INDIAN POINT UNIT 3
AUXILIARY FEEDWATER SYSTEM

A. SUMMARY

A.1 INTRODUCTION

The Indian Point Unit 3 auxiliary feedwater system (AFS) functions as a heat removal system for the steam generators. It can operate in conjunction with, or independently from, the main feedwater system for emergencies or as optional equipment in startup, shutdown, or hot standby conditions.

The analysis is based on the system as it exists in three given electrical states. These states are:

- Full power
- Loss of one bus (either bus 3A or bus 6A)
- No electric power.

The boundary of the analysis is pictured in Figure 1. The turbine steam supply from the steam generators, the piping systems and all of the auxiliary feedwater system components are included directly in the analysis. The water supplies themselves are not analyzed in detail, and the electrical power supplies are outside the boundary of the analysis as is the AFS actuation signal. The analysis is conditional on the presence of an AFS actuation signal. Finally, some human interactions are included within the analysis and some are outside the boundary. Within the boundaries, the human interaction through test and maintenance, as well as operator response to system failure on demand, are considered.

A.2 RESULTS

The AFS unavailability was calculated for the three states of the electric power system. The results are shown in Table 1, the AFS Unavailability Table. Table 1 indicates that there is considerable importance attached to the state of the electric power system. The AFS depends on two electrical buses for power, and is designed to function without electric power. However, loss of all electric power does increase the system unavailability since the two motor-driven pumps would become inoperative.

The dominant contributors to unavailability are different for each state of the electric power system. The dominant contributors to the full power state are:

- Nonrecoverable Random Failures - Failure of the CST and city water supply (mean unavailability: 1.07×10^{-6}, approximate unavailability contribution: 43.5%).

- Independent Human Error - Failure of the operator to valve in the city water coupled with a failure of the CST water supply (mean unavailability: 4.70×10^{-7}, approximate unavailability contribution: 19.1%).

- Independent Human Error - Failure of the operator to start the turbine-driven pump, maintenance on one motor-driven pump and failure of either set of discharge valves on the remaining motor-driven pump (mean unavailability: 3.24×10^{-7}, approximate unavailability contribution: 13.2%).

- Test and Maintenance - Motor-driven pump maintenance coupled with a failure of the turbine-driven pump train and failure of either set of discharge valves associated with the remaining motor-driven pump (mean unavailability: 1.44×10^{-7}, approximate unavailability contribution: 5.9%).

- Independent Human Error - Operator failure to start the turbine-driven pump coupled with a failure of one motor-driven pump and the failure of either set of discharge valves on the remaining motor-driven pump (mean unavailability: 1.19×10^{-7}, approximate unavailability contribution: 4.8%).

- Independent Human Error - Operator failure to start the turbine-driven pump coupled with failure of one motor-driven pump and maintenance on the other motor-driven pump (mean unavailability: 8.28×10^{-8}, approximate unavailability contribution: 3.4%).

- Test and Maintenance - Turbine-driven pump maintenance coupled with failure of one motor-driven pump and failure of either set of discharge valves on the other motor driven pump (mean unavailability: 7.03×10^{-8}, approximate unavailability contribution: 3.0%).

- Test and Maintenance - Motor-driven pump maintenance coupled with failure of the other two pumps (mean unavailability: 3.68×10^{-8}, approximate unavailability contribution: 1.5%).

For the case where one electrical bus was not functioning, the dominant contributors are:

- Independent Human Error - Operator failure to start the turbine-driven pump coupled with failure of either set of discharge valves on the remaining motor-driven pump (mean unavailability: 4.03×10^{-5}, approximate unavailability contribution: 27.2%).

- Independent Human Error - Operator failure to start the turbine-driven pump coupled with maintenance on the motor-driven pump (mean unavailability: 2.82×10^{-5}, approximate unavailability contribution: [illegible] %).

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- Test and Maintenance - Turbine-driven pump maintenance coupled with a failure in either set of the discharge valves on the remaining motor-driven pump (mean unavailability: 2.40×10^{-5}, approximate unavailability contribution: 16.2%).

- Nonrecoverable Random Failures - Failure of the turbine-driven pump and failure of either set of discharge valves on the remaining motor-driven pump (mean unavailability: 1.79×10^{-5}, approximate unavailability contribution: 12.1%).

- Test and Maintenance - Maintenance on the motor-driven pump and failure of the turbine-driven pump (mean unavailability: 1.25×10^{-5}, approximate unavailability contribution: 8.4%).

- Independent Human Error - Operator failure to start the turbine-driven pump coupled with a failure of the motor-driven pump (mean unavailability: 1.03×10^{-5}, approximate unavailability contribution: 7.0%).

- Test and Maintenance - Turbine pump maintenance coupled with a failure of the other motor-driven pump (mean unavailability: 6.12×10^{-6}, approximate unavailability contribution: 4.1%).

- Nonrecoverable Random Failures - Failure of turbine and motor-driven pump trains (mean unavailability: 4.56×10^{-6}, approximate unavailability contribution: 3.1%).

For the case of no electric power, the dominant contributors to unavailability are:

- Independent Human Error - Failure of the operator to start the turbine-driven pump (mean unavailability: 7.00×10^{-3}, approximate unavailability contribution: 49.0%)

- Test and Maintenance - Turbine-driven pump maintenance (mean unavailability: 4.16×10^{-3}, approximate unavailability contribution: 29.1%)

- Nonrecoverable Test and Maintenance - Failure of the turbine-driven pump train (mean unavailability: 3.10×10^{-3}, approximate unavailability contribution: 21.7%)

Below is a comparison of the AFS study to WASH-1400.

AFS Study Scenarios	Mean Unavailability
Full Power to the AFS (start to 8 hours)	2.46×10^{-6}
Loss of one bus to the AFS (start to 8 hours)	1.48×10^{-4}
No electrical power to the AFS (start to 8 hours)	1.43×10^{-2}
WASH-1400 Scenarios	
Small pipe break (start to 8 hours)	3.50×10^{-5}
Small pipe break (8 to 24 hours)	1.10×10^{-3}
Loss of net offsite electric power (start to 8 hours)	2.50×10^{-4}
Loss of net offsite electric power (8 to 24 hours)	3.40×10^{-3}
High energy pipe break (start)	2.20×10^{-2}

A.3 CONCLUSIONS

The results presented in this section show that in the emergency mode the Indian Point 3 auxiliary feedwater system is very reliable. Redundancy, separation, availability during testing, and recoverability make the system sound. Figure A shows the resulting curves for the three scenarios dealt with in this study. The results are based on the failure of the auxiliary feedwater system to deliver at least 200 gpm to each of two steam generators. Approximately 30 minutes are available from the time of reactor trip until auxiliary feedwater is required based on normal steam generator water inventories. The dominant contributors to conditional unavailability are human error (inaction), test and maintenance, and nonrecoverable random failures.

In the "Full Power" case, the dominant contributor is the failure of the two water sources. The other major contributions include three test and maintenance and four independent human error scenarios.

The "Loss of One Bus" case is dominated by two independent human error scenarios. The loss of electric power to the one motor is primarily responsible for the increased unavailability over the "Full Power" case. Additionally, there are three test and maintenance, two nonrecoverable random failure, and one independent human error scenarios.

The "No Power" case is quite different. Now only the turbine train can be available, so single element cutsets in the turbine train move up. Topping the list is the failure of the operator to start the turbine-driven pump, followed by test and maintenance, and then the nonrecoverable random failure of the turbine pump train. This case shows that even with multiple failures leading to a complete loss of all power, the AFS should operate successfully (less than a 2% chance of failure).

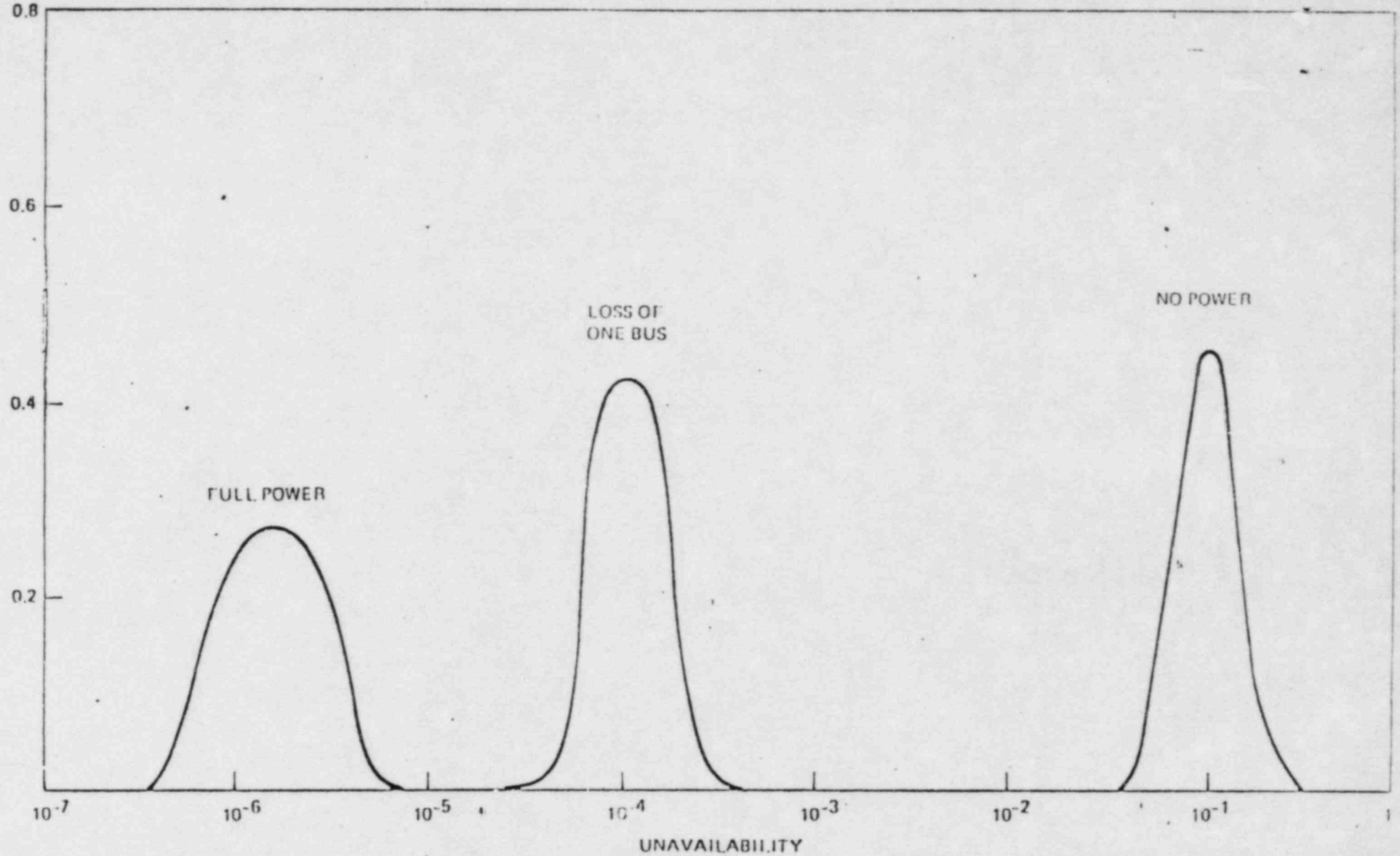

Figure A. Unavailability Probability Density of the Auxiliary Feedwater System

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B. SYSTEM DESCRIPTION

B.1 SYSTEM FUNCTION

The emergency function of the auxiliary feedwater system (AFS) is to provide heat removal for the reactor coolant system when the main feedwater system is unavailable. A simplified block diagram of the AFS is shown in Figure 2. Water is supplied through three pumps to each of four steam generators. The AFS must provide this function during small (less than 2-inch) loss of coolant accidents (LOCA) as well as during transients that lead to a loss of main feedwater. The AFS provides initial cooling to prevent overpressurization of the reactor coolant system and has sufficient water supplies to remove the residual heat generated by the reactor for at least 24 hours at hot shutdown conditions. The system is also used during normal plant startup, shutdown, and hot standby conditions. Requirements for success under emergency conditions are that flow from at least one pump (400 gpm) be delivered to at least two steam generators (200 gpm to each) within 30 minutes of the initial demand to preclude total loss of water inventory in the steam generator.

B.2 SYSTEM OPERATION (INCLUDING OPERATOR INTERACTION)

A simplified diagram of the auxiliary feedwater system for Indian Point Unit 3 is presented in Figure 3. The auxiliary feedwater system consists of two subsystems each capable of supplying 100% of the required flow. One subsystem utilizes two motor-driven pumps each with a capacity of 400 gpm. The discharge piping is arranged so that each pump supplies two steam generators. A separate subsystem utilizes a steam turbine-driven pump, with the steam supply from no. 32 and/or no. 33 steam generators upstream of the main steam isolation valves. A pressure reducing control valve reduces the steam supply pressure to the 600 psi design value of the turbine. The steam turbine-driven pump supplies a total of 800 gpm to all four steam generators.

Redundant water supplies are available to the AFS. The primary source is by gravity feed from the seismic Category I condensate storage tank with a total capacity of 600,000 gallons. Of this total volume, 360,000 gallons are dedicated for AFS use. Availability of water from this source is guaranteed by LCV-1158 which closes when the quantity of water in the condensate storage tank drops to 360,000 gallons, isolating the condensate storage tank outlet from other systems. Redundant level indicators and control room alarms are provided to monitor the condensate storage tank volume. When LCV-1158 closes, makeup to the main condensers is prevented and a sufficient quantity of water is assured to be available to remove the residual heat generated by the reactor for 24 hours at hot shutdown conditions. Two locked open manual valves, butterfly valve CT-6 and gate valve CT-64, are present in series along the main supply line from the condensate storage tank. Output from redundant position switches on both CT-6 and CT-64 are displayed and alarmed in the control room.

Each auxiliary feedwater pump takes suction from a common header through a check valve and an open manual gate valve (CT-32, CT-33: CT-26, CT-27: and CT-29, CT-30). Individual flow transmitters are provided on the suction to each of the two motor-driven pumps (no. 31 and no. 33). These instruments provide pump suction pressures indicated in the central control room by PI-1263-R, PI-1264-R, and PI-1265-R for each pump. These transmitters also provide a low-suction flow pump trip feature for each of the motor-driven pumps.

The emergency water supply for the auxiliary pumps is the one and one-half million gallon city water storage tank which is shared between Units 2 and 3. There is a normally open manual gate valve (CT-49) in the city water supply line located in an accessible tunnel outside the auxiliary pump building. Each pump is supplied from a header through a check and fail closed air-operated control valve which is normally closed (CT-25, PCV-1187; CT-28, PCV-1188; and CT-31, PCV-1189). These valves are controlled manually by a switch located in the central control room which operates the solenoid, applying or removing air from the valve. The valve position is indicated in the control room.

Discharge from each of the pumps is routed to the steam generators as illustrated in Figure 3. Steam generators 31 and 32 are supplied by motor-driven auxiliary feedwater pump 31. Steam generators 33 and 34 are supplied by motor-driven auxiliary feedwater pump 33. All four steam generators are supplied by the turbine-driven auxiliary feedwater pump 32.

Each of the individual auxiliary feedwater lines is provided with an air-operated, fail open, flow control valve for feedwater regulation (FCV-405A, B, C, D, and FCV-406A, B, C, D). The controller for the feedwater flow control valves for the motor-driven pumps (FCV-406A, B, C, D) and the controllers for the feedwater flow control valves for the turbine-driven pump (FCV-405A, B, C, and D) are normally maintained in a fully opened position. Each of these eight lines also includes a check valve and two manual isolation valves in series with the air-operated valve. A common flow transmitter for each steam generator is used to indicate flow in the central control room from the header common to the motor-driven and turbine-driven pump sections. Pump discharge pressure indicators are provided both locally and in the control room. Recirculation lines, which are provided for pump protection, are located upstream of the check valves at the pump discharges (BFD-31, 34, 39) and are routed back to the CST.

Level in the steam generators is maintained manually from the control room by positioning the flow control valves. Each valve can be positioned from the control room via electric/air converters. Air to these valves is from a common header which is supplied by instrument air compressors powered from 480V switchgear buses. The air supply to the valves is automatically backed up by an emergency high pressure nitrogen (bottle) system.

The pneumatic controls associated with the auxiliary pump flow control valves are provided with an automatic nitrogen backup. Three nitrogen bottles are located inside the auxiliary feed pump room which connect into the instrument air supply downstream of a check valve. A pressure regulator set at 50 psig will feed nitrogen into the instrument air supply system whenever the normal air supply pressure decreases below this setting. A pressure switch (PC-1355-S) located at the bottles will annunciate in the control room to warn the operator whenever the bottles require changing.

In addition to remote control from the control room, all of the AFS pumps and regulating valves can be operated locally in the auxiliary feedwater building.

The design of the AFS does not have the capability to automatically terminate feedwater flow to a depressurized steam generator and provide flow to the intact steam generator. This is accomplished by the operator.

