJ
NON-ISOLATED FLOW DIVERSION THROUGH F.W. RECIRC. LINE A
AF71C
V-152 RUPTURES
MVM1V152MJ
FLOW DIVERSION THROUGH STARTUP PUMP DISCHARGE LINE
AF71I
0R
M0F1632AMJ
MVD1V156MJ
V-152 OPEN
MVM1V1520C
FLOW DIVERSION ABOVE V-152
AF71E
T33
p.A-24

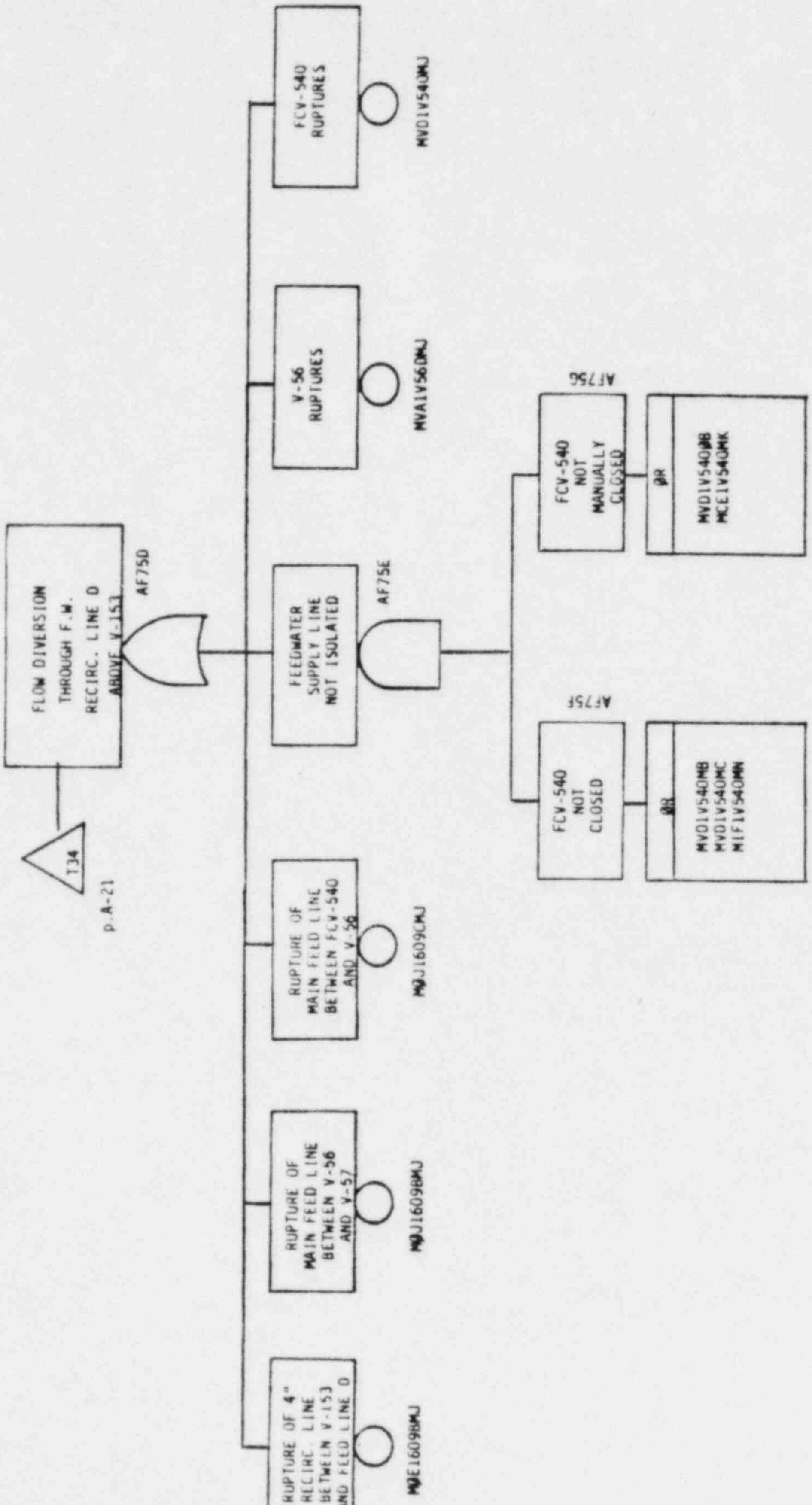

T30
p.A-14
p.A-15
p.A-16
p.A-17
FLOW DIVERSION FROM SUPPLY LINE D
AF75
FV-4224 RUPTURES
MVD14224MJ
RUPTURE OF 4" SUPPLY LINE D BETWEEN V-87 AND FV-4224
M0E1617CMJ
V-87 RUPTURES
MVM1V87DMJ
FLOW DIVERSION THROUGH F.W. RECIRC. LINE D
AF75A
RUPTURE OF 4" SUPPLY LINE D BETWEEN SUPPLY HEADER AND V-87
M0E1617DMJ
RUTPURE OF 8" SUPPLY HEADER BETWEEN V-125 AND V-126
M0G1613BMJ
RUPTURE OF 4" RECIRC. LINE BETWEEN SUPPLY LINE AND V-153
M0E1609AMJ
NON-ISOLATED FLOW DIVERSION THROUGH F.W. RECIRC. LINE D
AF75B
V-153 RUPTURES
MVM1V153MJ
V-153 OPEN
MVM1V1530C
FLOW DIVERSION ABOVE V-153
AF75D
T34
p.A-25

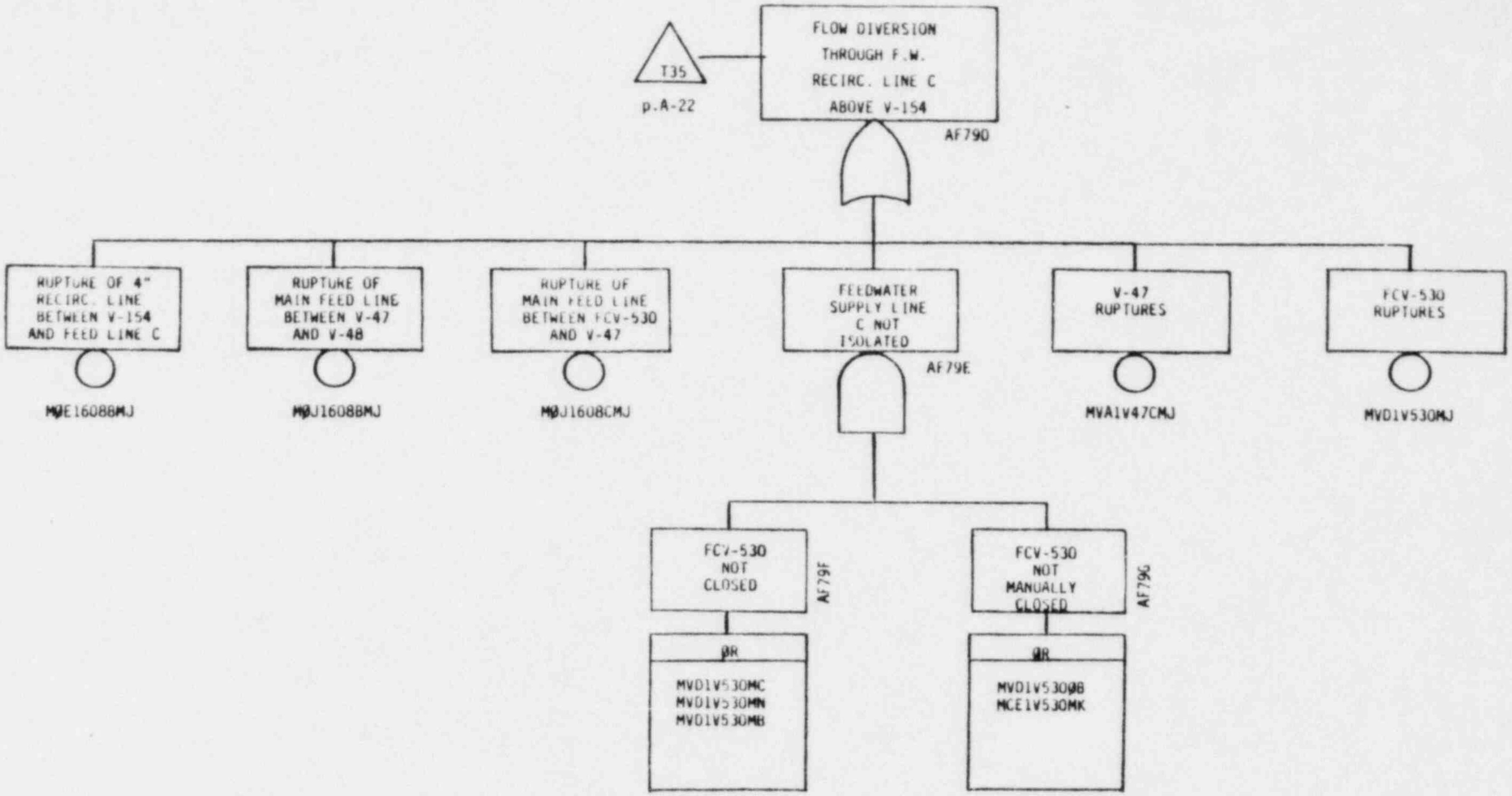

FLOW DIVERSION FROM SUPPLY LINE C
AF79
T31
p.A-15
p.A-16
p.A-17
p.A-18
FV-4234 RUPTURES
MVD14234MJ
RUPTURE OF 4" SUPPLY LINE C BETWEEN V-93 AND FV-4234
M0E1616CMJ
V-93 RUPTURES
MVM1V93CMJ
FLOW DIVERSION THROUGH F.W. RECIRC. LINE C
AF79A
RUPTURL OF 4" SUPPLY LINE C BETWEEN SUPPLY HEADER AND V-93
M0E1616DMJ
RUPTURE OF 8" SUPPLY HEADER BETWEEN V-126 AND V-127
M0G1613CMJ
RUPTURE OF 4" RECIRC. LINE BETWEEN SUPPLY LINE AND V-154
M0E1608AMJ
NON-ISOLATED FLOW DIVERSION THROUGH F.W. RECIRC. LINE C
AF79B
V-154 RUPTURES
MVM1V154MJ
V-154 OPEN
MVM1V1540C
FLOW DIVERSION ABOVE V-154
AF79D
T35
p.A-26

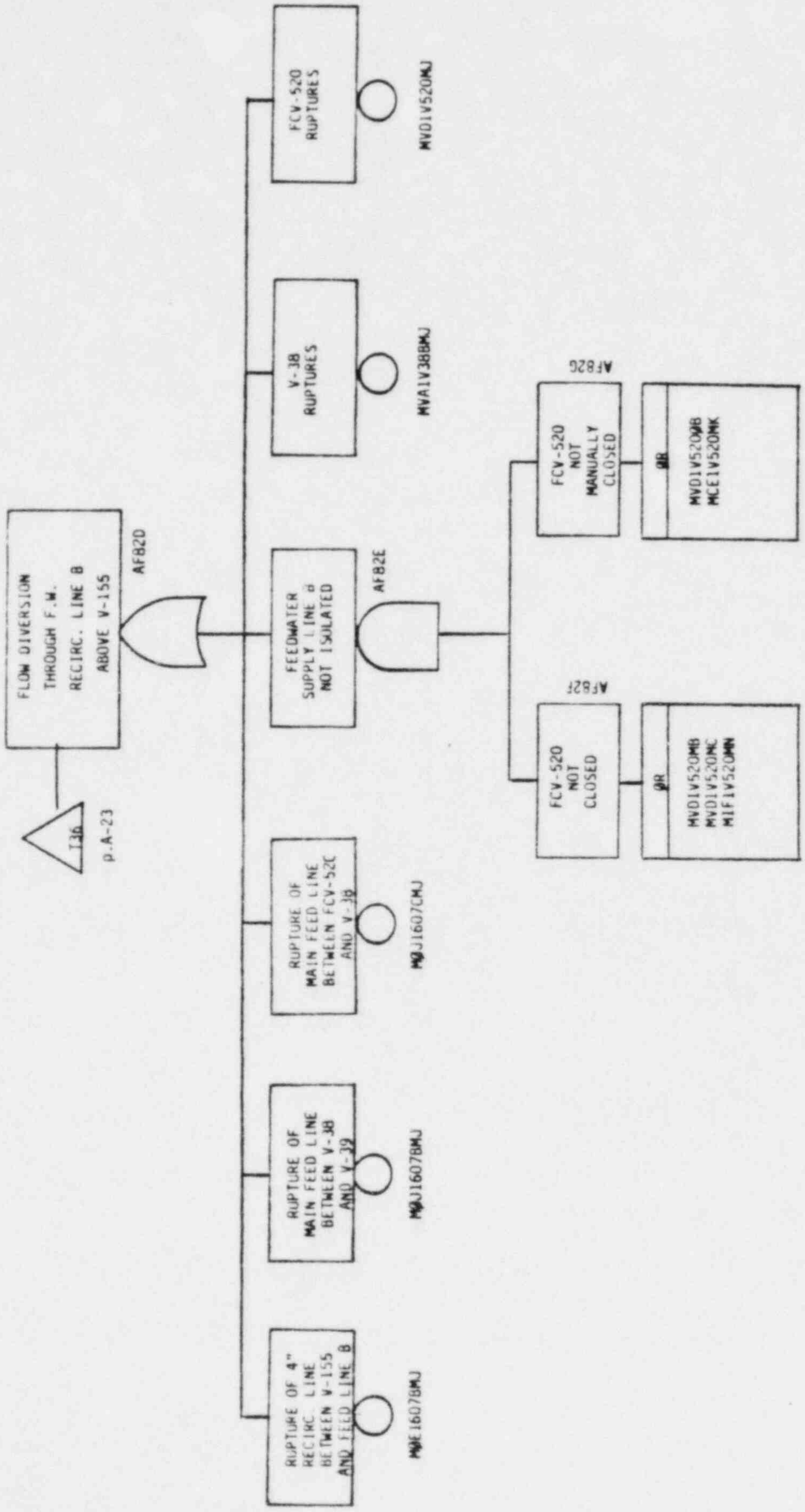

FLOW DIVERSION FROM SUPPLY LINE B
T32
p.A-15
p.A-16
p.A-17
p.A-18
AF82
FV-4224 RUPTURES
MVD14224MJ
RUPTURE IN 4" SUPPLY LINE B BETWEEN V-81 AND FV-4224
M0E1615CMJ
V-81 RUPTURES
MVM1V81BMJ
FLOW DIVERSION THROUGH F.W. RECIRC. LINE B
AF82A
RUPTURE OF 4" SUPPLY LINE B BETWEEN SUPPLY HEADER AND V-81
M0E1615DMJ
RUPTURE OF 8" SUPPLY HEADER BETWEEN V-127 AND REDUCER
M0G1613DMJ
V-71 RUPTURES
MVD1V71BMJ
RUPTURE OF 6" LINE BETWEEN V-71 AND REDUCER
M0F1612AMJ
RUPTURE OF 4" RECIRC. LINE BETWEEN SUPPLY LINE AND V-155
M0E1607AMJ
NON-ISOLATED FLOW DIVERSION THROUGH F.W. RECIRC. LINE B
AF82B
V-155 RUPTURES
MVM1V155MJ
V-155 OPEN
MVM1V1550C
FLOW DIVERSION ABOVE V-155
AF82D
T36
p.A-27

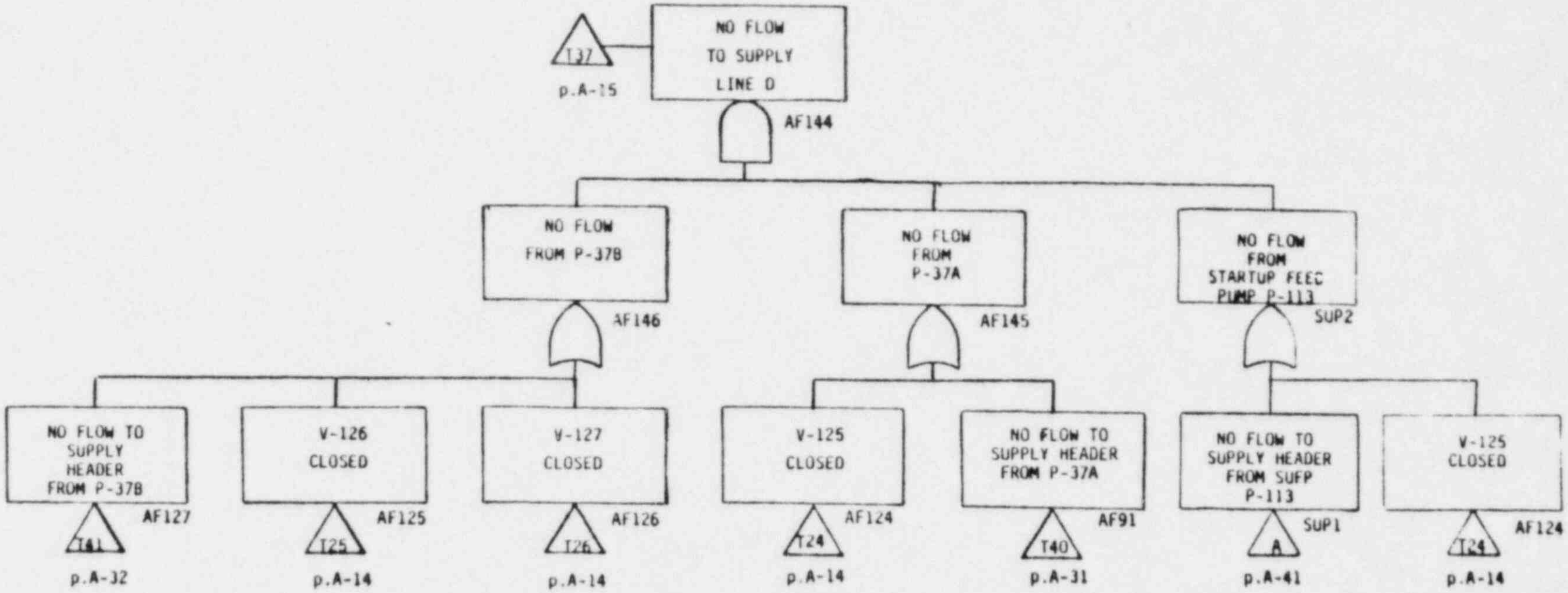


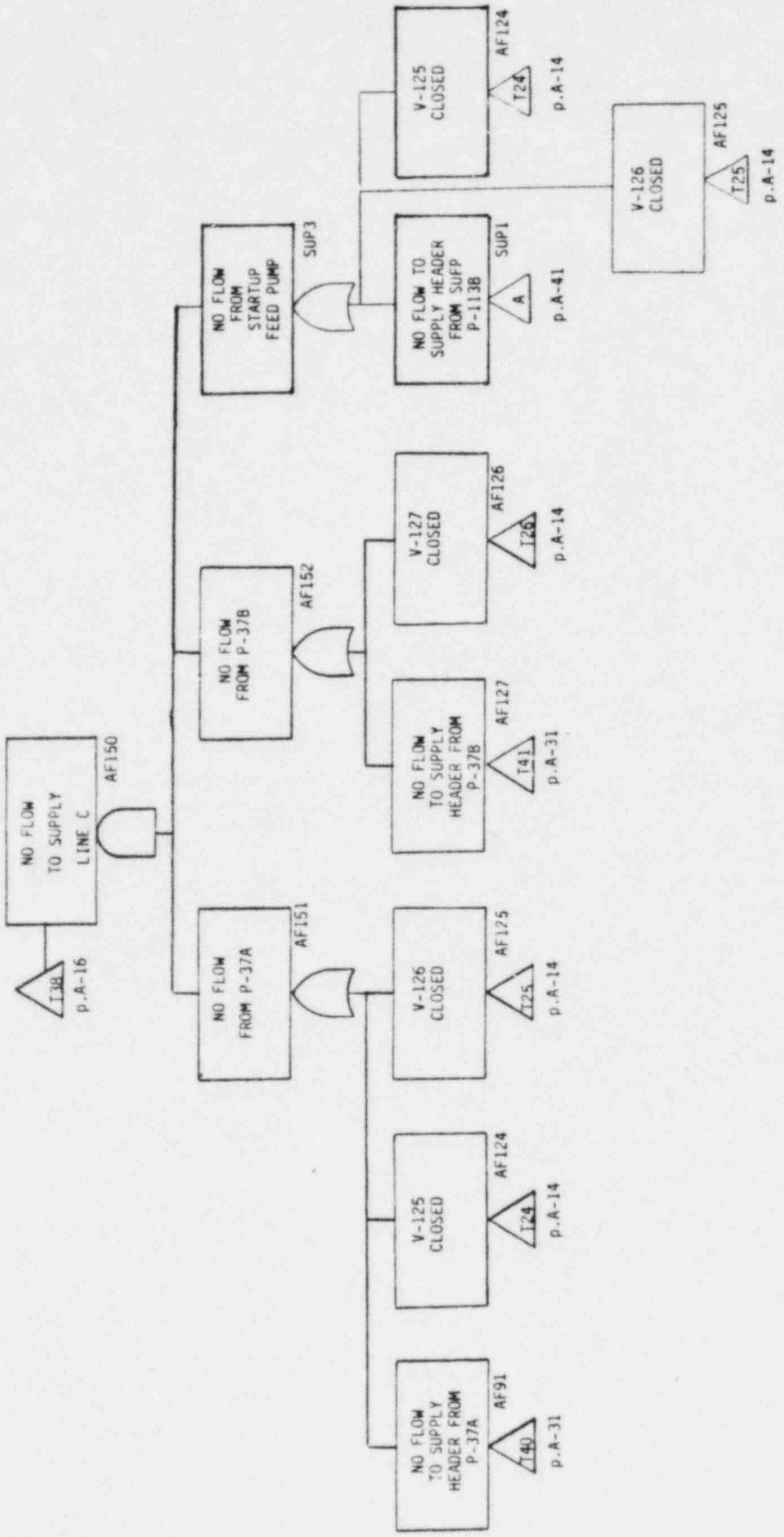
T33
p.A-20
FLOW DIVERSION THROUGH F.W. RECIRC. LINE A ABOVE V-152
AF71E
RUPTURE OF 4" RECIRC. LINE BETWEEN V-152 AND FEED LINE A
M0E1606BMJ
RUPTURE OF MAIN FEED LINE BETWEEN V-29 AND V-30
M0J1606BMJ
RUPTURE OF MAIN FEED LINE BETWEEN FCV-510 AND V-29
M0J1606CMJ
FEEDWATER SUPPLY LINE NOT ISOLATED
AF71F
V-29 RUPTURES
MVA1V29AMJ
FCV-510 RUPTURES
MVD1V510MJ
FCV-510 NOT CLOSED
AF71G
OR
MVD1V510MB
MVD1V510MC
MIF1V510MN
FCV-510 NOT MANUALLY CLOSED
AF71H
OR
MVD1V5100B
MCE1V510MK

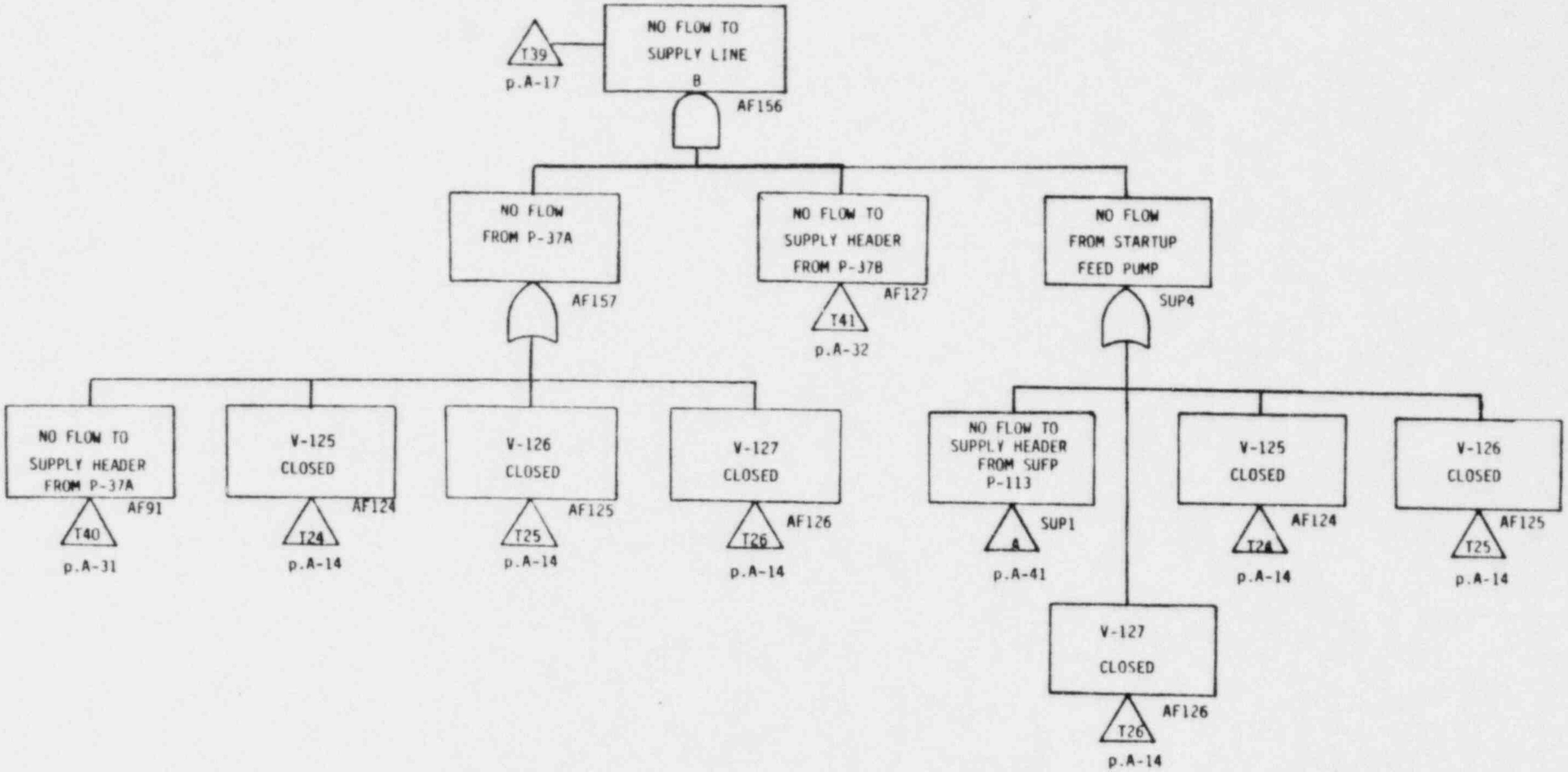

FLOW DIVERSION THROUGH F.W. RECIRC. LINE D ABOVE V-153
AF75D
T34
p.A-21
RUPTURE OF 4" RECIRC. LINE BETWEEN V-153 AND FEED LINE D
MQE1609BMJ
RUPTURE OF MAIN FEED LINE BETWEEN V-56 AND V-57
MQJ1609BMJ
RUPTURE OF MAIN FEED LINE BETWEEN FCV-540 AND V-56
MQJ1609CMJ
FEEDWATER SUPPLY LINE NOT ISOLATED
AF75E
V-56 RUPTURES
MVA1V56DMJ
FCV-540 RUPTURES
MVD1V540MJ
FCV-540 NOT CLOSED
AF75F
OR
MVD1V540MB
MVD1V540MC
MIF1V540MN
FCV-540 NOT MANUALLY CLOSED
AF75G
OR
MVD1V540OB
MCE1V540MK


