Pickard, Lowe and Garrick, Inc.
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DWS

DRAFT

INDIAN POINT 3
COMPONENT COOLING SYSTEM

A. SUMMARY

A.1 INTRODUCTION

The component cooling system (CCS) is evaluated for its ability to perform its heat removal function during the recirculation phase of all LOCAs and during all transient events. The primary function of the system following an accident is to remove residual and sensible heat from residual heat removal (RHR) heat exchangers, RHR pumps, safety injection pumps, charging pumps, and supply water to the auxiliary component cooling pumps for recirculation pump cooling.

The analysis is carried out under the following conditions:

- The system was operating in the normal mode of cooling prior to the LOCA or transient.
- No operator action to recover the system following failure or to correct deficiencies in the system are considered in this analysis for the first hour following an initiating event.
- System success is: one of three pumps starts and operates for 24 hours; and one heat exchanger continues to operate for 24 hours.

A.2 RESULTS

Table 1 summarizes the results obtained for the component cooling system analysis. Two cases of electric power are presented: "No Loss of Offsite Power" and "Loss of Offsite Power." Three boundary conditions for each electric power case are analyzed: power at all 480V buses, loss of power at a single bus, and loss of power at two 480V buses.

The analysis has revealed the following dominant contributors to failure of the CCS to supply a sufficient amount of cooled water to time t = 24 hours:

	Mean
Case 1 - No Loss of Offsite Power.	
- Power at all 480V buses	
• Passive valve failure (service water supply) (95.5%)	1.0×10^{-7}
- Power at two 480V buses	
• Failure of the two operable pump trains (94%)	1.6×10^{-6}
- Power at one 480V bus	
• Failure of the operable pump train (99.9%)	8.3×10^{-5}

• Case 2 - Loss of offsite power	Mean
- Power at all 480V buses	
• Random failures in the pump trains (63%)	1.9×10^{-7}
• Passive valve failure (service water supply) (31%)	1.0×10^{-7}
- Power at two 480V buses	
• Failure of the two operable pump trains (99.7%)	3.0×10^{-5}
- Power at one 480V bus	
• Failure of the operable pump train (99.9%)	1.5×10^{-3}

No comparison is made to WASH-1400 results as there is no comparable system analysis in WASH-1400.

A.3 CONCLUSIONS

The component cooling system is required to support plant operations and will be operating at the time of the initiating event. For this reason, this system is unusual in relation to the plant standby emergency systems in that the dominant contributors to system failure, with power available to all pumps, are passive valve and pipe failures.

B. SYSTEM DESCRIPTION

B.1 SYSTEM FUNCTION

The CCS is one of three subsystems of the auxiliary coolant system (ACS) of Indian Point 3. It is a closed loop cooling system which is designed to remove residual and sensible heat from various primary plant components during power operations, shutdown operation, and under accident and transient conditions. The system also provides a barrier between the primary plant and the environment to prevent radioactive releases to the environment.

A block diagram and a simplified system piping arrangement are presented in Figures 1 and 2. Success of the system is defined as: one of three CCS pumps operating initially, followed by a second pump as power is available; and one of two CCS heat exchangers operating supplying postaccident loads.

B.2 BASIC DESCRIPTION

The CCS consists of: Three pumps, two CCS heat exchangers which are cooled by service water, two CCS surge tanks, and two supply and return headers. Table 2 presents the normal and emergency flows required to the CCS and the number of pumps and heat exchangers required during various plant conditions.

The CCS pumps are horizontal, centrifugal pumps rated at 3,600 gpm at 150 psi. During normal plant operation, two of the three pumps are required to supply the necessry flow for plant cooling loads. During accident conditions, one of three pumps is required at the start of the recirculation phase to supply the necessary flow for the plant emergency cooling loads followed by a second pump as power becomes available.

The three CCS pumps are always lined up to the common pump discharge header and pump return header. The pump discharge header cross-tie valves and the pump suction header cross-tie valves are normally open during power operation. Both CCS heat exchangers are fed from the common pump discharge header. Low discharge pressure on either heat exchanger supply header (which indicates insufficient capacity) is annunciated on the ACS panel in the control room and starts the third CCS pump.

Each CCS pump requires a minimum flow of 500 gpm for the removal of pump heat. A low flow in the CCS supply header of 1,500 gpm is alarmed in the control room at the ACS panel.

The CCS pumps are supplied from the following 480V switchgear buses:

- Pump No. 31, Bus No. 5A
- Pump No. 32, Bus No. 2A
- Pump No. 33, Bus No. 6A

Each of these 480V switchgear buses is supplied by separate emergency diesel generators.

The CCS surge tanks are located in the primary auxiliary building (PAB) and have a normal working volume of 1,000 gallons. The surge tanks accommodate changes in operating volume of the CCS due to changes in operating temperature. The free volume of each tank is sufficient to accommodate an in-leakage from a rupture of a reactor coolant pump thermal barrier cooling coil for three minutes. Makeup to the tanks for system leakage is normally provided by the flash evaporator through a manual valve. The primary water storage tank is the alternate makeup supply for the surge tanks. The surge tanks are normally vented to atmosphere; however, high radiation detected at the CCS return headers causes automatic closing of the vent valves. Relief valves on the surge tanks discharge to the waste holdup tank to provide pressure relief when the normal vents are closed. The high radiation condition is alarmed in the control room. Surge tank levels are indicated and alarmed in the control room.

The two CCS heat exchangers are shell and tube-type heat exchangers which are cooled by the service water system. The heat exchangers are designed to remove 3.14 x 10^7 Btu/hr at a shell side ΔT of 12°F with 5,320 gpm CCS flow and a tube side ΔT of 7°F with 9,100 gpm service water flow. Both heat exchangers are lined up on the component cooling side and the service water side. After recirculation has started, service water is lined up to both heat exchangers and the component cooling loops are split into two distinct subsystems. During accident conditions, only one heat exchanger is required for heat removel. The heat exchanger outlet temperature is monitored and alarmed in the control room as is header return temperature.

The CCS is basically two distinct systems from the heat exchangers back to the CCS pumps. The necessary cooling lines are branched off of these main supply and return headers. Most of the components cooled by the CCS receive flow during all plant conditions; the exceptions are discussed in the following:

- Reactor coolant pump cooling. Two series, motor-operated, isolation valves are provided for the reactor coolant pump supply line, the reactor coolant pump motor cooling return line, and the thermal barrier return line. These valves are automatically closed upon receipt of a containment isolation phase B signal. Each valve in a single line receives power from a separate 480V MCC (either 36A or 36B) which in turn receives power from the vital switchgear buses. FCV-625 in the return line from the reactor coolant pump thermal barriers also closes on a high flow condition in this return line. This high flow condition is indicative of a thermal barrier cooling coil failure. Closure of FCV-625 limits the amount of in-leakage from this failure.