B.2.1 MOTOR-DRIVEN AUXILIARY FEEDWATER PUMP

The motor-driven auxiliary feedwater pumps are Ingersoll-Rand Company No. 3HMTA, nine-stage, horizontal split case centrifugal units, each of which supplies 400 gpm of water at a head of 1350 psi. The motor drives are furnished by Westinghouse Electric Corporation.

Auxiliary feedwater pumps 31 and 33 are driven by motors supplied from independent 480V emergency buses, 3A and 6A respectively. Control switches exist both locally and in the central control room on the condensate and feedwater supervisory panel. The local switches allow "Start and Stop" pushbutton operation of the pumps. The switches in the control room have three positions, "On-Auto-Trip." The following conditions will automatically start the pumps as described:

1. The loss of either of two main feedwater pumps.

2. Two-out-of-three coincidence of low-low steam generator level in any one of four steam generators.

3. In the event of a "Safety Injection" signal with a loss of offsite power, the following will occur:

   a. All buses will clear, tripping the pumps if they are on the line.

   b. The pumps will be provided with a start signal as part of the automatic safeguard bus reloading sequence.

4. Loss of offsite power with no "Safety Injection" signal will provide both pumps with a start signal after the diesels have tied into the 480V buses. A time delay is associated with starting the pumps to allow for loading of the diesels.

* Undervoltage on either bus 3A or 6A will trip the pump fed by the bus.

The following indications and alarms are provided in the central control room to monitor the pumps:

1. Pump on-off-auto trip lights
2. Safeguards off-normal alarm
3. Pump auto trip alarm
4. Pump on local control alarm.

Each motor-driven pump is provided with a pressure sustaining control system to prevent the pump from "running out." As the discharge pressure of the pump decreases below the set point of 1355 psia, PT-406A for pump 31 and PT-406B for pump 33 will generate a signal that will override the signal from the flow controllers on the condensate and feedwater supervisory panel. The signal will operate to close the valves until the pressure is restored in the discharge line having low pressure.

B.2.2 TURBINE-DRIVEN AUXILIARY FEEDWATER PUMP

The full-size turbine-driven pump is a Worthington Corporation No. 4-WT-127 horizontal, multi-stage, centrifugal pump with a capacity of 800 gpm at 1350 psi. The turbine drive is a horizontal axial flow, noncondensing unit rated at 970 HP at 3570 RPM. Steam to drive the turbine is supplied from the main steam lines associated with steam generators 32 and 33 upstream of the main steam isolation valves.

Two temperature controlled air-operated shutoff valves, PCV-1310A and PCV-1310B, are mounted in series in the steam line to the turbine-driven pump. These valves have been added to provide for the unlikely event of the steam line rupturing within the auxiliary feedwater pump room.

During turbine operation, the steam supply pressure is regulated by PCV-1139. This pressure control valve maintains a 600 psig steam pressure to the turbine. Pressure controller 1176-S senses the downstream pressure and generates a signal for use by the positioner. The control signal generated by the positioner is then applied to the diaphragm of PCV-1139 through the start solenoids. Pressure controller 1176-S will also alarm low pressure at 550 psig in the central control room. Once the pressure has been reduced, the steam enters the turbine steam chest which contains the governor and turbine trip valves.

The turbine-driven pump is a variable speed device, whereas the two motor-driven pumps are constant speed devices. The speed of the turbine-driven pump is governed by a remote pneumatic speed changer (HC-1118) that is located on the condensate and feedwater supervisory panel in the central control room. The speed changer is designed to operate over an entire speed range of 0 to 100%.

Pressure reducing valve PCV-1139 is used as the steam isolation and supply valve for the auxiliary feed pump turbine. The mode of operation of this valve is controlled by "Trip-Auto-On" switches: one located in the central control room, and one in the auxiliary boiler feed pump building. These switches control the position of solenoid valves mounted on the air inlet to the valve actuator. In their deenergized state, these solenoid valves allow the positioner output to open the valve. Normally, the valve is maintained in standby, with the control switches in "Auto." In this state, the positioner output is cut off and full instrument air pressure is applied to the valve actuator holding the valve closed. The solenoid valves will be automatically deenergized and the pump started by any of the following:

1. Two-out-of-three coincidence of low-low water level in any two of the four steam generators
2. Loss of offsite power (provided that a "safety injection" signal does not exist).

The turbine governor valve is controlled by a governor and speed changer. The speed changer can be operated locally or from the control room by HC-1118. A trip valve has been provided to immediately shut down the turbine on an overspeed of 4516 RPM. Turbine speed is indicated in the central control room and also locally. Under normal conditions, the operator must use HC-1118 to bring the turbine up to speed; the automatic signal to PCV-1139 will not do this. On loss of air to HC-1118, the speed changer fails in the full closed position. Operator action is required locally at the turbine to reset and operate the turbine-driven AFS pump.

B.3 SUPPORTING SYSTEMS

The AFS is started by a signal from the safeguards actuation system (SAS) which starts the motor-driven auxiliary feedwater pump. Manual actuation from the control room is also possible. Power supplies for each component requiring electrical power are identified in Table 2. The piping analysis is shown in Table 3. The instrument air system is the primary air supply for controlled operation of all air-operated valves in the system, as well as the speed control system on the auxiliary feedwater turbine. The city water supply system is required as a emergency water supply for the system.

The operator must open the three normally closed air-operated stop valves (PCV-1187, 1188, 1189) on the supply lines from the city water supply to the auxiliary feed pumps upon loss of flow from the condensate storage tank. This can be done from the control room under normal conditions. However, as the city water valves are fail closed valves, upon loss of AC power from the 120V AC distribution system or loss of instrument air coupled with the loss of the nitrogen bottle backup, these valves must be jacked open locally in the pump room. Due to the dependence of the auxiliary feedwater turbine speed control system (HC-1118) on instrument air, the operator must operate the turbine locally in the pump room upon loss of instrument air by use of a hand jack mechanism located on the controller.

B.4 TEST REQUIREMENTS

The following procedures form the test schedule for Indian Point Unit 3. The procedure number is in parentheses. A detailed account of both the required testing frequency and the indirect testing of all AFS components is provided in Table 8. The major test procedures and their general application are outlined below:

1. Each motor-driven auxiliary feedwater pump is started at intervals not greater than every month (3PT-M20) with full flow established to the steam generators once every refueling (3PT-R7).

2. The steam turbine-driven auxiliary feedwater pump is started at intervals not greater than every month (3PT-M20) with full flow established to the steam generators once every refueling (3PT-R7).

3. The air-operated discharge valves on both the motor-driven pump trains and the turbine pump train are stroked a least once each quarter (3PT-Q20).

4. The auxiliary feedwater pump turbine manual overspeed trip is tested on a variable schedule. The first test involves use of the manual overspeed turbine trip lever to trip the turbine during operation (3PT-V8A). The other test runs the turbine up until it actually overspeeds to test the setpoint of the mechanical overspeed trip mechanism. The turbine is uncoupled from the pump during this second test (3PT-V8B). For both of these tests, the trip mechanism must be reset following the test.

The automatic initiation of the two motor-driven AFS pumps upon receipt of an engineered safeguard (SI) signal is tested and verified at refueling (i.e., approximately 18 month intervals).

B.5 MAINTENANCE REQUIREMENTS

The plant technical specifications limit the amount of time that an auxiliary feedwater pump or auxiliary feedwater pump train may be out of service for 72 hours. Further, a minimum of 360,000 gallons of water in the condensate storage tank and the backup supply from the city water supply must be available. If during power operation, these conditions cannot be met within 72 hours, the reactor must be placed in the hot shutdown condition within the next 12 hours and subsequently cooled below 350°F using normal operating procedures.

B.6 COMMON CAUSE ANALYSIS

The method used to perform the common cause failure analysis is based on the system fault tree logic model. A search is performed to identify those combinations of basic events that result in system failure or more simply, the cutsets. In other quantifications, each cutset was evaluated by considering each basic event as an independent 'black box' with certain failure characteristics. Common cause differs in that it

seeks to identify a failure characteristic that each of the basic events in a cutset possess. A simple example could be a cutset where all of the basic events are located in the same room and susceptible to fire. The results of the common cause search are groups of cutsets identified by common failure characteristics and the absence of barriers. Barriers between components, both physical and administrative, are considered in the analysis.

C. LOGIC MODEL

C.1 TOP EVENTS

Requirements for success under emergency conditions are that flow from at least one pump (400 gpm) be delivered to at least two steam generators (200 gpm to each) within 30 minutes of the initial demand. Success of the system is examined for the conditional probabilities associated with loss of the various states of the electric power system, instrument air system, maintenance, and human error.

C.2 SYSTEM FAULT TREE

A fault tree was constructed to model the failures that must occur to prevent successful system operation. The top event is defined as "AFS Failure to Deliver at Least 200 gpm to Each of Two Steam Generators." Sufficient flow is defined as the flow from at least one pump train delivered to at least two steam generators. The fault tree shows that, for the system to fail, we must fail to deliver sufficient flow to at least three of the four steam generators. In each case, this requires that there is no or insufficient flow through the steam generator inlet valve section, or that there is no or insufficient flow delivered to that section. Secondly, we must have no or insufficient flow from either motor-driven pump (i.e., both must fail) and no or insufficient flow from the turbine-driven pump. Finally, there is no water from either of the two potential water sources. This complete fault tree model is presented in Figure 4 where the system is modeled down to the level of major components. Included were the pumps, valves, electrical supply, motor operators, and turbine and control mechanisms. Not modeled were drain lines, drain valves, piping, and connected lines which are small in size, i.e., whose failure would not significantly affect the system. The AFS is modeled from the water sources with the priority of water supplies being the Condensate Storage Tank and the city water tank to the steam generators. Electrically, it is modeled from the bus to the system.

C.3 FAULT TREE CODING

Table 4 is a list of basic events, their failure modes, their corresponding codes, and unavailability (or failure probability on demand).

C.4 MINIMAL CUTSETS

The minimal cutsets were identified using FATRAM (part of RAS). The valid minimal cutsets for each electric power state differed because when a power state was given as a condition, some of the cutsets changed. This, in a general sense, is why loss of electric power increases unavailability. An example would be a three-event cutset being reduced to a two-event cutset. One of the members no longer has a fractional unavailability; it has been defined as one. Therefore, the new two-event cutset will have a higher unavailability, and this, in turn, will lead to a higher system unavailability.

D. QUANTIFICATION

The most important cutsets are listed in Table 5. Random failures of some of the basic events are recoverable and must be combined with human error probabilities before final quantification. Table 5 is basic to the analysis that follows. For example, when the test and maintenance cause is introduced into, say, the turbine pump train, the turbine pump train failure modes are activated. Then the remaining cutset elements identify the other failures that must occur to cause system failure. Details of the analysis and results are given in the following sections.

The numbers that appear in the quantification of the AFS were calculated by a method of histogram multiplication. The histograms for the basic components are created from a mean and variance for those basic components. The basic components are then built into larger components as needed for evaluating the cutsets from the fault tree. Table 6 is a collection of the "supercomponents" used in the AFS calculations. Table 7 tells the story of how each supporting row and column of Table 1 was created, using the supercomponents and other needed data.

D.1 <u>RANDOM FAILURES</u> (See Tables 7.1, 7.2, and 7.3)

Random system failures reflect the system malfunctions that occur as a result of random component failures. The coincidental failure of each component in an AFS cutset results in a system random failure. These random failures can be divided into two types, nonrecoverable and recoverable. This situation does not include, and should be differentiated from, test and maintenance, common cause, and independent human errors.

Nonrecoverable random failures for the AFS are those which cannot be repaired within a specific time frame. The duration of the time frame depends on system demands and component capabilities.

Recoverable failures require action for success when a failure occurs. Section D.4 on human interaction will elaborate on the subject of recovery by repair of the system.

D.2 <u>TEST AND MAINTENANCE</u> (See Tables 7.4, 7.5, and 7.6)

D.2.1 TESTING

Testing of the AFS consists primarily of surveillance testing to satisfy the plant technical specifications and ASME Section XI requirements.

Monthly testing is performed on each AFS pump. For each pump test the manual gate valves in the pump discharge lines are closed and the pump is started manually (from the control room or the local control panel). Each pump is then run 20 to 30 minutes to allow for stabilization of the system. Required pump data is then taken and recorded. The AFS pump test is then stopped and the manual gate valves are opened fully. Successful completion of the pump monthly test requires that the AFS pump develop minimum differential pressure on recirculation flow.

The condensate storage tank (CST) is monitored by a continued redundant indicator and alarms to verify the volume of water it contains.

The other components in the system have different test intervals. Table 8 indicates these intervals.

D.2.2 MAINTENANCE

The plant technical specifications limit the amount of time an auxiliary feedwater pump or auxiliary feedwater pump train may be out of service to 72 hours after which the plant must shut down.

Packing replacement and adjustment is the dominant cause of maintenance on valves. In most cases, this maintenance can be performed with the valve in the normal position for system operation (fully open or fully closed). Valve repairs requiring disassembly of the valve, although not frequently occurring, may have a major impact on system availability due to system isolation requirements necessary to safely perform this maintenance. Those valves which require full AFS shutdown in order for repair also require a plant shutdown (per technical specifications) and, therefore, do not contribute to the maintenance unavailability of the AFS. Those valves requiring maintenance which only need a single AFS pump train to be shut down do contribute to maintenance unavailability of the AFS.

Pump maintenance consists of a range of actions from major disassembly to packing adjustment. For the AFS pumps, most maintenance performed requires isolation of the pump from the system and, therefore, contributes to the maintenance unavailability of the pump train.

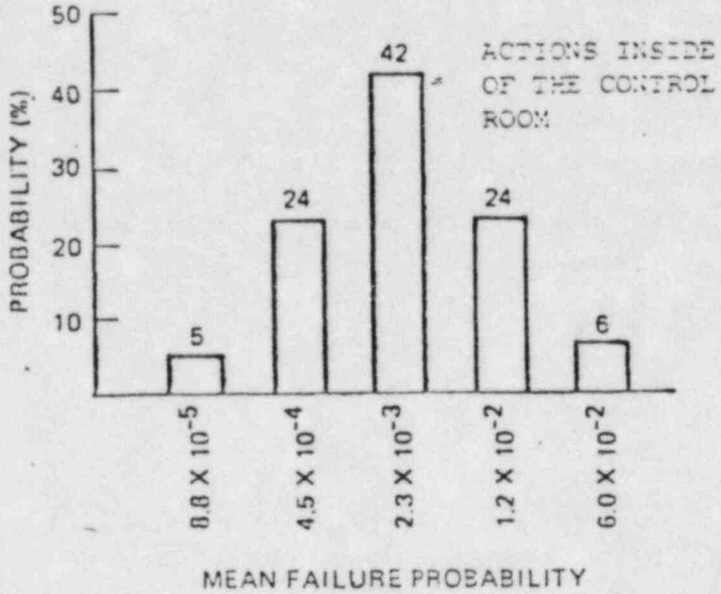
The maintenance on large motors ranges from inspection and cleaning to major disassembly. The prevalent failure mode is bearing failure which requires partial disassembly of the motor. All maintenance of the AFS pump motors contribute to maintenance unavailability and is included in the pump train maintenance unavailability.

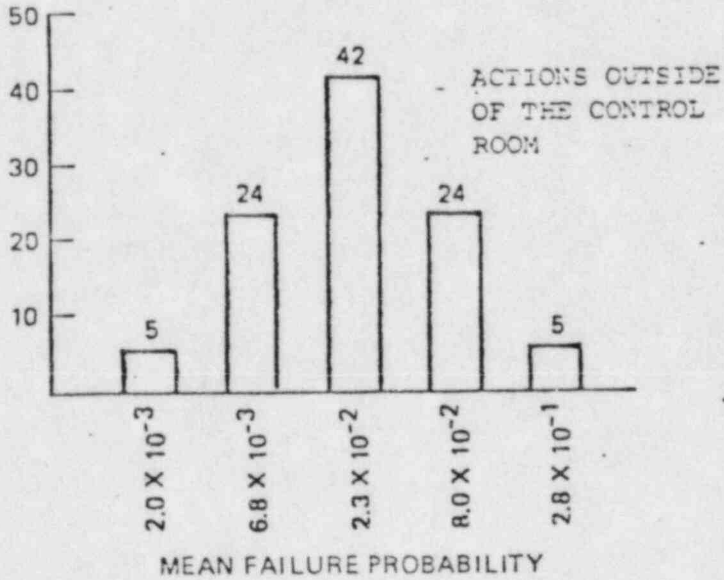
Turbine maintenance can range from simple adjustments to major disassembly. These outages are accounted for in the maintenance contribution to unavailability of the turbine-driven pump train. Table 9 gives the unavailability associated with maintenance on the motor-driven pump train and the turbine pump train. These figures are based on plant specific data as compiled.

D.3 HUMAN INTERACTION (See Tables 7.7, 7.8, and 7.9)

The likelihood of human inaction has been quantified into histograms using discussions with operators, supervisory personnel, and engineers; and after reviewing operating histories at other plants. The judgments take into account the high stres conditions in the control room during emergencies along wiht the competing time demands in the 30 minutes the operator will have to perform his task.