T35
p.A-22
FLOW DIVERSION THROUGH F.W. RECIRC. LINE C ABOVE V-154
AF790
RUPTURE OF 4" RECIRC. LINE BETWEEN V-154 AND FEED LINE C
MOE1608BMJ
RUPTURE OF MAIN FEED LINE BETWEEN V-47 AND V-48
MOJ1608BMJ
RUPTURE OF MAIN FEED LINE BETWEEN FCV-530 AND V-47
MOJ1608CMJ
FEEDWATER SUPPLY LINE C NOT ISOLATED
AF79E
V-47 RUPTURES
MVA1V47CMJ
FCV-530 RUPTURES
MVD1V530MJ
FCV-530 NOT CLOSED
AF79F
OR
MVD1V530MC
MVD1V530MN
MVD1V530MB
FCV-530 NOT MANUALLY CLOSED
AF79G
OR
MVD1V530OB
MCE1V530MK

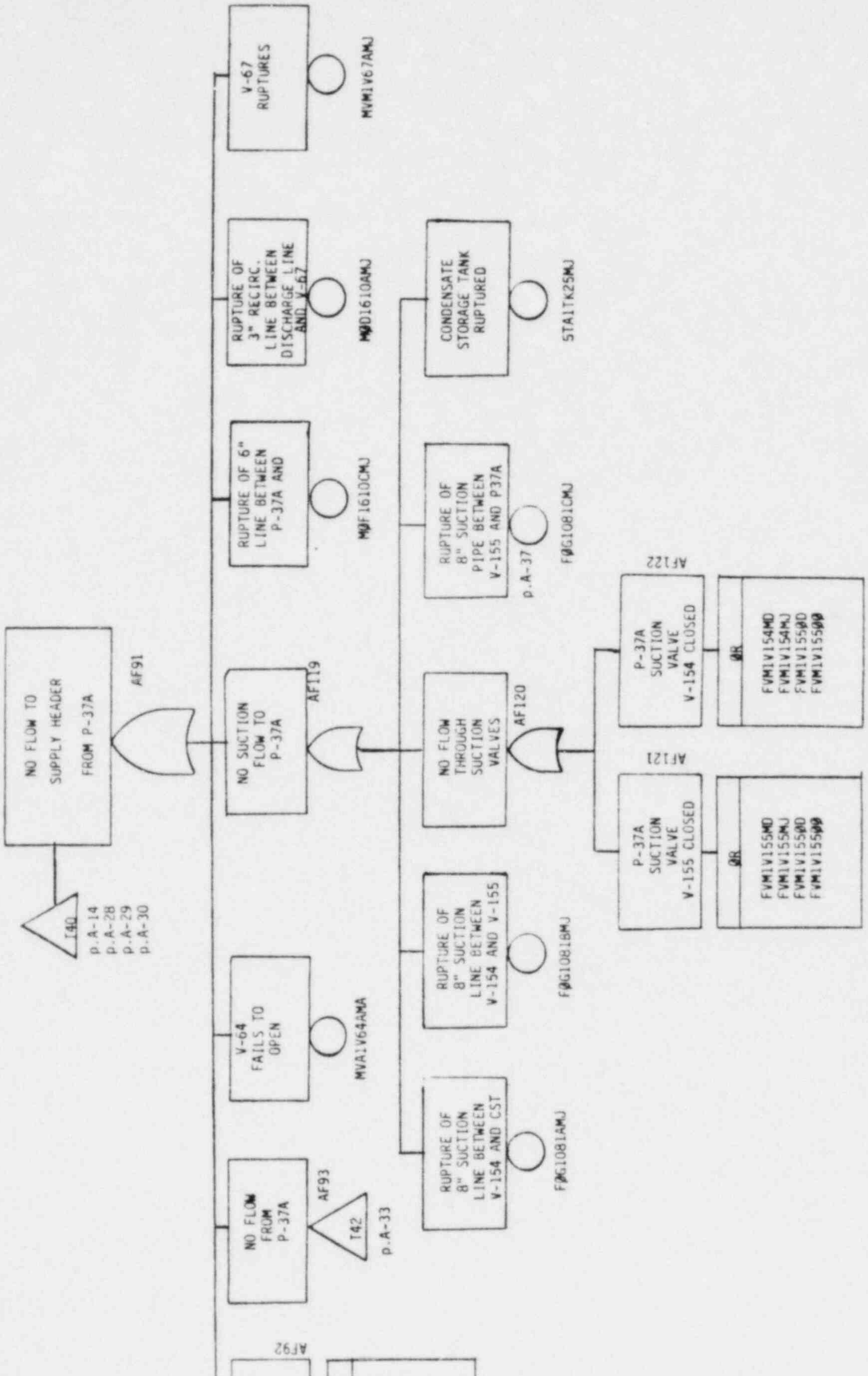

FLOW DIVERSION THROUGH F.W. RECIRC. LINE B ABOVE V-155
AF82D
T36
p.A-23
RUPTURE OF 4" RECIRC. LINE BETWEEN V-155 AND FEED LINE B
MOE1607BMJ
RUPTURE OF MAIN FEED LINE BETWEEN V-38 AND V-39
MOJ1607BMJ
RUPTURE OF MAIN FEED LINE BETWEEN FCV-520 AND V-38
MOJ1607CMJ
FEEDWATER SUPPLY LINE B NOT ISOLATED
AF82E
V-38 RUPTURES
MVA1V38BMJ
FCV-520 RUPTURES
MVD1V520MJ
FCV-520 NOT CLOSED
AF82F
OR
MVD1V520MB
MVD1V520NC
MIF1V520MN
FCV-520 NOT MANUALLY CLOSED
AF82G
OR
MVD1V520OB
MCE1V520MK

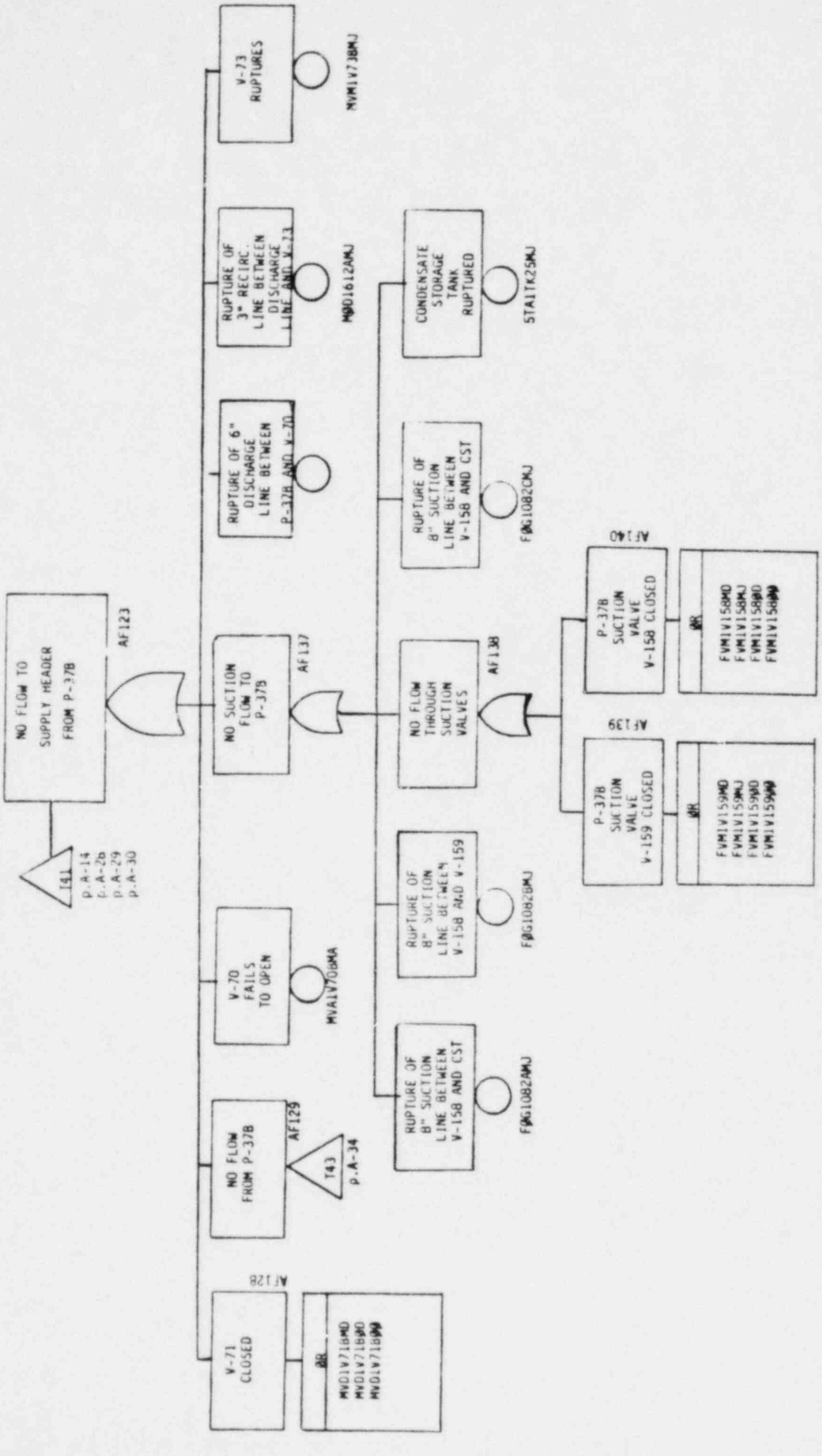

T37
p.A-15
NO FLOW TO SUPPLY LINE D
AF144
NO FLOW FROM P-37B
AF146
NO FLOW FROM P-37A
AF145
NO FLOW FROM STARTUP FEED PUMP P-113
SUP2
NO FLOW TO SUPPLY HEADER FROM P-37B
AF127
T41
p.A-32
V-126 CLOSED
AF125
T25
p.A-14
V-127 CLOSED
AF126
T26
p.A-14
V-125 CLOSED
AF124
T24
p.A-14
NO FLOW TO SUPPLY HEADER FROM P-37A
AF91
T40
p.A-31
NO FLOW TO SUPPLY HEADER FROM SUFP P-113
SUP1
A
p.A-41
V-125 CLOSED
AF124
T24
p.A-14

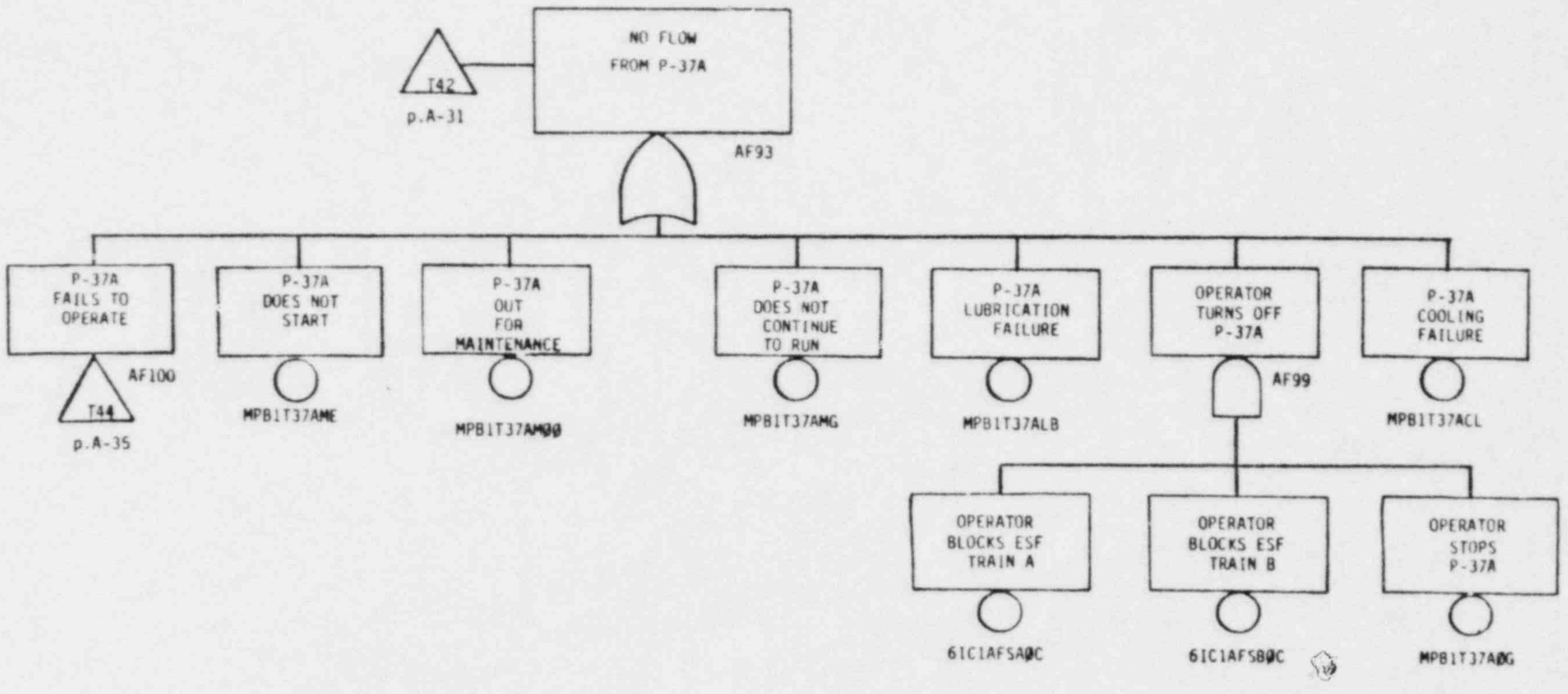

NO FLOW TO SUPPLY LINE C
AF150
T38
p.A-16
NO FLOW FROM P-37A
AF151
NO FLOW FROM P-37B
AF152
NO FLOW FROM STARTUP FEED PUMP
SUP3
NO FLOW TO SUPPLY HEADER FROM P-37A
AF91
T40
p.A-31
V-125 CLOSED
AF124
T24
p.A-14
V-126 CLOSED
AF125
T25
p.A-14
NO FLOW TO SUPPLY HEADER FROM P-37B
AF127
T41
p.A-31
V-127 CLOSED
AF126
T26
p.A-14
NO FLOW TO SUPPLY HEADER FROM SUFP P-113B
SUP1
A
p.A-41
V-125 CLOSED
AF124
T24
p.A-14
V-126 CLOSED
AF125
T25
p.A-14

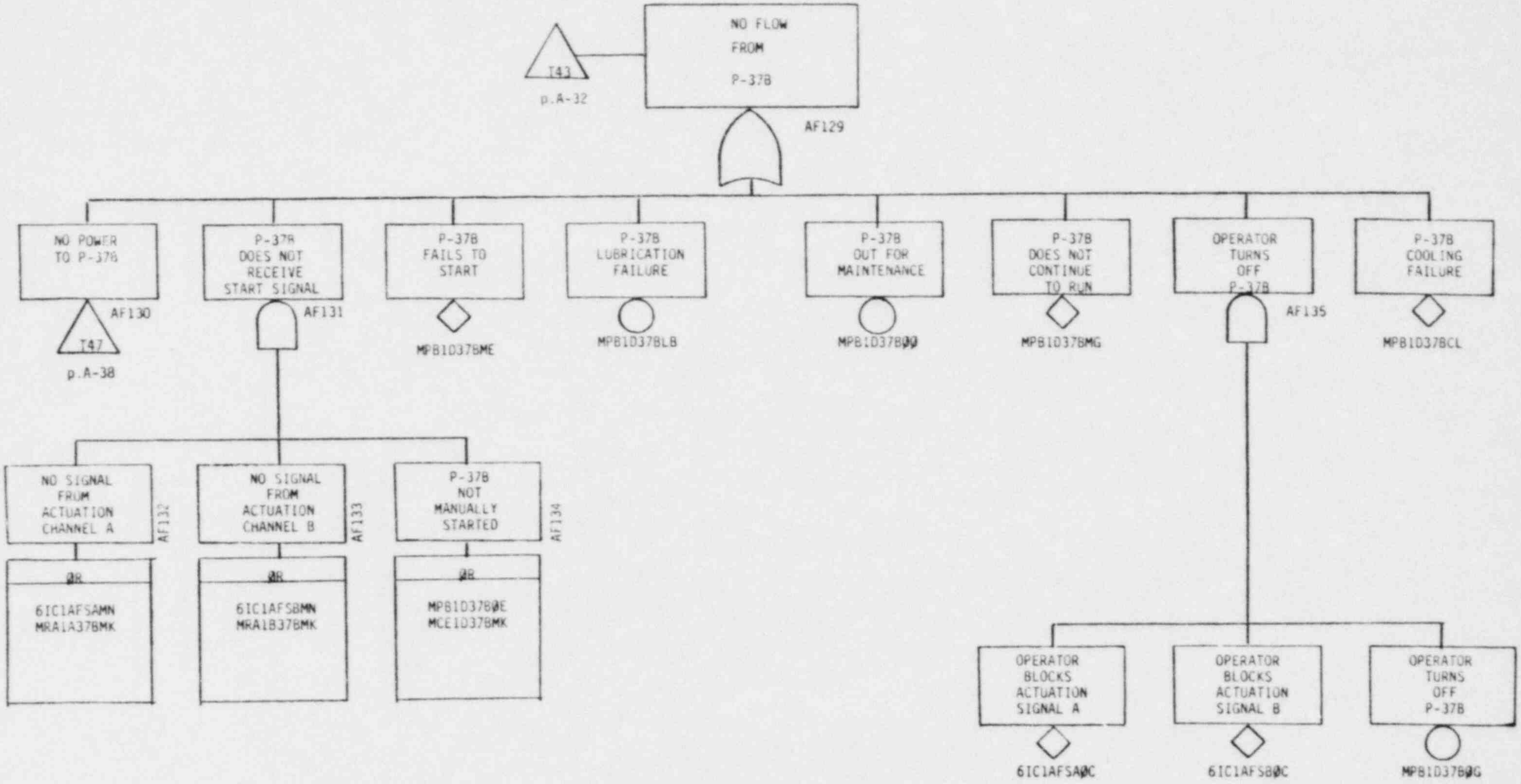


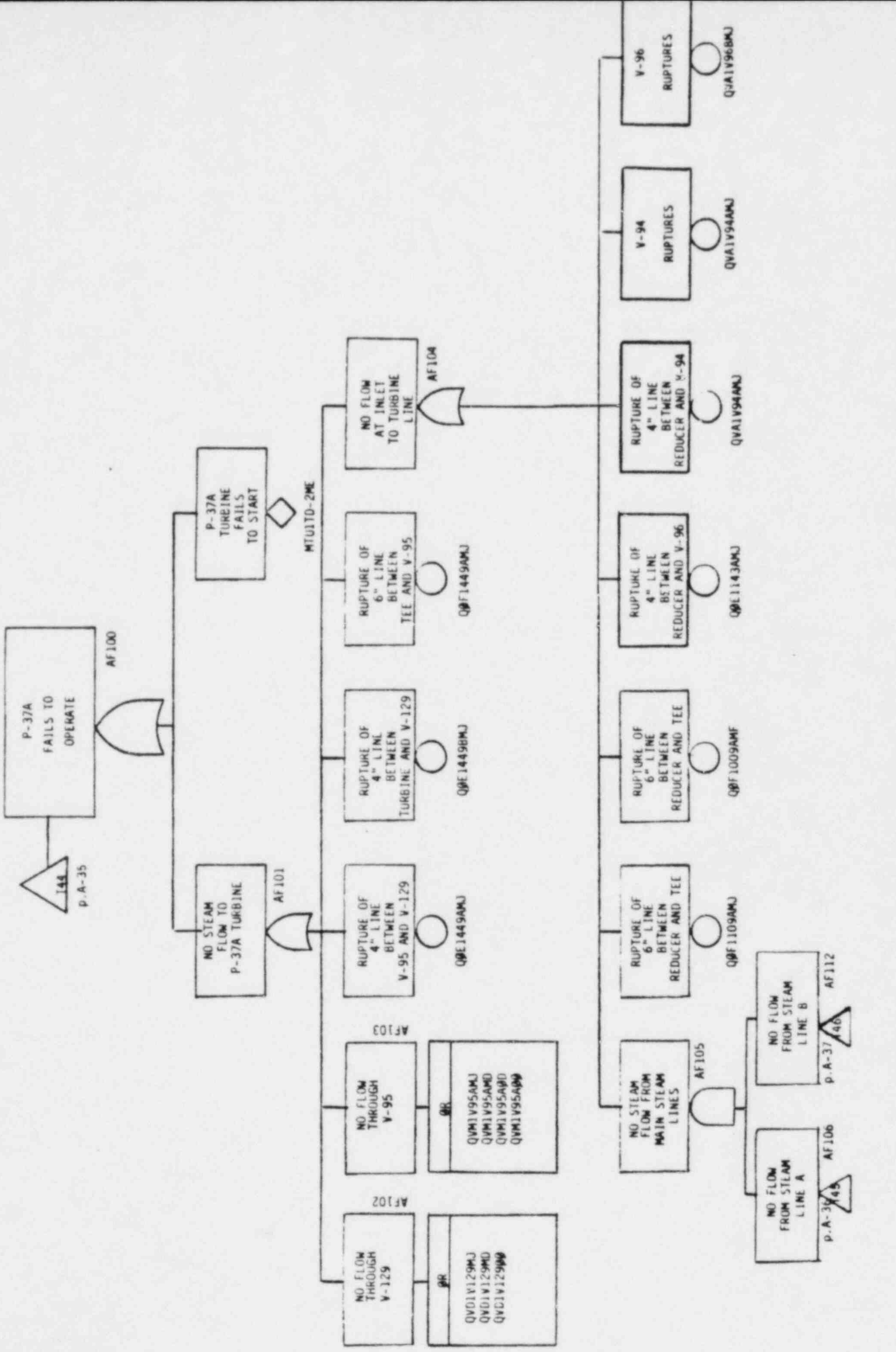
T39
p.A-17
NO FLOW TO SUPPLY LINE B
AF156
NO FLOW FROM P-37A
AF157
NO FLOW TO SUPPLY HEADER FROM P-37B
AF127
T41
p.A-32
NO FLOW FROM STARTUP FEED PUMP
SUP4
NO FLOW TO SUPPLY HEADER FROM P-37A
AF91
T40
p.A-31
V-125 CLOSED
AF124
T24
p.A-14
V-126 CLOSED
AF125
T25
p.A-14
V-127 CLOSED
AF126
T26
p.A-14
NO FLOW TO SUPPLY HEADER FROM SUFP P-113
SUP1
A
p.A-41
V-125 CLOSED
AF124
T24
p.A-14
V-126 CLOSED
AF125
T25
p.A-14
V-127 CLOSED
AF126
T26
p.A-14