- Excess letdown heat exchanger cooling. The supply line to this heat exchanger contains two, series, air-operated, normally open valves. These valves are designed to fail closed on loss of power or loss of air. These valves receive a containment isolation phase A automatic close signal. The return line from this heat exchanger contains two series, air-operated valves. One of the valves is normally closed. In all other respects, the operation of these valves is the same as the supply valves.

- Residual heat removal heat exchanger cooling. Each RHR heat exchanger receives component cooling water from a separate CCS supply header. Each RHR heat exchanger has a normally closed motoroperated valve located in the CCS outlet line. These valves receive an automatic open signal from the engineered safeguards actuation system.

The three safety injection pumps receive flow during all plant conditions. Two safety injection pumps are supplied from one CCS supply header; the third safety injection pump is supplied from the other CCS supply header. Each pump drives an attached circulating pump which is capable of supplying the cooling requirements for the safety injection pump using the water contained in the CCS supply headers. The CCS outlets of the three safety injection pumps are monitored for flow and alarmed in the control room on low flow.

The two RHR pumps also receive flow during all plant conditions, one from each supply header. Flow from these pumps is indicated locally and alarmed in the control room on low flow.

There are four auxiliary component cooling pumps which are used to supply component cooling water to the engineered safeguards system recirculation pumps. Two pumps supply a single recirculation pump from a single CCS supply header. These pumps are included in the low pressure recirculation system analysis and, therefore, are excluded from this analysis.

B.3 SYSTEM OPERATION DURING EMERGENCY CONDITIONS

As stated previously, two of the three CCS pumps are required to be in operation to support plant power operation and both CCS heat exchangers will be in operation (receiving service water). The following paragraphs discuss the response of this system to various emergency conditions.

- Unit Trip, No Blackout and No Safety Injection. When the unit trips and no blackout or safety injection occurs, the system will remain in operation as it was before the event since all power requirements will have transferred from the unit auxiliary transformer to the station auxiliary transformer, and the CCS pumps will continue to operate.

- Unit Trip, With Blackout and No Safety Injection. When this condition occurs, all CCS pumps are tripped. Electrical power is reestablished using the emergency diesel generators. CCS pumps are automatically started by this event as a function of energized (live) 480V buses.

  The CCS pump is started for th condition to protect the reactor coolant pumps (RCP) lower radi bearing and seal package since the charging pumps will have trippe and RCP seal and lower radial bearing water will be derived rom hot reactor coolant system (RCS) water. The component cooling water will cool this hot RCS water as it passes by the thermal barrier heat exchanger.

- Unit Trip, With Blackout and With Safety Injection. When this condition occurs, all CCS pumps are tripped. Electrical power is reestablished using the emergency diesel generators. The following events will occur in the component cooling loop:

  - Valves 822A and 822B (RHR heat exchangers) are opened.
  - The auxiliary component cooling pumps are started to protect the motors of the recirculation pumps from the containment accident atmosphere.
  - The shaft driven circulating pumps will be running when the safety injection pumps run and will supply cooling services for these pumps.

  These events occur automatically as a result of the engineered safeguards sequence signal. When the injection phase safeguards is completed and the recirculation phase is entered into, two CCS pumps or one CCS pump are started by recirculation phase switches RS-2 and RS-5. RS-2 will start one pump; RS-5 another pump if all four 480V buses are energized and a second service water pump is running. Positioning RS-2 to the "On" position will start pump 33; if it failed to start, pump 32 would be started; and if pump 32 failed to start, pump 31 would be started. This action is independent of the supporting service water system pumps. Positioning switch RS-5 to "On" will (providing power is available and two of the selected recirculation phase service water pumps are running) start pump 32. If pump 32 fails to start or is running, pump 31 is started.

- Unit Trip, No Blackout With Safety Injection. If there is a safety injection signal and the unit trips with no blackout, the CCS pumps which were running will continue running and the standby pump will start.

B.4 SUPPORT SYSTEMS

Successful operation of the CCS requires operation of the service water system and the electric power system. All three CCS pumps receive power from the 480V switchgear buses supplied by the emergency diesel generators. Both CCS heat exchangers receive service water from the conventional service water header.

B.5 INSTRUMENTATION AND CONTROLS

Control of the CCS pumps is accomplished by the plant operator from the ACS panel in the control room.

The control switch for each pump breaker is located at the ACS panel in the control room; status light indications are above each switch. As each pump breaker control circuit is identical, only the circuit for pump no. 31 will be discussed.

The control switch has four positions (spring-return to Auto).

- Pull-out. The pump is disabled from starting by any automatic start signal. With the switch in this position, the "Safeguards Equipment Locked Open" alarm will be annunciated on the safeguards panel in the control room.

- Stop. The pump breaker is tripped open.

- Auto. The pump will be started for any one of the following conditions:

  - Low discharge header pressure during normal operation.

  - Timed start on a "Unit Trip with Blackout or No SI" condition.

  - Timed start on a "SI and No Blackout" condition.

  - Automatic start during SI and blackout when shifting from the injection phase to the recirculation phase.

  NOTE: The operator must make the switchover, automatic starting is a result of recirculation phase switches RS-2 and RS-5 being turned to "On" by the operator.

- Start. The pump will be started.

  While the pump is running it can be tripped by:

  - Placing the control switch to the Stop or Pull-out position
  - Undervoltage on the assciated 480V switchgear bus
  - Blackout and SI conditions
  - Overload.

All motor-operated or air-operated valves used for containment isolation are operated from the containment isolation panel in the control room. The RHR heat exchanger outlet motor-operated valves are operated from the ACS panel in the control room.

Automatic operation of the CCS in response to emergency conditions has been discussed in the preceding paragraphs. The standby CCS pump will start automatically in response to a low header pressure from either

supply header (sensed at the heat exchanger inlet) or in response to a safety injection signal.

During system operation, header pressure, supply and return temperature, header flow, and individual component flows are monitored in the control room. Abnormal system conditions are alarmed in the control room on the ACS panel.