The following histograms represent the knowledge obtained.





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The table below indicates the mean and variance of the histograms above:

	With Existing Procedures	
	Mean	Variance
Actions in Control Room		
f (30 minutes)	.007	$(.02)^2$
Actions Outside Control Room		
f (30 minutes)	.044	$(.07)^2$

These failure frequency distributions are used in the following analyses to evaluate the probability that an operator takes correct action following a recoverable system failure.

The operator has the capability to recover from a loss of the following components:

1. Turbine-Driven Auxiliary Feedwater Pump Trip. A major contributor to turbine-driven auxiliary feedwater pumps failure to start on demand is a failure of the turbine controls; primarily due to turbine trip on overspeed during startup. The operator may manually reset the overspeed trip, or take control of the turbine driven AFS pump if during a demand this pump did not operate. Based on experience and plant-specific data for similar units, 50% of the failures to start are assumed recoverable within 30 minutes. The frequency of failure for the operator failing to take action within 30 minutes is f = 0.044 mean with 0.0049 variance.

2. Failure of Either Condensate Storage Tank Outlet Valve. Failures in either CST outlet valve are both dominant contributors to failure for the cases analyzed. There is a readily available source of water for the AFS in the event that no water is coming from the CST. The city water storage tank is lined up with the AFS and can supply the water needs. When the AFS experiences low suction, the operator can switch over to the city water by opening air-operated valves PCV-1187, 1188, and 1189. If the system air is out, it is assumed in the report that there would not be enough time to open the valves, since they do not have hand cranks and would have to be jacked open.

D.4. RESULTS OF COMMON CAUSE ANALYSIS

A review of existing plant procedures revealed a common cause failure potential during pump testing which occurs monthly. In these tests, the manual gate valves, BFD-48-1, 3, 5, and 7 for the turbine-driven pump, and BFD-36, 38, 41, and 43 for the motor-driven pumps, are closed and the pumps are run in the recirculation mode for 20 to 30 minutes. At the completion of these tests, the pumps are secured and the manual gate valves are opened. The common cause failure is the error of failing to reopen the manual gate valves after the flow test. Table 7-10 reflects the quantification of this common cause.

The components comprising the AFS are in two general locations, the auxiliary pump room and the switchgear room. With respect to susceptibilities the following is a treatment of component susceptibilities to the environment:

- Conducting Medium - None present. Even if brought into the area, the equipment is protected.
- Impact - The AFS is well protected against portable sources. There are no sources present except for the turbine pump which, because of its placement (angle with respect to the other pumps), poses no reasonable threat to them.
- Temperature - Fire is a possible risk and is dealt with in another section of this study. A turbine pump steam line break is also possible, but is numerically small with respect to other causes.
- Corrosion - No source of sufficient moisture; regular maintenance.
- Grit - Portable sources could be a problem, but equipment is well protected and heavy dirt is not generated during power operations.
- Vibration - Seismic problems are dealt with in another section of this study.
- Explosion - Very unlikely; only portable sources and they are carefully controlled. Sufficient separation exists to offer some protection.

The similar parts cutsets identified in Table 10 show a common cause effect due to a cutset containing all the same type of parts. If the parts fail as a group, the system will fail. These components are tested regularly but some problems may not be exposed. For example, if a few similar parts show signs that they are reaching the end of useful life, it may be a good idea to check all parts of that type. However, there are situations where tests do not accurately verify that a component is functioning properly. For example, the motor pump train is valved off and the pump is tested, but there is no flow test to ensure that the discharge valves are not plugged or otherwise obstructed. These environmental common cause candidates and the similar parts common

cause candidates have not been explicitly quantified in the AFS section, but are considered to be in the range of 10^{-10} or less (this applies to those characteristics above not dealt with in another section). This range was arrived at due to the fact that these events are less likely than a pipe rupture which has been quantified in WASH-1400 as 10^{-10} failures/hr.

The common cause contribution is primarily due to a common human failure following testing--leaving all manual gate valves in the closed position following testing. This is a recoverable failure and the unavailability contribution includes the 30 minute response time for operator intervention. Other common cause contributions except seismic, which is evaluated in another section of this study, were found to be negligible when compared to the tabulated values.

D.5 OTHER

The category "other" like parts of the common cause analysis are not explicitly quantified in the AFS section. The same argument applies here. "Other" contributors to unavailability happen with much less frequency than pipe rupture, and therefore, would have a value less than that of a pipe rupture failure rate. Since the pipe rupture number (1.0×10^{-10} failures/hr) is not at all dominate in the AFS section, a smaller number would not be of significance either. Thus the category "other" is defined as ϵ which in the AFS section is less than 1.0×10^{-10}.

TABLE 1

INDIAN POINT UNIT 3
AUXILIARY FEEDWATER SYSTEM UNAVAILABILITY TABLE

Contributor	Full Power	Loss Of One Bus	No Power
Mean Nonrecoverable Random Failures	1 / 1.14×10^{-6}	2 / 2.41×10^{-5}	3 / 3.11×10^{-3}
Mean Nonrecoverable Test and Maintenance	4 / 2.81×10^{-7}	5 / 4.33×10^{-5}	6 / 4.16×10^{-3}
Mean Independent Human Error	7 / 1.03×10^{-5}	8 / 8.10×10^{-5}	9 / 7.04×10^{-3}
Mean Common Cause	10 / 1.35×10^{-8}	10 / 1.35×10^{-8}	10 / 1.35×10^{-8}
Mean of Others	ϵ	ϵ	ϵ
Total Mean	2.46×10^{-6}	1.48×10^{-4}	1.43×10^{-2}
Dominant Contributors to Total			
Approximate Percentage of Total Mean (Reference table to see for this column)	91 (11)	97 (12)	100 (13)
Mean	2.36×10^{-6}	1.44×10^{-4}	1.43×10^{-2}
Variance	3.62×10^{-12}	1.05×10^{-8}	1.70×10^{-4}
5th Percentile	4.77×10^{-7}	5.22×10^{-5}	4.90×10^{-3}
Median	1.71×10^{-6}	1.10×10^{-4}	1.03×10^{-2}
95th Percentile	5.82×10^{-5}	3.18×10^{-4}	2.58×10^{-2}

[1] Calculated details are found in Table 7.X (i.e., 7.1 through 7.10).

TABLE 2

INDIAN POINT 3--COMPONENT POWER SUPPLY SUMMARY

Component	Power Supply	Primary Source [4]	Backup Source [5]	Function
A. STEAM SUPPLY TRAIN				
PCV-1139 (20-1/ABFP2)[1]	125 Volt DC Pnl. 31	Battery 31	Bus 3A	Stm. Supply to Aux. Blr. Fd. Pump 32 Turbine (N.C.)
PCV-1139 (20-2/ABFP2)[2]	125 Volt DC Pnl. 31	Battery 31	Bus 3A	Stm. Supply to Aux. Blr. Fd. Pump 32 Turbine (N.C.)
PCV-1310A (SOV-1310)[1]	125 Volt DC Pnl. 33	Battery 31	Bus 3A	Stm. Supply Isolation Valve to Aux. BFP 32 Turbine (N.O.)
PCV-1310B (SOV-1311)[1]	125 Volt DC Pnl. 34	Battery 32	Bus 3A	Stm. Supply Isolation Valve to Aux. BFP 32 Turbine (N.O.)
B. TURBINE PUMP 32 TRAIN				
Aux. Blr. Fd. Pump 32	Steam Driven	Residual Heat Generated Steam	--	--
PCV-1188 (SOV-1288)[3]	120 Volt AC Instrument Bus 31	Battery 31	Bus 3A	Valve on alt. path from City Wtr. Sys. for Aux. Fdwtr. Pump 32 Suction (N.C.)
FCV-405A[1]	120 Volt AC Instrument Bus 31	Battery 31	Bus 3A	Aux. Blr. Fd. Pump 32 Discharge to Stm. Gen. 31 (N.C.)
FCV-405B[1]	120 Volt AC Instrument Bus 31	Battery 31	Bus 3A	Aux. Blr. Fd. Pump 32 Discharge to Stm. Gen. 32 (N.C.)
FCV-405C[1]	120 Volt AC Instrument Bus 31	Battery 31	Bus 3A	Aux. Blr. Fd. Pump 32 Discharge to Stm. Gen. 33 (N.C.)
FCV-405D[1]	120 Volt AC Instrument Bus 31	Battery 31	Bus 3A	Aux. Blr. Fd. Pump 32 Discharge to Stm. Gen. 34 (N.C.)
C. MOTOR-DRIVEN PUMP 31 TRAIN				
Aux. Blr. Fd. Pump 31	480 Volt Bus 3A	Bus 3A	Dsl. 31	--
PCV-1187 (SOV-1287)[3]	120 Volt AC Instrument Bus 33	Battery 33	Dsl. 31	Valve on Alt. Path from City Wtr Sys. for Aux. Fd. Pump 31 Suction (N.C.)
FCV-406A[1]	120 Volt AC Instrument Bus 33	Battery 33	Dsl. 31	Aux. Blr. Fd. Pump 31 Discharge to Stm. Gen. 31 (N.O.)
FCV-406B[1]	120 Volt AC Instrument Bus 33	Battery 33	Dsl. 31	Aux. Blr. Fd. Pump 31 Discharge to Stm. Gen. 32 (N.O.)
D. MOTOR-DRIVEN PUMP 33 TRAIN				
Aux. Blr. Fd. Pump 33	480 Volt Bus 6A	Bus 6A	Dsl. 32	--
PCV-1189 (SOV-1289)[3]	120 Volt AC Instrument Bus 32	Battery 32	Dsl. 32	Valve on Alt. path from City Water Sys. for Aux. Fd. Pump 33 Suction (N.C.)
FCV-406C[1]	120 Volt AC Instrument Bus 32	Battery 32	Dsl. 32	Aux. Blr. Fd. Pump 33 Discharge to Stm. Gen. 33 (N.O.)
FCV-406D[1]	120 Volt AC Instrument Bus 32	Battery 32	Dsl. 32	Aux. Blr. Fd. Pump 33 Discharge to Stm. Gen. 34 (N.O.)
E. MISCELLANEOUS				
LCV-1158 (SOV-1258)[3]	125 Volt DC Dist. Pnl. 31	Battery 31	Dsl. 32	Condensate Storage Tank low-level shutoff valve (N.O.)
CT-6[4]	Hand Operated	--		Condensate Storage Tank discharge valve (L.O.)
CT-64[4]	Hand Operated	--		Condensate Storage Tank discharge valve (L.O.)

[1] Valve Fails Open on Loss of Air or Electric Power.
[2] Valve Fails Open on Loss of Air and cannot be Closed Without Electric Power.
[3] Valve Fails Closed on Loss of Air or Electric Power.
[4] AC Instrument Buses are powered off of corresponding DC panel.
[5] [illegible]

(N.C.) = Normally Closed
(N.O.) = Normally Open
(L.O.) = Locked Open

TABLE 3

INDIAN POINT 3 PIPING ANALYSIS

Pipe Section	Diameter (inches)	System Failure	Potential for Other System Impact	Initiating Event	Comments
Condensate Storage Tank Supply Line	12	No	None	No	Almost entire section can be isolated.
City Water Storage Tank Supply Line (before CT-49)	16	No	None	No	Almost entire section can be isolated.
City Water Storage Tank Supply Line (after CT-49)	8	No	None	No	Almost entire section can be isolated.
Aux Feed Line Downstream of BFD-79-3 to Steam Generator 33	4/18 AFWS/MF	No	Yes - Main Feed	Feed Line Break	Not isolated from steam generator downstream of the feedwater isolation valves.
Aux Feed Line Downstream of BFD-79-3 to Steam Generator 34	4/18 AFWS/MF	No	Yes - Main Feed	Feed Line Break	Not isolated from steam generator downstream of the feedwater isolation valves.
Aux Feed Line Downstream of BFD-79-3 to Steam Generator 32	4/18 AFWS/MF	No	Yes - Main Feed	Feed Line Break	Not isolated from steam generator downstream of the feedwater isolation valves.
Aux Feed Line Downstream of BFD-79-3 to Steam Generator 31	4/18 AFWS/MF	No	Yes - Main Feed	Feed Line Break	Not isolated from steam generator downstream of the feedwater isolation valves.
Main Steam to AFWS Turbine Upstream of MS-41	4	No	Yes - Main Steam	Steam Line Break	No isolation but only 4 inch break.
Main Steam to AFWS Turbine Upstream of MS-42	4	No	Yes - Main Steam	Steam Line Break	No isolation but only 4 inch break.
Main Steam to AFWS Turbine Downstream of MS-41 and MS-42	4	No	Yes - Main Steam	Steam Line Break	No isolation but only 4 inch break.

TABLE 4

BASIC EVENTS FOR THE INDIAN POINT 3 AFWS

Reference*	Component	Component (Basic Event)	Failure Mode	Unavailability or Failures/Demand	
				Mean	Variance
	JBSAC3AS	Electric train with AC bus 3A	Loss of function	assumed on or off	
	JBSAC6AS	Electric train with AC bus 6A	Loss of function	assumed on or off	
	4BSDC3AS	DC control power to bus 3A	Loss of function	assumed on or off	
	4BSDC6AS	DC control power to bus 6A	Loss of function	assumed on or off	
	NOAIR00S	Instrument air system	Loss of function	assumed to be off	
9	PAV405AG	Air-operated flow control valve FCV-405A	Plugged	1.11 x 10^{-3}	2.98 x 10^{-6}
9	PAV405BG	Air-operated flow control valve FCV-405B	Plugged	1.11 x 10^{-3}	2.98 x 10^{-6}
9	PAV405CG	Air-operated flow control valve FCV-405C	Plugged	1.11 x 10^{-3}	2.98 x 10^{-6}
9	PAV405DG	Air-operated flow control valve FCV-405D	Plugged	1.11 x 10^{-3}	2.98 x 10^{-6}
8	PAV1139Q	Main steam air-operated valve PCV-1139	Failure to operate or plug	5.60 x 10^{-4}	4.12 x 10^{-7}
8	PAV1187Q	Air-operated shutoff valve PCV-1187	Failure to operate or plug	3.00 x 10^{-2}	2.11 x 10^{-3}
8	PAV1188Q	Air-operated shutoff valve PCV-1188	Failure to operate or plug	3.00 x 10^{-2}	2.11 x 10^{-3}
8	PAV1189Q	Air-operated shutoff valve PCV-1189	Failure to operate or plug	3.00 x 10^{-2}	2.11 x 10^{-3}
9	PAV406AG	Air-operated flow control valve FCV-406A	Failure to operate or plug	1.61 x 10^{-3}	3.38 x 10^{-6}
9	PAV406BG	Air-operated flow control valve FCV-406B	Failure to operate or plug	1.61 x 10^{-3}	3.38 x 10^{-6}
9	PAV406CG	Air-operated flow control valve FCV-406C	Failure to operate or plug	1.61 x 10^{-3}	3.38 x 10^{-6}
9	PAV406DG	Air-operated flow control valve FCV-406D	Failure to operate or plug	1.61 x 10^{-3}	3.38 x 10^{-6}
9	PAV310AG	Air-operated automatic high temperature shutoff valve PCV-1310A	Plugged	6.17 x 10^{-5}	9.19 x 10^{-9}
9	PAV310BG	Air-operated automatic high temperature shutoff valve PCV-1310B	Plugged	6.17 x 10^{-5}	9.19 x 10^{-9}
4	6CV0001X	Check valve on main feed supply BFD 6-1	Component open and does not close	2.76 x 10^{-6}	7.79 x 10^{-12}
4	6CV0002X	Check valve on main feed supply BFD 6-2	Component open and does not close	2.76 x 10^{-6}	7.79 x 10^{-12}
4	6CV0003X	Check valve on main feed supply BFD 6-3	Component open and does not close	2.76 x 10^{-6}	7.79 x 10^{-12}
4	6CV0004X	Check valve on main feed supply BFD 6-4	Component open and does not close	2.76 x 10^{-6}	7.79 x 10^{-12}
3	PCV0541Q†	Check valve MS-41	Component closed and does not open	1.00 x 10^{-5}	0.00
3	PCV0542Q†	Check valve MS-42	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0C25Q	Check valve CT-25	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0C26Q	Check valve CT-26	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0C28Q	Check valve CT-28	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0029Q	Check valve CT-29	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0C31Q	Check valve CT-31	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0031Q	Check valve BFD-31	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0032Q	Check valve CT-32	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0034Q	Check valve BFD-39-1	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0035Q	Check valve BFD-35	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0037Q	Check valve BFD-37	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0039Q	Check valve BFD-39-3	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}
3	PCV0040Q	Check valve BFD-40	Component closed and does not open	6.91 x 10^{-5}	1.03 x 10^{-8}

*See Item number in Section B.2 (Table B.2-2, Data Tables). "Q" indicates that the values for unavailability came from generic data, not plant-specific data.

†These two valves are tested monthly but you can only verify that one works. For this reason one valve has been defined as failed.