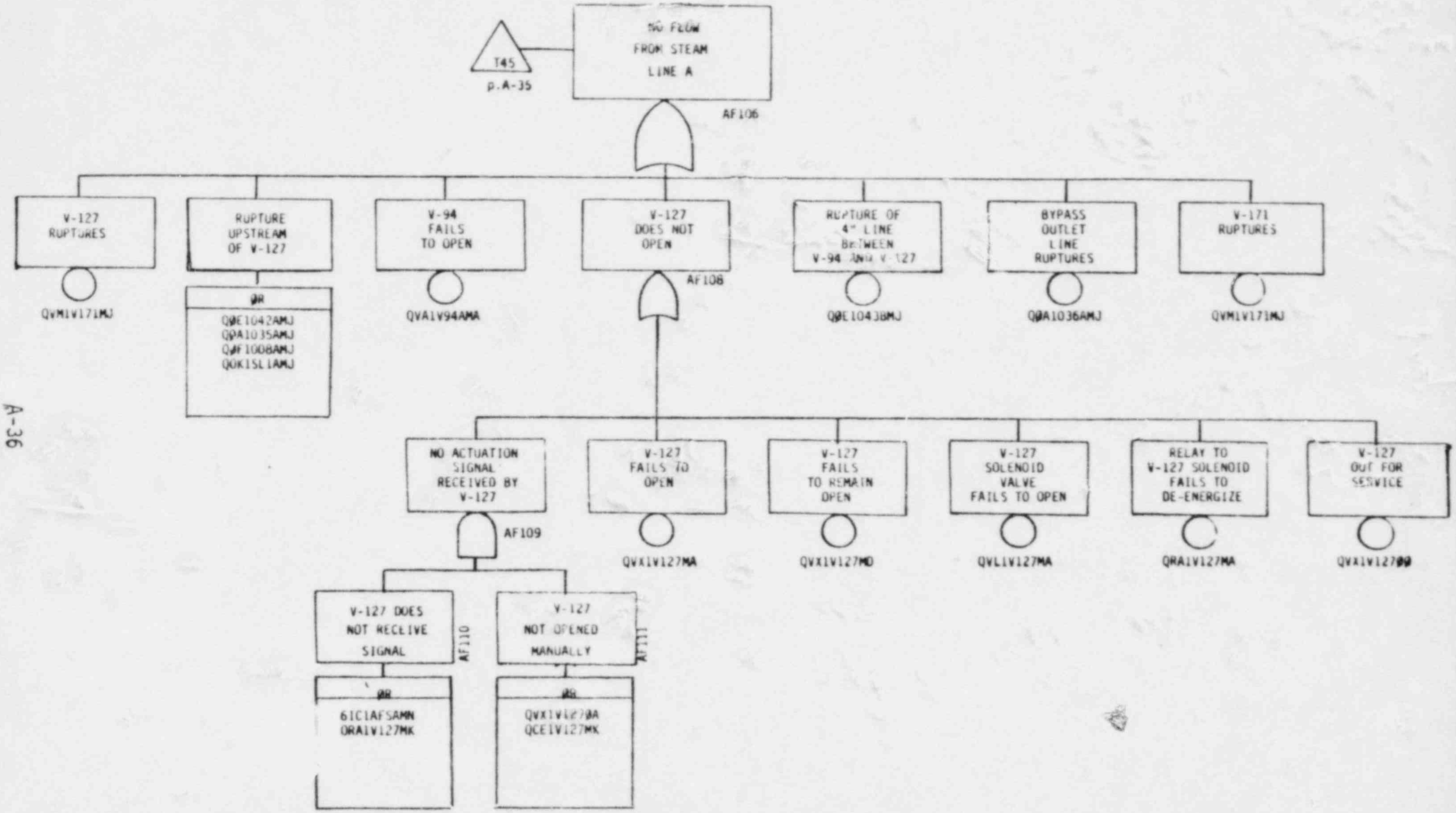

NO FLOW TO SUPPLY HEADER FROM P-37A
AF91
T40
p.A-14
p.A-28
p.A-29
p.A-30
V-65 CLOSED
AF92
0R
MVD1V65AMD
MVD1V65A0D
MVD1V65A00
NO FLOW FROM P-37A
AF93
T42
p.A-33
V-64 FAILS TO OPEN
MVA1V64AMA
NO SUCTION FLOW TO P-37A
AF119
RUPTURE OF 6" LINE BETWEEN P-37A AND
M0F1610CMJ
RUPTURE OF 3" RECIRC. LINE BETWEEN DISCHARGE LINE AND V-67
M0D1610AMJ
V-67 RUPTURES
MVM1V67AMJ
RUPTURE OF 8" SUCTION LINE BETWEEN V-154 AND CST
F0G1081AMJ
RUPTURE OF 8" SUCTION LINE BETWEEN V-154 AND V-155
F0G1081BMJ
NO FLOW THROUGH SUCTION VALVES
AF120
RUPTURE OF 8" SUCTION PIPE BETWEEN V-155 AND P37A
p.A-37
F0G1081CMJ
CONDENSATE STORAGE TANK RUPTURED
STA1TK25MJ
P-37A SUCTION VALVE V-155 CLOSED
AF121
0R
FVM1V155MD
FVM1V155MJ
FVM1V1550D
FVM1V15500
P-37A SUCTION VALVE V-154 CLOSED
AF122
0R
FVM1V154MD
FVM1V154MJ
FVM1V1550D
FVM1V15500

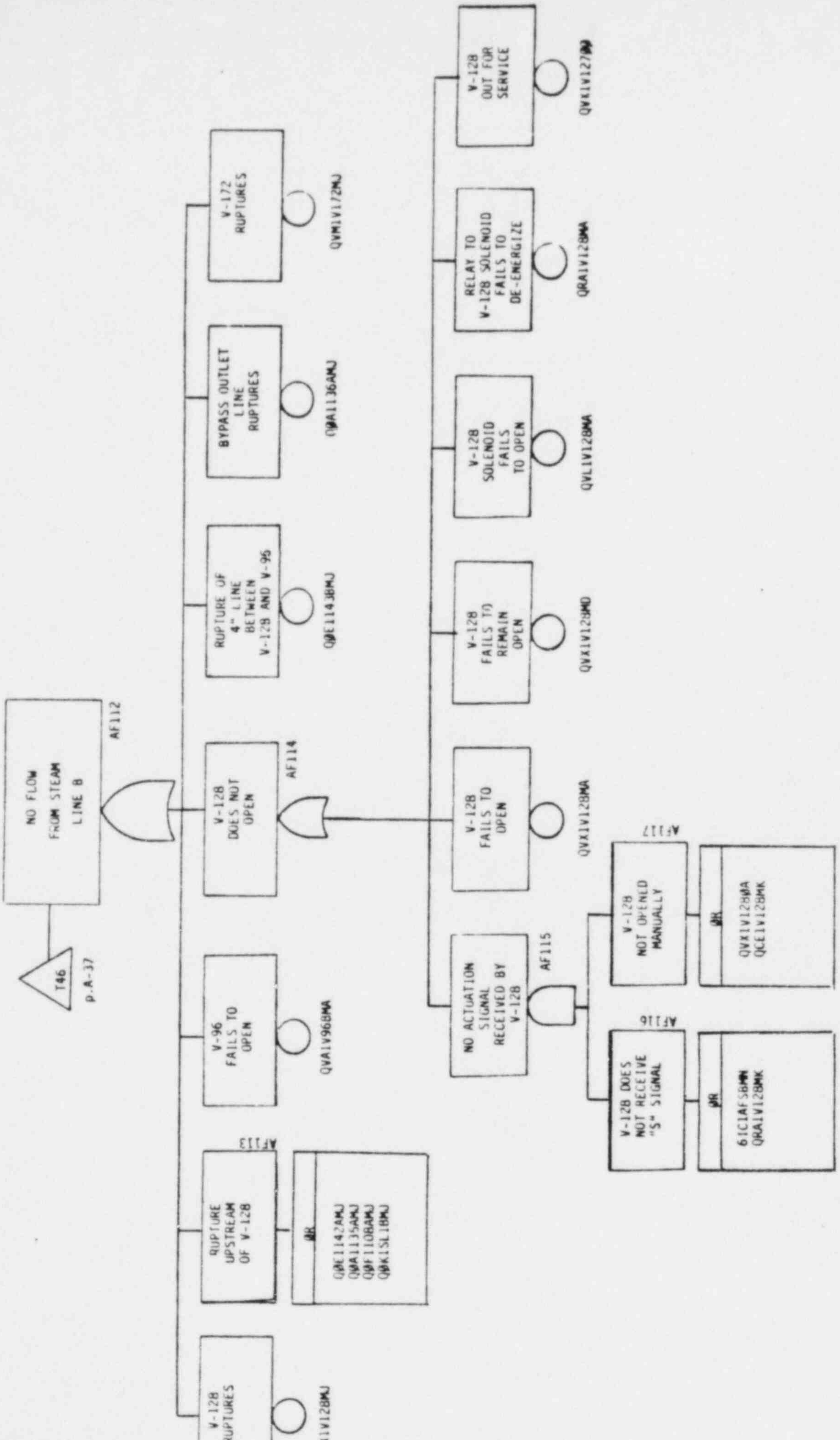

NO FLOW TO SUPPLY HEADER FROM P-37B
AF123
T41
p.A-14
p.A-26
p.A-29
p.A-30
V-71 CLOSED
AF128
OR
MVO1V71BMD
MVO1V71B0D
MVO1V71B00
NO FLOW FROM P-37B
AF129
T43
p.A-34
V-70 FAILS TO OPEN
MVA1V70BMA
NO SUCTION FLOW TO P-37B
AF137
RUPTURE OF 8" SUCTION LINE BETWEEN V-158 AND CST
F0G1082AMJ
RUPTURE OF 8" SUCTION LINE BETWEEN V-158 AND V-159
F0G1082BMJ
NO FLOW THROUGH SUCTION VALVES
AF138
P-37B SUCTION VALVE V-159 CLOSED
AF139
OR
FVM1V159MD
FVM1V159MJ
FVM1V1590D
FVM1V15900
P-37B SUCTION VALVE V-158 CLOSED
AF140
OR
FVM1V158MD
FVM1V158MJ
FVM1V1580D
FVM1V15800
RUPTURE OF 8" SUCTION LINE BETWEEN V-158 AND CST
F0G1082CMJ
CONDENSATE STORAGE TANK RUPTURED
STA1TK25MJ
RUPTURE OF 6" DISCHARGE LINE BETWEEN P-37B AND V-70
RUPTURE OF 3" RECIRC. LINE BETWEEN DISCHARGE LINE AND V-73
M001612AMJ
V-73 RUPTURES
MVM1V73BMJ

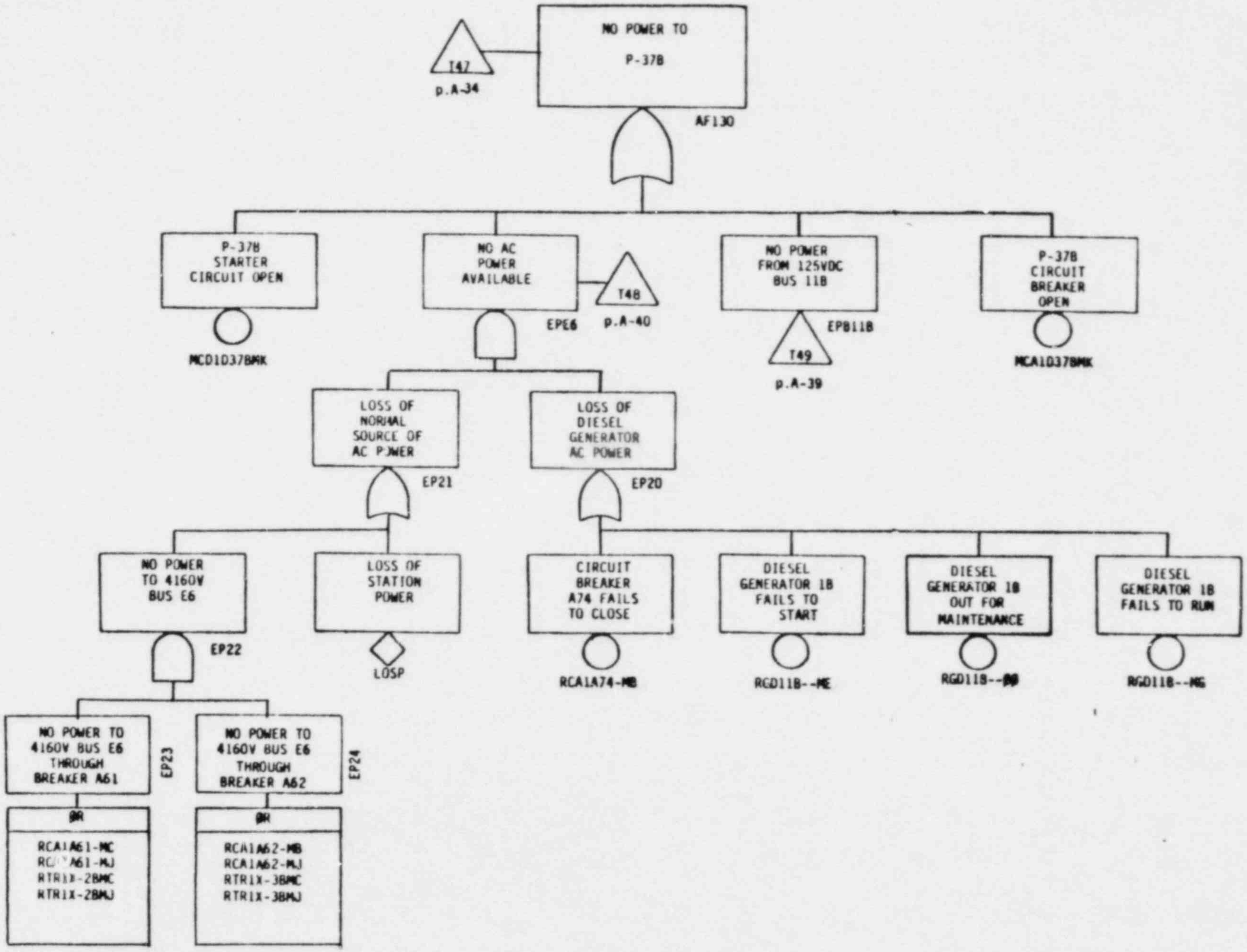

NO FLOW FROM P-37A
T42
p.A-31
AF93
P-37A FAILS TO OPERATE
AF100
T44
p.A-35
P-37A DOES NOT START
MPB1T37AME
P-37A OUT FOR MAINTENANCE
MPB1T37AM00
P-37A DOES NOT CONTINUE TO RUN
MPB1T37AMG
P-37A LUBRICATION FAILURE
MPB1T37ALB
OPERATOR TURNS OFF P-37A
AF99
P-37A COOLING FAILURE
MPB1T37ACL
OPERATOR BLOCKS ESF TRAIN A
6IC1AFSA0C
OPERATOR BLOCKS ESF TRAIN B
6IC1AFSB0C
OPERATOR STOPS P-37A
MPB1T37A0G

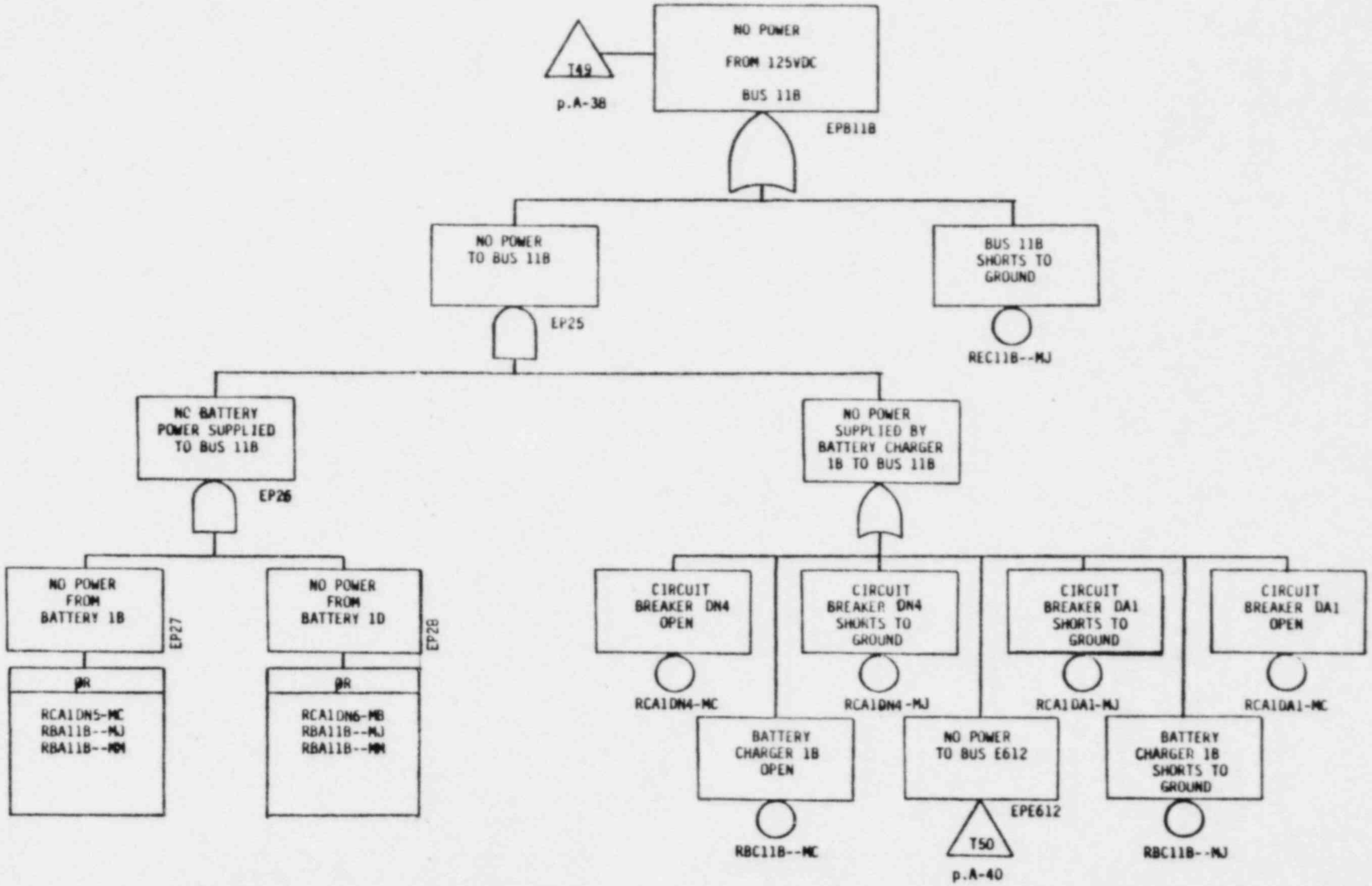

I43
p.A-32
NO FLOW FROM P-37B
AF129
NO POWER TO P-37B
AF130
T47
p.A-38
P-37B DOES NOT RECEIVE START SIGNAL
AF131
P-37B FAILS TO START
MPB1D37BME
P-37B LUBRICATION FAILURE
MPB1D37BLB
P-37B OUT FOR MAINTENANCE
MPB1D37B00
P-37B DOES NOT CONTINUE TO RUN
MPB1D37BMG
OPERATOR TURNS OFF P-37B
AF135
P-37B COOLING FAILURE
MPB1D37BCL
NO SIGNAL FROM ACTUATION CHANNEL A
AF132
OR
6IC1AFSAMN
MRA1A37BMK
NO SIGNAL FROM ACTUATION CHANNEL B
AF133
OR
6IC1AFSBMN
MRA1B37BMK
P-37B NOT MANUALLY STARTED
AF134
OR
MPB1D37B0E
MCE1D37BMK
OPERATOR BLOCKS ACTUATION SIGNAL A
6IC1AFSA0C
OPERATOR BLOCKS ACTUATION SIGNAL B
6IC1AFSB0C
OPERATOR TURNS OFF P-37B
MPB1D37B0G

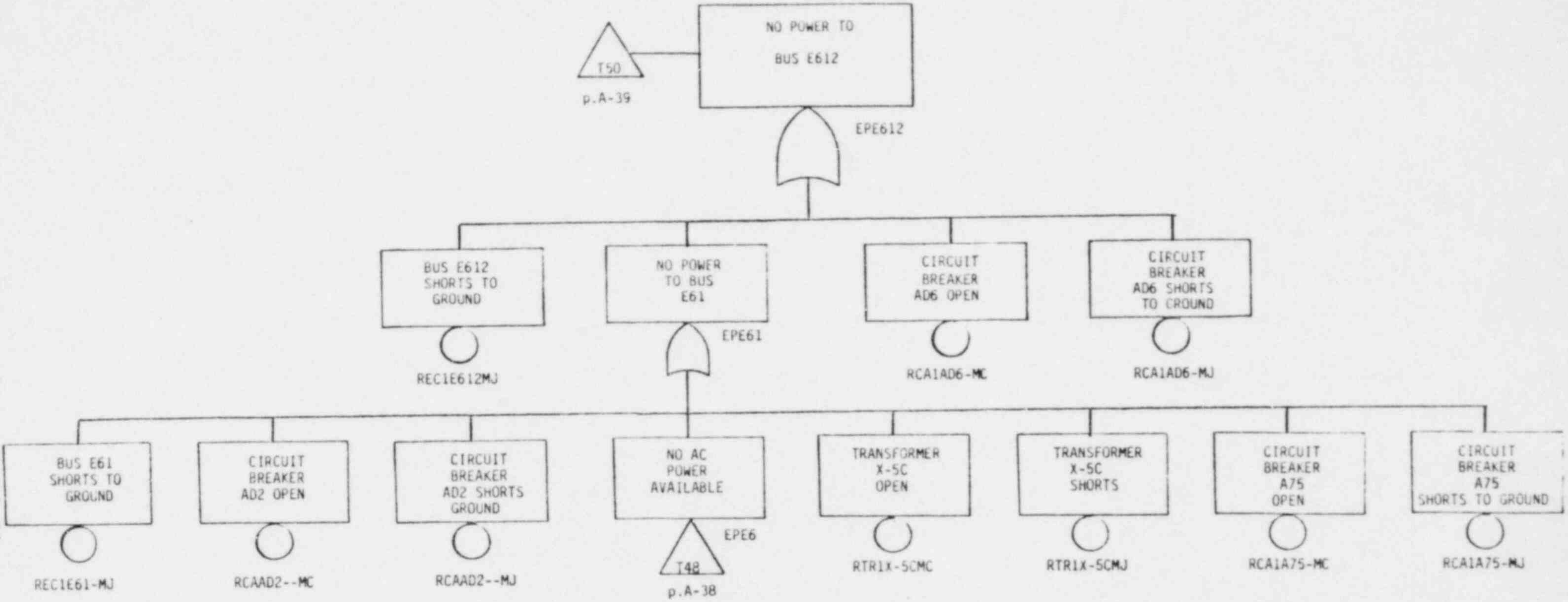

P-37A FAILS TO OPERATE
AF100
T44
p.A-35
NO STEAM FLOW TO P-37A TURBINE
AF101
P-37A TURBINE FAILS TO START
MTU1TD-2ME
NO FLOW THROUGH V-129
AF102
OR
QVD1V129MJ
QVD1V129MD
QVD1V129WW
NO FLOW THROUGH V-95
AF103
OR
QVM1V95AMJ
QVM1V95AMD
QVM1V95AMD
QVM1V95AWW
RUPTURE OF 4" LINE BETWEEN V-95 AND V-129
Q0E1449AMJ
RUPTURE OF 4" LINE BETWEEN TURBINE AND V-129
Q0E1449BMJ
RUPTURE OF 6" LINE BETWEEN TEE AND V-95
Q0F1449AMJ
NO FLOW AT INLET TO TURBINE LINE
AF104
NO STEAM FLOW FROM MAIN STEAM LINES
AF105
NO FLOW FROM STEAM LINE A
AF106
T45
p.A-36
NO FLOW FROM STEAM LINE B
AF112
T46
p.A-37
RUPTURE OF 6" LINE BETWEEN REDUCER AND TEE
Q0F1109AMJ
RUPTURE OF 6" LINE BETWEEN REDUCER AND TEE
Q0F1009AMF
RUPTURE OF 4" LINE BETWEEN REDUCER AND V-96
Q0E1143AMJ
RUPTURE OF 4" LINE BETWEEN REDUCER AND V-94
QVA1V94AMJ
V-94 RUPTURES
QVA1V94AMJ
V-96 RUPTURES
QVA1V96BMJ

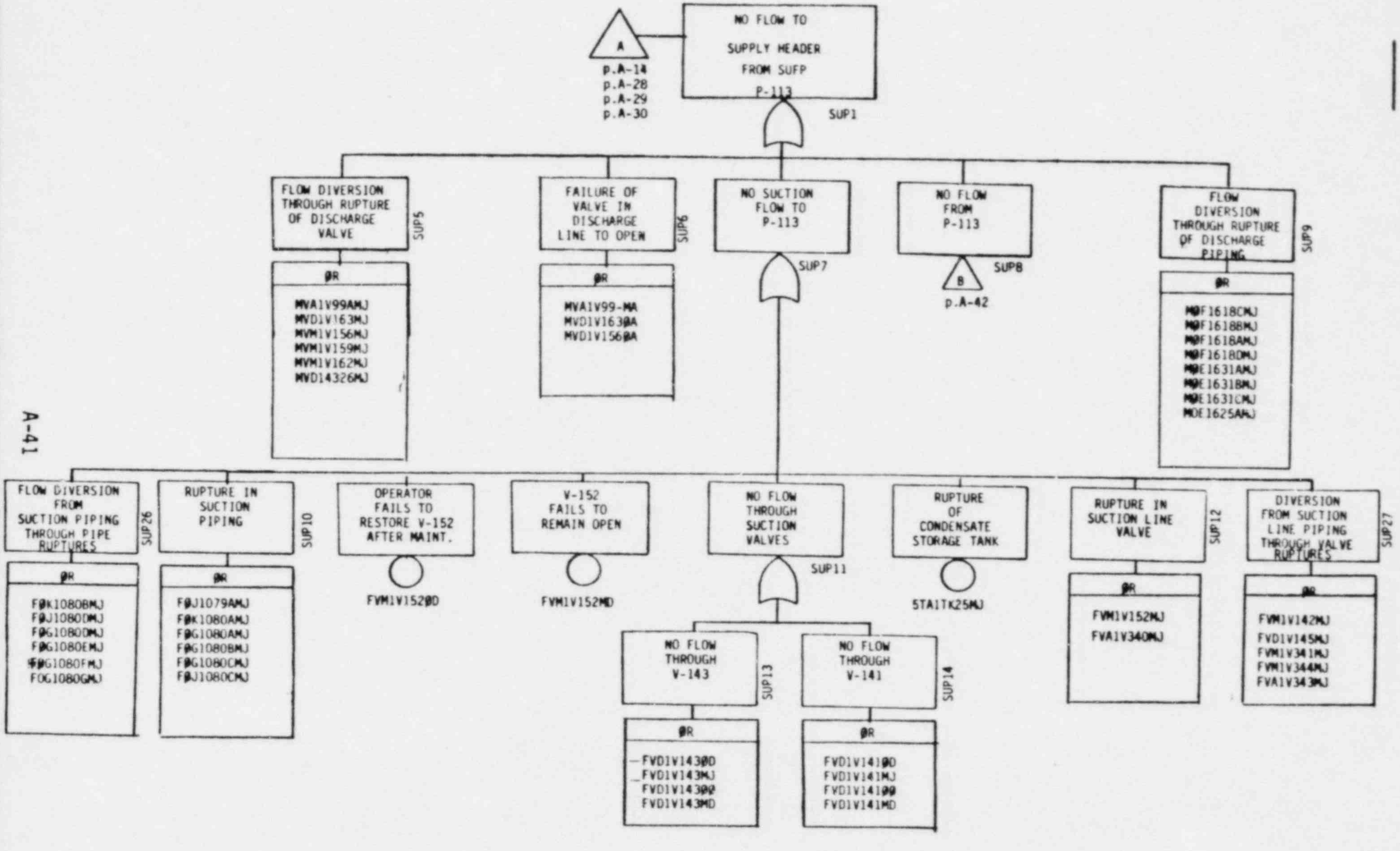

T45
p.A-35
NO FLOW FROM STEAM LINE A
AF106
V-127 RUPTURES
QVM1V171MJ
RUPTURE UPSTREAM OF V-127
OR
Q0E1042AMJ
Q0A1035AMJ
Q0F1008AMJ
QOK1SL1AMJ
V-94 FAILS TO OPEN
QVA1V94AMA
V-127 DOES NOT OPEN
AF108
RUPTURE OF 4" LINE BETWEEN V-94 AND V-127
Q0E1043BMJ
BYPASS OUTLET LINE RUPTURES
Q0A1036AMJ
V-171 RUPTURES
QVM1V171MJ
NO ACTUATION SIGNAL RECEIVED BY V-127
AF109
V-127 FAILS TO OPEN
QVX1V127MA
V-127 FAILS TO REMAIN OPEN
QVX1V127MD
V-127 SOLENOID VALVE FAILS TO OPEN
QVL1V127MA
RELAY TO V-127 SOLENOID FAILS TO DE-ENERGIZE
QRA1V127MA
V-127 OUT FOR SERVICE
QVX1V12700
V-127 DOES NOT RECEIVE SIGNAL
AF110
OR
6IC1AFSAMN
QRA1V127MK
V-127 NOT OPENED MANUALLY
AF111
OR
QVX1V1270A
QCE1V127MK