B.6 TECHNICAL SPECIFICATIONS

The plant technical specifications require that the reactor not be brought above the cold shutdown condition unless:

- Two CCS water pumps together with their associated piping and valves are operable. This condition may be modified to allow one of the two operable pumps to be out of service provided it is restored to an operable status within 24 hours.
- Two CCS heat exchangers and associated piping and valves are operable. One CCS heat exchanger or other passive component may be out of service for a period not to exceed 48 hours provided the system still operates at design accident capability.
- Two auxiliary component cooling pumps, one per each recirculation pump, together with their associated piping and valves are operable.
- Two auxiliary component cooling pumps serving the same recirculation pump may be out of service, provided at least one is restored to an operable status within 24 hours and at least one auxiliary component cooling pump serving the other recirculation pump is demonstrated to be operable.
- If the CCS is not restored to meet the above requirements within the times specified, then:
  - If the reactor is critical, it shall be brought to the hot shutdown condition utilizing normal operating procedures. The shutdown shall start no later than at the end of the specified time period.
  - If the reactor is subcritical, the reactor coolant system temperature and pressure shall not be increased more than 25°F and 100 psi, respectively, over existing values.
  - In either case, if the requirements for operable components are not satisfied within an additional 48 hours, the reactor shall be brought to the cold shutdown condition utilizing normal operating procedures. The shutdown shall start no later than the end of the 48-hour period.

B.7 TESTING AND MAINTENANCE

1. Automatic starting of the CCS pumps and the auxiliary component cooling pumps in response to recirculation switchover is performed every refueling cycle.

   Periodic testing of the CCS pumps is required by ASME Section XI. The required frequency of testing is monthly during normal plant operation. ASME Section XI also requires monthly testing of the auxiliary component cooling pumps. Pump operability is checked annually using 3PT-A9. In addition to the annual operability check, plant operating procedures require a weekly shift of operating CCS pumps.

   Routine monitoring of the CCS is performed by the plant operators to determine system status.

2. Periodic maintenance is performed as required on the components of the CCS system. This maintenance includes such items as lubrication, inspection, and adjustment.

3. Contribution of Maintenance.

   A review of plant work permits revealed two maintenance actions on CCS pumps in 4-1/2 years of plant operation. (This excludes cold shutdown periods.) Using the data from the work permits, we obtain for the probability of pump unavailability due to maintenance the following distribution:

   Mean: 1.84×10^{-2} Unavailability of a component cooling pump due to maintenance

   Variance: 1.64×10^{-4}.

   Upon completion of pump maintenance, testing is performed to determine pump operability and to ensure correct system lineup. At the completion of this testing, the pump is returned to its normal lineup (auto or running).

B.8 OPERATOR INTERACTION WITH THE COMPONENT COOLING SYSTEM

As this system is required to support normal plant operation, most operator errors that affect system operation will be annunciated or indicated in the control room within a short period of time after their occurrence. These actions include placing the standby pump switch in the "Pull-Out" position, or mispositioning manual or power operated valves. These errors do not contribute to system unavailability on demand during accident conditions.

Operator error after maintenance is precluded by the testing that is performed at the completion of the maintenance and the requirements imposed on system operability.

Operator error during the shift from injection phase to recirculation phase of LOCA events is possible and is discussed in the recirculation system description.

Operator error during the splitting of the CCS and service water system is discussed in Section D.5 of this analysis.

B.9 COMMON CAUSE ANALYSIS

Table 3 represents a listing of the components included in the component cooling system analysis, their failure mode, their location, and their susceptibility to various causes of common cause failure. The contribution of common cause failures to system failure is presented in Section D.6.

C. SYSTEM FAULT TREE MODELING AND RESULTS

C.1 EVENT TREES

In the event trees, the CCS is included with failure of the recirculation phase events.

C.2 SYSTEM FAULT TREES

Figure 3 presents the fault tree developed for the Indian Point 3 CCS. The top event, "No or Insufficient Flow (NOIF) from the Component Cooling Water System", may be further defined as flow delivered to the supply headers that is less than the capacity of one component cooling pump.

C.3 FAULT TREE CODING

Table 3 is a list of basic events, their failure modes, the corresponding codes, and the failure rates associated with these events.

C.4 MINIMAL CUTSETS

The minimal cutsets for the CCS are identified in Table 4.

The single event cutsets, block F of Figure 1, consist of piping failures which result in system failure and failures in the service water supply to the CCS heat exchangers. The piping failure effects table, (Table 5) presents the results of the analysis of piping failures on the CCS.

The two event cutsets, blocks D and E of Figure 1, consist of failures in the two heat exchanger trains, failures in the supply and return headers, and failures of the two surge tanks. Block D consists of the following basic events:

- TXV34--C: Service water inlet valve, SWN-34, transfers closed
- TXV36--C: Service water outlet valve, SWN-36, transfers closed
- UXV759AC: Heat exchanger 31 inlet valve, 759A, transfers closed
- UXV765AC: Heat exchanger 31 outlet valve, 765A, transfers closed
- UHE0031L: Heat exchanger 31 loss of cooling capability (rupture, plugging, etc.)
- UTK0031L: CC surge tank 31 leak or rupture.

Block E consists of the following basic events:

- TXV34-1C: Service water inlet valve, SWN-34-1, transfers closed
- TXV36-1C: Service water outlet valve, SWN-36-1, transfers closed
- UXV759BC: Heat exchanger 32 inlet valve, 759B, transfers closed
- UXV765BC: Heat exchanger 32 outlet valve, 765B, transfers closed
- TXV33--C: Service water crossover valve, SWN-33, transfers closed

- TXV33-1C: Service water crossover valve, SWN-33-1, transfers closed
- UHE0032L: Heat exchanger 32 loss of cooling capability (rupture, plugging, etc.)
- UTK0032L: CC surge tank 32 leak or rupture.

Blocks A, B, and C of Figure 1 identify the components that comprise the three event cutsets. Block A consists of the following basic events:

- JBS-35AD: No power at switchgear bus 5A
- 4BS-331D: No control power at switchgear bus 5A
- UXV760AC: Pump 31 suction valve, 760A, transfers closed
- UXV762AC: Pump 31 discharge valve, 762C, transfers closed
- UCV761AQ: Pump 31 discharge check valve, 761A, transfers closed/fails to open
- UPM0031S: Pump 31 fails mechanically; start or run
- UM00031S: Motor for pump 31 fails
- UCC0031F: Control circuit for pump 31 fails.