TABLE 4 (continued)

BASIC EVENTS FOR THE INDIAN POINT 3 AFWS

Reference*	Component	Component (Basic Event)	Failure Mode	Unavailability or Failures/Demand: Mean	Unavailability or Failures/Demand: Variance
3	PCV0042Q	Check valve BFD-42	Component closed and does not open	6.91×10^{-5}	1.01×10^{-8}
3	PCV0470Q	Check valve BFD-47-0	Component closed and does not open	6.91×10^{-5}	1.01×10^{-8}
3	PCV0471Q	Check valve BFD-47-1	Component closed and does not open	6.91×10^{-5}	1.01×10^{-8}
3	PCV0472Q	Check valve BFD-47-2	Component closed and does not open	6.91×10^{-5}	1.01×10^{-8}
3	PCV0473Q	Check valve BFD-47-3	Component closed and does not open	6.91×10^{-5}	1.01×10^{-8}
3	PCV0068Q	Check valve BFD-68-0	Component closed and does not open	6.91×10^{-5}	1.01×10^{-8}
3	PCV0067Q	Check valve BFD-67-1	Component closed and does not open	6.91×10^{-5}	1.01×10^{-8}
3	PCV0070Q	Check valve BFD-70-2	Component closed and does not open	6.91×10^{-5}	1.01×10^{-8}
3	PCV0069Q	Check valve BFD-69-3	Component closed and does not open	6.91×10^{-5}	1.01×10^{-8}
	PCXOP3AS	Valve controller on valve PCV-1310A	Loss of function	Included in PAV1310A	
	PCXOP3BS	Valve controller on valve PCV-1310B	Loss of function	Included in PAV1310B	
	PCXSR3AS	Temperature sensor circuitry on valve PCV-1310A	Loss of function	Included in PAV1310A	
	PCXSR3BS	Temperature sensor circuitry on valve PCV-1310B	Loss of function	Included in PAV1310B	
	PCX1187S	Signal to open PCV-1187	Loss of function	Included in PAV1187Q	
	PCX1188S	Signal to open PCV-1188	Loss of function	Included in PAV1188Q	
	PCX1189S	Signal to open PCV-1189	Loss of function	Included in PAV1189Q	
	PMO0031S	Motor operator to AFW pump 31	Loss of function	Included in PPM0031R	
	PMO0033S	Motor operator to AFW pump 33	Loss of function	Included in PPM0033R	
11, 20	PPM0031R	AFW motor pump 31	Does not start or operate	1.40×10^{-3}	1.25×10^{-6}
12, 21	PPT0032R	AFW turbine pump 32	Does not start or operate	2.31×10^{-3}	1.11×10^{-5}
11, 20	PPM0033R	AFW motor pump 33	Does not start or operate	1.40×10^{-3}	1.25×10^{-6}
**	6SG32OFS	Steam generator 32	Loss of function	1.05×10^{-4}	2.76×10^{-8}
**	6SG33OFS	Steam generator 33	Loss of function	1.05×10^{-4}	2.76×10^{-8}
	PTB0032S	Turbine control for AFW pump 32	Loss of function	Included in PPT0032R	
49	PTKCITYS	City water supply tank	Loss of function	3.10×10^{-7}	6.79×10^{-12}
49	PTKOCSTS	Condensate storage tank	Loss of function	3.10×10^{-7}	6.79×10^{-12}
1	PXV0006G	Manual isolation butterfly valve CT-6	Plugged	3.34×10^{-5}	1.35×10^{-9}
1	PXV0027G	Manual isolation gate valve CT-27	Plugged	3.34×10^{-5}	1.35×10^{-9}
1	PXV0030G	Manual isolation gate valve CT-30	Plugged	3.34×10^{-5}	1.35×10^{-9}
1	PXV0033G	Manual isolation gate valve CT-33	Plugged	3.34×10^{-5}	1.35×10^{-9}
1	PXV0036G	Manual isolation gate valve BFD-39-1	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0038G	Manual isolation gate valve BFD-38	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0041G	Manual isolation gate valve BFD-39-3	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PCV0043G	Manual isolation gate valve BFD-43	Plugged	6.02×10^{-4}	4.37×10^{-7}

**See Table 6.5

TABLE 4 (continued)

BASIC EVENTS FOR THE INDIAN POINT 3 AFWS

Reference*	Component	Component (Basic Event)	Failure Mode	Unavailability or Failures/Demand	
				Mean	Variance
1	PXV0049G	Manual isolation gate valve CT-49	Plugged	1.60×10^{-2}	3.09×10^{-4}
1	PXV0054G	Manual isolation gate valve MS-54	Plugged	3.34×10^{-5}	1.35×10^{-9}
1	PXV0064G	Manual isolation gate valve CT-64	Plugged	3.34×10^{-5}	1.35×10^{-9}
1	PXV0430G	Manual isolation gate valve BFD-48-0	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0431G	Manual isolation gate valve BFD-48-1	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0432G	Manual isolation gate valve BFD-48-2	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0433G	Manual isolation gate valve BFD-48-3	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0434G	Manual isolation gate valve BFD-48-4	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0435G	Manual isolation gate valve BFD-48-5	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0436G	Manual isolation gate valve BFD-48-6	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0437G	Manual isolation gate valve BFD-48-7	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0620G	Manual isolation gate valve PGD-62-0	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0621G	Manual isolation gate valve PGD-62-1	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0622G	Manual isolation gate valve PGD-62-2	Plugged	6.02×10^{-4}	4.37×10^{-7}
1	PXV0623G	Manual isolation gate valve PGD-62-3	Plugged	6.02×10^{-4}	4.37×10^{-7}

TABLE 5

SUPERCOMPONENT CUTSETS (UP TO THREE BASIC EVENTS)

There are no cutsets containing one basic event.

Cutsets with two basic events.

1) 1) WW2 WW1

Cutsets with three basic events.

4)	1)	WP3-OP	WC2	WP2	2)	WD2	WP3-OP	WP2	3)	WD2	WD3	WD4
7)	4)	WP3-OP	WC1	WP2	5)	WD1	WP3-OP	WP2	6)	WD1	WD3	WD4
10)	7)	WP3-OP	WP1	WD4	8)	WD3-OP	WP1	WC4	9)	WD1	WD2	WD4
13)	10)	WP3-OP	WP1	WD3	11)	WP3-OP	WP1	WP2	12)	WP3-OP	WP1	WC3
14)	13)	WD1	WD2	WD3								

TABLE 5

SUPERCOMPONENT MEAN AND VARIANCE--INDIAN POINT 3

Table 6.1. Supercomponent W1--CST Water Supply

Component (Ref. Table 4)	Fail/Hour	Variance	MTTR (hours)	Mean Unavailability	Variance	Reference*
1. PXV0006G	9.15×10^{-8}	1.01×10^{-14}	365	3.34×10^{-5}	1.35×10^{-9}	1
2. PXV0064G	9.15×10^{-8}	1.01×10^{-14}	365	3.34×10^{-5}	1.35×10^{-9}	1
3. PTKOCSTS	8.48×10^{-10}	5.10×10^{-17}	365	3.10×10^{-7}	6.79×10^{-12}	49

Supercomponent W1 Mean = 6.71×10^{-5}, Variance = 4.22×10^{-9}

*See item number in Section B.2 (Table B.2-2, Data Tables).

SUPERCOMPONENT W1 LAYOUT

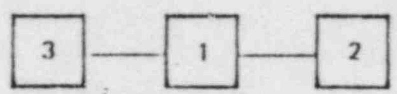

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TABLE 6 (continued)

SUPERCOMPONENT MEAN AND VARIANCE--INDIAN POINT 3

Table 6.2. Supercomponent W2--City Water Supply

Component (Ref. Table 4)	Fail/Hour	Variance	MTTR (hours)	Mean Unavailability	Variance	Reference*
1. PXV0043G++	9.15×10^{-8}	1.01×10^{-14}	$1.75 \times 10^{+5}$	1.60×10^{-2}	3.09×10^{-4}	1
2. PTKCITYS	8.43×10^{-10}	5.10×10^{-17}	365	3.10×10^{-7}	6.79×10^{-12}	49

Supercomponent W2 Mean = 1.60×10^{-2}, Variance = 3.09×10^{-4}

*See item number in Section B.2 (Table B.2-2, Data Tables).

++Since these components are never flow tested to be sure they are not plugged, the MTTR used was one-half of the plant life time of 40 years or $1.75 \times 10^{+5}$ hrs.

SUPERCOMPONENT W2 LAYOUT

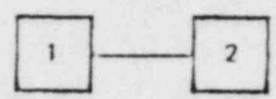

TABLE 6 (continued)

SUPERCOMPONENT MEAN AND VARIANCE--INDIAN POINT 3

Table 6.3. Supercomponent R1, R2, R3--CST Supply Valves

Component (Ref. Table 4)	Fail/Hour	Variance	MTTR (hours)	Mean Unavailability	Variance	Reference*
1. PCV0026Q (29Q, 32Q)	--	--	--	6.91×10^{-5}	1.03×10^{-8}	3
2. PXV0027G (30G, 33G)	9.15×10^{-8}	1.01×10^{-14}	365	3.34×10^{-5}	1.35×10^{-9}	1

Supercomponent R1, R2, R3 Mean = 1.02×10^{-4}, Variance = 1.17×10^{-8}

*See item number in Section B.2 (Table B.2-2, Data Tables).

SUPERCOMPONENT R1, R2, R3 LAYOUT

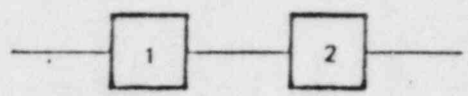

TABLE 6 (continued)

SUPERCOMPONENT MEAN AND VARIANCE--INDIAN POINT 3

Table 5.4. Supercomponent S1, S2, S3--City Supply Valves

Component (Ref. Table 4)	Fail/Hour	Variance	MTTR (hours)	Mean Unavailability	Variance	Reference*
1. PCVOC25Q (C28Q, C31Q)	--	--	--	6.91×10^{-5}	1.03×10^{-8}	3
2. PAV1187Q (1188Q, 1189Q)	--	--	--	--	--	-
plug	1.69×10^{-7}	6.90×10^{-14}	1.75^{+5}	2.96×10^{-2}	2.11×10^{-3}	9
failure to operate	--	--	--	4.98×10^{-4}	4.03×10^{-7}	8

Supercomponent S1, S2, S3 Mean = 3.01×10^{-2}, Variance = 1.41×10^{-3}

*See item number in Section B.2 (Table B.2-2, Data Tables).

SUPERCOMPONENT S1, S2, S3 LAYOUT

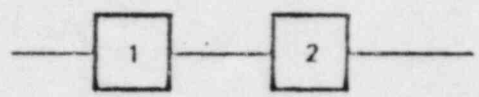

TABLE 6 (continued)

SUPERCOMPONENT MEAN AND VARIANCE--INDIAN POINT 3

Table 6.5. Supercomponent P1, P2--Motor Pump Train 31, 33

Component (Ref. Table 4)	Fail/Hour	Variance	MTTR (hours)	Mean Unavailability	Variance	Reference*
1. PPM0031N (33N)						
fail to start	--	--	--	1.36×10^{-3}	1.22×10^{-6}	11
fail to operate	9.99×10^{-6}	1.98×10^{-9}	4**	4.00×10^{-5}	3.17×10^{-8}	20
2. PCV0139Q (339Q)	--	--	--	6.91×10^{-5}	1.03×10^{-8}	3

*See item number in Section B.2 (Table B.2-2, Data Tables).

**Suggested time for AFWS to perform its limited function (1/2 of 8 hours) (D.B).

Supercomponent P1, P2 Mean = 1.47×10^{-3}, Variance = 1.06×10^{-6}

SUPERCOMPONENT P1, P2 LAYOUT

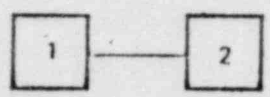

TABLE 6 (continued)

SUPERCOMPONENT MEAN AND VARIANCE--INDIAN POINT 3

Table 6.6. Supercomponent P3--Turbine Pump Train 32

Component (Ref. Table 4)	Fail/Hour	Variance	MTTR (hours)	Mean Unavailability	Variance	Reference*
1. PAV11390						
plug	1.69×10^{-7}	6.90×10^{-14}	365	6.17×10^{-5}	9.19×10^{-9}	9
fail to operate	--	--	--	4.98×10^{-4}	4.03×10^{-7}	8
2. PP400324						
fail to start+	--	--	--	8.03×10^{-4}	2.53×10^{-6}	12
fail to operate	3.77×10^{-4}	5.30×10^{-7}	4**	1.51×10^{-3}	3.43×10^{-6}	21
3. PCV00310	--	--	--	6.91×10^{-5}	1.03×10^{-8}	3
4. PCV05410+++	--	--	--	1.00	0.00	3
5. PCV05420+++	--	--	--	6.91×10^{-5}	1.03×10^{-8}	3
6. PAV310AG	1.69×10^{-7}	6.90×10^{-14}	365	6.17×10^{-5}	9.19×10^{-9}	9
7. PAV310BG	1.69×10^{-7}	6.90×10^{-14}	365	6.17×10^{-5}	9.19×10^{-9}	9
8. PXV0054G	9.15×10^{-8}	1.01×10^{-14}	365	3.34×10^{-5}	1.35×10^{-9}	1
9. GSG220FS	4.37×10^{-6}	4.79×10^{-11}	24	1.05×10^{-4}	2.76×10^{-8}	++
10. GSG230FS	4.37×10^{-6}	4.79×10^{-11}	24	1.05×10^{-4}	2.76×10^{-8}	++

Supercomponent P3 Mean = 3.10×10^{-3}, Variance = 6.52×10^{-6}.

*See item number in Section 3.2 (Table 3.2-2, Data Tables).

**Suggested time for AFWS to perform its limited function (1/2 of 8 hours) (from D.B)

+Based on experience and plant-specific data for similar units, 50% of the failure to start are assumed recoverable within 30 minutes (mean 1.65×10^{-3} to 8.03×10^{-4}, variance 1.03×10^{-5} to 2.53×10^{-6}).

++Steam generator failure is dominated by a tube rupture failure of 3.83×10^{-2}/yr and a variance of 3.58×10^{-3}. The reference for this is the initiating event occurrance probability Table 3.3.2-18. This number has been converted to 4.37×10^{-6}/hr and a variance of 4.79×10^{-11}. The mean time to repair is taken to be 1/2 of 48 hours. This is based on the isolation of the steam generator and shutdown times. Although the actual mean time to repiar is generally greater than 48 hours, after this time the system will be shut down with no need for the auxiliary feedwater system.

+++These two valves are tested monthly but you can only verify that one works. For this reason one valve has been defined as failed.

SUPERCOMPONENT P3 LAYOUT

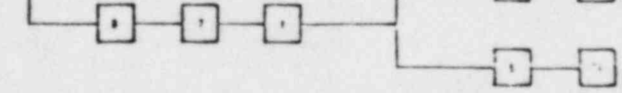

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TABLE 6 (continued)

SUPERCOMPONENT MEAN AND VARIANCE--INDIAN POINT 3

Table 6.7. Supercomponent C1, C2, C3, C4--Motor-Driven Pump Discharge Valves

Component (Ref. Table 4)	Fail/Hour	Variance	MTTR (hours)	Mean Unavailability	Variance	Reference*
1. PXV0620G (621, 622, 623)	9.15×10^{-8}	1.01×10^{-14}	6575	6.02×10^{-4}	4.37×10^{-7}	1
2. PAV406AG (406B, C, D) plug	1.69×10^{-7}	6.90×10^{-14}	6575	1.11×10^{-3}	2.98×10^{-6}	9
fail to operate	--	--	--	4.98×10^{-4}	4.03×10^{-7}	8
3. PCV0037Q (35, 40, 42)	--	--	--	6.91×10^{-5}	1.03×10^{-8}	3
4. PXV0038G (36, 41, 43)	9.15×10^{-8}	1.01×10^{-14}	6575	6.02×10^{-4}	4.37×10^{-7}	1

Supercomponent Mean = 2.88×10^{-3}, Variance = 3.96×10^{-6}.

*See item number in Section B.2 (Table B.2-2, Data Tables).

SUPERCOMPONENT C1, C2, C3, C4 LAYOUT

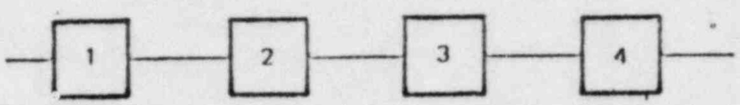

TABLE 6 (continued)

SUPERCOMPONENT MEAN AND VARIANCE--INDIAN POINT 3

Table 6.8. Supercomponent E1, E2, E3, E4--Turbine-Driven Pump Discharge Valves

Component (Ref. Table 4)	Fail/Hour	Variance	MTTR (hours)	Mean Unavailability	Variance	Reference*
1. PXV0430G (432, 434, 436)	9.15×10^{-8}	1.01×10^{-14}	6575	6.02×10^{-4}	4.37×10^{-7}	1
2. PAV405AQ (405B, C, D)	1.69×10^{-7}	6.90×10^{-14}	6575	1.11×10^{-3}	2.98×10^{-6}	9
3. PCV0470Q (471, 472, 473)	--	--	--	6.91×10^{-5}	1.03×10^{-8}	3
4. PXV0431G (483, 485, 487)	9.15×10^{-3}	1.01×10^{-14}	6575	6.02×10^{-4}	4.37×10^{-7}	1

Supercomponent E1, E2, E3, E4 Mean = 2.38×10^{-3}, Variance = 3.62×10^{-6}.