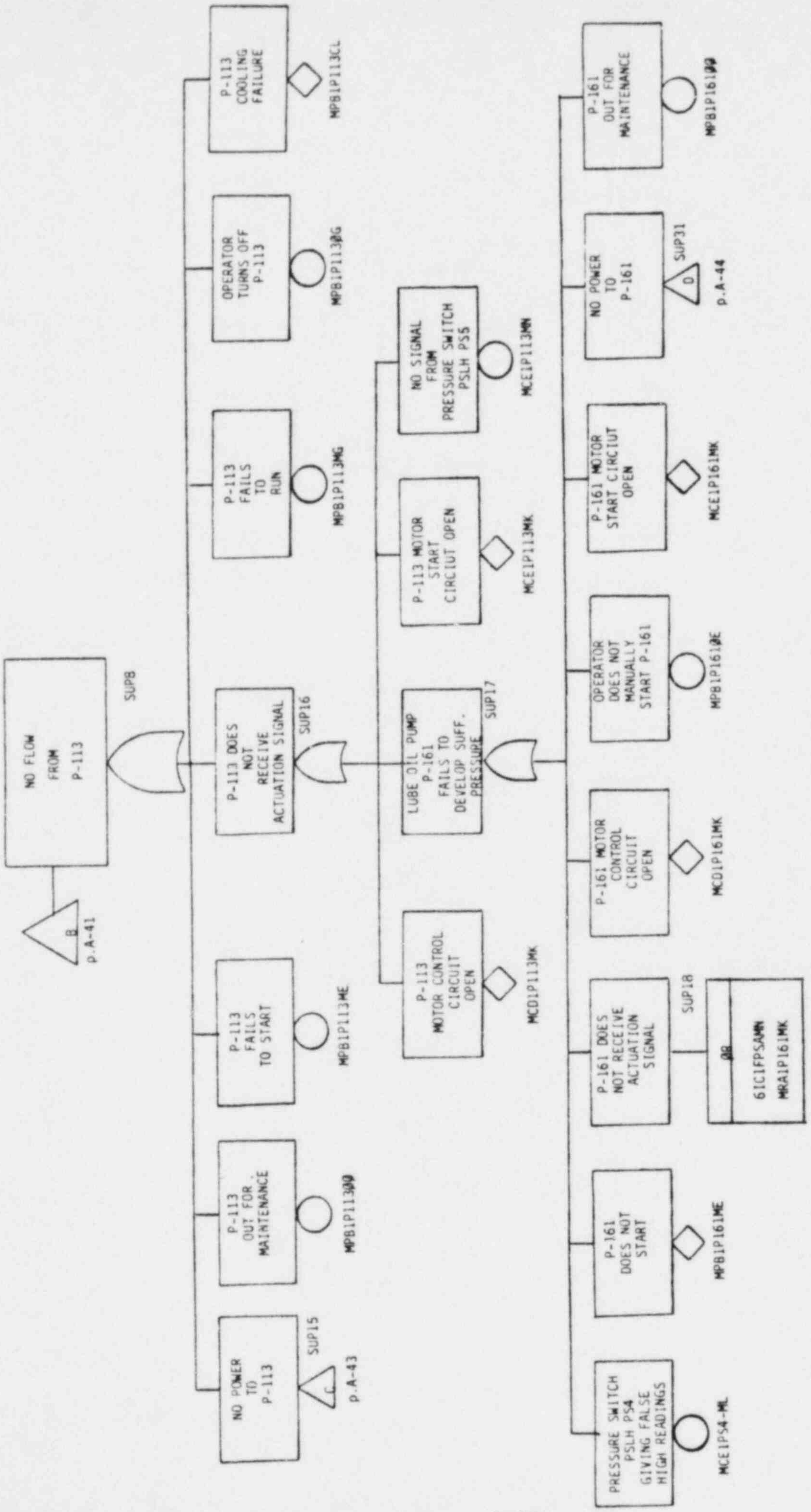

T46
p.A-37
NO FLOW FROM STEAM LINE B
AF112
V-128 RUPTURES
QVXIV128MJ
RUPTURE UPSTREAM OF V-128
AF113
OR
Q0E1142AMJ
Q0A1135AMJ
Q0F1108AMJ
Q0KISL18MJ
V-96 FAILS TO OPEN
QVAIV968MA
V-128 DOES NOT OPEN
AF114
RUPTURE OF 4" LINE BETWEEN V-128 AND V-95
Q0E1143BMJ
BYPASS OUTLET LINE RUPTURES
Q0A1136AMJ
V-172 RUPTURES
QVMIV172MJ
NO ACTUATION SIGNAL RECEIVED BY V-128
AF115
V-128 DOES NOT RECEIVE "S" SIGNAL
AF116
OR
6ICIAFSBMN
QRAIV128MK
V-128 NOT OPENED MANUALLY
AF117
OR
QVXIV1280A
QCEIV128MK
V-128 FAILS TO OPEN
QVXIV128MA
V-128 FAILS TO REMAIN OPEN
QVXIV128MD
V-128 SOLENOID FAILS TO OPEN
QVLIV128MA
RELAY TO V-128 SOLENOID FAILS TO DE-ENERGIZE
QRAIV128MA
V-128 OUT FOR SERVICE
QVXIV127MJ

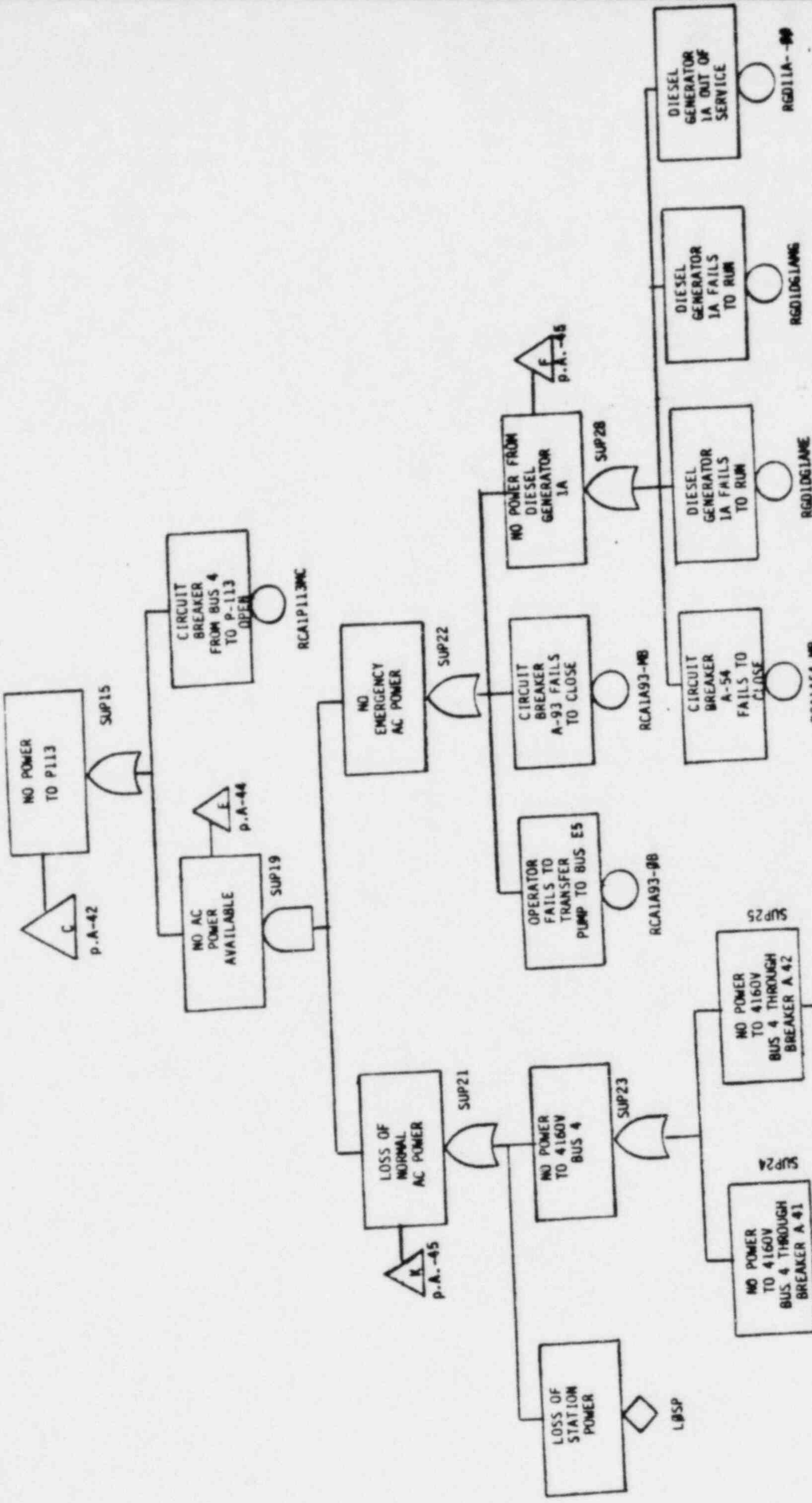

NO POWER TO P-37B
T47
p.A-34
AF130
P-37B STARTER CIRCUIT OPEN
MCD1D37BMK
NO AC POWER AVAILABLE
EPE6
T48
p.A-40
NO POWER FROM 125VDC BUS 11B
EP811B
T49
p.A-39
P-37B CIRCUIT BREAKER OPEN
MCA1D37BMK
LOSS OF NORMAL SOURCE OF AC POWER
EP21
LOSS OF DIESEL GENERATOR AC POWER
EP20
NO POWER TO 4160V BUS E6
EP22
LOSS OF STATION POWER
LOSP
CIRCUIT BREAKER A74 FAILS TO CLOSE
RCA1A74-MB
DIESEL GENERATOR 1B FAILS TO START
RGD11B--ME
DIESEL GENERATOR 1B OUT FOR MAINTENANCE
RGD11B--00
DIESEL GENERATOR 1B FAILS TO RUN
RGD11B--MG
NO POWER TO 4160V BUS E6 THROUGH BREAKER A61
EP23
OR
RCA1A61-MC
RC/'A61-MJ
RTR1X-2BMC
RTR1X-2BMJ
NO POWER TO 4160V BUS E6 THROUGH BREAKER A62
EP24
OR
RCA1A62-MB
RCA1A62-MJ
RTR1X-3BMC
RTR1X-3BMJ

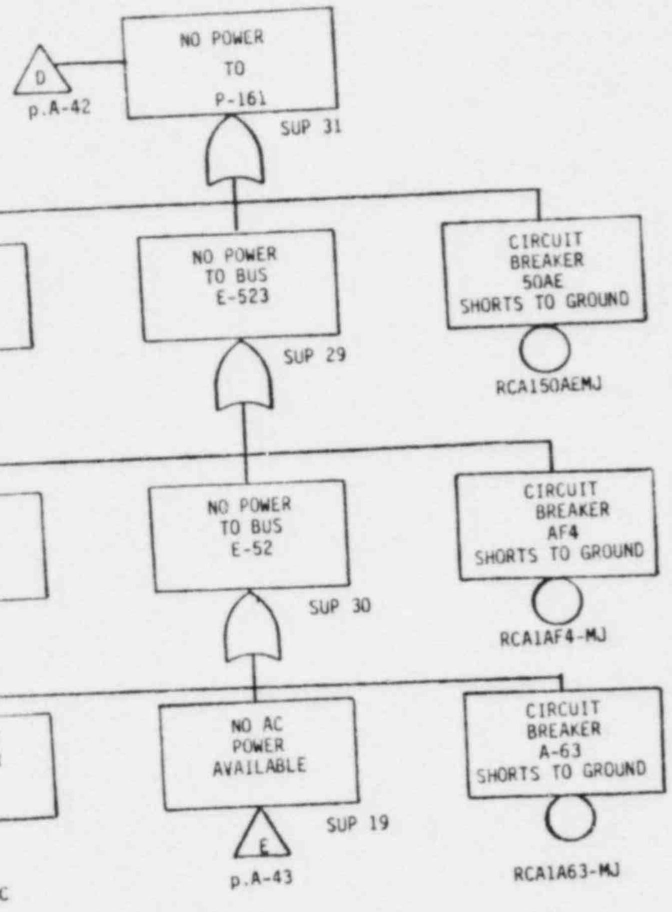

NO POWER FROM 125VDC BUS 11B
EPB11B
T49
p.A-38
NO POWER TO BUS 11B
EP25
BUS 11B SHORTS TO GROUND
REC11B--MJ
NC BATTERY POWER SUPPLIED TO BUS 11B
EP26
NO POWER SUPPLIED BY BATTERY CHARGER 1B TO BUS 11B
NO POWER FROM BATTERY 1B
EP27
OR
RCA1DN5-MC
RBA11B--MJ
RBA11B--MM
NO POWER FROM BATTERY 1D
EP28
OR
RCA1DN6-MB
RBA11B--MJ
RBA11B--MM
CIRCUIT BREAKER DN4 OPEN
RCA1DN4-MC
BATTERY CHARGER 1B OPEN
RBC11B--MC
CIRCUIT BREAKER DN4 SHORTS TO GROUND
RCA1DN4-MJ
NO POWER TO BUS E612
EPE612
T50
p.A-40
CIRCUIT BREAKER DA1 SHORTS TO GROUND
RCA1DA1-MJ
BATTERY CHARGER 1B SHORTS TO GROUND
RBC11B--MJ
CIRCUIT BREAKER DA1 OPEN
RCA1DA1-MC

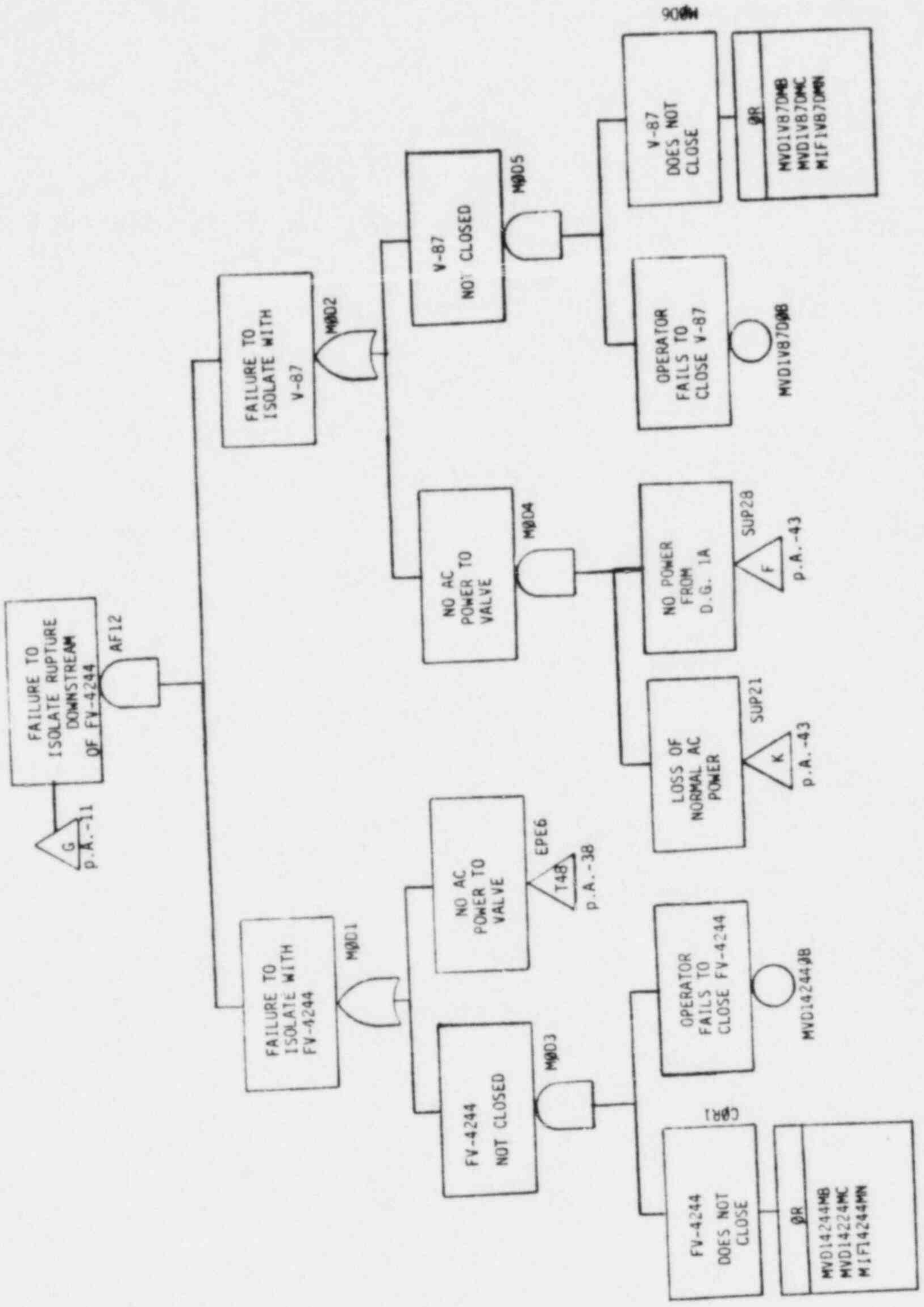

NO POWER TO BUS E612
T50
p.A-39
EPE612
BUS E612 SHORTS TO GROUND
REC1E612MJ
NO POWER TO BUS E61
EPE61
CIRCUIT BREAKER AD6 OPEN
RCA1AD6-MC
CIRCUIT BREAKER AD6 SHORTS TO GROUND
RCA1AD6-MJ
BUS E61 SHORTS TO GROUND
REC1E61-MJ
CIRCUIT BREAKER AD2 OPEN
RCAAD2--MC
CIRCUIT BREAKER AD2 SHORTS GROUND
RCAAD2--MJ
NO AC POWER AVAILABLE
EPE6
T48
p.A-38
TRANSFORMER X-5C OPEN
RTR1X-5CMC
TRANSFORMER X-5C SHORTS
RTR1X-5CMJ
CIRCUIT BREAKER A75 OPEN
RCA1A75-MC
CIRCUIT BREAKER A75 SHORTS TO GROUND
RCA1A75-MJ

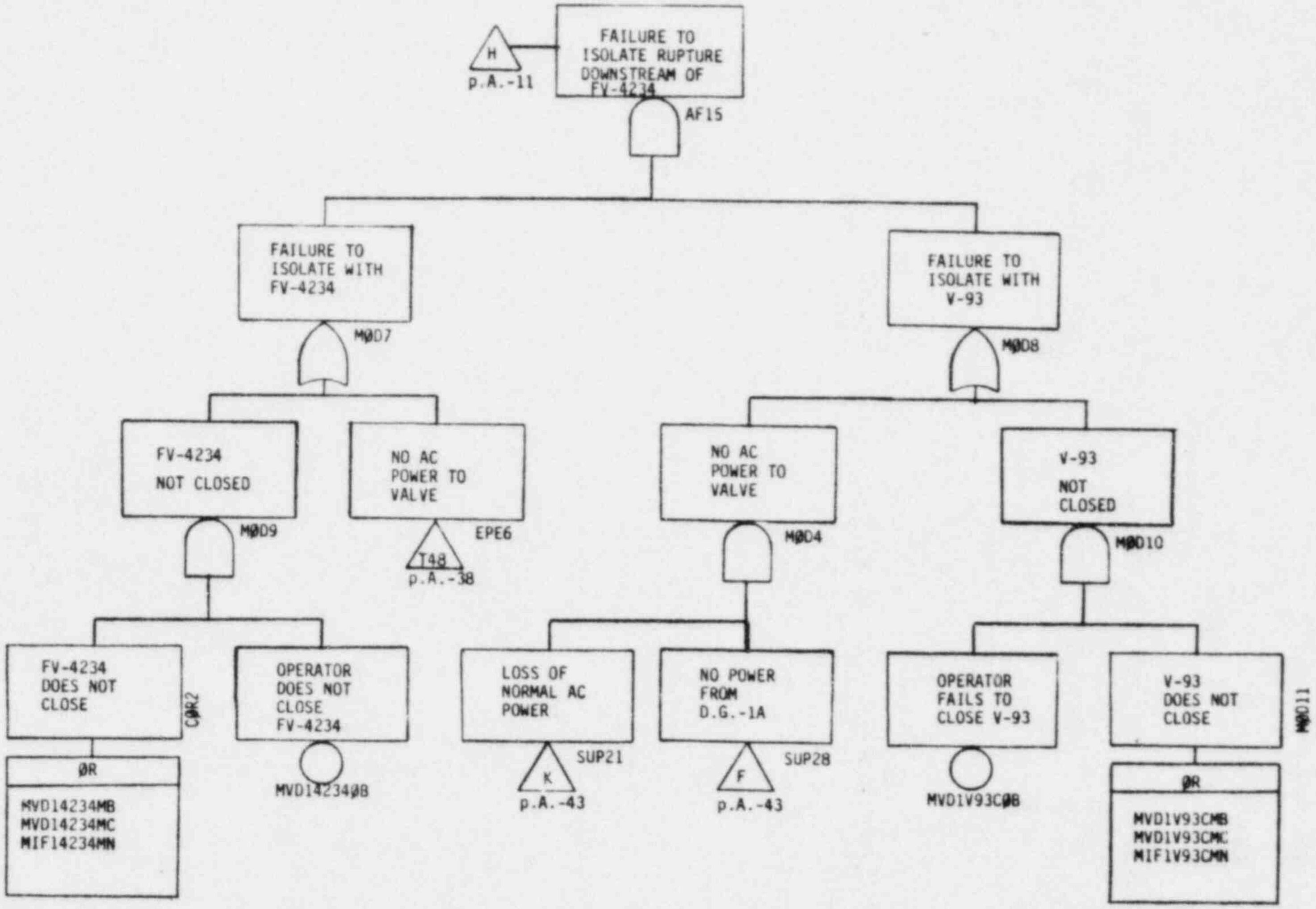

NO FLOW TO SUPPLY HEADER FROM SUFP P-113
SUP1
A
p.A-14
p.A-28
p.A-29
p.A-30
FLOW DIVERSION THROUGH RUPTURE OF DISCHARGE VALVE
SUP5
OR
MVA1V99AMJ
MVD1V163MJ
MVM1V156MJ
MVM1V159MJ
MVM1V162MJ
MVD14326MJ
FAILURE OF VALVE IN DISCHARGE LINE TO OPEN
SUP6
OR
MVA1V99-MA
MVD1V163OA
MVD1V156OA
NO SUCTION FLOW TO P-113
SUP7
NO FLOW FROM P-113
SUP8
B
p.A-42
FLOW DIVERSION THROUGH RUPTURE OF DISCHARGE PIPING
SUP9
OR
MOF1618CMJ
MOF1618BMJ
MOF1618AMJ
MOF1618DMJ
MOE1631AMJ
MOE1631BMJ
MOE1631CMJ
MDE1625AMJ
FLOW DIVERSION FROM SUCTION PIPING THROUGH PIPE RUPTURES
SUP26
OR
FOK1080BMJ
FOJ1080DMJ
FOG1080DMJ
FOG1080EMJ
FOG1080FMJ
FOG1080GMJ
RUPTURE IN SUCTION PIPING
SUP10
OR
FOJ1079AMJ
FOK1080AMJ
FOG1080AMJ
FOG1080BMJ
FOG1080CMJ
FOJ1080CMJ
OPERATOR FAILS TO RESTORE V-152 AFTER MAINT.
FVM1V152OD
V-152 FAILS TO REMAIN OPEN
FVM1V152MD
NO FLOW THROUGH SUCTION VALVES
SUP11
NO FLOW THROUGH V-143
SUP13
OR
FVD1V143OD
FVD1V143MJ
FVD1V143OO
FVD1V143MD
NO FLOW THROUGH V-141
SUP14
OR
FVD1V141OD
FVD1V141MJ
FVD1V141OO
FVD1V141MD
RUPTURE OF CONDENSATE STORAGE TANK
STA1TK25MJ
RUPTURE IN SUCTION LINE VALVE
SUP12
OR
FVM1V152MJ
FVA1V340MJ
DIVERSION FROM SUCTION LINE PIPING THROUGH VALVE RUPTURES
SUP27
OR
FVM1V142MJ
FVD1V145MJ
FVM1V341MJ
FVM1V344MJ
FVA1V343MJ