Block B consists of the following basic events:

- JBS-32AD: No power at switchgear bus 2A
- 4BS-333D: No control power at switchgear bus 2A
- UXV760BC: Pump 32 suction valve, 760B, transfers closed
- UXV762BC: Pump 32 discharge valve, 762B, transfers closed
- UCV761BQ: Pump 32 discharge check valve, 761B, transfers closed/fails to open
- UPM0032S: Pump 32 fails mechanically; start or run
- UM00032S: Motor for pump 32 fails
- UCC0032F: Control circuit for pump 32 fails.

Block C consists of the following basic events:

- JBS-33AD: No power at switchgear bus 6A
- 4BS-333D: No control power at switchgear bus 6A
- UXV760CC: Pump 33 suction valve, 760C, transfers closed
- UXV762CC: Pump 33 discharge valve, 762C, transfers closed
- UCV761CQ: Pump 33 discharge check valve, 761C, transfers closed/fails to open
- UPM0033S: Pump 33 fails mechanically; start or run
- UM00033S: Motor for pump 33 fails
- UCC0033F: Control circuit for pump 33 fails.

D. QUANTIFICATION BOUNDARY CONDITION, OFFSITE POWER AVAILABLE

D.1 QUANTIFICATION OF SINGLE FAILURES (BLOCK F) (HARDWARE)

The single event failures consist of piping failures which fail the entire CC system, no flow from the conventional service water header, and service water valve SWN-31 transferring closed.

- No flow from the conventional service water header. This failure results in plant shutdown and is detected upon occurrence. This event is quantified at the event tree level and is shown here only for completeness.
- Pipe failures. Table 5 identifies the pipe sections whose failure results in CCS failure. The mean and variance for failure in a single section of pipe is:

  Mean: 8.60×10^{-10} Probability of failure per hour per section

  Variance: 6.00×10^{-17}.

  We have determined 17 major sections of CCS piping whose failure results in system failure. This results in the following piping contribution to failure:

  Mean: 1.46×10^{-8} Probability of failure per hour

  Variance: 1.24×10^{-13}.

- SWN-31 transfers closed. This valve is normally open and the failure of interest transfers closed. This failure mode results in a loss of service water flow to the CCS heat exchangers which causes high temperature alarms on the CCS heat exchanger outlet. Recovery from this failure during normal plant operation consists of transferring the service water supply to the CCS heat exchangers to the other service water header. The mean and variance for this event are:

  Mean: 9.15×10^{-8} Probability of failure per hour

  Variance: 1.01×10^{-4}.

  The single event contribution to system failure per hour is now:

  $$Q_{Block\ F} = \text{piping} + \text{valve}$$

  $$= 1.06 \times 10^{-7}$$

  $$\text{Variance}_{Block\ F} = 1.53 \times 10^{-14}.$$

The failures described above require immediate plant shutdown if they occur during plant operation. For this reason, single failures prior to the initiating event are not considered in this analysis.

The single failures which affect this analysis are those which occur after the initiating event. The time period of interest is the first 24 hours after the initiating event. After the first hour following an initiating event, the CCS is split by procedure into two separate and distinct subsystems. Operator error during this split is discussed in Section D.5 of this analysis. After the split, there are no single failures which can fail the CCS. For these reasons, the single event failure contributions to system failure are those failures which occur during the first hour after an initiating event. The probability of system failure due to single event failures is described by the following mean and variance:

Mean: 1.06×10^{-7}

Variance: 1.53×10^{-14}.

D.2 QUANTIFICATION OF TWO EVENT CUTSETS (BLOCKS D AND E) (HARDWARE)

As stated in Section C.4, the two event cutset contributions to failure consist of failures in blocks D and E of Figure 1. For block D we have:

Manual valve (service water) (2)
(failure per hour)

Mean: 9.15×10^{-8}

Variance: 1.01×10^{-14}

Manual valve (CCW) (2)
(failure per hour)

Mean: 9.15×10^{-8}

Variance: 1.01×10^{-14}

Heat exchanger
(failure per hour)

Mean: 9.73×10^{-7}

Variance: 3.34×10^{-12}

Surge tank (leak or rupture)
(failure per hour)
(same as pipe rupture)

Mean: 8.60×10^{-10}

Variance: 6.00×10^{-17}.

The probability of failure for block D is now:

Mean (D): $4\ \alpha \text{valve} + \alpha \text{heat exchanger} + \alpha \text{tank}$

$= 1.34 \times 10^{-6}$

Variance (D): 2.84×10^{-12}.

For block E, we have two additional service water valves in the supply line. This results in the following distribution for the probability of failure of block E:

Mean: 1.52×10^{-6}

Variance: 3.01×10^{-12}.

The failures described above are failures per hour, and we are interested in failures on demand. Note that failures in either component cooling train which occur during plant operation are immediately detectable. Operator action would then be taken to determine the cause, and repairs would be initiated. These failures are included in the maintenance contribution to system failure. Given that the system was operating prior to the initiating event, the failures that affect this system are those failures which occur from the time of the initiating event to time t = 24 hours after the initiating event. Approximately 1 hour after the initiating event, the operator is directed, by procedure, to split the CCS and the service water system into two distinct subsystems. This results in a change in the components in blocks D and E. Block D now consists of:

- TXV34--C
- TXV36--C
- UXV759AC
- UXV765AC
- UHE0031L
- UTK0031L
- TXV32--C
- Nine sections of CCS piping (including pump suction and discharge cross-ties).

Block E consists of:

- TXV34-1C
- TXV36-1C
- UXV759C
- UXV765BC
- UHE0032L
- UTX0032L
- TXV31--C
- Seven sections of CCS piping.

NOTE: After the split, CCS pumps 31 and 32 will be supplying heat exchanger 31 and CCS pump 33 will be supplying heat exchanger 32. The CCS heat exchanger cross-tie will be isolated.

The following equation defines probability of system failure due to random failures in blocks D and E:

$$
\begin{aligned}
Q = & \left[(4V3 + V2 + V1)\ (6V3 + V2 + V1)\right] \\
& + \ 1 - (4V3 + V2 + V1)\ (6V3 + V2 + V1) \\
& \times \left[23(5V3 + V2 + V1 + 9V4)\right] \times \left[23(5V3 + V2 + V1 + 7V4)\right]
\end{aligned}
$$

where

V1 = Probability of surge tank failure

V2 = Probability of heat exchanger failure

V3 = Probability of a manual valve transferring closed

V4 = Probability of a single pipe section failure

Using the above equation, the probability of system failure due to random two event failures is:

Mean: 3.52×10^{-9}

Variance: 2.91×10^{-16}.