*See item number in Section B.2 (Table B.2-2, Data Tables).

SUPERCOMPONENT E1, E2, E3, E4 LAYOUT

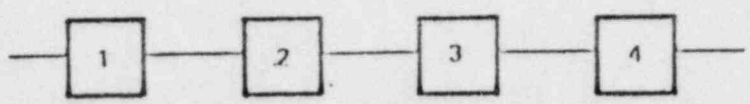

TABLE 6 (continued)

SUPERCOMPONENT MEAN AND VARIANCE--INDIAN POINT 3

Table 6.9. Supercomponent D1, D2, D3, D4--Steam Generator Supply Valves

Component (Ref. Table 4)	Fail/Hour	Variance	MTTR (hours)	Mean Unavailability	Variance	Reference*
1. PCV0067Q (68, 69, 70)	--	--	--	6.91×10^{-5}	1.03×10^{-8}	3
2. 6CV0004X	6.91×10^{-7}	4.87×10^{-13}	4**	2.76×10^{-6}	7.79×10^{-12}	4

Supercomponent D1, D2, D3, D4 Mean = 7.19×10^{-5}, Variance = 1.03×10^{-8}

*See item number in Section B.2 (Table B.2-2, Data Tables).

**Suggested time for AFWS to perform its limited function (1/2 of 8 hours) (D.8).

SUPERCOMPONENT D1, D2, D3, D4 LAYOUT

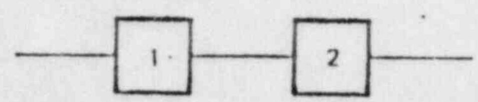

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.1. Nonrecoverable Random Failures
Full Power

RAS Developed Dominant Cutsets

Cutset	Unavailability	Approximate Contribution
1. Failure of the CST water supply, W1 (Table 6.1) and failure of the city water supply, W2 (Table 6.2)	1.07×10^{-6}	94.4%
TOTAL	1.14×10^{-6}	100.0%

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.2. Nonrecoverable Random Failures, One Bus Unavailable

RAS Developed Dominant Cutsets

Cutset	Unavailability	Approximate Contribution
1. Failure of the turbine-driven pump train, P3 (Table 5.6) and failure of a motor-driven pump discharge valve on the functioning pump, C1, C2, C3, C4 (Table 6.7)	1.79×10^{-5}	74.2%
2. Failure of the turbine-driven pump train, P3 (Table 6.6) and failure of the motor-driven pump train that still has electric power, P1, P2 (Table 6.5)	4.56×10^{-6}	18.9%
3. Failure of the CST water supply, W1 (Table 6.1) and failure of the city water supply, W2 (Table 6.2)	1.07×10^{-6}	4.5%
TOTAL	2.41×10^{-5}	100.0%

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.3. Nonrecoverable Random Failures, No Power

RAS Developed Dominant Cutsets		
Cutset	Unavailability	Approximate Contribution
1. Failure of the turbine-driven pump train, P3 (Table 6.6)	3.10×10^{-3}	99.7%
TOTAL	3.11×10^{-3}	100.0%

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.4. Test and Maintenance, and Nonrecoverable Random Failure
Full Power

RAS Developed Dominant Cutsets		
Cutset	Unavailability	Approximate Contribution
1. Motor-driven pump maintenance (Table 9) coupled with failure of the turbine-driven pump train P3 (Table 6.6) and failure of a motor-driven pump discharge valve of the functioning pump, C1, C2, C3, C4 (Table 6.7)	1.44×10^{-7}	51.2%
2. Turbine-driven pump maintenance (Table 9) coupled with failure of one motor-driven pump train, P1, P2 (Table 6.5) and a motor-driven pump discharge valve failure in the other motor pump train, C1, C2, C3, C4 (Table 6.7)	7.03×10^{-8}	25.0%
3. Motor-driven pump maintenance (Table 9) coupled with failures of the other two pump trains, P1 or P2, and P3 (Tables 6.5 and 6.6)	3.68×10^{-8}	13.1%
TOTAL	2.81×10^{-7}	100.0%

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.5. Test and Maintenance, and Nonrecoverable Random Failure
One Bus Available

RAS Developed Dominant Cutsets

Cutset	Unavailability	Approximate Contribution
1. Turbine-driven pump maintenance (Table 9) coupled with a failure of either set of motor pump-driven discharge valves C1, C2, C3, C4 (Table 6.7) associated with the motor-driven pump having power.	2.40×10^{-5}	55.4%
2. Motor-driven pump maintenance (Table 9) coupled with a failure of the turbine-driven pump train, P3 (Table 6.6)	1.25×10^{-5}	28.9%
3. Turbine-driven pump maintenance (Table 9) coupled with a failure of the remaining motor-driven pump.	6.12×10^{-6}	14.1%
TOTAL	4.33×10^{-5}	100.0%

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.6. Test and Maintenance, and Nonrecoverable Random Failure
No Power

RAS Developed Dominant Cutsets

Cutset	Unavailability	Approximate Contribution
1. Turbine-driven pump maintenance (Table 9)	4.16×10^{-3}	100.0%
TOTAL	4.16×10^{-3}	100.0%

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.7. Independent Human Error, Test and Maintenance, and Nonrecoverable Random Failures, Full Power

RAS Developed Dominant Cutsets

Cutset	Unavailability	Approximate Contribution
1. Operator failure (Section D.3) to open the city water valves coupled with a failure of the CST water supply, W1 (Table 6.1)	4.70×10^{-5}	45.6%
2. Operator failure (Section D.3) to start the turbine-driven pump, motor-driven pump maintenance , P1, P2 (Table 6.5), and a failure of either set of discharge valves, C1, C2, C3, C4 (Table 6.7) of the remaining motor-driven pump.	3.24×10^{-7}	31.5%
3. Operator failure (Section D.3) to start the turbine-driven pump, failure of one motor-driven pump train, P1, P2 (Table 6.5) and a failure of either set of discharge valves, C1, C2, C3, C4 (Table 6.7) of the remaining motor-driven pump.	1.19×10^{-7}	11.6%
4. Operator failure (Section D.3) to start the turbine-driven pump, maintenance on one and failure of the other motor-driven pump.	8.28×10^{-8}	8.0%
TOTAL	1.03×10^{-6}	100.0%

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.8. Independent Human Error, Test and Maintenance, and Nonrecoverable Random Failures, One Bus Available

RAS Developed Dominant Cutsets

Cutset	Unavailability	Approximate Contribution
1. Operator failure (Section D.3) to start the turbine-driven pump coupled with a loss of either set of motor-driven pump discharge valves associated with the remaining pump, C1, C2, C3, C4 (Table 6.7).	4.03×10^{-5}	49.8%
2. Operator failure (Section D.3) to start the turbine-driven pump coupled with maintenance on the remaining motor-driven pump (Table 9).	2.82×10^{-5}	34.8%
3. Operator failure (Section D.3) to start the turbine-driven pump coupled with a failure of the remaining motor-driven pump.	1.03×10^{-5}	12.7%
TOTAL	8.10×10^{-5}	100.0%

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.9. Independent Human Error, Test and Maintenance, and Nonrecoverable Random Failures, No Power

RAS Developed Dominant Cutsets

Cutset	Unavailability	Approximate Contribution
1. Failure of the operator (Section D.3) to start the motor-driven pump.	7.00×10^{-3}	99.5%
TOTAL	7.04×10^{-3}	100.0%

TABLE 7

INDIAN POINT UNIT 3
DEVELOPMENT OF ENTRIES TO AFS UNAVAILABILITY TABLE (TABLE 1)

Table 7.10. Common Cause/Human Error

Failure to restore gate valves following AFW pump tests (e.g., BFD-36, 38, 41, 43, 48-1, 48-3, 48-5, and 48-7), together with failure of independent verification to note failure and correct, along with the operator failure to correct the valves during a need for the AFS is:

$$(1.02 \times 10^{-5})(3.03 \times 10^{-2})(.044) = 1.36 \times 10^{-8}$$

The equation and numbers are from the Human Error Rates section of this report.

- Each pump action of the two valve closures and reopenings is considered highly dependent (Equation 8), $N = 1.00 \times 10^{-3}$ from Table 1 in the Human Error Rates section.

- Successive tests of the other two pump trains are considered moderately dependent (Equation 7).

$$(1.00 \times 10^{-3})\left(\frac{1 + 1.00^{-3}}{2}\right)\left(\frac{1 + 6.00^{-3}}{7}\right)\left(\frac{1 + 6.00^{-3}}{7}\right) = 1.02 \times 10^{-5}$$

- The checker's task is considered completely dependent (Equation 9) for each separate pump train and highly dependent for each separate pump train, $N = 1.00 \times 10^{-1}$.

$$(1.00 \times 10^{-1})(1)\left(\frac{1 + 1.00 \times 10^{-1}}{2}\right)\left(\frac{1 + 1.00 \times 10^{-1}}{2}\right) = 3.03 \times 10^{-2}$$

- Also the whole thing must go without notice by the operator if the auxiliary feed system is used, .044.

There are other permutations of common cause which include combinations of random failures, maintenance outages, and states of the electric power system. However, the resulting system unavailabilities are at least two orders of magnitude less than the base number presented above.

TABLE 8

INDIAN POINT 3 AFWS TESTING FREQUENCY

Component	Component (Basic Event)	Scheduled Testing (Procedure)	Indirect Testing	Effective Test Schedule
J0SAC3AS	Electric train with AC bus 3A	None	Always Energized	Constant Monitoring
J0SAC6AS	Electric train with AC bus 6A	None	Always Energized	Constant Monitoring
40SDC3AS	DC control power to bus 3A	None	Always Energized	Constant Monitoring
40SDC6AS	DC control power to bus 6A	None	Always Energized	Constant Monitoring
HOAIROOS	Instrument air system	None	Always Energized	Constant Monitoring
PAV405AG	Air-operated flow control valve FCV-405A	(2)*	(5)	18 months
PAV405BG	Air-operated flow control valve FCV-405B	(2)*	(5)	18 months
PAV405CG	Air-operated flow control valve FCV-405C	(2)*	(5)	18 months
PAV405DG	Air-operated flow control valve FCV-405D	(2)*	(5)	18 months
PAV1139G	Main steam air-operated valve PCV-1139	(1)		Monthly
PAV1187Q	Air-operated shutoff valve PCV-1187		(5)	Never
PAV1187Q	Air-operated shutoff valve PCV-1188		(5)	Never
PAV1137Q	Air-operated shutoff valve PCV-1189		(5)	Never
PAV406AG	Air-operated flow control valve FCV-406A	(2)*	(5)	18 months
PAV406BG	Air-operated flow control valve FCV-406B	(2)*	(5)	18 months
PAV406CG	Air-operated flow control valve FCV-406C	(2)*	(5)	18 months
PAV406DG	Air-operated flow control valve FCV-406D	(2)*	(5)	18 months
PAV310AG	Air-operated automatic high temperature shutoff valve PCV-1310A	(1)		18 months
PAV310BG	Air-operated automatic high temperature shutoff valve PCV-1310B	(1)		18 months

*Valves are stroked but there is no flow verification.

(1) Monthly (3PT-M20)
(2) Quarterly (3PT-Q20)
(3) Variable (3PT-V8A)
(4) Variable (3PT-V8B)
(5) Refueling (3PT-R7) assumed to be every 18 months.

TABLE 8 (continued)

INDIAN POINT 3 AFWS TESTING FREQUENCY

Component	Component (Basic Event)	Scheduled Testing (Procedure)	Indirect Testing	Effective Test Schedule
6CV0001X	Check valve on main feed supply line 1		(5)	18 months
6CV0002X	Check valve on main feed supply line 2		(5)	18 months
6CV0003X	Check valve on main feed supply line 3		(5)	18 months
6CV0004X	Check valve on main feed supply line 4		(5)	18 months
PCV0541Q	Check valve MS-41*		(1)*	Monthly - Never*
PCV0542Q	Check valve MS-42*		(1)*	Monthly - Never*
PCV0C25Q	Check valve CT-25			Never
PCV0C26Q	Check valve CT-26		(1),(5)	Monthly
PCV0C28Q	Check valve CT-28			Never
PCV0029Q	Check valve CT-29		(1),(5)	Monthly
PCV0C31Q	Check valve CT-31			Never
PCV0031Q	Check valve BFD-31		(5)	18 Months
PCV0032Q	Check valve CT-32	(1)	(1),(5)	Monthly
PCV0034Q	Check valve BFD-34		(5)	18 months
PCV0035Q	Check valve BFD-35		(5)	18 months
PCV0037Q	Check valve BFD-37		(5)	18 months
PCV0039Q	Check valve BFD-39		(5)	18 months
PCV0040Q	Check valve BFD-40		(5)	18 months
PCV0042Q	Check valve BFD-42		(5)	18 months
PCV0470Q	Check valve BFD-47-0		(5)	18 months
PCV0471Q	Check valve BFD-47-1		(5)	18 months
PCV0472Q	Check valve BFD-47-2		(5)	18 months
PCV0473Q	Check valve BFD-47-3		(5)	18 months
PCV0790Q	Check valve BFD-79-0		(5)	18 months
PCV0791Q	Check valve BFD-79-1		(5)	18 months
PCV0792Q	Check valve BFD-79-2		(5)	18 months
PCV0793Q	Check valve BFD-79-3		(5)	18 months
PCXOP3AS	Valve controller on valve PCV-1310A		(1)#,(5)#	Monthly

*The monthly test 3PT-M20 proves only that one of the check valves, MS-41 or MS-42, worked properly.
#Verifies only that it has not improperly closed valves under test conditions.

TABLE 8 (continued)

INDIAN POINT 3 AFWS TESTING FREQUENCY

Component	Component (Basic Event)	Scheduled Testing (Procedure)	Indirect Testing	Effective Test Schedule
PCXOP3AS	Valve controller on valve PCV-1310A		(1)#,(5)#	Monthly
PCXOP3BS	Valve controller on valve PCV-1310B		(1)#(5)#	Monthly
PCXSR3AS	Temperature sensor circuitry on valve PCV-1310A		(1)#(5)#	Monthly
PCXSR3BS	Temperature sensor circuitry on valve PCV-1310B		(1)#(5)#	Monthly
PCX1187S	Signal to open PCV-1187			Never
PCX1188S	Signal to open PCV-1188			Never
PCX1189S	Signal to open PCV-1189			Never
PMO0031S	Motor operator to AFW pump 31	(1),(5)		Monthly
PMO0033S	Motor operator to AFW pump 33	(1),(5)		Monthly
PPM0031M	AFW motor pump 31	(1),(5)		Monthly
PPM0032M	AFW turbine pump 32	(1),(5)		Monthly
PPM0033M	AFW motor pump 33	(1),(5)		Monthly
6SG32OFS	Steam generator 32		Always working	Constantly Monitored
6SG33OFS	Steam generator 33		Always working	Constantly Monitored
PTB0032S	Turbine control for AFW pump 32	(1),(3),(4)		Monthly
PTKCITYS	City water supply tank		(1)	Monthly
PTKOCSTS	Condensate storage tank	(1)		Monthly
PXV0006G	Manual isolation gate valve CT-6	(1)		Monthly
PXV0027G	Manual isolation gate valve CT-27	(1)		Monthly
PXV0030G	Manual isolation gate valve CT-30	(1)		Monthly
PXV0033G	Manual isolation gate valve CT-33	(1)		Monthly
PXV0036G	Manual isolation gate valve BFD-36		(5)	18 months
PXV0038G	Manual isolation gate valve BFD-38		(5)	18 months
PXV0041G	Manual isolation gate valve BFD-41		(5)	18 months
PXV0043G	Manual isolation gate valve BFD-43		(5)	18 months
PXV0049G	Manual isolation gate valve CT-49		(5)	Never
PXV0054G	Manual isolation gate valve MS-54	(1)		Monthly

#Verifies only that it has not improperly closed valves under conditions of test.