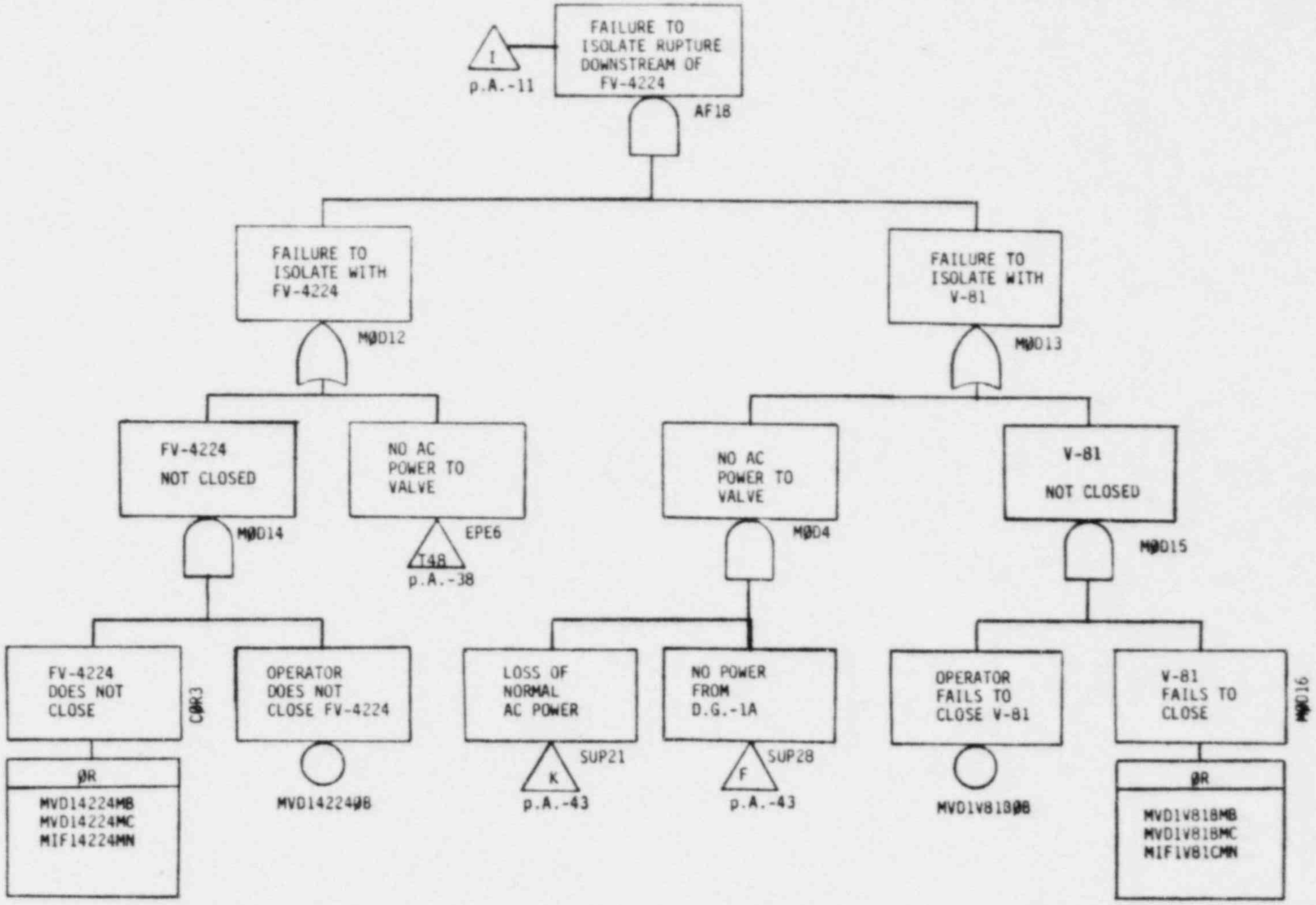

NO FLOW FROM P-113
SUP8
B
p.A-41
NO POWER TO P-113
SUP15
C
p.A-43
P-113 OUT FOR MAINTENANCE
MPB1P11300
P-113 FAILS TO START
MPB1P113ME
P-113 DOES NOT RECEIVE ACTUATION SIGNAL
SUP16
P-113 FAILS TO RUN
MPB1P113MG
OPERATOR TURNS OFF P-113
MPB1P1130G
P-113 COOLING FAILURE
MPB1P113CL
P-113 MOTOR CONTROL CIRCUIT OPEN
MCD1P113MK
LUBE OIL PUMP P-161 FAILS TO DEVELOP SUFF. PRESSURE
SUP17
P-113 MOTOR START CIRCIUT OPEN
MCE1P113MK
NO SIGNAL FROM PRESSURE SWITCH PSLH PS5
MCE1P113MN
PRESSURE SWITCH PSLH PS4 GIVING FALSE HIGH READINGS
MCE1PS4-ML
P-161 DOES NOT START
MPB1P161ME
P-161 DOES NOT RECEIVE ACTUATION SIGNAL
SUP18
OR
6IC1FPSAMN
MRA1P161MK
P-161 MOTOR CONTROL CIRCUIT OPEN
MCD1P161MK
OPERATOR DOES NOT MANUALLY START P-161
MPB1P1610E
P-161 MOTOR START CIRCIUT OPEN
MCE1P161MK
NO POWER TO P-161
SUP31
D
p.A-44
P-161 OUT FOR MAINTENANCE
MPB1P16100

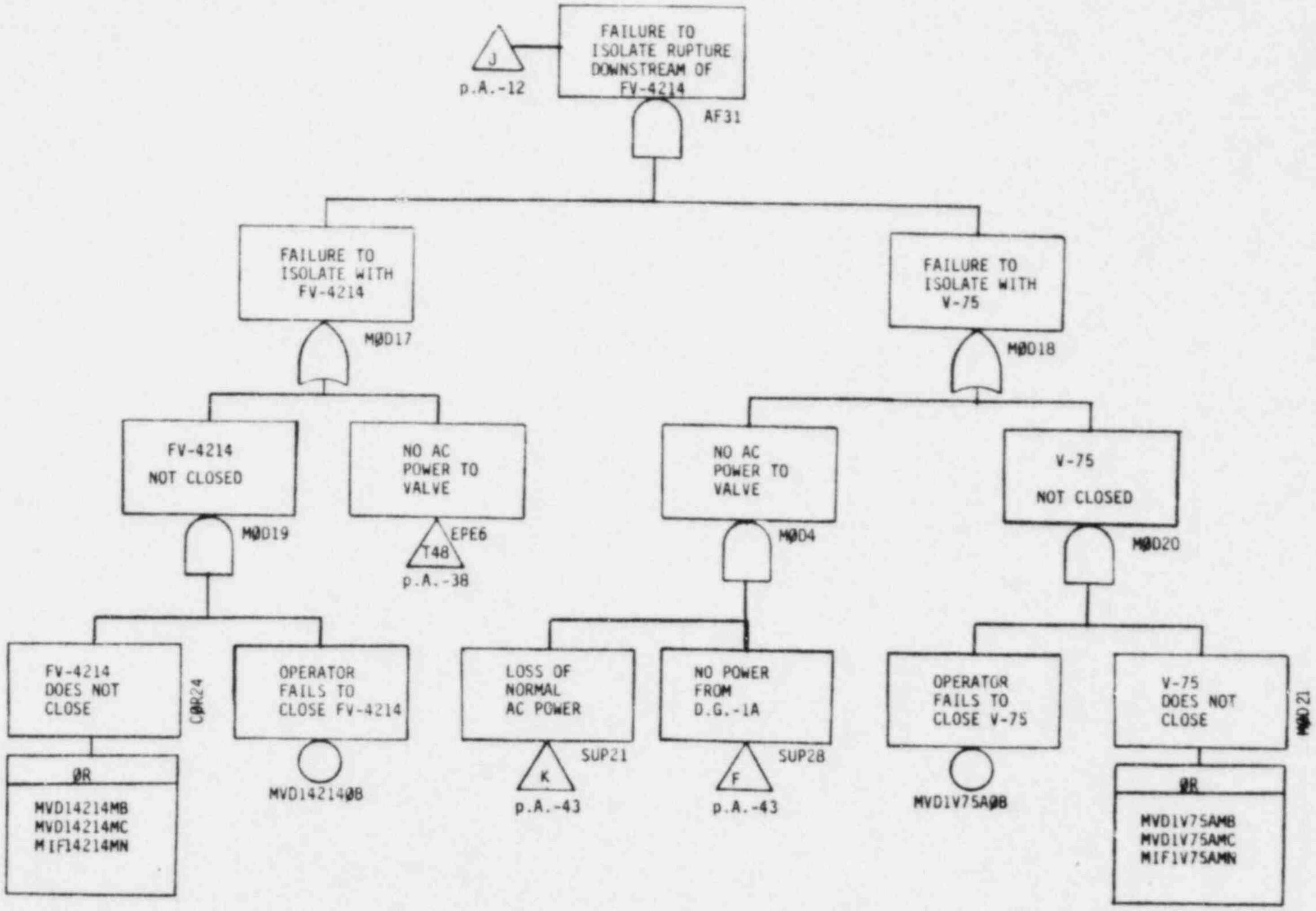

NO POWER TO P113
SUP15
C
p.A-42
NO AC POWER AVAILABLE
SUP19
F
p.A-44
CIRCUIT BREAKER FROM BUS 4 TO P-113 OPEN
RCA1P113MC
LOSS OF NORMAL AC POWER
SUP21
K
p.A.-45
NO EMERGENCY AC POWER
SUP22
LOSS OF STATION POWER
LØSP
NO POWER TO 4160V BUS 4
SUP23
NO POWER TO 4160V BUS 4 THROUGH BREAKER A 41
SUP24
ØR
RCA1A41-MC
RCA1A41-MJ
RTR1X-2BMC
RTR1X-2BMJ
NO POWER TO 4160V BUS 4 THROUGH BREAKER A 42
SUP25
ØR
RCA1A42-MB
RCA1A42-MJ
RTR1X-3BMC
RTR1X-3BMJ
OPERATOR FAILS TO TRANSFER PUMP TO BUS E5
RCA1A93-ØB
CIRCUIT BREAKER A-93 FAILS TO CLOSE
RCA1A93-MB
NO POWER FROM DIESEL GENERATOR 1A
SUP28
F
p.A.-46
CIRCUIT BREAKER A-54 FAILS TO CLOSE
RCA1A54-MB
DIESEL GENERATOR 1A FAILS TO RUN
RGD1DG1AME
DIESEL GENERATOR 1A FAILS TO RUN
RGD1DG1AMG
DIESEL GENERATOR 1A OUT OF SERVICE
RGD11A--


p.A-42
D
NO POWER TO P-161
SUP 31
CIRCUIT BREAKER 50AE OPEN
RCA150AEMC
NO POWER TO BUS E-523
SUP 29
CIRCUIT BREAKER 50AE SHORTS TO GROUND
RCA150AEMJ
CIRCUIT BREAKER AF4 OPEN
RCA1AF4-MC
NO POWER TO BUS E-52
SUP 30
CIRCUIT BREAKER AF4 SHORTS TO GROUND
RCA1AF4-MJ
CIRCUIT BREAKER A-63 OPEN
RCA1A63-MC
NO AC POWER AVAILABLE
SUP 19
E
p.A-43
CIRCUIT BREAKER A-63 SHORTS TO GROUND
RCA1A63-MJ


G
p.A.-11
FAILURE TO ISOLATE RUPTURE DOWNSTREAM OF FV-4244
AF12
FAILURE TO ISOLATE WITH FV-4244
MO01
FAILURE TO ISOLATE WITH V-87
MO02
FV-4244 NOT CLOSED
MO03
NO AC POWER TO VALVE
EPE6
T48
p.A.-38
NO AC POWER TO VALVE
MO04
V-87 NOT CLOSED
MO05
FV-4244 DOES NOT CLOSE
COR1
OR
MVD14244MB
MVD14224MC
MIF14244MN
OPERATOR FAILS TO CLOSE FV-4244
MVD14244OB
LOSS OF NORMAL AC POWER
SUP21
K
p.A.-43
NO POWER FROM D.G. 1A
SUP28
F
p.A.-43
OPERATOR FAILS TO CLOSE V-87
MVD1V87DOB
V-87 DOES NOT CLOSE
MO06
OR
MVD1V87DMB
MVD1V87DMC
MIF1V87DMN


H
p.A.-11
FAILURE TO ISOLATE RUPTURE DOWNSTREAM OF FV-4234
AF15
FAILURE TO ISOLATE WITH FV-4234
MOD7
FAILURE TO ISOLATE WITH V-93
MOD8
FV-4234 NOT CLOSED
MOD9
NO AC POWER TO VALVE
EPE6
T48
p.A.-38
NO AC POWER TO VALVE
MOD4
V-93 NOT CLOSED
MOD10
FV-4234 DOES NOT CLOSE
COR2
OR
MVD14234MB
MVD14234MC
MIF14234MN
OPERATOR DOES NOT CLOSE FV-4234
MVD14234OB
LOSS OF NORMAL AC POWER
K
SUP21
p.A.-43
NO POWER FROM D.G.-1A
F
SUP28
p.A.-43
OPERATOR FAILS TO CLOSE V-93
MVD1V93COB
V-93 DOES NOT CLOSE
MOD11
OR
MVD1V93CMB
MVD1V93CMC
MIF1V93CMN


FAILURE TO ISOLATE RUPTURE DOWNSTREAM OF FV-4224
I
p.A.-11
AF18
FAILURE TO ISOLATE WITH FV-4224
MØD12
FAILURE TO ISOLATE WITH V-81
MØD13
FV-4224 NOT CLOSED
MØD14
NO AC POWER TO VALVE
EPE6
T48
p.A.-38
NO AC POWER TO VALVE
MØD4
V-81 NOT CLOSED
MØD15
FV-4224 DOES NOT CLOSE
CØR3
ØR
MVD14224MB
MVD14224MC
MIF14224MN
OPERATOR DOES NOT CLOSE FV-4224
MVD14224ØB
LOSS OF NORMAL AC POWER
SUP21
K
p.A.-43
NO POWER FROM D.G.-1A
SUP28
F
p.A.-43
OPERATOR FAILS TO CLOSE V-81
MVD1V81ØØB
V-81 FAILS TO CLOSE
MØD16
ØR
MVD1V81BMB
MVD1V81BMC
MIF1V81CMN


J
p.A.-12
FAILURE TO ISOLATE RUPTURE DOWNSTREAM OF FV-4214
AF31
FAILURE TO ISOLATE WITH FV-4214
M0D17
FAILURE TO ISOLATE WITH V-75
M0D18
FV-4214 NOT CLOSED
M0D19
NO AC POWER TO VALVE
EPE6
T48
p.A.-38
NO AC POWER TO VALVE
M0D4
V-75 NOT CLOSED
M0D20
FV-4214 DOES NOT CLOSE
C0R24
0R
MVD14214MB
MVD14214MC
MIF14214MN
OPERATOR FAILS TO CLOSE FV-4214
MVD142140B
LOSS OF NORMAL AC POWER
SUP21
K
p.A.-43
NO POWER FROM D.G.-1A
SUP28
F
p.A.-43
OPERATOR FAILS TO CLOSE V-75
MVD1V75A0B
V-75 DOES NOT CLOSE
M0D21
0R
MVD1V75AMB
MVD1V75AMC
MIF1V75AMN

APPENDIX B

FAULT TREE DATA

TABLE B.1

MECHANICAL AND ELECTRICAL COMPONENT FAILURE RATES

			FAILURE RATE					
			WASH-1400	GE	NRC		IEEE-500	RECOMMENDED
CATEGORY	COMPONENT	FAILURE MODE			BWR	PWR		
Pumps	Pump (Motor Driven)	Fails to start	1×10^{-3}/d	7.9×10^{-6}/hr.	3.7×10^{-4}/d	5.3×10^{-4}/d (2.4×10^{-3}/d)*		2.4×10^{-3}/d
		Fails to run	3×10^{-5}/hr.		8.4×10^{-6}/hr	3×10^{-6}/hr. (3.4×10^{-3}/d)*		3.4×10^{-3}/d
	Pumps (Turbine Driven)	Fails to start	3×10^{-3}/d	7.9×10^{-6}/hr.	5.5×10^{-4}/d	4×10^{-3}/d (8.4×10^{-3}/d)*		8.4×10^{-3}/d
		Fails to run	3×10^{-5}/hr.		8.4×10^{-6}/hr	3×10^{-6}/hr. (5.7×10^{-3}/d) *		5.7×10^{-3}/d
Motors	Motor	Fails to start	3×10^{-4}/d					3×10^{-4}/d
		Fails to run	1×10^{-5}/hr.	1×10^{-6}/hr.				1×10^{-5}/hr
Diesel	Diesels	Fails to start	3×10^{-2}/d			4.0×10^{-2}/d (monthly)		4.0×10^{-2}/d
		Fails to run	3×10^{-3}/hr.			3.0×10^{-2}/hr (monthly)		3.0×10^{-2}/hr.
Pipe	Pipe $\leq$ 3"	Rupture	1×10^{-9}/hr.					1×10^{-9}/hr
	Pipe > 3"	Rupture	1×10^{-10}/hr.					1×10^{-10}/hr
Valves	Motor Operated	NO FO	1×10^{-3}/d	1.6×10^{-6}/hr	3×10^{-3}/d	2×10^{-3}/d		2×10^{-3}/d
		NC FC	1×10^{-3}/d	1.5×10^{-6}/hr				1×10^{-3}/d
		NO FC	1×10^{-4}/d	0.15×10^{-6}/hr	1×10^{-3}/d	5×10^{-4}/d		5×10^{-4}/d
		NC FO	1×10^{-4}/d	0.16×10^{-6}/hr				1×10^{-4}/d
		Rupture	1×10^{-8}/hr.					1×10^{-8}/hr
	Check Valve	Fails to open	1×10^{-4}/d	0.15×10^{-6}/d	1×10^{-4}/d	2×10^{-4}/d ***		2×10^{-4}/d
		Internal Leak	3×10^{-7}/hr.**	1.6×10^{-6}/hr	1.2×10^{-6}/hr	4.7×10^{-7}/hr		4.7×10^{-7}/hr
		Rupture	1×10^{-8}/hr					1×10^{-8}/hr
	Manual Valve	FTRO (plug)	1×10^{-4}/d					1×10^{-4}/d
		Rupture	1×10^{-8}/hr.		1×10^{-7}/hr	2×10^{-8}/hr		2×10^{-8}/hr
		Fail to operate			1×10^{-4}/d	8×10^{-5}/d		8×10^{-5}/d
	Motor Driven Operators	Spurious Opening					1.2×10^{-7}/hr	1.2×10^{-7}/hr
		Spurious Closing					1.2×10^{-7}/hr	1.2×10^{-7}/hr
		Fail to Open					2.5×10^{-6}/d	2.5×10^{-6}/d
		Fail to Close					2.5×10^{-6}/d	2.5×10^{-6}/d

* Specific to Aux. Feed Pumps

** 95 percent confidence bound

*** Value for Westinghouse

TABLE B.1

MECHANICAL AND ELECTRICAL COMPONENT FAILURE RATES

			FAILURE RATE					
			WASH-1400	GE	NRC		IEEE-500	RECOMMENDED
CATEGORY	COMPONENT	FAILURE MODE			BWR	PWR		
Valves (cont'd)	Solenoid Operated	Fail to operate	1×10^{-3}/d					1×10^{-3}/d
		FTRO (plug)	1×10^{-4}/d					1×10^{-1}/d
		Rupture	1×10^{-8}/hr					1×10^{-8}/hr
	Air Operated	Fail to operate	3×10^{-4}/d		3×10^{-3}/d	9×10^{-4}/d		9×10^{-4}/d
		FTRO (plug)	1×10^{-4}/d			1×10^{-7}/hr		1×10^{-4}/d
		Rupture	1×10^{-8}/hr		4×10^{-7}/hr	1×10^{-7}/hr		1×10^{-7}/hr
	Relief Valves	Fail to open	1×10^{-5}/d		8×10^{-3}/d			8×10^{-3}/d
		Premature open	1×10^{-5}/hr		4×10^{-3}/d	1.0×10^{-5}/hr		1.0×10^{-5}/hr
		Fail to close			5×10^{-3}/d			5×10^{-3}/d
	Safety Valves (PWR)	Fail to open	3×10^{-3}/d			6.2×10^{-3}/d		6.2×10^{-3}/d
		Premature open	3×10^{-6}/hr			1×10^{-5}/hr		1×10^{-5}/hr
		Fail to close	1×10^{-2}/d					1×10^{-2}/d
Valve Actuators	Solenoid: Normally open	Spurious energization					3.4×10^{-8}/hr	3.4×10^{-8}/hr
		Spurious de-energization					7.1×10^{-7}/hr	7.1×10^{-7}/hr
		Fail to energize					1.6×10^{-6}/d	1.6×10^{-6}/d
		Fail to de-energize					1.4×10^{-6}/d	1.4×10^{-6}/d
	Solenoid: Normally closed	Spurious energization					4.4×10^{-8}/hr	4.4×10^{-8}/hr
		Spurious de-energization					9.0×10^{-7}/hr	9.0×10^{-7}/hr
		Fail to energize					2.0×10^{-6}/d	2.0×10^{-6}/d
		Fail to de-energize					1.5×10^{-6}/d	1.5×10^{-6}/d
	Piston: Double Acting	Spurious open					4.5×10^{-7}/hr	4.5×10^{-7}/hr
		Spurious close					4.5×10^{-7}/hr	4.5×10^{-7}/hr
		Fail open					8.7×10^{-7}/d	8.7×10^{-7}/d
		Fail to close					1.1×10^{-6}/d	1.1×10^{-6}/d
	Piston: Single Acting	Spurious open					3.2×10^{-7}/hr	3.2×10^{-7}/hr
		Spurious close					3.5×10^{-7}/hr	3.5×10^{-7}/hr
		Fail to open					1.2×10^{-6}/d	1.2×10^{-6}/d
		Fail to close					1.6×10^{-6}/d	1.6×10^{-6}/d

TABLE B.1

MECHANICAL AND ELECTRICAL COMPONENT FAILURE RATES

CATEGORY	COMPONENT	FAILURE MODE	FAILURE RATE					
			WASH-1400	GE	NRC		IEEE-500	RECOMMENDED
					BWR	PWR		
Valve Actuators (cont'd)	Diaphragm	Spurious open					1.7×10^{-7}/hr	1.7×10^{-7}/hr
		Spurious close					1.6×10^{-7}/hr	1.6×10^{-7}/hr
		Fail to open					2.5×10^{-7}/d	2.5×10^{-7}/d
		Fail to close					3.2×10^{-7}/d	3.2×10^{-7}/d
Battery	Wet Cell Batteries	Fail to provide proper output	3×10^{-6}/hr				1.5×10^{-6}/hr	3×10^{-6}/hr
Battery Chargers	Battery charger	Fail to provide proper output					1.2×10^{-4}/hr	1.2×10^{-4}/hr
Circuit Breakers	Fuses	Fail to open	1×10^{-5}/d					1×10^{-5}/d
		Premature open	1×10^{-6}/hr					
	< 1000 v	Premature open					2.1×10^{-8}/hr	2.1×10^{-8}/hr
	1000-3000 v	Premature open					1.1×10^{-8}/hr	1.1×10^{-8}/hr
	Circuit Breakers	Fail to transfer	1×10^{-3}/d					1×10^{-3}/d
		Premature transfer	1×10^{-6}/d					
	(AC)	Fail to open					1.9×10^{-4}/d	1.9×10^{-4}/d
		Fail to close					4.4×10^{-6}/d	4.4×10^{-6}/d
	(DC)	Fail to open					1.8×10^{-4}/d	1.8×10^{-4}/d
	Relays (Protective)	Fail to open					$.50 \times 10^{-6}$/d	$.5 \times 10^{-6}$/d
		Fail to close					2.9×10^{-6}/d	2.9×10^{-6}/d
	(Control and Sequentially Programmed)	Fail to open					3.1×10^{-6}/d	3.1×10^{-6}/d
		Fail to close					3.9×10^{-6}/d	3.9×10^{-6}/d

TABLE B.1

MECHANICAL AND ELECTRICAL COMPONENT FAILURE RATES

CATEGORY	COMPONENT	FAILURE MODE	FAILURE RATE					
			WASH-1400	GE	NRC		IEEE-500	RECOMMENDED
					BWR	PWR		
Circuit Breakers (cont'd)	Relays (Motors)	Failure to energize	1×10^{-4}/d					1×10^{-4}/d
		Coil open	1×10^{-7}/hr					1×10^{-7}/hr
		Coil short to power	1×10^{-8}/hr					1×10^{-8}/hr
Transformers	Transformers	Open circuit: Primary or Secondary	1×10^{-6}/hr					1×10^{-6}/hr
		Short: Primary to Secondary	1×10^{-6}/hr					1×10^{-6}/hr
	Single Phase:							
	2 - 30KV	Open					3.2×10^{-8}/hr	3.2×10^{-8}/hr
	Three phase:							
	Dry 15 - 40KV	Open					7.4×10^{-8}/hr	7.4×10^{-8}hr
	601V - 15KV	Open					3.9×10^{-8}/hr	3.9×10^{-8}/hr
	Liquid 2 - 30 KV	Open					3.6×10^{-8}/hr	3.6×10^{-8}/hr
	31 - 72 KV	Open					5.2×10^{-8}/hr	$.2 \times 10^{-8}$/hr
	73 - 145KV	Open					8.6×10^{-9}/hr	8.6×10^{-9}/hr
	146 - 242KV	Open					1.9×10^{-8}/hr	1.9×10^{-8}/hr
	243 - 346KV	Open					9.2×10^{-9}/hr	9.2×10^{-9}/hr
	347 - 550KV	Open					5.4×10^{-8}/hr	5.4×10^{-8}/hr
Electrical Distribution	Bus	Open					4.2×10^{-9}/hr	4.2×10^{-9}/hr
		Short					7×10^{-8}/hr	7.0×10^{-8}/hr
	Wires	Open Circuit	3×10^{-6}/hr					3×10^{-6}/hr
		Short to Ground	3×10^{-7}/hr					3×10^{-7}/hr
		Short to Power	1×10^{-5}/hr					1×10^{-5}/hr
	Power Supply	No Output					1.4×10^{-6}/hr	1.4×10^{-6}/hr

TABLE B.1

MECHANICAL AND ELECTRICAL COMPONENT FAILURE RATES

			FAILURE RATE					
			WASH-1400	GE	NRC		IEEE-500	RECOMMENDED
CATEGORY	COMPONENT	FAILURE MODE			BWR	PWR		
Electrical Distribution (Cont'd)	Cable Power: Copper	Open circuit					9.1×10^{-7}/hr	9.1×10^{-7}/hr
		Short to ground					1.7×10^{-6}/hr	1.7×10^{-6}/hr
		Short to power					1.0×10^{-6}/hr	1.0×10^{-6}/hr
	Aluminum	Open circuit					1.1×10^{-6}/hr	1.1×10^{-6}/hr
		Short to ground					3.9×10^{-6}/hr	3.9×10^{-6}/hr
		Short to power					1.5×10^{-6}/hr	1.5×10^{-6}/hr
	Control: Copper	Open circuit					9.1×10^{-7}/hr	9.1×10^{-7}/hr
		Short to ground					2.4×10^{-6}/hr	2.4×10^{-6}/hr
		Short to power					1.0×10^{-6}/hr	1.0×10^{-6}/hr
	Terminal Boards	Open	1×10^{-7}/hr				3.3×10^{-6}/hr	$3.3. \times 10^{-6}$/hr
		Short	1×10^{-8}/hr				1.4×10^{-6}/hr	1.4×10^{-6}/hr
Instrumentation and Controls	Relay	Coil fails to operate	1×10^{-4}/d	$.4 \times 10^{-6}$/hr				1×10^{-4}/d
		Coil fails to open	3×10^{-7}/hr	$.08 \times 10^{-6}$/hr				3×10^{-7}/hr
	Temperature Sensing Device [3]	Fails to operate				1.4×10^{-6}/hr		1.4×10^{-6}/hr
		Degraded operation				6.6×10^{-7}/hr		6.6×10^{-7}/hr
	Temperature Element	Fail to operate					1.8×10^{-6}/hr	1.8×10^{-6}/hr
		Degraded operation					1.2×10^{-6}/hr	1.2×10^{-6}/hr
	Temperature Transmitter	Fails to operate					3.8×10^{-7}/hr	3.8×10^{-7}/hr
		Degraded operation					3.6×10^{-7}/hr	3.6×10^{-7}/hr