D.3 QUANTIFICATION OF THREE EVENT CUTSETS (BLOCKS A, B, C) (HARDWARE FAILURES)

As stated in Section C.4, the three event cutset contribution to system failure on demand consists of random failures in the pump trains, blocks A, B, and C of Figure 1. For block A we have:

- Pump (including motor and controls)
  - Failure to start (on demand)

    Mean: 1.36×10^{-3}

    Variance: 1.22×10^{-6}.
  - Failure to run (per hour)

    Mean: 3.26×10^{-6}

    Variance: 2.47×10^{-11}.

- Manual valve
  - Transfers closed (per hour)

    Mean: 9.15×10^{-8}

    Variance: 1.01×10^{-14}.

- Check valve
  - Fails to open (on demand)

    Mean: 6.91×10^{-5}

    Variance: 1.03×10^{-8}.

Blocks B and C consist of similar components. With a safety injection signal and no loss of offsite power, the CCS pumps which were running continue to run. The probability of failure per hour of a running CCS pump train is described by the following distribution (made up of pump failure to continue running and manual valves transferring closed):

Mean: 3.44×10^{-6}

Variance: 2.13×10^{-11}.

For a time, $t = 24$ hours, we have the following distribution for failure of an operating pump train:

Mean: 8.26×10^{-5}

Variance: 1.23×10^{-8}.

With a loss of offsite power, the CCS pumps are started as a result of the operator action which occurs when entering the recirculation phase of the accident (with the diesel generators available). The probability of failure to start on demand of a previously operating CCS pump train is made up of: Pump failure to start on demand; check valve failure to open on demand; and the transferring closed of either the pump suction valve or discharge valve during the period of time that the pump is idle. For a time, $t \leq$ one hour, the probability of failure of a single manual valve is:

Mean: 9.15×10^{-8}

Variance: 1.01×10^{-14}.

For a single previously operating pump train, the probability of failure on demand is described by the following distribution:

Mean: 1.43×10^{-3}

Variance: 1.13×10^{-6}.

Given a successful start, the CCS pump must operate for 24 hours. The total probability of failure (start and operate for 24 hours) for a single previously operating CCS pump train is now:

Mean: 1.51×10^{-3}

Variance: 1.03×10^{-6}.

During plant operation, one CCS pump train is normally in standby. Pump failure to start on demand and check valve failure to open on demand remain as previously defined; however, the manual valves' contribution to pump train failure on demand must be developed. Plant procedures require routine shifting of the CCS pumps weekly. The fault detection time for this event is taken as one-half of the test interval (84 hours). This results in the following distribution for failure of a single manual valve in the standby pump train:

Mean: 7.69×10^{-6}

Variance: 6.74×10^{-11}.

The failure of the standby pump train to start on demand is now described by the following mean and variance:

Mean: 1.44×10^{-3}

Variance: 1.13×10^{-6}.

Given a successful start, the pump must continue to run for 24 hours, which results in a total failure probability for the standby pump of:

Mean: 1.53×10^{-3}

Variance: 1.03×10^{-6}.

The following expression defines the probability of failure for the CCS pumps with differing probabilities for the status of the standby pump.

$$Q_{\text{pumps}} = P(1S)\left[\binom{2}{2} P(OP)^2 \times P(STBY)\right] + 3P(OS)\left[\binom{2}{2} P(OP)^2\right]$$

where:

P(1S) = Probability of having one pump in standby which equals 1 - (probability of maintenance of a single CCS pump) .

P(OS) = Probability of having one CCS pump undergoing maintenance.

P(OP) = Probability of failure of a running (or previously running) pump (to t = 24 hours).

P(STBY) = Probability of failure of the standby pump (to t = 24 hours).

For the pump contribution to system failure, with no loss of offsite power and power available at all 480V switchgear buses, we have the following distribution:

Mean: 9.15×10^{-10}

Variance: 7.99×10^{-16}.

For the pump contribution to system failure, with a loss of offsite power and power available at all 480V switchgear buses, we have the following distribution:

Mean: 1.87×10^{-7}

Variance: 1.21 x 10-13.

D.4 QUANTIFICATION OF TEST AND MAINTENANCE

D.4.1 Test Contribution

Testing of the CCS consists of starting the standby CCS pump monthly to satisfy ASME Section XI requirements and the weekly pump shift to satisfy plant operating requirements.

No system lineup changes are required for this testing. Therefore, no contribution of system failure on demand is assigned because of testing.

D.4.2 Maintenance Contribution

The maintenance contribution to system failure is included with the quantification of the pump trains' effect on system failure.

D.5 QUANTIFICATION OF HUMAN INTERACTION

The operator error of failing to switch from injection to recirculation is presented in the recirculation system analysis and is not quantified here.

With sufficient electric power, and after the shift to recirculation has been successfully completed, the operator is required by plant procedures to shift the CCS and service water system lineups. This shift results in splitting the CCS and the service water system into distinct subsystems. After the shift, pumps 31 or 32 of the CCS will be supplying a single header, and pump 33 will be supplying the other header. Each CCS heat exchanger will be receiving water from a separate service water header.

No probability for system failure due to operator errors in this shift are assigned for the following reasons:

- In order to start the shift, plant conditions must be stable, with sufficient electric power available and the shift to recirculation successfully completed. Conditions in the control room by this time

will be approaching the conditions in the control room during normal plant operations.

- The procedure details by valve number, the sequence of steps that must be performed to complete the shift. Verification of each significant change is monitored by monitoring the system conditions; major errors will be immediately detected and corrected.
- If problems are encountered, the shift is not made and the system remains or is returned to the normal lineup.

D.6 QUANTIFICATION OF COMMON CAUSE

Although there are many similar components sharing common locations in the CCS, a large portion of these components are not highly susceptible to common cause failure mechanisms bacause they perform a passive function. These items include manual valves, check valves, tanks, heat exchangers, and piping. The active components of the system, the CCS pumps, and various motor-operated valves are more likely candidates for common cause failure and are discussed below. External events such as earthquakes, flooding, etc., are discussed elsewhere in this report.

a. Fire. The three CCS pumps share a common room in the primary auxiliary building at elevation 68'. The "Review of the Indian Point Station Fire Protection Program" described this area as having a low fire loading and postulated no fires which could affect all three CCS pumps.

b. Moisture. Located in the vicinity of the CCS pumps are the CCS heat exchangers, the CCS surge tank, and the piping and valves for alignment and isolation of this equipment. Leakage (spray) from these components is detectable during plant operation and would be corrected upon occurrence prior to damage occurring. This common cause failure is not quantified for the above reason.

c. Grit. During plant operation, no grit producing activities occur. During plant shutdown, these activities are protected against by plant procedures. This mechanism for common cause failure is not quantified for this analysis.

d. Other causes - Other common cause susceptibilities, such as manufacturer, test and maintenance procedures, etc., are possible contributors to common cause failure of the CCS pumps. However, the plant test program, maintenance program, and technical specifications combine to (1) aid in discovery of pump problems and (2) limit the effects of common cause failures. No quantification is performed for these causes of failure.