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TABLE 8 (continued)

INDIAN POINT 3 AFWS TESTING FREQUENCY

Component	Component (Basic Event)	Scheduled Testing (Procedure)	Indirect Testing	Effective Test Schedule
PXV0064G	Manual isolation gate valve CT-64	(1),(5)		Monthly
PXV0480G	Manual isolation gate valve BFD-48-0	(1)*		18 months
PXV0481G	Manual isolation gate valve BFD-48-1	(1)*		18 months
PXV0482G	Manual isolation gate valve BFD-48-2	(1)*		18 months
PXV0483G	Manual isolation gate valve BFD-48-3	(1)*		18 months
PXV0484G	Manual isolation gate valve BFD-48-4	(1)*		18 months
PXV0485G	Manual isolation gate valve BFD-48-5	(1)*		18 months
PXV0486G	Manual isolation gate valve BFD-48-6	(1)*		18 months
PXV0487G	Manual isolation gate valve BFD-48-7	(1)*		18 months
PXV0620G	Manual isolation gate valve BFD-62-0			18 months
PXV0621G	Manual isolation gate valve BFD-62-1			18 months
PXV0622G	Manual isolation gate valve BFD-62-2			18 months
PXV0623G	Manual isolation gate valve BFD-62-3			18 months

* Valves are stroked but there is no flow verification.

TABLE 9

INDIAN POINT UNIT 3 AFWS
PLANT-SPECIFIC MAINTENANCE EXPERIENCE

Motor-Driven Pump Trains (Table B.3-8b)

Outages	8
Total Duration of Outage Hours	234
Total Reported Operation Hours	39,840

Mean Unavailability* (per train) = 4.03×10^{-3}

Turbine-Driven Pump Train (Table B.3-8a)

Outages	5
Total Duration of Outage Hours	170
Total Reported Operation Hours	19,920

Mean unavailability + 4.16×10^{-3}

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*The mean was derived from the Appendix B data, see Figure B.3-10b.

+The mean was derived from the Appendix B data, see Figure B.3-10a.

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TABLE 10

INDIAN POINT 3 - COMMON CAUSE CANDIDATES FOR SIMILAR PARTS

(Number of cutset combinations)

Part	Minimum Cutset Order							
	1	2	3	4	5	6	7	8
Air-Controlled Valves				12		4		
Electric Train								
Check Valves			45	220	317	86	24	
Electrical Components		4						
Motor Operator								
System Air								
Pump			1					
Steam Generator								
Turbine								
Tank		1						
Manual Valves		2		50	32	352	128	

TABLE 11

FULL POWER

INDIAN POINT 3 AFWS
DOMINANT CONTRIBUTORS TO CONDITIONAL UNAVAILABILITY

Rank	Event Description	Mean Unavailability	Approximate Unavailability Contribution (%)
1	Failure of the CST water supply and of the city water supply. (Table 7.1.1)	1.07×10^{-6}	43.5
2	Operator failure to open the city water valves coupled with a failure of the CST water supply. (Table 7.7.1)	4.70×10^{-7}	19.1
3	Operator failure to start the turbine-driven pump, motor-driven pump maintenance, and a failure of either set of discharge valves of the remaining motor-driven pump (Table 7.7 2)	3.24×10^{-7}	13.2
4	Motor-driven pump maintenance coupled with failure of the turbine-driven pump train and failure of a motor-driven pump discharge valve of the functioning pump. (Table 7.4.1)	1.44×10^{-7}	5.9
5	Operator failure to start the turbine-driven pump, failure of one motor-driven pump train, and a failure of either set of discharge valves of the remaining motor-driven pump. (Table 7.7.3)	1.19×10^{-7}	4.8
6	Operator failure to start the turbine-driven pump, maintenance on one and failure of the other motor-driven pump. (Table 7.7.4)	8.25×10^{-8}	3.4
7	Turbine-driven pump maintenance coupled with failure of one motor-driven pump train, and a motor-driven pump discharge valve failure in the other motor pump train. (Table 7.4.2)	7.03×10^{8}	3.0
8	Motor-driven pump maintenance coupled with failures of the other two pump trains. (Table 7.4.3)	3.58×10^{-8}	1.5

TABLE 12

ONE BUS UNAVAILABLE

INDIAN POINT UNIT 3 AFWS
DOMINANT CONTRIBUTORS TO CONDITIONAL UNAVAILABILITY (continued)

Rank	Event Description	Mean Unavailability	Approximate Unavailability Contribution (%)
1	Operator failure to start the turbine-driven pump coupled with a loss of either set of motor-driven pump discharge valves associated with the remaining pump. (Table 7.8.1)	4.03×10^{-5}	27.2
2	Operator failure to start the turbine-driven pump coupled with maintenance of the remaining motor-driven pump. (Table 7.8.2)	2.82×10^{-5}	19.1
3	Turbine-driven pump maintenance coupled with a failure of either set of motor-driven pump discharge valve associated with the motor-driven pump having power. (Table 7.5.1)	2.40×10^{-5}	16.2
4	Failure of the turbine-driven pump train, and failure of a motor-driven pump discharge valve on the functioning pump. (Table 7.2.1)	1.79×10^{-5}	12.1
5	Motor-driven pump maintenance coupled with a failure of the turbine-driven pump train. (Table 7.5.2)	1.25×10^{-5}	8.4
6	Operator failure to start the turbine-driven pump coupled with a failure of the remaining motor-driven pump. (Table 7.8.3)	1.03×10^{-5}	7.0
7	Turbine-driven pump maintenance coupled with a failure of the remaining motor-driven pump. (Table 7.5.3)	6.12×10^{-6}	4.1
8	Failure of the turbine-driven pump train, and failure of the motor-driven pump train that still has electric power. (Table 7.2.2)	4.55×10^{-6}	3.1

TABLE 13

NO POWER

INDIAN POINT UNIT 3 AFWS
DOMINANT CONTRIBUTORS TO CONDITIONAL UNAVAILABILITY (continued)

Rank	Event Description	Mean Unavailability	Approximate Unavailability Contribution(%)
1	Failure of the operator to start the motor driven pump. (Table 7.9.1)	7.00×10^{-3}	49.0
2	Turbine-driven pump maintenance. Table 7.6.1)	4.16×10^{-3}	29.1
3	Failure of the turbine-driven pump train. (Table 7.3.1)	3.10×10^{-3}	21.7