[3] Sensing Device includes switch, monitor, sensor, and transmitter

TABLE B.1

MECHANICAL AND ELECTRICAL COMPONENT FAILURE RATES

CATEGORY	COMPONENT	FAILURE MODE	FAILURE RATE					
			WASH-1400	GE	NRC		IEEE-500	RECOMMENDED
					BWR	PWR		
Instrumentation and Control (Cont'd)	Temperature Switches	Failed to operate		2.3×10^{-6}/hr			1.2×10^{-7}/d	1.2×10^{-7}/d
		Spurious operation					1.4×10^{-7}/d	1.4×10^{-7}/d
		Degraded operation					4.8×10^{-7}/d	4.8×10^{-7}/d
		Fails closed		$.33 \times 10^{-6}$/hr				$.33 \times 10^{-6}$/hr
	Pressure Sensing Device	Fails to operate			7.1×10^{-7}/hr	6×10^{-7}/hr		6×10^{-7}/hr
		Degraded operation			8.3×10^{-6}/hr	3.7×10^{-6}/hr		3.7×10^{-6}/hr
	Pressure Element	Fails to operate		1.1×10^{-6}/hr				1.1×10^{-6}/hr
	Pressure Transmitter	Fails to operate					9.2×10^{-7}/hr	9.2×10^{-7}/hr
		Degraded operation					6.3×10^{-7}/hr	6.3×10^{-7}/hr
	Pressure Switch	Fails to operate	1×10^{-4}/d				2.0×10^{-7}/d	2.0×10^{-7}/d
		Spurious operation					4.8×10^{-8}/d	4.8×10^{-8}/d
		Degraded operation					5.7×10^{-8}/d	5.7×10^{-8}/d
	Flow Sensing Device	Fail to operate			5.9×10^{-7}/hr	4.8×10^{-6}/hr		4.8×10^{-6}/hr
		Degraded operation			2.9×10^{-6}/hr	2.5×10^{-5}/hr		2.5×10^{-6}/hr
	Flow Element	Fail to operate					3.1×10^{-7}/hr	3.1×10^{-7}/hr
		Degraded operation					1.8×10^{-7}/hr	1.8×10^{-7}/hr
	Flow Controller	Fail to operate		4.2×10^{-6}/hr				4.2×10^{-6}/hr
	Flow Transmitters	Fail to operate					1.4×10^{-6}/hr	1.4×10^{-6}/hr
		Degraded operation					1.4×10^{-6}hr	1.4×10^{-6}/hr
	Flow Switches	Fail to operate		4.2×10^{-6}/hr			1.3×10^{-8}/d	1.3×10^{-8}/d
		Spurious operation					1.2×10^{-8}/d	1.2×10^{-8}/d
		Degraded operation					1.7×10^{-8}/d	1.7×10^{-9}/d
	Limit Switch	Fail to operate	3.4×10^{-4}/d					3.4×10^{-4}/d
	Manual Switch	Fail to transfer	1×10^{-5}/d					1×10^{-5}/d

TABLE B.1

MECHANICAL AND ELECTRICAL COMPONENT FAILURE RATES

CATEGORY	COMPONENT	FAILURE MODE	FAILURE RATE					RECOMMENDED
			WASH-1400	GE	NRC		IEEE-500	
					BWR	PWR		
Instrumentation and Control (Cont'd)	Level Sensing Device	Fail to operate			3.1×10^{-6}/hr	2.6×10^{-6}/hr		2.6×10^{-6}/hr
		Degraded operation			5.7×10^{-6}/hr	5.2×10^{-6}/hr		5.2×10^{-6}/hr
	Level Element			3.9×10^{-6}/hr				3.9×10^{-6}/hr
	Level Transmitter	Fail to operate					1.4×10^{-6}/hr	1.4×10^{-6}/hr
		Degraded operation					1.1×10^{-6}/hr	1.1×10^{-6}/hr
	Level Switch	Fail to operate					3×10^{-7}/d	3×10^{-7}/d
		Spurious operations					3.4×10^{-8}/d	3.4×10^{-8}/d
		Degraded operations					4.5×10^{-7}/d	4.5×10^{-7}/d
	Level Controller	Fail to operate					1×10^{-6}/hr	1×10^{-6}/hr
		Spurious operations					1×10^{-6}/hr	1×10^{-6}/hr
		Degraded operation					2×10^{-6}/hr	2×10^{-6}/hr
	E/S Converter	Fail to operate		4.2×10^{-6}/hr				4.2×10^{-6}/hr
	Square Root Converter	Fail to operate		4.2×10^{-6}/hr				4.2×10^{-6}/hr
	Power Supply	Fail to operate		4.2×10^{-6}/hr			2.8×10^{-6}/hr	2.8×10^{-6}/hr
		Degraded operation					1.9×10^{-6}/hr	1.9×10^{-6}/hr
	Solid State: Low Power	Fails to Function	1×10^{-6}/hr					1×10^{-6}/hr
		Fails Shorted	1×10^{-7}/hr					1×10^{-6}/hr
	High Power	Fails to Function	3×10^{-6}/hr					3×10^{-6}/hr
		Fails Shorted	1×10^{-6}/hr					1×10^{-6}/hr
	Torque Switch	Fails to operate	1×10^{-4}/d					1×10^{-4}/d
	Switch Contacts	Normally open switches fail to close	1×10^{-7}/hr					1×10^{-7}/hr
		Normally closed switches fail to close	3×10^{-8}/hr					3×10^{-8}/hr
		Short across contacts	1×10^{-8}/hr					1×10^{-8}/hr

TABLE B.2

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
QVB1SGAR0H	S.G.A. Relief Valve Calibration Valve	6.0×10^{-7}	1.2×10^{-6}/hr
QVB1SGDR0H	S.G.D. Relief Valve Calibration Shift	6.0×10^{-7}	1.2×10^{-6}/hr
QVB1SGCR0H	S.G.C. Relief Valve Calibration Shift	6.0×10^{-7}	1.2×10^{-6}/hr
QVB1SGRR0H	S.G.B. Relief Valve Calibration Shift	6.0×10^{-7}	1.2×10^{-6}/hr
QVB1SGARMM	S.G.A Relief Valve Control Wiring Reversed	4.2×10^{-8}	8.4×10^{-8}/hr
QIX1SGDRMM	S.G.D Relief Valve Control Wiring Reversed	4.2×10^{-8}	8.4×10^{-8}/hr
QIX1SGCRMM	S.G.C Relief Valve Control Wiring Reversed	4.2×10^{-8}	8.4×10^{-8}/hr
QIX1SGBRMM	S.G.B Relief Valve Control Wiring Reversed	4.2×10^{-8}	8.4×10^{-8}/hr
MPB1T37AMG	Turbine Driven Pump P-37A Fails to Run	5.7×10^{-3}	5.7×10^{-3}/d
MPB1D37BMG	Motor Driven Pump P-37B Fails to Run	3.4×10^{-3}	3.4×10^{-3}/d
MVD1V30AMJ	Isolation Valve V-30 In Feedwater Supply Line to S.G.A Ruptures	5×10^{-8}	1×10^{-7}/hr
MVA1V29AMJ	Check Valve V-29 In Feedwater Supply Line To S.G.A Ruptures	5×10^{-9}	1×10^{-8}/hr
MVA1V29AMJ	Stop Check Valve V-76 In Aux. Feed. Supply Line A Ruptures	5×10^{-9}	1×10^{-8}/hr
MVD14214MJ	Flow Control Valve FV-4214 In Aux. Feed. Supply Line A Ruptures	5×10^{-8}	1×10^{-7}/hr
MVA1V94DMJ	Stop Check Valve V-94 In Aux. Feed. Supply Line D Rupture	5×10^{-9}	1×10^{-8}/hr
MVD14244MJ	Flow Control Valve FV-4244 In Aux. Feed. Supply Line D Ruptures	5×10^{-8}	1×10^{-7}/hr
MVA1V88CMJ	Stop Check Valve V-88 In Aux. Feed. Supply Line C Rupture	5×10^{-9}	1×10^{-8}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVD14234MJ	Flow Control Valve FV-4234 In Aux. Feed Supply Line C Ruptures	5×10^{-8}	1×10^{-7}/hr
MVA1V82BMJ	Stop Check Valve V-82 In Aux. Feed. Supply Line B Ruptures	5×10^{-9}	1×10^{-8}/hr
MVD14224MJ	Flow Control Valve FV-4244 In Aux. Feed. Supply Line B Ruptures	5×10^{-8}	1×10^{-7}/hr
MVD1V57DMJ	Isolation Valve V-57 In Feedwater Supply Line D Ruptures	5×10^{-8}	1×10^{-7}/hr
MVA1V56DMJ	Check Valve V-56 In Feedwater Supply Line D Ruptures	5×10^{-9}	1×10^{-8}/hr
MVD1V48CMJ	Isolation Valve V-48 In Feedwater Supply Line C Ruptures	5×10^{-8}	1×10^{-7}/hr
MVA1V47CMJ	Check Valve V-47 In Feedwater Supply Line C Ruptures	5×10^{-9}	1×10^{-8}/hr
MVD1V39BMJ	Isolation Valve V-39 In Feedwater Supply Line B Ruptures	5×10^{-8}	1×10^{-7}/hr
MVA1B38BMJ	Check Valve V-38 In Feedwater Supply Line B Ruptures	5×10^{-9}	1×10^{-8}/hr
MVM1V75AMJ	Manual Valve V-75 In Aux. Feed. Supply Line A Ruptures	1×10^{-8}	2×10^{-8}/hr
VMD1V65AMJ	Gear Driven Valve V-65 In P-37A Discharge Line Ruptures	5×10^{-9}	1×10^{-8}/jr
MVM1V152MJ	Manual Valve V-152 In Feedwater Recirc. Line A Ruptures	1×10^{-8}	2×10^{-8}/hr
MVD1V156MJ	Gear Driven Valve V-156 In Start-up Feed Pump Discharge Line Rup.	5×10^{-9}	1×10^{-8}/hr
MVD1V510MJ	Flow Control Valve FCV-510 In Feed. Supply Line A Ruptures	5×10^{-8}	1×10^{-7}/hr
MVM1V87DMJ	Manual Valve V-87 In Aux. Feed. Supply Line D Ruptures	1×10^{-8}	2×10^{-8}/hr
MVM1V153MJ	Manual Valve V-153 In Feedwater Recirc. Line D Ruptures	1×10^{-8}	2×10^{-8}/hr
MVD1V540MJ	Flow Control Valve FCV-540 In Feed. Supply Line D Ruptures	5×10^{-8}	1×10^{-7}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVM1V93CMJ	Manual Valve V-93 In Aux. Feed. Supply Line C Ruptures	1×10^{-8}	2×10^{-8}/hr
MVM1V154MJ	Manual Valve V-154 In Feedwater Recirc. Line C Ruptures	1×10^{-8}	2×10^{-8}/hr
MDV1V530MJ	Flow Control Valve FCV-530 In Feed. Supply Line C Ruptures	5×10^{-8}	1×10^{-7}/hr
MVM1V81BMJ	Manual Valve V-81 In Aux. Feed. Line B Ruptures	1×10^{-8}	2×10^{-8}/hr
MVD1V71BMJ	Gear Driven Valve V-71 In P-37B Discharge Line Rupture	5×10^{-9}	1×10^{-8}/hr
MVM1V155MJ	Manual Valve V-155 In Feedwater Recirc. Line B Ruptures	1×10^{-8}	2×10^{-8}/hr
MVD1V520MJ	Flow Control Valve FCV-520 In Feed. Supply Line B Ruptures	5×10^{-8}	1×10^{-7}/hr
MVA1V64AMJ	Check Valve V-64 In P-37A Discharge Line Ruptures	5×10^{-9}	1×10^{-8}/hr
MVA1V70BMJ	Check Valve V-70 In P-38B Discharge Line Ruptures	5×10^{-9}	1×10^{-8}/hr
QVD1V129MJ	Valve V-129 In P-37A Turbine Steam Inlet Line Ruptures	5×10^{-9}	1×10^{-8}/hr
QVM1V95AMJ	Manual Valve V-95 In P-37A Turbine Steam Inlet Line Ruptures	1×10^{-8}	2×10^{-8}/hr
QVA1V94AMJ	Check Valve V-94 In Steam Supply Line A to P-37A Ruptures	5×10^{-9}	1×10^{-8}/hr
QVA1V96BMJ	Check Valve V-96 In Steam Supply Line A to P-37A Ruptures	5×10^{-9}	1×10^{-8}/hr
QVX1V127MJ	Steam Supply Line A Control Valve V-127 Ruptures	5×10^{-8}	1×10^{-7}/hr
QVM1V171MJ	Steam Supply Line A Manual Bypass Valve V-171 Ruptures	1×10^{-8}	2×10^{-8}/hr
QVX1V128MJ	Steam Supply Line B Control Valve V-128 Ruptures	5×10^{-8}	1×10^{-7}/hr
QMV1V172MJ	Steam Supply Line B Manual Bypass Valve V-172 Ruptures	1×10^{-8}	2×10^{-8}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
FVM1V155MJ	Manual Valve V-155 In P-37A Suction Line Ruptures	1×10^{-8}	2×10^{-8}/hr
FVM1V154MJ	Manual Valve V-154 In P-37A Suction Line Ruptures	1×10^{-8}	2×10^{-8}/hr
FVM1V159MJ	Manual Valve V-159 In P-27A Suction Line Ruptures	1×10^{-8}	2×10^{-8}/hr
FVM1V158MJ	Manual Valve V-158 In P-37A Suction Line Ruptures	1×10^{-8}	2×10^{-8}/hr
MVD1V30AMB	Isolation Valve V-30 In Feedwater Supply Line A Fails To Close	9×10^{-4}	9×10^{-4}/d
MVD14244MB	Flow Control Valve FV-4244 In Aux. Feed Supply Line D Fails To Close	2×10^{-3}	2×10^{-3}/d
MVD14234MB	Flow Control Valve FV-4234 In Aux. Feed. Supply Line D Fails To Close	9×10^{-4}	9×10^{-4}/d
MVD14224MB	Flow Control Valve FV-4224 In Aux. Feed. Supply Line D Fails To Close	9×10^{-4}	9×10^{-4}/d
MVD1V57DMB	Isolation Valve V-57 In Feedwater Supply Line D Fails To Close	9×10^{-4}	9×10^{-4}/d
MVD14214MB	Flow Control Valve FV-4214 In Aux. Feed. Supply Line A Fails To Close	9×10^{-4}	2×10^{-3}/d
MVD1V48CMB	Isolation Valve V-48 In Feedwater Supply Line C Fails To Close	9×10^{-4}	9×10^{-4}/d
MVD1V39BMB	Isolation Valve V-39 In Feedwater Supply Line C Fails To Close	9×10^{-4}	9×10^{-4}/d
MVD1V510MB	Flow Control Valve FCV-510 In Feed. Supply Line A Fails To Close	9×10^{-4}	9×10^{-4}/d
MVD1V540MB	Flow Control Valve FCV-540 In Feed. Supply Line D Fails to Close	9×10^{-4}	9×10^{-4}/d
MVD1V530MB	Flow Control Valve FCV-530 In Feed. Supply Line C Fails To Close	9×10^{-4}	9×10^{-4}/d
MVD1V520MB	Flow Control Valve FCV-520 In Feed. Supply Line B Fails To Close	9×10^{-4}	9×10^{-4}/d
MVD1V30AMC	Isolation Valve V-30 In Feedwater Supply Line A Fails To Remain Cl.	2.3×10^{-7}	4.5×10^{-7}/h

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVD14244MC	Flow Control Valve FV-4244 In Aux. Feed. Supply Line D Fails To Remain Closed	6.0×10^{-8}	1.2×10^{-7}/hr
MVD14234MC	Flow Control Valve FV-4234 In Aux. Feed. Supply Line C Fails To Remain Closed	6.0×10^{-8}	1.2×10^{-7}/hr
MVD14224MC	Flow Control Valve FV-4224 In Aux. Feed. Supply Line B Fails To Remain Closed	6.0×10^{-8}	1.2×10^{-7}/hr
MVD1V57DMC	Isolation Valve V-57 In Feedwater Supply Line D Fails To Remain Closed	2.3×10^{-7}	4.5×10^{-7}/hr
MVD14214MC	Flow Control Valve FV-4214 In Aux. Feed. Supply Line A Fails To Remain Closed	6.0×10^{-8}	1.2×10^{-7}/hr
MVD1V48CMC	Isolation Valve V-48 In Feedwater Supply Line C Fails To Remain Closed	2.3×10^{-7}	4.5×10^{-7}/hr
MVD1V39BMC	Isolation Valve V-39 In Feedwater Supply Line B Fails To Remain Closed	2.3×10^{-7}	4.5×10^{-7}/hr
MVD1V510MC	Flow Control Valve FCV-150 In Feed. Supply Line A Fails To Remain Closed	8.5×10^{-8}	1.7×10^{-7}/hr
MVD1V540MC	Flow Control Valve FCV-540 In Feed. Supply Line D Fails To Remain Closed	8.5×10^{-8}	1.7×10^{-7}/hr
MVD1V530MC	Flow Control Valve FCV-530 In Feed. Supply Line C Fails To Remain Closed	8.5×10^{-8}	1.7×10^{-7}/hr
MVD1V520MC	Flow Control Valve FCV-520 In Feed. Supply Line B Fails To Remain Closed	8.5×10^{-8}	1.7×10^{-7}/hr
MVD14214MD	Flow Control Valve FV-4214 Fails To Remain Open	8×10^{-8}	1.6×10^{-7}/hr
MVD14244MD	Flow Control Valve FV-4244 Fails To Remain Open	8×10^{-8}	1.6×10^{-7}/hr
MVD14234MD	Flow Control Valve FV-4234 Fails To Remain Open	8×10^{-8}	1.6×10^{-7}/hr
MVD14224MD	Flow Control Valve FV-4224 Fails To Remain Open	8×10^{-8}	1.6×10^{-7}/hr
MVD1V65AMD	Isolation Valve V-65 Fails To Remain Open (Plugged)	1×10^{-4}	1×10^{-4}/d
QVD1V129MD	Steam Supply Inlet Valve V-129 Fails To Remain Open	2.3×10^{-7}	4.5×10^{-7}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVD1V125MD	Isolation Valve V-125 Fails To Remain Open (Plugged)	1×10^{-4}	1×10^{-4}/d
MVD1V126MD	Isolation Valve V-126 Fails To Remain Open (Plugged)	1×10^{-6}	1×10^{-4}/d
MVD1V127MD	Isolation Valve V-127 Fails To Remain Open (Plugged)	1×10^{-4}	1×10^{-4}/d
MVD1V71BMD	Isolation Valve V-71 Fails To Remain Open (Plugged)	1×10^{-4}	1×10^{-4}/d
QVX1V127MA	Steam Supply Line A Flow Valve V-127 Fails To Open	9×10^{-4}	9×10^{-4}/d
QVX1V128MA	Steam Supply Line B Flow Valve V-128 Fails To Open	9×10^{-4}	9×10^{-4}/d
QVX1V127MD	Steam Supply Line A Flow Valve V-127 Fails To Remain Open	2.3×10^{-7}	4.5×10^{-7}/hr
QVX1V128MD	Steam Supply Line B Fails To Remain Open	2.3×10^{-7}	4.5×10^{-7}/hr
MVA1V76AMA	Stop Check Valve V-76 Fails To Open	2×10^{-4}	2×10^{-4}/d
MVA1V94DMA	Stop Check Valve V-94 Fails To Open	2×10^{-4}	2×10^{-4}/d
MVA1V88CMA	Stop Check Valve V-88 Fails To Open	2×10^{-4}	2×10^{-4}/d
MVA1V82BMA	Stop Check Valve V-82 Fails To Open	2×10^{-4}	2×10^{-4}/d
MVA1V64AMA	Check Valve V-64 Fails To Open	2×10^{-4}	2×10^{-4}/d
QVA1V94AMA	Steam Supply Line A Check Valve V-94 Fails To Open	2×10^{-4}	2×10^{-4}/d
QVA1V96BMA	Steam Supply Line B Check Valve V-96 Fails To Open	2×10^{-4}	2×10^{-4}/d
MVA1V70BMA	Check Valve V-70 Fails To Open	2×10^{-4}	2×10^{-4}/d
MVD1V75AMD	Valve V-75 In Aux. Feed Supply Line A Plugged	1×10^{-4}	1×10^{-4}/d