NOTE: The CCS pump breakers are susceptible to the common cause failure mechanisms of fire, moisture and grit due to their common location in the switchgear room. Quantification and discussion of these effects are presented in the event tree analysis as these effects would be felt throughout the plant.

D.7 SYSTEM FAILURE QUANTIFICATION

The failure frequency per demand for the CCS is made up of the following contributors: single event, double event, and triple event random hardware failures; test and maintenance in conjunction with random hardware failures; human error contribution to failure; and common cause contribution to failure.

The probability of failure of the CCS, given no loss of offsite power, to time (t = 24 hours) is characterized by the following mean and variance:

Q_{system}: αsingles + αdoubles + αtriples + αT&M
αoperator error + αcommon cause

1.11×10^{-7}

Variance: 1.54×10^{-14}

With a loss of offsite power, we have the following distribution for failure of the CCS to operate to time, t = 24 hours:

Q_{system}: 2.97×10^{-7}

Variance: 1.34×10^{-13}.

E. QUANTIFICATION BOUNDARY CONDITION, LOSS OF ONSITE POWER BUS(ES)

1. Loss of a single 480V bus

a. No loss of offsite power. The following equation defines the probability of failure for the CCS pumps given a loss of a single 480V switchgear bus supply:

$$Q_{pumps} = P(1S)\ [P(OP) \times P(STBY)] + P(0S)\ [P(OP)]$$

where the terms of the equation remain as defined in Section D.3. For conservatism, the failed 480V switchgear bus is defined as a bus supplying a running CCS pump. The pump train contribution to system failure under the conditions defined above is:

Mean: 1.64×10^{-6}

Variance: 5.72×10^{-12}.

The probability of system failure under these conditions is:

Q_{system}: 1.75×10^{-6}

Variance: 5.72×10^{-12}.

b. Loss of offsite power. The equation defined above is also applicable for this case. The pump train contribution to system failure under these conditions is:

Mean: 3.01×10^{-5}

Variance: 8.38×10^{-10}.

The probability of system failure is now:

Q_{system}: 3.02×10^{-5}

Variance: 8.37×10^{-10}.

2. Loss of two 480V buses

a. No loss of offsite power. Under these conditions, the contribution to system failure of the CCS pumps is the value determined for a single CCS pump. From Section D.3, the value for an operating pump to time t =24 hours is:

Mean: 8.26×10^{-5}

Variance: 1.23×10^{-8}

This results in the following probability of system failure under these conditions:

Q_{system}: 8.27×10^{-5}

Variance: 1.22×10^{-8}.

b. Loss of offsite power. Under this condition, the contribution to system failure of the CCS pumps is the value determined for a single, previously operating, CCS pump. From Section D.3, this value is:

Mean: 1.51×10^{-3}

Variance: 1.03×10^{-6}

which results in a system probability of failure of:

Q_{system}: 1.51×10^{-3}

Variance: 1.03×10^{-6}.

TABLE 1

SUMMARY OF RESULTS--COMPONENT COOLING SYSTEM ANALYSIS

Case 1--No Loss Of Offsite Power

	Mean	Variance	5th Percentile	95th Percentile	Median	WASH-1400
Boundary Condition Power at All Buses						
Singles	1.1×10^{-7}	1.5×10^{-14}	2.0×10^{-8}	2.6×10^{-7}	6.6×10^{-8}	
Heat Exchangers	3.5×10^{-9}	2.9×10^{-16}	6.3×10^{-11}	1.1×10^{-8}	8.1×10^{-10}	No Comparable Analysis
Pump Trains	9.1×10^{-10}	8.0×10^{-18}	4.1×10^{-12}	3.3×10^{-9}	1.2×10^{-10}	
Test and Maintenance		(with pump trains)				
Operator Error	-					
Common Cause	-					
Other	-					
System	1.1×10^{-7}	1.5×10^{-14}	2.2×10^{-8}	2.6×10^{-7}	7.5×10^{-8}	
Boundary Condition Power at Two Buses						
Singles	1.1×10^{-7}	1.5×10^{-14}	2.0×10^{-8}	2.6×10^{-7}	6.6×10^{-8}	
Heat Exchangers	3.5×10^{-9}	2.9×10^{-16}	6.3×10^{-11}	1.1×10^{-8}	8.1×10^{-10}	No Comparable Analysis
Pump Trains	1.5×10^{-6}	5.7×10^{-12}	1.4×10^{-7}	4.7×10^{-6}	8.5×10^{-7}	
Test and Maintenance		(with pump trains)				
Operator Error	-					
Common Cause	-					
Other	-					
System	1.8×10^{-6}	5.7×10^{-12}	2.4×10^{-7}	4.8×10^{-6}	1.0×10^{-6}	
Boundary Condition Power at One Bus						
Singles	1.1×10^{-7}	1.5×10^{-14}	2.0×10^{-8}	2.6×10^{-7}	6.6×10^{-8}	
Heat Exchangers	3.5×10^{-9}	2.9×10^{-16}	6.3×10^{-11}	1.1×10^{-8}	8.1×10^{-10}	No Comparable Analysis
Pump Trains.	8.3×10^{-5}	1.2×10^{-8}	1.2×10^{-5}	2.0×10^{-4}	4.5×10^{-5}	
Test and Maintenance		(with pump trains)				
Operator Error	-					
Common Cause	-					
Other	-					
System	8.3×10^{-5}	1.2×10^{-8}	1.1×10^{-5}	2.4×10^{-4}	4.7×10^{-5}	

TABLE 1 (continued)