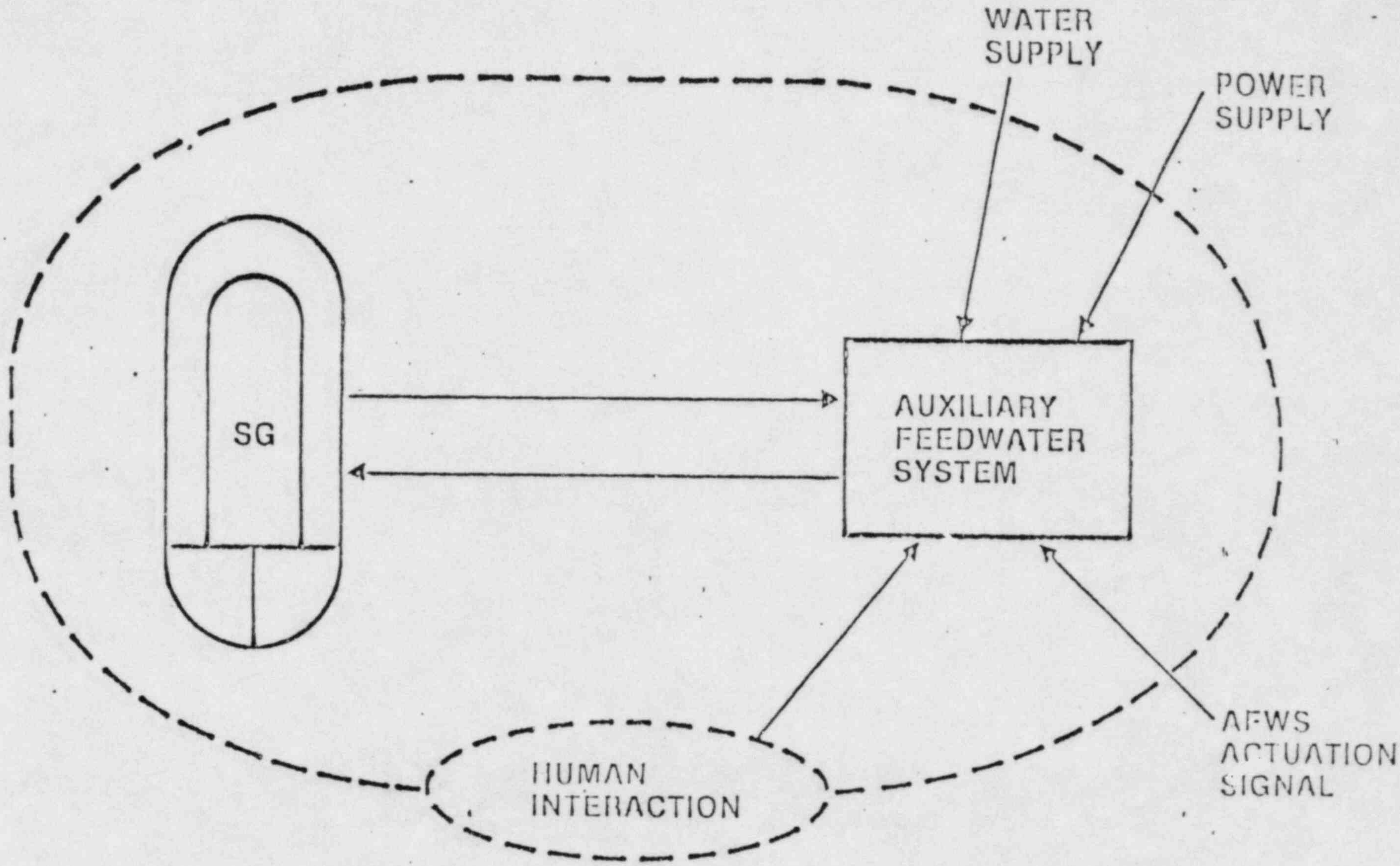


Figure 1. Boundary of Analysis for Indian Point Unit 3

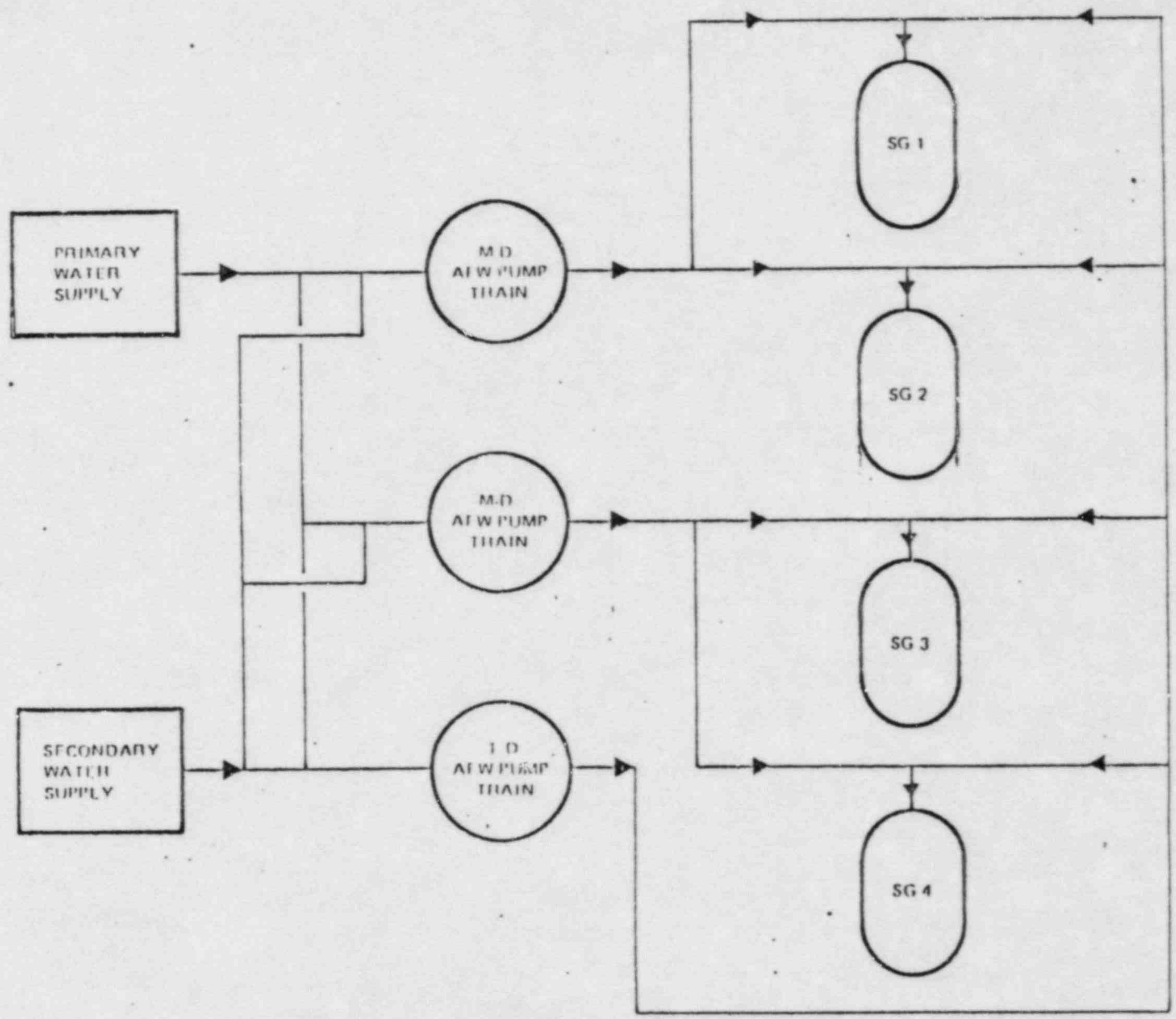


Figure 2. Simplified Block Diagram of Indian Point Unit 3

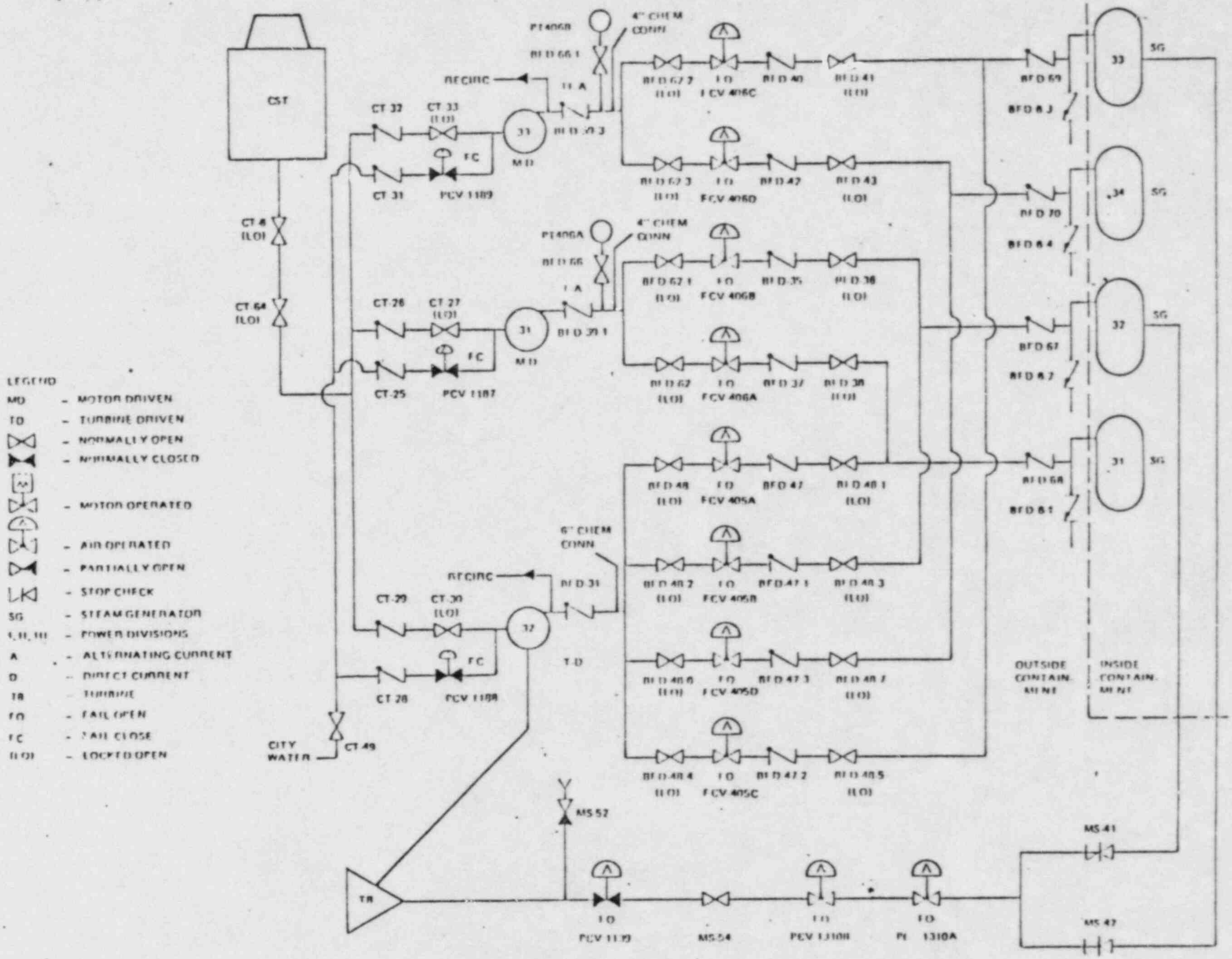


Figure 3. Indian Point 3 Auxiliary Feedwater System Schematic

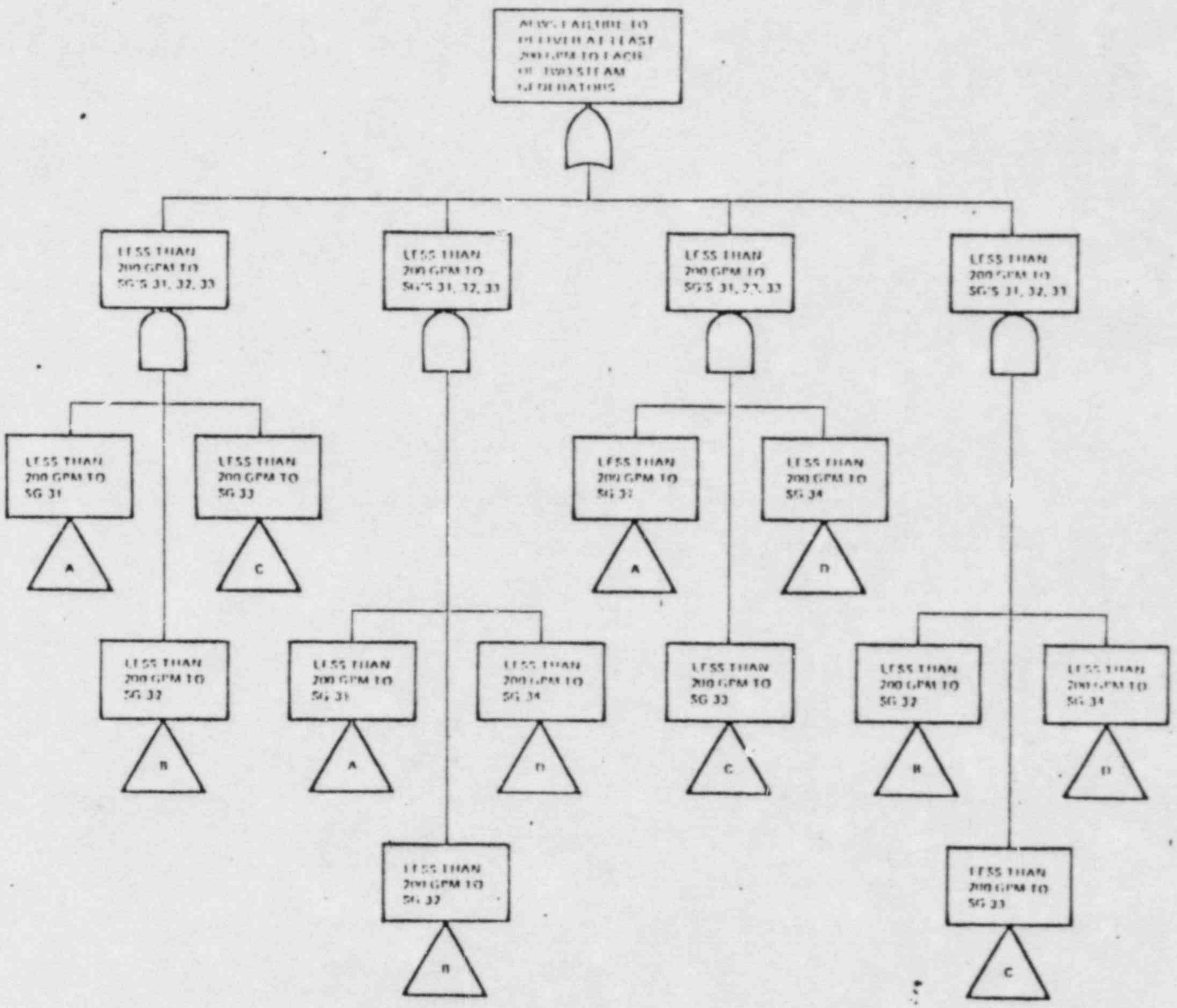
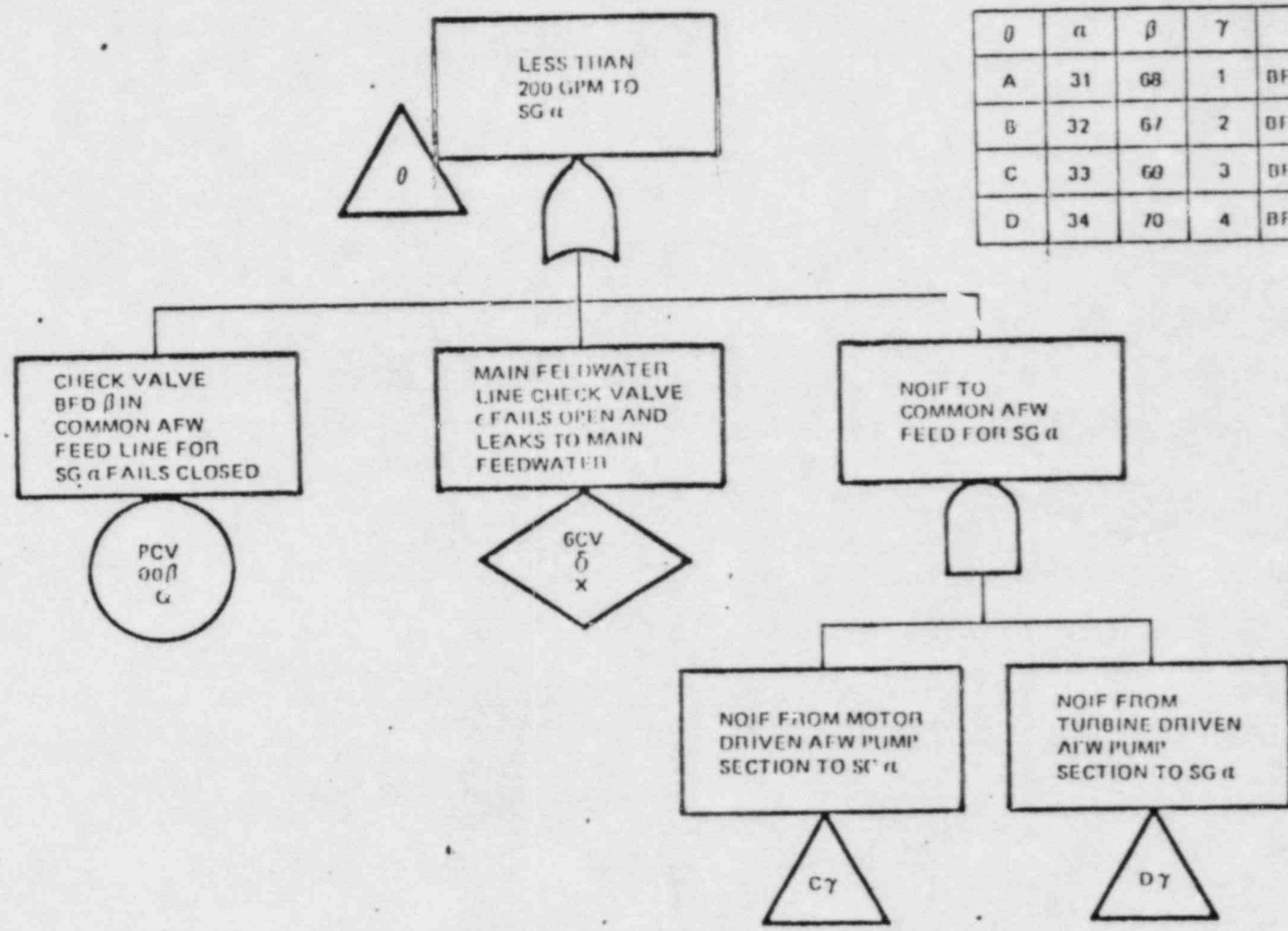


Figure 4. Indian Point Unit 3 Fault Tree
(Sheet 1 of 10)



θ	α	β	γ	ε	δ
A	31	68	1	BFD 6 1	0001
B	32	67	2	BFD 6 2	0002
C	33	68	3	BFD 6 3	0003
D	34	70	4	BFD 6 4	0004

Figure 4. (Sheet 2 of 10)

γ	α	ϕ	ν	$\eta 1$	$\eta 2$	β	ϵ	λ	μ
1	31	31	39 1	62 0	38	37	406A	1	34
2	32	31	39 1	62 1	36	35	406B	1	34
3	33	33	39 3	62 2	43	42	406C	2	39
4	34	33	39 3	62 3	41	40	406D	2	39

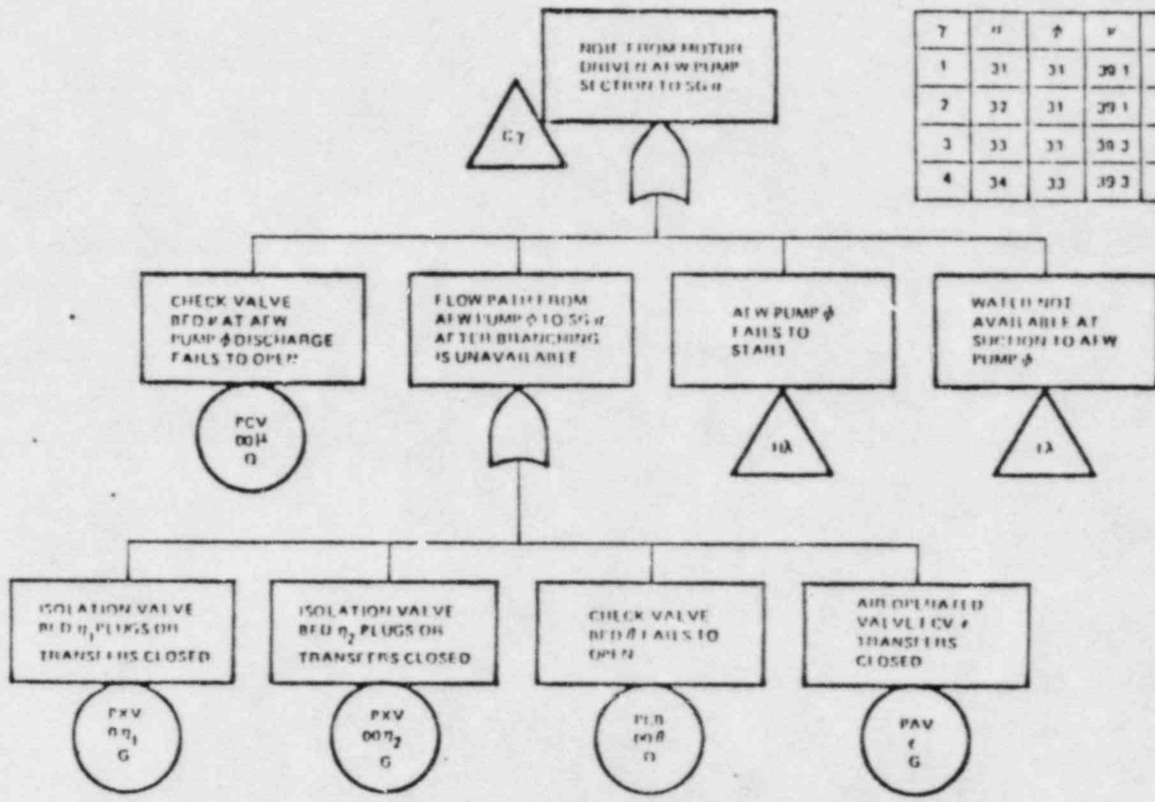
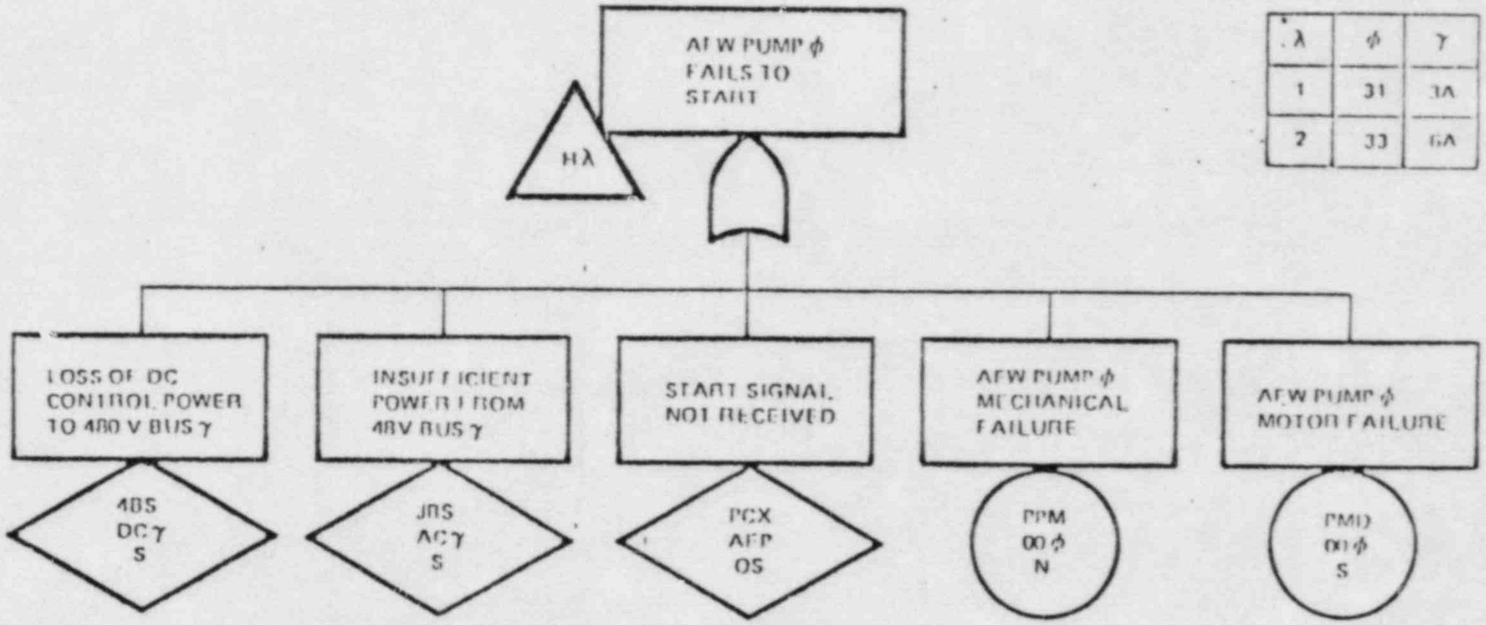


Figure 4. (Sheet 3 of 10)



λ	φ	γ
1	31	3A
2	33	6A

Figure 4. (Sheet 4 of 10)