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVD1V87DMD	Valve V-87 In Aux. Feed Supply Line D Plugged	1×10^{-4}	1×10^{-4}/d
MVD1V93CMD	Valve V-93 In Aux. Feed Supply Line C Plugged	1×10^{-4}	1×10^{-4}/d
MVD1V81BMD	Valve V-81 In Aux. Feed Supply Line B Plugged	1×10^{-4}	1×10^{-4}/d
QVM1V95AMD	Manual Valve V-95 In Turbine Steam Supply Line Plugged	1×10^{-4}	1×10^{-4}/d
FVM1V155MD	Manual Valve V-155 In P-37A Suction Line Plugged	1×10^{-4}	1×10^{-4}/d
FVM1V154MD	Manual Valve V-154 In P-37A Suction Line Plugged	1×10^{-4}	1×10^{-4}/d
FVM1V159MD	Manual Valve V-159 In P-37B Suction Line Plugged	1×10^{-4}	1×10^{-4}/d
FVM1V158MD	Manual Valve V-158 In P-37B Suction Line Plugged	1×10^{-4}	1×10^{-4}/d
M0J1606BMJ	Feedwater Supply Line Ruptures Between V-20 and V-30	5×10^{-11}	1×10^{-10}/hr
M0J1606AMJ	Feedwater Supply Line Ruptures Between V-30 and S.G.A	5×10^{-11}	1×10^{-10}/hr
M0E1614AMJ	Aux. Feed. Supply Line A Ruptures Between V-76 and Main Supply Line A	5×10^{-11}	1×10^{-10}/hr
M0E1614BMJ	Aux. Feed. Supply Line A Ruptures Between FV-4214 and V-76	5×10^{-11}	1×10^{-10}/hr
M0J1609AMJ	Feedwater Supply Line D Ruptures Between V-57 and S.G.D	5×10^{-11}	1×10^{-10}/hr
M0E1617AMJ	Aux. Feed Supply Line D Ruptures Between V-94 and Main Feed. Supply Line D	5×10^{-11}	1×10^{-10}/hr
M0J1608AMJ	Feedwater Supply Line C Ruptures Between V-48 and S.G.C	5×10^{-11}	1×10^{-10}/hr
M0E1616AMJ	Aux. Feed. Supply Line C Ruptures Between V-88 and Main Feed. Supply Line C	5×10^{-11}	1×10^{-10}/hr
M0E1616BMJ	Aux. Feed Supply Line C Ruptures Between FV-4234 and V-88	5×10^{-11}	1×10^{-10}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
M0J160/AMJ	Feedwater Supply Line B Ruptures Between V-39 and S.G.B	5×10^{-11}	1×10^{-10}/hr
M0E1615AMJ	Aux. Feed. Supply Line B Ruptures Between V-82 and Main Feed. Supply Line B	5×10^{-11}	1×10^{-10}/hr
M0E1615BMJ	Aux. Feed. Supply Line B Ruptures Between V-4224 and V-82	5×10^{-11}	1×10^{-10}/hr
M0E1609BMJ	Feedwater Supply Line D Ruptures Between V-56 and V-57	5×10^{-11}	1×10^{-10}/hr
M0J1608BMJ	Feedwater Supply Line C Ruptures Between V-47 and V-48	5×10^{-11}	1×10^{-10}/hr
M0J1607BMJ	Feedwater Supply Line B Ruptures Between V-38 and V-39	5×10^{-11}	1×10^{-10}/hr
M0E1614CMJ	Aux. Feed Supply Line A Ruptures Between V-75 and FV-4214	5×10^{-11}	1×10^{-10}/hr
M0E1614DMJ	Aux. Feed. Supply Line A Ruptures Between V-75 and Aux. Feed Supply Header	5×10^{-11}	1×10^{-10}/hr
M0G1613AMJ	Aux. Feed Supply Header Ruptures Between V-125 and Reducer	5×10^{-11}	1×10^{-10}/hr
M0F1610AMJ	Aux. Feed Pump P-37A Discharge Piping Ruptures Between V-65 and Supply Header	5×10^{-11}	1×10^{-10}/hr
M0F1606AMJ	Feedwater Recirc. Line A Ruptures Between Aux. Feed. Supply A and V-152	5×10^{-11}	1×10^{-10}/hr
M0F1632AMJ	Startup Feed Pump Discharge Line Ruptures Between V-156 and Aux. Feed. Supply Header	5×10^{-11}	1×10^{-10}/hr
M0E1606BMJ	Feedwater Recirc. Line A Ruptures Between V-152 and Main Feed Supply Line A	5×10^{-11}	1×10^{-10}/hr
M0J1606CMJ	Feedwater Supply Line A Ruptures Between FCV-510 and V-29	5×10^{-11}	1×10^{-10}/hr
M0E1617CMJ	Aux. Feed Supply Line D Ruptures Between V-87 and FV-4224	5×10^{-11}	1×10^{-10}/hr
M0E1617DMJ	Aux. Feed Supply Line D Ruptures Between V-87 and Aux. Feed Supply Header	5×10^{-11}	1×10^{-10}/hr
M0G1613BMJ	Aux. Feed. Supply Header Ruptures Between V-87 and V-126	5×10^{-11}	1×10^{-10}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
M0E1609AMJ	Feedwater Recirc. Line D Ruptures Between Aux. Feed. Supply Line D and V-153	5×10^{-11}	1×10^{-10}/hr
M0E1609BMJ	Feedwater Recirc. Line D Ruptures Between V-153 and Main Feedwater Supply Line D	5×10^{-11}	1×10^{-10}/hr
M0J1609CMJ	Feedwater Supply Line D Ruptures Between FCV-540 and V-56	5×10^{-11}	1×10^{-10}/hr
M0E1616CMJ	Aux. Feed. Supply Line C Ruptures Between V-93 and FV-5234	5×10^{-11}	1×10^{-10}/hr
M0E1616DMJ	Aux. Feed Supply Line C Ruptures Between V-93 and Aux. Feed. Supply Header	5×10^{-11}	1×10^{-10}/hr
M0G1613CMJ	Aux. Feed Supply Header Ruptures Between V-126 and V-127	5×10^{-11}	1×10^{-10}/hr
M0E1608AMJ	Feedwater Recirc. Line C Ruptures Between Aux. Feed. Supply Line C and V-154	5×10^{-11}	1×10^{-10}/hr
M0E1608BMJ	Feedwater Recir. Line C Ruptures Between V-154 and Main Feedwater Supply Line C	5×10^{-11}	1×10^{-10}/hr
M0J1608CMJ	Feedwater Supply Line C Ruptures Between FCV-530 and V-47	5×10^{-11}	1×10^{-10}/hr
M0E1615CMJ	Aux. Feed Supply Line B Ruptures Between V-81 and FV-4224	5×10^{-11}	1×10^{-10}/hr
M0E1615DMJ	Aux. Feed Supply Line B Ruptures Between V-81 and Aux. Feed Supply Header	5×10^{-11}	1×10^{-10}/hr
M0G1613DMJ	Aux. Feed Supply Header Ruptures Between V-127 and Reducer	5×10^{-11}	1×10^{-10}/hr
M0F1612AMJ	Feed. Pump P-37B Discharge Line Ruptures Between V-71 & Reducer	5×10^{-11}	1×10^{-10}/hr
M0E1607AMJ	Feedwater Recirc. Line B Ruptures Between Aux. Feed Supply Line B and V-155	5×10^{-11}	1×10^{-10}/hr
M0E1607BMJ	Feedwater Recirc. Line B Ruptures Between V-155 and Main Feedwater Supply Line B	5×10^{-11}	1×10^{-10}/hr
M0J1607CMJ	Feedwater Supply Line B Ruptures Between FCV-520 and V-38	5×10^{-11}	1×10^{-10}/hr
M0F1610BMJ	Feed. Pump P-37A Discharge Line Ruptures Between V-64 and V-65	5×10^{-11}	1×10^{-10}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
M0F1612BMJ	Feed Pump P-37B Discharge Line Ruptures Between V-70 and V-71	5×10^{-11}	1×10^{-10}/hr
M0F1612CMJ	Feed Pump P-37A Discharge Line Ruptures Between P-37A and V-64	5×10^{-11}	1×10^{-10}/hr
M0D1610AMJ	Feed Pump P37A Recirc. Line Ruptures Between V-67 and Pump Discharge Line	5×10^{-10}	1×10^{-9}/hr
Q0E1449AMJ	Turbine Steam Supply Line Ruptures Between V-95 and V-129	5×10^{-11}	1×10^{-10}/hr
Q0E1449BMJ	Turbine Steam Supply Line Ruptures Between V-129 and Turbine	5×10^{-11}	1×10^{-10}/hr
Q0F1449AMJ	Turbine Steam Supply Line Ruptures Between Tee and V95	5×10^{-11}	1×10^{-10}/hr
Q0F1109AMJ	Steam Supply Line B Ruptures Between Reducer and Turbine Inlet Line Tee	5×10^{-11}	1×10^{-10}/hr
Q0F1009AMJ	Steam Supply Line A Ruptures Between Reducer and Turbine Inlet Line Tee	5×10^{-11}	1×10^{-10}/hr
Q0E1143AMJ	Steam Supply Line B Ruptures Between V-128 and V-96	5×10^{-11}	1×10^{-10}/hr
Q0E1043AMJ	Steam Supply Line A Ruptures Between V-127 and V-94	5×10^{-11}	1×10^{-10}/hr
Q0E1043BMJ	Steam Supply Line A Ruptures Between V-94 and Reducer	5×10^{-11}	1×10^{-10}/hr
Q0A1036AMJ	Steam Bypass Exit Line Ruptures Between V-171 and Steam Supply Line A	5×10^{-10}	1×10^{-9}/hr
Q0E1042AMJ	Steam Supply Line A Ruptures Between Reducer and V-127	5×10^{-11}	1×10^{-10}/hr
Q0A1035AMJ	Steam Bypass Inlet Line Ruptures Between Steam Supply Line A and V-171	5×10^{-10}	1×10^{-9}/hr
Q0F1008AMJ	Steam Supply Line A Ruptures Between Main Steam Line A and Reducer	5×10^{-11}	1×10^{-10}/hr
Q0K1SL1AMJ	Main Steam Line A Ruptures	5×10^{-11}	1×10^{-10}/hr
Q0F1143BMJ	Steam Supply Line B Ruptures Between V-96 and Reducer	5×10^{-11}	1×10^{-10}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
Q0A1136AMJ	Steam Bypass Exit Line Ruptures Between V-172 and Steam Supply Line B	5×10^{-10}	1×10^{-9}/hr
Q0E1142AMJ	Steam Supply Line B Ruptures Between Reducer and V-128	5×10^{-11}	1×10^{-10}/hr
Q0A1135AMJ	Steam Bypass Inlet Line Ruptures Between V-172 and Steam Supply Line B	5×10^{-10}	1×10^{-9}/hr
Q0F1108AMJ	Steam Supply Line B Ruptures Between Main Steam Line B and Reducer	5×10^{-11}	1×10^{-10}/hr
Q0K1SL1BMJ	Main Steam Line B Ruptures	5×10^{-11}	1×10^{-10}/hr
F0G1081AMJ	Feed Pump P-37A Suction Line Ruptures Between V-15 and Pump Inlet	5×10^{-11}	1×10^{-10}/hr
F0G1081BMJ	Feed Pump P-37A Suction Line Ruptures Between V-154 and V-155	5×10^{-11}	1×10^{-10}/hr
F0G1081CMJ	Feed Pump P-37A Suction Line Ruptures Between Condensate Tank and V-154	5×10^{-11}	1×10^{-10}/hr
M0E1612CMJ	Feed PumpP-37B Discharge Line Ruptures Between P-37B and V-70	5×10^{-11}	1×10^{-10}/hr
M0D1612AMJ	Feed Pump P-37B Recirc. Line Ruptures Between V-73 and Pump Discharge Line	5×10^{-11}	1×10^{-9}/hr
F0G1082AMJ	Feed Pump P-37B Suction Line Ruptures Between V-159 and Pump Inlet	5×10^{-11}	1×10^{-10}/hr
F0G1082BMJ	Feed Pump P-37B Suction Line Ruptures Between V-158 and V-159	5×10^{-11}	1×10^{-10}/hr
F0G1082CMJ	Feed Pump P-37B Suction Line Ruptures Between Condensate Tank and V-158	5×10^{-11}	1×10^{-10}/hr
MPB1T37AME	Turbine Driven Feed Pump-37A Fails To Start	8.4×10^{-3}	8.4×10^{-3}/d
MPB1D37BME	Motor Driven Feed Pump P-37B Fails To Start	2.4×10^{-3}	2.4×10^{-3}/d
MPB1T37A00	Turbine Driven Feed P-37A Out of Service	4.2×10^{-4}	
MPB1D37B00	Motor Driven Feed Pump P-37B Out Of Service	9.4×10^{-4}	

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVD1421400	Flow Control Valve FV-4214 Out of Service	8.5×10^{-4}	
MVD1V75A00	Valve Out of Service	8.5×10^{-4}	
MVD1422400	Flow Control Valve FV-4244 Out of Service	8.5×10^{-4}	
MVD1V87D00	Valve V-87 Out of Service	8.5×10^{-4}	
MVD1423400	Flow Control Valve FV-4234 Out of Service	8.5×10^{-4}	
MVD1V93C00	Valve V-93 Out of Service	8.5×10^{-4}	
MVD1422400	Flow Control Valve FV-4224 Out of Service	8.5×10^{-4}	
MVD1V81B00	Valve V-81 Out of Service	8.5×10^{-4}	
MVD1V65A00	Isolation Valve V-65 Out of Service	2.0×10^{-3}	
QVD1V12900	Steam Supply Valve V-129 Out of Service	1.0×10^{-4}	
QMV1V95A00	Manual Valve V-95 Out of Service	0.0	
QVX1V12700	Steam Supply Valve V-127 Out of Service	8.7×10^{-4}	
QVX1V12800	Steam Supply Valve V-128 Out of Service	8.7×10^{-4}	
FVM1V15500	P-37A Suction Valve V-155 Out of Service	0.0	
FVM1V15400	P-37A Suction Valve V-154 Out of Service	0.0	
MVD1V12600	Isolation Valve V-125 Out of Service	0.0	
MVD1V12600	Isolation Valve V-126 Out of Service	0.0	

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVD1V12700	Isolation Valve V-127 Out of Service	0.0	
MVD1V71B00	Isolation Valve V-71 Out of Service	2.0×10^{-3}	
FVM1V15900	P-37B Suction Valve V-159 Out of Service	0.0	
FVM1V15800	P-37B Suction Valve V-158 Out of Service	0.0	
QVX1V1270A	Operator Fails to Open Steam Supply Valve V-127	5×10^{-3}	5×10^{-3}/d
QVX1V1280A	Operator Fails to Open Steam Supply Valve V-128	5×10^{-3}	5×10^{-3}/d
MVD1V30A0B	Operator Fails to Close Feedwater Supply Line A Isolation Valve V-30	5×10^{-3}	5×10^{-3}/d
MVD142240B	Operator Fails to Close Flow Control Valve FV-4224	5×10^{-3}	5×10^{-3}/d
MVD142240B	Operator Fails to Close Flow Control Valve FV-4234	5×10^{-3}	5×10^{-3}/d
MVD142440B	Operator Fails to Close Flow Control Valve FV-4244	5×10^{-3}	5×10^{-3}/d
MVD1V57D0B	Operator Fails to Close Feedwater Supply Line D isolation Valve V-57	5×10^{-3}	5×10^{-3}/d
MVD142140B	Operator Fails to Close Flow Control Valve FV-4214	5×10^{-3}	5×10^{-3}/d
MDV1V48C0B	Operator Fails to Close Feedwater Supply Line C Isolation Valve V-48	5×10^{-3}	5×10^{-3}/d
MVD1B39B0B	Operator Fails to Close Feedwater Supply Line B Isolation Valve V-39	5×10^{-3}	5×10^{-3}/d
MVD1V5100B	Operator Fails to Close Feedwater Flow Control Valve FCV-510	5×10^{-3}	5×10^{-3}/d
MVD1V1250B	Operator Fails to Close Supply Header Isolation Valve V-125	.9	.9
MVD1V5400B	Operator Fails to Close Feedwater Flow Control Valve FCV-540	5×10^{-3}	5×10^{-3}/d

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVD1V1260B	Operator Fails to Close Supply Header Isolation Valve V-126	.9	.9
MVD1V5300B	Operator Fails to Close Feedwater Flow Control Valve FCV-530	5×10^{-3}	$5 \times 10^{-3}/d$
MDV1V1270B	Operator Fails to Close Supply Header Isolation Valve V-127	.9	.9
MVD1V5200B	Operator Fails to Close Feedwater Flow Control Valve FCV-520	5×10^{-3}	$5 \times 10^{-3}/d$
MVD1V65A0B	Operator Fails to Close P-37B Discharge Isolation Valve V-65	.9	.9
MVD1V71B0B	Operator Fails to Close P-37B Discharge Isolation Valve V-71	.9	.9
MVM1V1520C	Operator Fails to Restore Manual Valve V-152	1×10^{-3}	$1 \times 10^{-3}/d$
MVM1V1530C	Operator Fails to Restore Manual Valve V-153	1×10^{-3}	$1 \times 10^{-3}/d$
MVM1V1540C	Operator Fails to Restore Manual Valve V-154	1×10^{-3}	$2 \times 10^{-3}/d$
MVM1V1550C	Operator Fails to Restore Manual Valve V-155	1×10^{-3}	$1 \times 10^{-3}/d$
6IC1AFSA0C	Operator Defeats Train A"S" Signal	1×10^{-4}	$1 \times 10^{-4}/d$
6IC1AFSB0C	Operator Defeats Train B"S" Signal	1×10^{-4}	$1 \times 10^{-4}/d$
MVD142140D	Operator Inadvertently Closes Flow Control Valve FV-4214	1×10^{-4}	$1 \times 10^{-4}/d$
MVD1V75A0D	Operator Inadvertently Closes Valve V-75	1×10^{-4}	$1 \times 10^{-4}/d$
MVM142440D	Operator Inadvertently Closes Flow Control Valve FV-4244	1×10^{-4}	$1 \times 10^{-4}/d$
MVD1V87D0D	Operator Inadvertently Closes Valve V-87	1×10^{-4}	$1 \times 10^{-4}/d$
MVD142340D	Operator Inadvertently Closes Flow Control Valve FV-4234	1×10^{-4}	$1 \times 10^{-4}/d$

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVD1V93C0D	Operator Inadvertently Closes Valve V-93	1×10^{-4}	1×10^{-4}/d
MVD142240D	Operator Inadvertently Closes Flow Control Valve FV-4224	1×10^{-4}	1×10^{-4}/d
MVD1V81B0D	Operator Inadvertently Closes Valve V-81	1×10^{-4}	1×10^{-4}/d
MVM1V65A0D	Operator Fails to Restore P-37A Isolation Valve V-65	1×10^{-4}	1×10^{-4}/d
QVD1V95A0D	Operator Fails to Restore Manual Valve V-95	1×10^{-3}	1×10^{-3}/d
FMV1V1550D	Operator Fails to Restore P-37A Suction Valve V-155	1×10^{-3}	1×10^{-3}/d
FVM1V1540D	Operator Fails to Restore P-27A Suction Valve V-154	1×10^{-3}	1×10^{-3}/d
MVD1V1250D	Operator Fails to Restore Supply Header Valve V-125	1×10^{-3}	1×10^{-3}/d
MVD1V1250D	Operator Fails to Restore Supply Header Valve V-126	1×10^{-3}	1×10^{-3}/d
MVD1V1270D	Operator Fails to Restore Supply Header Valve V-127	1×10^{-3}	1×10^{-3}/d
MVD1V71B0D	Operator Fails to Restore P-37B Discharge Isolation Valve V-71	1×10^{-4}	1×10^{-4}/d
FVM1V1590D	Operator Fails to Restore P-37B Suction Valve V-159	1×10^{-3}	1×10^{-3}/d
FVM1V1580D	Operator Fails to Restore P-37B Suction Valve V-158	1×10^{-3}	1×10^{-3}/d
MPB1D37B0E	Operator Fails to Start Motor Driven Pump P-37B	1×10^{-3}	1×10^{-3}/d
MPB1T37A0G	Operator Turns Off Turbine Driven Pump P-37A	1×10^{-4}	1×10^{-4}/d
MPB1D37B0G	Operator Turns Off Motor Driven Pump P-37B	1×10^{-4}	1×10^{-4}/d
MCA2D37BMK	Circuit Breaker to Motor Driven Pump P-37B Open	1.5×10^{-6}	4.2×10^{-9}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
QRA2V127MK	Control Circuit to Steam Supply Valve V-127 Open	6.5×10^{-4}	9.1×10^{-7}/h
QRA1V128MK	Control Circuit to Steam Supply Valve V-128 Open	6.5×10^{-4}	9.1×10^{-7}/h
MRA1A37BMK	Train A Control Circuit to Motor Pump P-37B Open	5.9×10^{-3}	9.1×10^{-7}/h
MRA1B37BMK	Train B Control Circuit to Motor Pump P-37B Open	5.9×10^{-3}	9.1×10^{-7}/h
MCE1V510MK	Flow Control Valve FCV-510 Flow Control Switch Open	1.5×10^{-8}	3×10^{-8}/hr
MCE1V540MK	Flow Control Valve FCV-540 Flow Control Seitch Open	1.5×10^{-8}	3×10^{-8}/hr
MCE1V530MK	Flow Control Valve FCV-530 Flow Control Switch Open	1.5×10^{-8}	3×10^{-8}/hr
MCE1V520MK	Flow Control Valve FCV-520 Flow Control Switch Open	1.5×10^{-8}	3×10^{-8}/hr
QCE1V127MK	Steam Supply Valve V-127 Switch Open	2.2×10^{-5}	3×10^{-8}/hr
MCE1D37BMK	P-37B Motor Controller Circuit Open	3.3×10^{-4}	9.1×10^{-7}/h
MCK1D37BMK	P-37B Motor Starter Circuit Open	1.2×10^{-3}	1.2×10^{-3}/d
MPB1T37ALB	Turbine Driven Feed Pump P-37A Lubrication Failure	0.0	
MPB1D37BLB	Motor Driven Feed Pump P-37B Luabrication Failure	0.0	
LOSP	Loss of Station Power	7×10^{-6}	1.4×10^{-5}/h
5TA1TK25MJ	Condensate Storage Tank Ruptured	5×10^{-11}	1×10^{-10}/hr
6IC1FWIAMN	No Train A Feedwater Isolation Signal	5.8×10^{-3}	5.8×10^{-3}/d
MIF14224MN	No Signal From FE-4224 to Flow Control Valve FV-4224	2.0×10^{-3}	3.1×10^{-7}/h

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MIF14234MN	No Signal From FE-4234 to Flow Control Valve FV-4234	2.0×10^{-3}	3.1×10^{-7}/hr
MIF14244MN	No Signal From FE-4224 to Flow Control Valve FV-4244	2.0×10^{-3}	3.1×10^{-7}/hr
MIF14214MN	No Signal From FE-4214 to Flow Control Valve FV-4214	2.0×10^{-3}	3.1×10^{-7}/hr
6IC1FWSBMN	No Train B Feedwater Isolation Signal	5.8×10^{-3}	5.8×10^{-3}/d
MIF1V510MN	No Signal From FE-510 to Flow Control Valve FCV-510	1.5×10^{-7}	3.1×10^{-7}/hr
MIF1V540MN	No Signal From FE-540 to Flow Control Valve FCV-540	1.5×10^{-7}	3.1×10^{-7}/hr
MIF1V530MN	No Signal From FE-530 to Flow Control Valve FCV-530	1.5×10^{-7}	3.1×10^{-7}/hr
MIF1V520MN	No Signal From FE-520 to Flow Control Valve FCV-520	1.5×10^{-7}	3.1×10^{-7}/hr
6IC1AFSAMN	No Signal From Safety Injection Signal Train A	5.8×10^{-3}	5.8×10^{-3}/d
6IC1AFSBNM	No Signal From Safety Injection Signal Train B	5.8×10^{-3}	5.8×10^{-3}/d
MVD14214M0	Spurious Signal to Flow Control Valve FV-4214	1.2×10^{-8}	1.2×10^{-8}/d
MVD14244M0	Spurious Signal to Flow Control Valve FV-4244	1.2×10^{-8}	1.2×10^{-8}/d
MVD14234M0	Spurious Signal to Flow Control Valve FV-4234	1.2×10^{-8}	1.2×10^{-8}/d
MVD14224M0	Spurious Signal to Flow Control Valve FV-4224	1.2×10^{-8}	1.2×10^{-8}/d
REC11B--MJ	125 DC Bus 11B Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
REC1E612MJ	460 V AC Bus E612 Shorts to Ground	3.5×10^{-8}	7×19^{-8}/hr
REC1E61-MJ	480 V AC Bus E61 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr

TABLE B.2

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
RCA1A74-MB	Diesel Generator DG-1B Circuit Breaker A74 Fails to Close	1×10^{-3}	1×10^{-3}/d
RCA1DN6-MB	Crossover Circuit Breaker DN6 Fails to Close	1×10^{-3}	1×10^{-3}/d
RCA2A61-MC	Circuit Breaker A61 Open	2.1×10^{-9}	4.2×10^{-9}/hr
RCA1A62-MF	Circuit Breaker A62 Fails to Close	1×10^{-3}	1×10^{-3}/d
RCA1DN4-MC	Circuit Breaker DN4 Open	2.1×10^{-9}	4.2×10^{-9}/hr
RCA1DN5-MC	Circuit Breaker DN5 Open	2.1×10^{-9}	4.2×10^{-9}/hr
RCA1DA1-MC	Circuit Breaker DA1 Open	2.1×10^{-9}	4.2×10^{-9}/hr
RCA1AD6-MC	Circuit Breaker AD6 Open	2.1×10^{-9}	4.2×10^{-9}/hr
RCA1AD2-MC	Circuit Breaker AD2 Open	2.1×10^{-9}	4.2×10^{-9}/hr
RCA1A41-MC	Circuit Breaker A41 Open	2.1×10^{-9}	4.2×10^{-9}/hr
RCA1A41-MJ	Circuit Breaker A41 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RCA1A42-MB	Circuit Breaker A42 Fails to Close	1×10^{-3}	1×10^{-3}/d
RCA1A42-MJ	Circuit Breaker A42 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RCA1A61-MJ	Circuit Breaker A61 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RCA1A62-MJ	Circuit Breaker A62 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RCA1DN5-MJ	Circuit Breaker DN5 Shorts to Ground	3.5×10^{-8}	7×19^{-8}/hr
RCA1DA1-MJ	Circuit Breaker DA1 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
RCA1AD6-MJ	Circuit Breaker AD6 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RCA1AD2-MJ	Circuit Breaker AS2 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RCA1A75-MJ	Circuit Breaker A75 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RBC11B--MC	Battery Charger 1B Opens	2.1×10^{-9}	4.2×10^{-9}/hr
RBC11B--MJ	Battery Charger 1B Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RBA11B--MJ	Battery 1B Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RBA11D--MJ	Battery 1D Shorts to Ground	3.6×10^{-8}	7×10^{-8}/hr
RBA11B--MM	Battery 1B Undercharged	1.3×10^{-6}	3×10^{-6}/hr
RBA11D--MM	Battery 1D Undercharged	1.5×10^{-6}	3×10^{-6}/hr
RTR1X-5CMC	Transformer X-5c Open	5×10^{-7}	1×10^{-6}/hr
RTR1X-2BMJ	Transformer S-2B Shorts	5×10^{-7}	1×10^{-6}/hr
RTR1X-2BMC	Transformer S-2B Opens	5×10^{-7}	1×10^{-6}/hr
RTR1X-5CMJ	Transformer X-5C Shorts	5×10^{-7}	1×10^{-6}/hr
RTR1X-3BMC	Transformer X-3B Opens	5×10^{-7}	1×10^{-6}/hr
RTR1X-3BMJ	Transformer X-3B Shorts	5×10^{-7}	1×10^{-6}/hr
RGD11B--ME	Diesel Generator DG-1B Fails to Start	1.0×10^{-2}	1.0×10^{-2}/d
RGD11B--MG	Diesel Generator DG-1B Fails to Run	3.0×10^{-3}	6.0×10^{-3}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
RGD11B--00	Diesel Generator DG-1B Out of Service	7×10^{-4}	
RGD11A--00	Diesel Generator DG-1A Out of Service	7×10^{-4}	
MHX1TBRAMJ	S.G.A Steam Line Rupture	5×10^{-11}	1×10^{-10}/hr
MHX1SHRAMJ	S.G. A Shell Rupture	5×10^{-11}	1×10^{-10}/hr
MHX1TBRDMJ	S.G.D Steam Line Rupture	5×10^{-11}	1×10^{-10}/hr
MHX1SHRDMJ	S.G.D Shell Rupture	5×10^{-11}	1×10^{-10}/hr
MHX1TBRCMJ	S.G.C Steam Line Rupture	5×10^{-11}	1×10^{-10}/hr
MHX1SHRCMJ	S.G.C Shell Rupture	5×10^{-11}	1×10^{-10}/hr
MHX1TBRBMJ	S.G.B Steam Line Rupture	5×10^{-11}	1×10^{-10}/hr
MHX1SHRBMJ	S.G.B Shell Rupture	5×10^{-11}	1×10^{-10}/hr
MPB1T37ACL	Turbine Driven Feed Pump P-37A Cooling Loss	0.0	
MPB1D37BCL	Motor Driven Feed Pump P-37B Cooling Loss	0.0	
MTU1TD-2ME	Turbine Fails to Start	0.0	
QRA1C127MA	Control Relay on Solenoid Valve to Steam Supply Valve V-127 Fails to Open	3.1×10^{-6}	3.1×10^{-6}/d
QRA1V128MA	Control Relay on Solenoid Valve to Steam Supply Valve V-128 Fails to Open	3.1×10^{-6}	3.1×10^{-6}/d
QVL1V127MA	Solenoid Valve on Steam Valve to Steam Supply Valve V-128 Fails to Open	1.4×10^{-6}	1.4×10^{-6}/d
QLV1V128MA	Solenoid Valve on Steam Supply Valve V-128 Fails to Open	1.4×10^{-6}	$1,4 \times 10^{-6}$/d