SUMMARY OF RESULTS--COMPONENT COOLING SYSTEM ANALYSIS

Case 2--Loss Of Offsite Power

	Mean	Variance	5th Percentile	95th Percentile	Median	W-1400
Boundary Condition Power at All Buses						
Singles	1.1×10^{-7}	1.5×10^{-14}	2.0×10^{-8}	2.5×10^{-7}	6.6×10^{-8}	No Comparable Analysis
Heat Exchangers	3.5×10^{-9}	2.9×10^{-16}	6.3×10^{-11}	1.1×10^{-8}	8.1×10^{-10}	
Pump Trains	1.9×10^{-7}	1.2×10^{-13}	7.0×10^{-9}	6.0×10^{-7}	7.0×10^{-8}	
Test and Maintenance		(with pump trains)				
Operator Error	-					
Common Cause	-					
Other	-					
System	3.0×10^{-7}	1.3×10^{-13}	5.4×10^{-8}	7.8×10^{-7}	1.9×10^{-7}	
Boundary Condition Power at Two Buses						
Singles	1.1×10^{-7}	1.5×10^{-14}	2.0×10^{-8}	2.6×10^{-7}	5.5×10^{-8}	No Comparable Analysis
Heat Exchangers	3.5×10^{-9}	2.9×10^{-16}	6.3×10^{-11}	1.1×10^{-8}	8.1×10^{-10}	
Pump Trains	3.0×10^{-5}	8.4×10^{-10}	5.1×10^{-6}	7.3×10^{-5}	2.0×10^{-5}	
Test and Maintenance		(with pump trains)				
Operator Error	-					
Common Cause	-					
Other	-					
System	3.0×10^{-5}	8.4×10^{-10}	5.3×10^{-6}	7.4×10^{-5}	2.0×10^{-5}	
Boundary Condition Power at One Bus						
Singles	1.1×10^{-7}	1.5×10^{-14}	2.0×10^{-8}	2.6×10^{-7}	6.6×10^{-8}	No Comparable Analysis
Heat Exchangers	3.5×10^{-9}	2.9×10^{-16}	6.3×10^{-11}	1.1×10^{-8}	8.1×10^{-10}	
Pump Trains	1.5×10^{-3}	1.0×10^{-6}	4.3×10^{-4}	3.5×10^{-3}	1.2×10^{-3}	
Test and Maintenance		(with pump trains)				
Operator Error	-					
Common Cause	-					
Other	-					
System	1.5×10^{-3}	1.0×10^{-6}	4.3×10^{-4}	3.4×10^{-3}	1.2×10^{-3}	

TABLE 2

REQUIRED CCS FLOWS FOR PLANT CONDITIONS

Components Cooled	Normal Operation Flow (gpm)		Shutdown Flow (gpm)		Accident Conditions Flow (gpm)	
	Component	Total	Component	Total	Component	Total
1. High Head Safety Injection Pumps	15/pump	45	15/pump	45	15/pump	45
2. Residual Heat Removal Pumps	15/pump	30	15/pump	30	15/pump	30
3. Residual Heat Exchanger	-	-	-	4000	-	4000
4. Recirculation Pumps	-	-	-	-	40/pump	80
5. Spent Fuel Pit Heat	2000	2000	2000	2000	-	-
6. Reactor Coolant Pumps						
a. Upper Motor Bearing Heat Exchanger	150/pump	600	-	-	-	-
b. Lower Motor Bearing Heat Exchanger	5/pump	20	-	-	-	-
c. Pump Thermal Barrier	25/pump	100		-	-	-
7. Letdown Heat Exchanger		1000		-		-
8. Seal Water Heat Exchanger		200		-		-
9. Primary Makeup Water Heat Exchanger		400		-		-
10. Boric Acid Regeneration System		815		-		-
11. Waste Evaporation System		155		-		-
12. Charging Pumps	90	270	-	-	-	-
13. Excess Letdown Heat Exchanger		230		-		-
14. Reactor Vessel Support Blocks		50		-		-
15. Miscellaneous Sample Heat Exchangers		168		-		-
		6,100		6,075		4,155
	Two of Three Pumps One of Two Heat Exchangers		Two of Three Pumps One of Two Heat Exchangers		Two of Three Pumps One of Two Heat Exchangers	

TABLE 3

BASIC EVENT DATA COMPONENT COOLING - INDIAN POINT 3

Event Description and Failure Mode	Fault Tree Coding	Failure Data					Common Cause Data		Comments
		Mean	H/D	Variance	MTTR	Reference No.*	Location	Susceptibility	
No Power at Switchgear Bus 2A	JBS-32AD	-	-	-	-	-	Control Bldg. El 15'	V, I, H, M	See EP Analysis
No Power at Switchgear Bus 5A	JBS-35AD	-	-	-	-	-	Control Bldg. El 15'	"	See EP Analysis
No Power at Switchgear Bus 6A	JBS-36AD	-	-	-	-	-	Control Bldg. El 15'	"	See EP Analysis
No Control Power at Switchgear Bus 2A	4BS-333D	-	-	-	-	-	Control Bldg. El 15'	"	See EP Analysis
No Control Power at Switchgear Bus 5A	4BS-331D	-	-	-	-	-	Control Bldg. El 15'	"	See EP Analysis
No Control Power at Switchgear Bus 6A	4BS-332D	-	-	-	-	-	Control Bldg. El 15'	"	See EP Analysis
No Flow from Service Water Supply Header (Conventional)	TSW2NOFL	-	-	-	-	-	NA	-	See SW Analysis
CC Pump 31 Does Not Start Does Not Continue Running	UPM0031S	1.36×10^{-3} 3.26×10^{-6}	D H	1.22×10^{-6} 2.47×10^{-11}	- In Text	11 15	PAB El 41'	V, H, I	
CC Pump 32 Does Not Start Does Not Continue Running	UPM0032S	1.36×10^{-3} 3.26×10^{-6}	D H	1.22×10^{-6} 2.47×10^{-11}	- In Text	11 15	PAB El 41'	V, H, I	
CC Pump 33 Does Not Start Does Not Continue Running	UPM0033S	1.36×10^{-3} 3.26×10^{-6}	D H	1.22×10^{-6} 2.47×10^{-11}	- In Text	11 15	PAB El 41'	V, H, I	
CC Pump 31 Motor, Does Not Start/Run	UM00031N	-	-	-	-	-	Same as Pump	V, I, H, M	With Pump
CC Pump 32 Motor, Does Not Start/Run	UM00032N	-	-	-	-	-	Same as Pump	V, I, H, M	With Pump
CC Pump 33 Motor, Does Not Start/Run	UM00033N	-	-	-	-	-	Same as Pump	V, I, H, M	With Pump

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*Reference number refers to item numbers in the plant failure data section of this report.