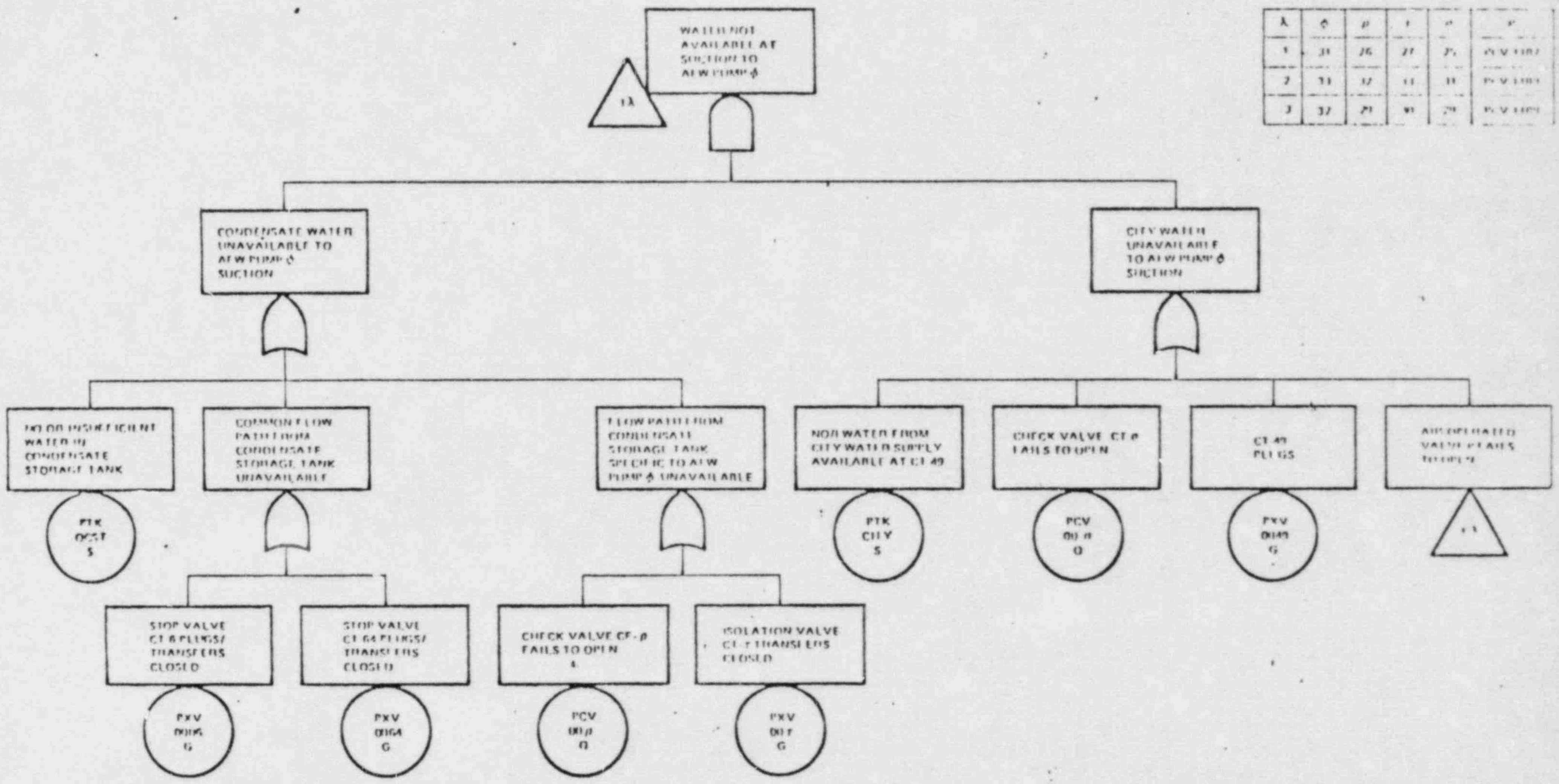
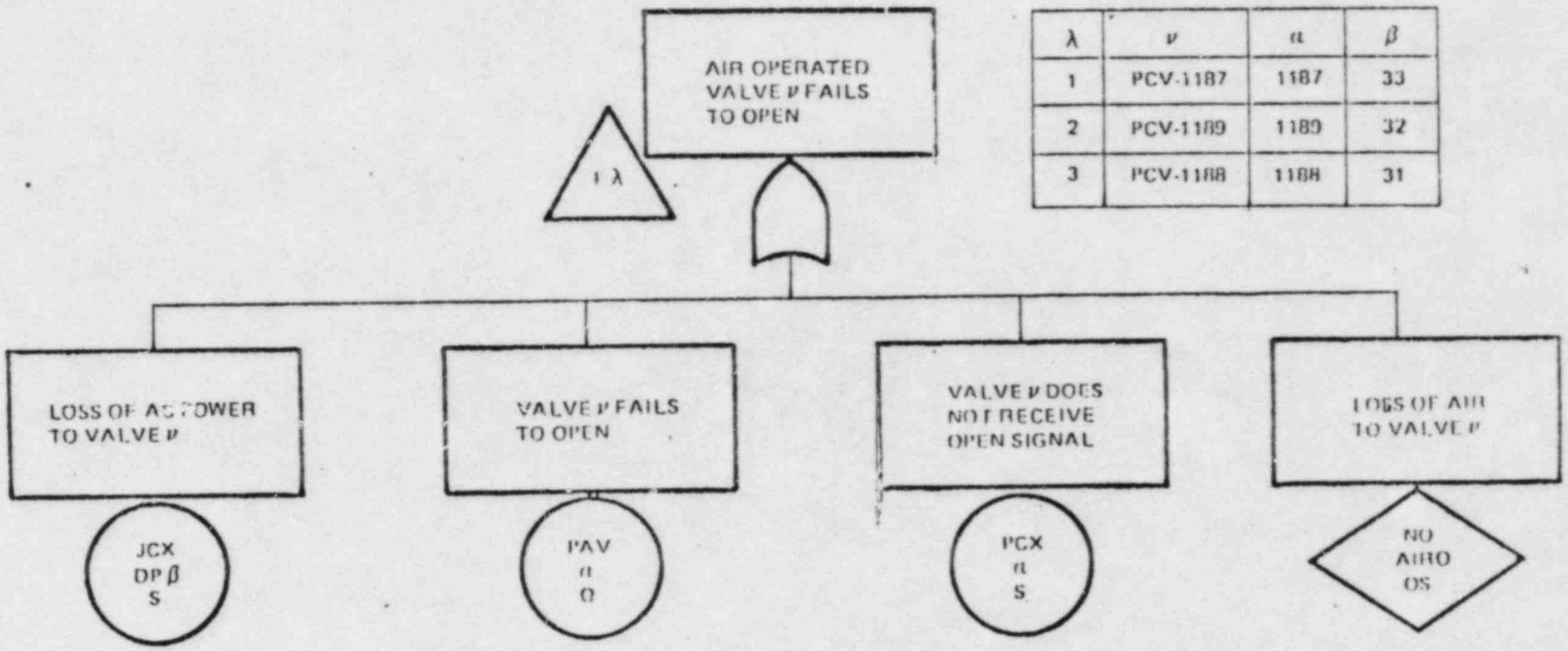


Figure 4. (Sheet 5 of 10)



λ	ν	α	β
1	PCV-1187	1187	33
2	PCV-1189	1189	32
3	PCV-1188	1188	31

Figure 4. (Sheet 6 of 10)

γ	α	η_1	η_2	θ	τ	λ
1	31	48-0	48-1	47-0	405A	5
2	32	48-2	48-3	47-1	405B	6
3	33	48-4	48-5	47-2	405C	7
4	34	48-6	48-7	47-3	405D	8

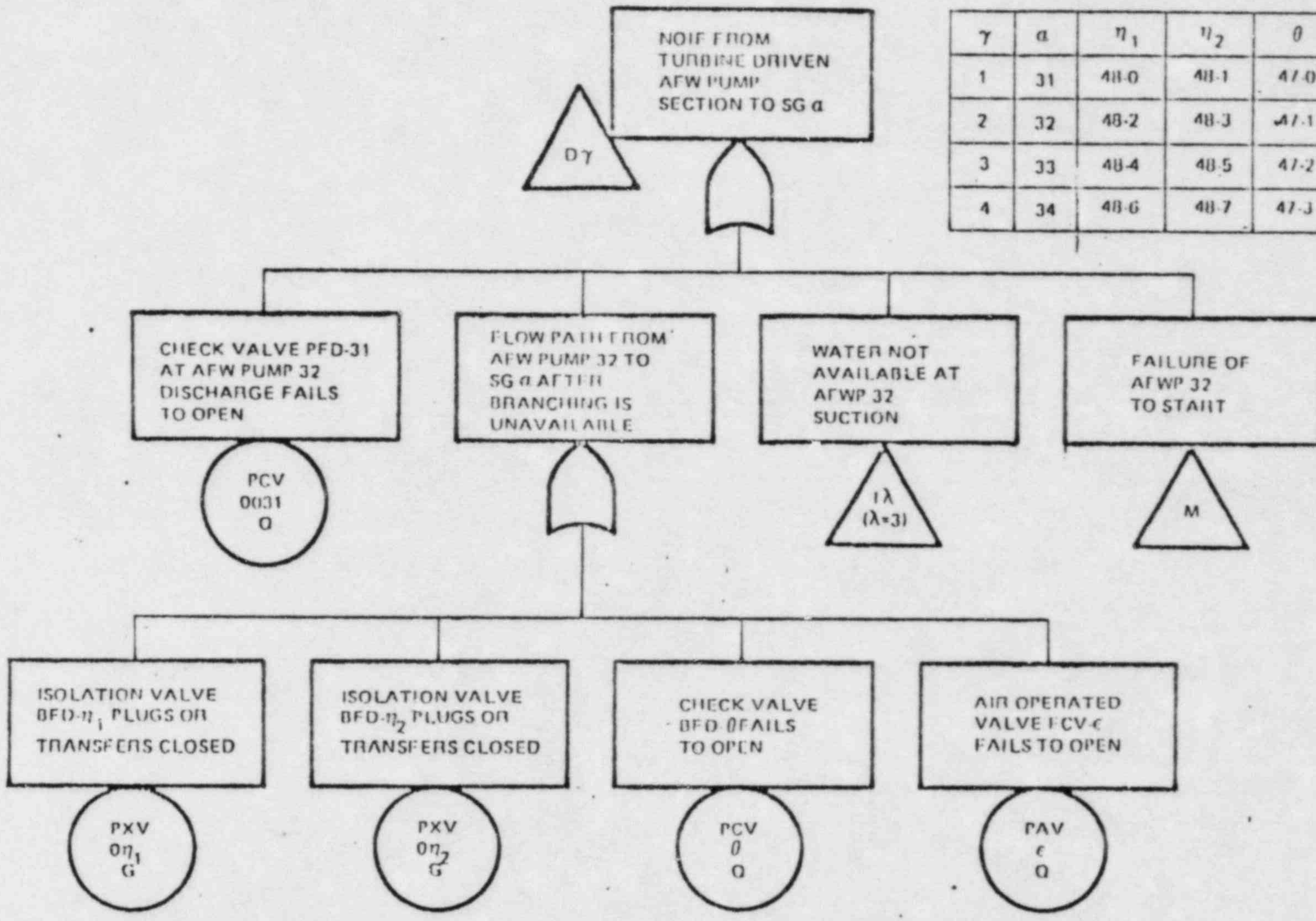


Figure 4. (Sheet 7 of 10)

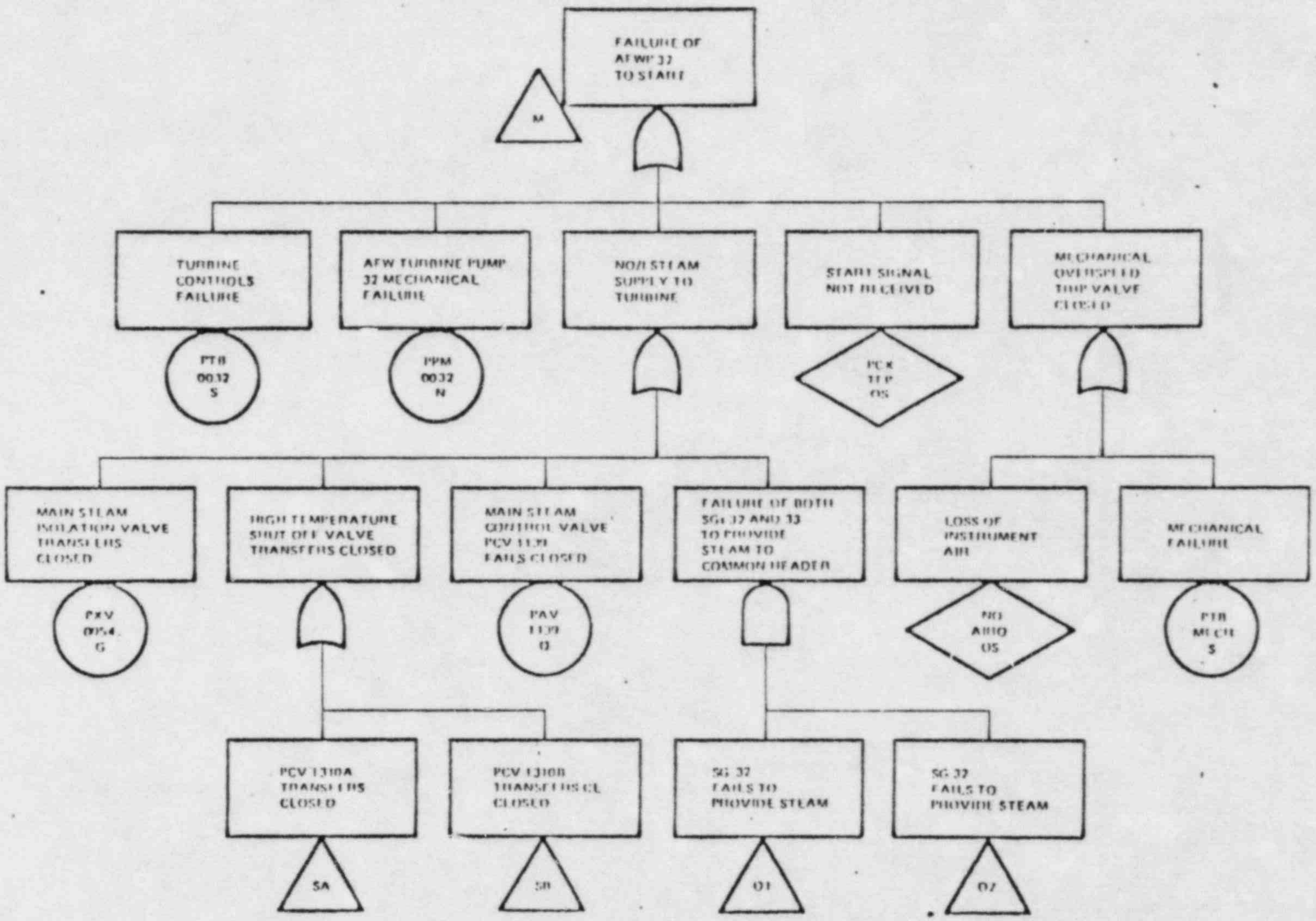
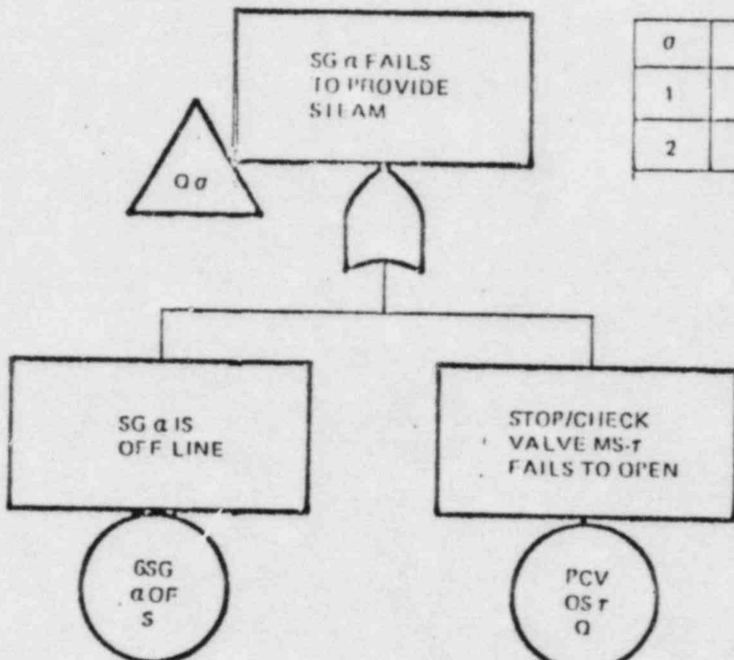


Figure 4. (Sheet 8 of 10)



σ	α	τ
1	32	41
2	33	42

Figure 4. (Sheet 9 of 10)

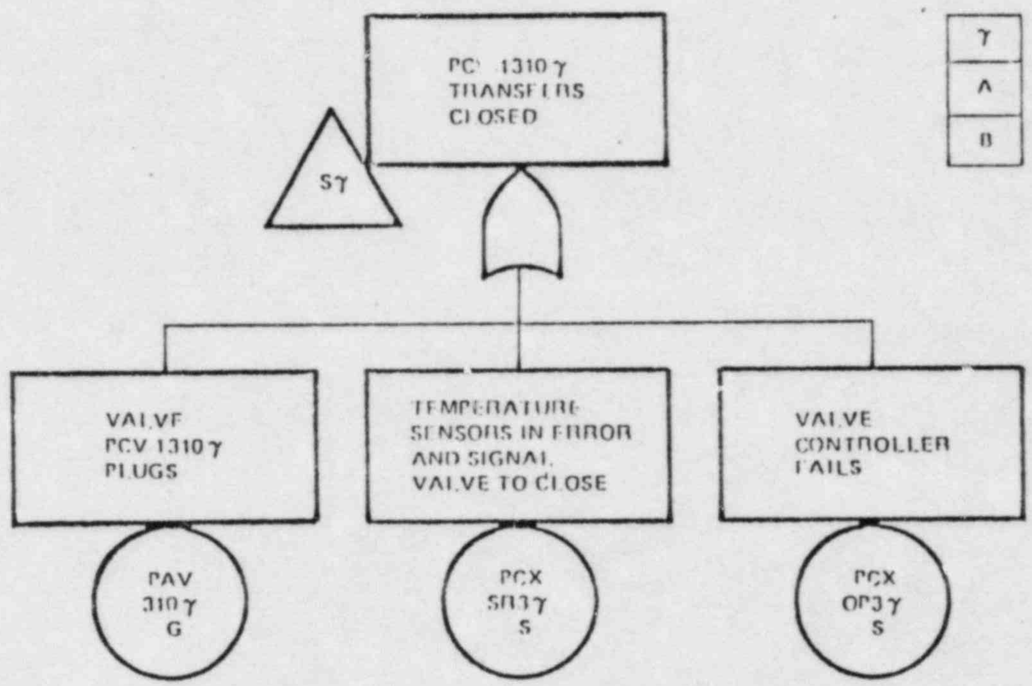


Figure 4. (Sheet 10 of 10)