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
QVB1V06AMC	Safety Valve V-6 on Steam Line A Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V07AMC	Safety Valve V-7 on Steam Line A Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V10AMC	Safety Valve V-10 on Steam Line A Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V08AMC	Safety Valve V-8 on Steam Line A Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V09AMC	Safety Valve V-9 on Steam Line A Opens	5×10^{-6}	1×10^{-5}/hr
QVB1SGARMC	Relief Valve on Main Steam Line A Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V50DMC	Safety Valve V-50 on Steam Line D Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V51DMC	Safety Valve V-51 on Steam Line D Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V52DMC	Safety Valve V-52 on Steam Line D Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V53DMC	Safety Valve V-53 on Steam Line D Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V54DMC	Safety Valve V-54 on Steam Line D Opens	5×10^{-6}	1×10^{-5}/hr
QVB1SGDRMC	Relief Valve on Main Steam Line D Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V36CMC	Safety Valve V-36 on Steam Line C Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V37CMC	Safety Valve V-37 on Steam Line C Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V38CMC	Safety Valve V-38 on Steam Line C Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V39CMC	Safety Valve V-39 on Steam Line C Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V40CMC	Safety Valve V-40 on Steam Line C Opens	5×10^{-6}	1×10^{-5}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
QVB1SGCRMC	Relief Valve on Main Steam Line C Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V22BMC	Safety Valve V-22 on Steam Line B Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V23BMC	Safety Valve V-23 on Steam Line B Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V24BMC	Safety Valve V-24 on Steam Line B Opens	5×10^{-6}	1×10^{-5}/hr
QVB1V25BMC	Safety Valve V-25 on Steam Line B Opens	5×10^{-6}	1×10^{-6}/hr
QVB1V26BMC	Safety Valve V-26 on Steam Line B Opens	5×10^{-6}	1×10^{-6}/hr
QVB1SGBRMC	Relief Valve on Main Steam Line B Opens	5×10^{-6}	1×10^{-5}/hr
0EC1SGARMM	Loss of Voltage on S.G.A Relief Valve Controller	7×17^{-7}	1.4×10^{-6}/hr
0EC1SGBRMM	Loss of Voltage onS.G.B Relief Valve Controller	7×10^{-7}	1.4×10^{-6}/hr
0EC1SGCRMM	Loss of Voltage on S.G.A Relief Valve Controller	7×10^{-7}	1.4×10^{-6}/hr
0EC1SGDRMM	Loss of Voltage of S.G.D Relief Valve Controller	7×10^{-7}	1.4×10^{-6}/hr
MVD1V8700B	Operator Fails to Close V-87	5×10^{-3}	5×10^{-3}/d
MVD1V93C0B	Operator Fails to Close V-93	5×10^{-3}	5×10^{-3}/d
MVD1V81B0B	Operator Fails to Close V-81	5×10^{-3}	5×10^{-3}/d
MVD1V75A0B	Operator Fails to Close V-75	5×10^{-3}	5×10^{-3}/d
MVD1V87DMB	Valve V-87 Does Not Close	2×10^{-3}	2×10^{-3}/d
MVD1V93CMB	Valve V-93 Does Not Close	2×10^{-3}	2×10^{-3}/d

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
MVD1V81BMB	Valve V-81 Does Not Close	2×10^{-3}	2×10^{-3}/d
MVD1V75AMB	Valve V-75 Does Not Close	2×10^{-3}	2×10^{-3}/d
MVD1V87DMC	Valve V-87 Fails to Remain Closed	6×10^{-8}	1.2×10^{-7}/hr
MVD1V93CMC	Valve V-93 Fails to Remain Closed	6×10^{-8}	1.2×10^{-7}/hr
MVD1V81BMC	Valve V-81 Fails to Remain Closed	6×10^{-8}	1.2×10^{-7}/hr
MVD1V75AMC	Valve V-75 Fails to Remain Closed	6×10^{-8}	1.2×10^{-7}/hr
MIF1V87DMN	Valve V-87 Fails to Receive Signal	2×10^{-3}	2×10^{-3}/d
MIF1V93CMN	Valve V-93 Fails to Receive Signal	2×10^{-3}	2×10^{-3}/d
MIF1V81BMN	Valve V-81 Fails to Receive Signal	2×10^{-3}	2×10^{-3}/d
MIF1V75AMN	Valve V-75 Fails to Receive Signal	2×10^{-3}	2×10^{-3}/d
M0F1618CMJ	Rupture of 6" Line Between V-99 and Tee	5×10^{-11}	1×10^{-10}/hr
M0F1618BMJ	Rupture of 6" Line Between V-163 and Tee	5×10^{-11}	1×10^{-10}/hr
M0F1618AMJ	Rupture of 6" Line Between V-163 and V-156	5×10^{-11}	1×10^{-10}/hr
M0F1618DMJ	Rupture of 6" Line Between P-113 and V-99	5×10^{-11}	1×10^{-10}/hr
M0E1631AMJ	Rupture of 4" Line Between Discharge Pipe and FW V-156	5×10^{-11}	1×10^{-10}/hr
M0E1631BMJ	Rupture of 4" Line Between Discharge Pipe and FW V-159	5×10^{-11}	1×10^{-10}/hr
M0E1631CMJ	Rupture of 4" Line Between Discharge Pipe and FW V-162	5×10^{-11}	1×10^{-10}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
M0D1625AMJ	Rupture of 6" Line Between Discharge Pipe and PCV-4326	5×10^{-11}	1×10^{-10}/hr
F0T1079AMJ	Rupture of 16" Condensate Line Between Tank and V-141	5×10^{-11}	1×10^{-10}/hr
F0K1080AMJ	Rupture of 24" Condensate Line Between V-143 and V-141	5×10^{-11}	1×10^{-10}/hr
F0K1080BMJ	Rupture of 24" Line Between Suction Line and V-142	5×10^{-11}	1×10^{-10}/hr
F0J1080CMJ	Rupture of 20" Suction Line Between V-143 and Tee	5×10^{-11}	1×10^{-10}/hr
F0J1080DMJ	Rupture of 20" Suction Line Between Tee and V-145	5×10^{-11}	1×10^{-10}/hr
F0G1080AMJ	Rupture of 8" Line Between Tee and V-340	5×10^{-11}	1×10^{-10}/hr
F0F1080BMJ	Rupture of 8" Line Between V-340 and V-152	5×10^{-11}	1×10^{-10}/hr
F0G1080CMJ	Rupture of 8" Line Between V-152 and P-113	5×10^{-11}	1×10^{-10}/hr
MVA1V99AMJ	Rupture of V-99	5×10^{-9}	1×10^{-8}/hr
MVP1V163MJ	Rupture of V-163	5×10^{-9}	1×10^{-8}/hr
MVM1V156MJ	Rupture of FWV-156	1×10^{-8}	2×10^{-8}/hr
MVM1V159MJ	Rupture of FWV-159	1×10^{-8}	2×10^{-8}/hr
F0F10900MJ	Rupture of Bypass Inlet Line Between Tee and V-341	5×10^{-10}	1×10^{-10}/hr
FVM1V152MJ	Rupture of V-152	1×10^{-8}	2×10^{-8}/hr
FVA1V340MJ	Rupture of V-340	5×10^{-9}	1×10^{-8}/hr
FVM1V142MJ	Rupture of V-142	1×10^{-8}	2×10^{-8}/hr

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
FVM1V341MJ	Rupture of V-341	1×10^{-8}	2×10^{-8}/hr
MVD14326MJ	Rupture of PCV-4326	5×10^{-8}	1×10^{-7}/hr
FVD1V145MJ	Rupture of V-145	5×10^{-9}	1×10^{-8}/hr
FVA1V343MJ	Rupture of V-343	5×10^{-9}	1×10^{-8}/hr
F0G1080EMJ	Rupture of Bypass Outlet Line Between V-341 and Tee	5×10^{-10}	1×10^{-10}/hr
F0G1090FMJ	Rupture of Bypass Outlet Line Between V-344 and Tee	5×10^{-10}	1×10^{-10}/hr
F0F1080GMJ	Rupture of 8" Line Between V-344 and V-343	5×10^{-10}	1×10^{-10}/hr
FMJ1V344MJ	Rupture of V-344	1×10^{-8}	2×10^{-8}/hr
MVM1V162MJ	Rupture of FWV-162	1×10^{-8}	2×10^{-8}/hr
FVD1V143MJ	Rupture of P-113 Suction Isolation Valve V-143	5×10^{-9}	1×10^{-8}/hr
FVD1V141MJ	Rupture of P-113 Suction Isolation Valve V-141	5×10^{-9}	1×10^{-8}/hr
MVA1V99-MA	Check Valve V-99 Fails to Open	2×10^{-4}	2×10^{-4}/d
FVM1V152MD	Manual Isolation Valve V-152 Fails to Remain Open (Plugs)	1×10^{-4}	1×10^{-4}/d
FVD1V143MD	Isolation Valve V-143 Fails to Remain Open	1×10^{-4}	1×10^{-4}/d
FVD1V141MD	Isolation Valve V-143 Fails to Remain Open	1×10^{-4}	1×10^{-4}/d
MVD1V1630A	Operator Fails to Open V-163	1×10^{-2}	1×10^{-2}/d
MVD1V1560A	Operator Fails to Open V-156	1×10^{-2}	1×10^{-2}/d

TABLE B.2 (Continued)

FAULT IDENTIFIERS FOR THE SEABROOK EMERGENCY FEED STATION

FAULT IDENTIFIER	DESCRIPTION	UNAVAILABILITY	FAILURE RATE
FVM1V1520D	Operator Fails to Restore V-152	1×10^{-3}	1×10^{-3}/d
FVD1V1430D	Operator Fails to Restore V-143	1×10^{-3}	1×10^{-3}/d
FVD1V1410D	Operator Fails to Restore V-141	1×10^{-3}	1×10^{-3}/d
MPB1P11300	P-113 Out of Service	7.0×10^{-4}	
MPB1P16100	P-161 Out of Service	5×10^{-4}	
MPB1P113ME	P-113 Fails to Start	4×10^{-3}	4×10^{-3}/d
MPB1P161ME	P-161 Fails to Start	4×10^{-3}	4×10^{-3}/d
RCA1E42-MJ	Circuit Breaker 1E42 Shorts to Ground	3.5×10^{-8}	7×10^{-8}/hr
RCA1A93-0B	Operator Fails to Close Circuit Breaker A-93	1×10^{-2}	1×10^{-2}/d
RCA1A93-MB	Circuit Breaker A-93 Fails to Close	1×10^{-3}	1×10^{-3}/d
RCA1A54-MB	Diesel Generator 1A Circuit Breaker A-54 Fails to Close	1×10^{-3}	1×10^{-3}/d
RGD1DG1AME	Diesel Generator a A Fails to Start	1.0×10^{-2}	1.0×10^{-2}/d
RGD1DG1AMG	Diesel Generator 1 A Fails to Run	3.0×10^{-3}	6.0×10^{-3}/hr
6IC1FPSAMN	No Actuation Signal Generated	5.8×10^{-3}	5.8×10^{-3}/d
FVD1V14300	Startup Feedpump Suction Isolation Valve V-143 Out of Service	1.2×10^{-4}	
FVD1V14100	Startup Feedpump Suction Isolation Valve V-141 Out of Service	0.0	

APPENDIX C

Engineering Drawing List For the Seabrook Nuclear Station Emergency and Startup Feedwater Systems

	Drawing Title	Number
	Mechanical System P&I Diagrams:	
1.	Main Steam System (Sheet 1)	9763-F-202074
2.	Emergency Feedwater System	9763-F-202076
3.	Condensate System	9763-F-202077
4.	Feedwater System	9763-F-202079
5.	Compressed Air System, Key Plan	9763-F-202105
6.	Compressed Air System	9763-F-202106
7.	Turbine Building Compressed Air Headers	9763-F-202107
8.	Miscellaneous Buildings Compressed Air Headers	9763-F-202108
	Electrical System One Line Diagrams:	
1.	Unit Electrical Distribution	9763-F-310002
2.	4160V Switchgear Bus 1-E5	9763-F-310007
3.	480V Unit Substation Buses 1-E51 and 1-E52	9763-F-310013
4.	125VDC and 120VAC Instrument Buses	9763-F-310041
5.	Turbine Building 480V Motor Control Center 1-E523	9763-F-310046
	Logic Diagrams:	
1.	Symbols	9763-M-503100
2.	FW-Start-up Feed P-113	9763-M-503580
3.	FW-Prelube P-161 For Start-up Feed P-113 Sht 1	9763-M-503581
4.	FW Emerg Fd P-37A Steam Supply Vlv (MS-V128) Train B	9763-M-503584
5.	FW Emerg Fd P-37A Stm Supply Vlv (MS-V127) Train A	9763-M-503585
6.	FW-Emerg Feed P-37B	9763-M-503586

7.	FW-Emerg FW Bypass/Inop Status Alarm	9763-M-503599
8.	MS-Trip & Throttle Valve V-129	9763-M-503672
9.	FW-Emergency Valves	9763-M-504152
10.	FW-Emergency Valves	9763-M-504155
11.	FW-Valve-V148	9763-M-504156
12.	FW-Prelube P-161 For Start-up Fd P-113 Sht 2	9763-M-504157

Control Loop Diagrams:

1.	FW-Start-up Feed P-113 & Prelube Pmp P-161	9763-M-506480
2.	FW-Feed Pump P-32B Speed Control & Disch	9763-M-506481
3.	FW-Emerg Feed Pump P-37A (Turbine Driven)	9763-M-506497
4.	FW-Emerg Feed Pump P-37B Discharge Flow	9763-M-506498
5.	FW-Emerg Feed Pump P-37B TE-4271 & TE-4347	9763-M-506499
6.	MS Supply To Emerg Fd Pmp Turbine Isol Vlv	9763-M-506555
7.	FW-Emerg Feed Pump P-37A Discharge Flow	9763-M-507043
8.	FW-Emerg Feed Pump P-37B	9763-M-507044
9.	FW-Emerg FW Valve FV-4214	9763-M-507056
10.	FW-Emerg FW Valve FV-4224	9763-M-507057
11.	FW-Emerg FW Valve FV-4234	9763-M-507058
12.	FW-Emerg FW Valve FV-4244	9763-M-507059
13.	Start-up Feed Pump 1-P-113 Prelube Pump 1-P-161	9763-M-310844 SHCN1a
14.	Prelube Pump 1-P-161 Legend & Switch	9763-M-310844 SHCN1b

15.	Prelube Pump 1-P-161 Cable Schematic	9763-M-310844 SHCN1c

FSAR Drawings:

1.	Functional Diagrams-Reactor Trip Signals	Figure 7.2-1 Sheet 2
2.	Functional Diagrams-Pressurizer Trip Signals	Figure 7.2-1 Sheet 6
3.	Functional Diagrams-Steam Generator Trip Signals	Figure 7.2-1 Sheet 7
4.	Functional Diagrams-Safeguards Actuation Signals	Figure 7.2-1 Sheet 8
5.	Functional Diagrams-Auxiliary Feedwater Pumps Startup	Figure 7.2-1 Sheet 15
6.	Separation of Instrument and Control Power Sources	Figure 8.3-3

APPENDIX D

WAM CODE RESULTS

WAM Results for Loss of Main Feedwater

System Unavailability Calculated by **WAMBAM**:

```
1028          AFW               2.06786E-05
```

Important Cut-sets as Caculated by **WAMCUT**:

```
CUT SETS FOR GATE   AFW          ORDERED BY PROBABILITY

  1.     3.40E-06     MPB1D37BMG     MVD1V1250D
  2.     2.40E-06     MPB1D37BME     MVD1V1250D
  3.     2.00E-06     MVD1V71B00     MVD1V1250D
  4.     1.20E-06     MVD1V1250D     MCD1D37BMK
  5.     1.00E-06     MVD1V1250D     FVM1V15800
  6.     1.00E-06     MVD1V1250D     FVM1V15900
  7.     9.40E-07     MPB1D37B00     MVD1V1250D
  8.     3.40E-07     MPB1D37BMG     MVD1V125MD
  9.     3.14E-07     MPB1D37BMG     MPB1T37AME     MVD1V1630A
 10.     2.86E-07     MPB1D37BMG     MPB1T37AME     MVD1V1560A
 11.     2.40E-07     MVD1V125MD     MPB1D37BME
 12.     2.22E-07     MPB1T37AME     MPB1D37BME     MVD1V1630A
 13.     2.13E-07     MPB1T37AMG     MPB1D37BMG     MVD1V1630A
 14.     2.02E-07     MPB1T37AME     MPB1D37BME     MVD1V1560A
 15.     2.00E-07     MVA1V70BMA     MVD1V1250D
 16.     2.00E-07     MVD1V125MD     MVD1V71B00
 17.     1.94E-07     MPB1T37AMG     MPB1D37BMG     MVD1V1560A
 18.     1.85E-07     MPB1T37AME     MVD1V71B00     MVD1V1630A
 19.     1.68E-07     MPB1T37AME     MVD1V71B00     MVD1V1560A
 20.     1.66E-07     MPB1D37BMG     MPB1T37AME     6IC1FPSAMN
 21.     1.50E-07     MPB1T37AMG     MPB1D37BM     MVD1V1630A
 22.     1.37E-07     MPB1T37AMG     MPB1D37BME     MVD1V1560A
 23.     1.25E-07     MPB1T37AMG     MVD1V71B00     MVD1V1630A
 24.     1.20E-07     MVD1V125MD     MCD1D37BMK
 25.     1.17E-07     MPB1T37AME     MPB1D37BME     6IC1FPSAMN
 26.     1.14E-07     MPB1D37BMG     MPB1T37AME     MPB1P113ME
 27.     1.14E-07     MPB1D37BMG     MPB1T37AME     MPB1P161ME
 28.     1.14E-07     MPB1T37AMG     MVD1V71B00     MVD1V1560A
 29.     1.12E-07     MPB1T37AMG     MPB1D37BMG     6IC1FPSAMN
 30.     1.11E-07     MPB1D37BMG     MPB1T37AME     MRA1P161MK
 31.     1.11E-07     MPB1T37AME     MCD1D37BMK     MVD1V1630A
 32.     1.01E-07     MPB1T37AME     MCD1D37BMK     MVD1V1560A
```

WAM Results for Loss of Offsite Power

System Unavailability Calculated by WAMBAM:

```
          1028          AFW                   5.63720E-05
```

Important Cut-sets as Calculated by WAMCUT:

```
CUT SETS FOR GATE  AFW          ORDERED BY PROBABILITY

   1.      1.00E-05      MVD1V1250D      RGD11B--ME
   2.      3.40E-06      MPB1D37BMG      MVD1V1250D
   3.      3.00E-06      MVD1V1250D      RGD11B--MG
   4.      2.40E-06      MPB1D37BME      MVD1V1250D
   5.      2.00E-06      MVD1V71B00      MVD1V1250D
   6.      1.20E-06      MVD1V1250D      MCD1D37BMK
   7.      1.00E-06      MVD1V125MD      RGD11B--ME
   8.      1.00E-06      MVD1V1250D      FVM1V1580D
   9.      1.00E-06      MVD1V1250D      FVM1V1590D
  10.      1.00E-06      MVD1V1250D      RCA1A74-MB
  11.      9.40E-07      MPB1D37B00      MVD1V1250D
  12.      9.24E-07      MPB1T37AME      RGD11B--ME      MVD1V1630A
  13.      8.40E-07      MPB1T37AME      RGD11B--ME      RCA1A93-0B
  14.      8.40E-07      MPB1T37AME      RGD11B--ME      RGD1DG1AME
  15.      8.40E-07      MPB1T37AME      RGD11B--ME      MVD1V1560A
  16.      7.00E-07      MVD1V1250D      RGD11B--00
  17.      6.27E-07      MPB1T37AMG      RGD11B--ME      MVD1V1630A
  18.      5.70E-07      MPB1T37AMG      RGD11B--ME      RCA1A93-0B
  19.      5.70E-07      MPB1T37AMG      RGD11B--ME      RGD1DG1AME
  20.      5.70E-07      MPB1T37AMG      RGD11B--ME      MVD1V1560A
  21.      4.87E-07      MPB1T37AME      RGD11B--ME      6IC1FFSAMN
  22.      3.40E-07      MPB1D37BMG      MVD1V125MD
  23.      3.36E-07      MPB1T37AME      RGD11B--ME      MPB1P113ME
  24.      3.36E-07      MPB1T37AME      RGD11B--ME      MPB1P161ME
  25.      3.31E-07      MPB1T37AMG      RGD11B--ME      6IC1FFSAMN
  26.      3.28E-07      MPB1T37AME      RGD11B--ME      MRA1P161MK
  27.      3.14E-07      MPB1D37BMG      MPB1T37AME      MVD1V1630A
  28.      3.00E-07      MVD1V125MD      RGD11B--MG
  29.      2.86E-07      MPB1D37BMG      MPB1T37AME      RCA1A93-0B
  30.      2.86E-07      MPB1D37BMG      MPB1T37AME      RGD1DG1AME
  31.      2.86E-07      MPB1D37BMG      MPB1T37AME      MVD1V1560A
  32.      2.77E-07      MPB1T37AME      RGD11B--MG      MVD1V1630A
  33.      2.52E-07      MPB1T37AME      RGD11B--MG      RCA1A93-0B
  34.      2.52E-07      MPB1T37AME      RGD11B--MG      RGD1DG1AME
  35.      2.52E-07      MPB1T37AME      RGD11B--MG      MVD1V1560A
  36.      2.52E-07      MPB1T37AME      RGD11B--ME      RGD1DG1AMG
  37.      2.40E-07      MVD1V125MD      MPB1D37BME
  38.      2.28E-07      MPB1T37AMG      RGD11B--ME      MPB1P113ME
  39.      2.28E-07      MPB1T37AMG      RGD11B--ME      MPB1P161ME
  40.      2.22E-07      MPB1T37AMG      RGD11B--ME      MRA1P161MK
  41.      2.22E-07      MPB1T37AME      MPB1D37BME      MVD1V1630A
  42.      2.20E-07      MV1DV65A00      RGD11B--ME      MVD1V1630A
  43.      2.13E-07      MPB1T37AMG      MPB1D37BMG      MVD1V1630A
```

WAM Results for Loss of Offsite Power - cont'd

Important Cut-sets as Calculated by WAMCUT:

44.	2.02E-07	MPB1T37AME	MPB1D37BME	RCA1A93-0B
45.	2.02E-07	MPB1T37AME	MPB1D37BME	RGD1DG1AME
46.	2.02E-07	MPB1T37AME	MPB1D37BME	MVD1V1560A
47.	2.00E-07	MVA1V70BMA	MVD1V1250D	
48.	2.00E-07	MVD1V125MD	MVD1V71B00	
49.	2.00E-07	MVD1V65A00	RGD11B--ME	RCA1A93-0B
50.	2.00E-07	MVD1V65A00	RGD11B--ME	RGD1DG1AME
51.	2.00E-07	MVD1V65A00	RGD11B--ME	MVD1V1560A
52.	1.94E-07	MPB1T37AMG	MPB1D37BMG	RCA1A93-0B
53.	1.94E-07	MPB1T37AMG	MPB1D37BMG	RGD1DG1AME
54.	1.94E-07	MPB1T37AMG	MPB1D37BMG	MVD1V1560A
55.	1.88E-07	MPB1T37AMG	RGD11B--MG	MVD1V1630A
56.	1.85E-07	MPB1T37AME	MVD1V71B00	MVD1V1630A
57.	1.71E-07	MPB1T37AMG	RGD11B--MG	RCA1A93-0B
58.	1.71E-07	MPB1T37AMG	RGD11B--MG	RGD1DG1AME
59.	1.71E-07	MPB1T37AMG	RGD11B--MG	MVD1V1560A
60.	1.71E-07	MPB1T37AMG	RGD11B--ME	RGD1DG1AMG
61.	1.68E-07	[illegible]1T37AME	MVD1V71B00	RCA1A93-0B
62.	1.68E-07	MPB1T37AME	MVD1V71B00	RGD1DG1AME
63.	1.68E-07	MPB1T37AME	MVD1V71B00	MVD1V1560A
64.	1.66E-07	MPB1D37BMG	MPB1T37AME	6IC1FFSAMN
65.	1.50E-07	MPB1T37AMG	MPB1D37BME	MVD'V1630A
66.	1.46E-07	MPB1T37AME	RGD11B--MG	6IC1FFSAMN
67.	1.37E-07	MPB1T37AMG	MPB1D37BME	RCA1A93-0B
68.	1.37E-07	MPB1T37AMG	MPB1D37BME	RGD1DG1AME
69.	1.37E-07	MPB1T37AMG	MPB1D37BME	MVD1V1560A
70.	1.25E-07	MPB1T37AMG	MVD1V71B00	MVD1V1630A
71.	1.20E-07	MVD1V125MD	MCD1D37BMK	
72.	1.17E-07	MPB1T37AME	MPB1D37BME	6IC1FFSAMN
73.	1.16E-07	MVD1V65A00	RGD11B--ME	6IC1FFSAMN
74.	1.14E-07	MPB1D37BMG	MPB1T37AME	MPB1P113ME
75	1.14E-07	MPB1D37BMG	MPB1T37AME	MPB1P161ME
76.	1.14E-07	MPB1T37AMG	MVD1V71B00	RCA1A93-0B
77.	1.14E-07	MPB1T37AMG	MVD1V71B00	RGD1DG1AME
78.	1.14E-07	MPB1T37AMG	MVD1V71B00	MVD1V1560A
79.	1.12E-07	MPB1T37AMG	MPB1D37BMG	6IC1FFSAMN
80.	1.11E-07	MPB1D37BMG	MPB1T37AME	MRA1P161MK
81.	1.11E-07	MPB1T37AME	MCD1D37BMK	MVD1V1630A
82.	1.10E-07	FVM1V1540D	RGD11B--ME	MVD1V1630A
83.	1.10E-07	FVM1V1550D	RGD11B--ME	MVD1V1630A
84.	1.10E-07	QVD1V95A0D	RGD11B--ME	MV1V1630A
85.	1.01E-07	MPB1T37AME	RGD11B--MG	MPB1P113ME
86.	1.01E-07	MPB1T37AME	RGD11B--MG	MPB1P161ME
87.	1.01E-07	MPB1T37AME	MCD1D37BMK	RCA1A93-0B
88.	1.01E-07	MPB1T37AME	MCD1D37BMK	RGD1DG1AME
89.	1.01E-07	MPB1T37AME	MCD1D37BMK	MVD1V1560A
90.	1.01E-07	MPB1T37AME	RGD11B--ME	MCD1P113MK
91.	1.01E-07	MPB1T37AME	RGD11B--ME	MCD1P161MK

WAM Results for Total Loss of AC Power

System Unavailability Calculated by WAMBAM:

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702          AFW                    2.13190E-02
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Important Cut-sets as Calculated by WAMCUT:

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CUT SETS FOR GATE  AFW          ORDERED BY PROBABILITY

   1.     8.40E-03     MPB1T37AME
   2.     5.70E-03     MPB1T37AMG
   3.     2.00E-03     MVD1V65AOO
   4.     1.00E-03     MVD1V125OD
   5.     1.00E-03     FVM1V154OD
   6.     1.00E-03     FVM1V155OD
   7.     1.00E-03     QVD1V95AOD
   8.     4.20E-04     MPB1T37AOO
   9.     2.00E-04     MVA1V64AMA
  10.     1.00E-04     MVD1V125MD
  11.     1.00E-04     FVM1V154MD
  12.     1.00E-04     FVM1V155MD
  13.     1.00E-04     QVM1V95AMD
  14.     1.00E-04     QVD1V129OO
  15.     1.00E-04     MVD1V65AOD
  16.     1.00E-04     MVD1V65AMD
  17.     8.50E-05     MVD1421400     MVD1V126OD
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