TABLE 3 (continued)

BASIC EVENT DATA COMPONENT COOLING - INDIAN POINT 3

Event Description and Failure Mode	Fault Tree Coding	Failure Data					Common Cause Data		Comments
		Mean	H/D	Variance	MTTR	Reference No.*	Location	Susceptibility	
Pump 31 Discharge Valve, Transfers Closed	UXV762AC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Pump Discharge	I	
Pump 32 Discharge Valve, Transfers Closed	UXV762BC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Pump Discharge	I	
Pump 33 Discharge Valve, Transfers Closed	UXV762CC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Pump Discharge	I	
Heat Exchanger 31 Inlet Valve, Transfers Closed	UXV759AC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Near Heat Exchanger	I	
Heat Exchanger 32 Inlet Valve, Transfers Closed	UXV759BC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Near Heat Exchanger	I	
Heat Exchanger 31 Outlet Valve, Transfers Closed	UXV765AC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Near Heat Exchanger	I	
Heat Exchanger 32 Outlet Valve, Transfers Closed	UXV765BC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Near Heat Exchanger	I	
SW Inlet to Heat Exch. 31, Transfers Closed	TXV034AC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	PAB Near Heat Exchanger	I	
SW Inlet to Heat Excn. 32, Transfers Closed	TXV034BC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	PAB Near Heat Exchanger	I	
SW Outlet from Heat Exchanger 31, Transfers Closed	TXV035AC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	PAB Near Heat Exchanger	I	
SW Outlet from Heat Exchanger 32, Transfers Closed	TXV035BC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	PAB Near Heat Exchanger	I	

*Reference number refers to item numbers in the plant failure data section of this report.

TABLE 3 (continued)

BASIC EVENT DATA COMPONENT COOLING - INDIAN POINT 3

Event Description and Failure Mode	Fault Tree Coding	Failure Data					Common Cause Data		Comments
		Mean	H/D	Variance	MTTR	Reference No.*	Location	Susceptibility	
CC Pump 31 Breaker, Does Not Close/ Transfers Open	UCB0031X	-	-	-	-	-	Switchgear Bus 5A	V, I, H, M	With Pump
CC Pump 32 Breaker, Does Not Close/ Transfers Open	UCB0032X	-	-	-	-	-	Switchgear Bus 2A	V, I, H, M	With Pump
CC Pump 33 Breaker, Does Not Close/ Transfers Open	UCB0033X	-	-	-	-	-	Switchgear Bus 6A	V, I, H, M	With Pump
CC Surge Tank 31 Leak or Rupture	UTK0031L	8.60×10^{-10}	H	6.00×10^{-17}	In Text	48	PAB El 81'	I	
CC Surge Tank 32 Leak or Rupture	UHE0031L	8.60×10^{-10}	H	6.00×10^{-17}	In Text	48	PAB El 81'	I	
CC Heat Exchanger 31, Loss of Cooling Capability (Leak/Rupture)	UHE0031L	9.73×10^{-7}	H	3.34×10^{-12}	In Text	24	PAB El 55 to 81'	I	
CC Heat Exchanger 32, Loss of Cooling Capability (Leak/Rupture)	UHE0032L	9.73×10^{-7}	H	3.34×10^{-12}	In Text	24	PAB El 55 to 81'	I	
Pump 31 Suction Valve, Transfers Closed	UXV760AC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Pump Suction	I	
Pump 32 Suction Valve, Transfers Closed	UXV760BC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Pump Suction	I	
Pump 33 Suction Valve, Transfers Closed	UXV760CC	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Pump Suction	I	
Pump 31 Discharge Check Valve, Fails to Open	UCV761AQ	6.91×10^{-5}	D	1.03×10^{-8}	-	3	Pump Discharge	I	
Pump 32 Discharge Check Valve, Fails to Open	UCV761BQ	6.91×10^{-5}	D	1.03×10^{-8}	-	3	Pump Discharge	I	
Pump 33 Discharge Check Valve, Fails to Open	UCV761CQ	6.91×10^{-5}	D	1.03×10^{-8}	-	3	Pump Discharge	I	

*Reference number refers to item numbers in the plant failure data section of this report.

TABLE 3 (continued)

BASIC EVENT DATA COMPONENT COOLING - INDIAN POINT 3

Event Description and Failure Mode	Fault Tree Coding	Failure Data					Common Cause Data		Comments
		Mean	H/D	Variance	MTTR	Reference No.*	Location	Susceptibility	
SW Supply Valve, 31, Transfers Closed	TXV31--C	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Pipe Tunnel	I	
SW Supply Valve, 32, Transfers Closed	TXV32--C	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Pipe Tunnel	I	
SW Supply Valve, 33, Transfers Closed	TXV33--C	9.15×10^{-8}	H	1.01×10^{-14}	In Text	1	Pipe Tunnel	I	
SW Supply Valve, 34, Transfers Closed	TXV33-1C	9.15×10^{-6}	H	1.01×10^{-14}	In Text	1	Pipe Tunnel	I	
CC Pipe Failure	UPPFAILS	8.60×10^{-10}	H	6.00×10^{-17}	See Text	49	Various	I	

*Reference number refers to item numbers in the plant failure data section of this report.

TABLE 4

COMPONENT COOLING WATER SYSTEM INDIAN POINT 3 MINIMAL CUTSETS
(Sheet 1 of 4)

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PRINTOUT OF MINIMAL CUT SETS FOR PHASE 1

TITLE:    COMPONENT COOLING WATER SYSTEM INDIAN POINT 3


CUT SETS WITH  1 BASIC EVENTS.

     1        1) [illegible]          2) TXV31--C        3) TSWINOIL



CUT SETS WITH  2 BASIC EVENTS.

            1)  UTR0031L   UTR0032L        2)  UXV759AC   UXV759BC        3)  UHE0031L   UXV759BC        4)  UXV765AC   UXV759BC
            5)  TXV034AC   UXV759BC        6)  TXV035AC   UXV759BC        7)  UXV759AC   UHE0032L        8)  UHE0031L   UHE0032L
            9)  UXV765AC   UHE0032L       10)  TXV034AC   UHE0032L       11)  TXV035AC   UHE0032L       12)  UXV759AC   UXV765BC
           13)  UHE0031L   UXV765BC       14)  UXV765AC   UXV765BC       15)  TXV034AC   UXV765BC       16)  TXV035AC   UXV765BC
           17)  UXV759AC   TXV034BC       18)  UHE0031L   TXV034BC       19)  UXV765AC   TXV034BC       20)  TXV034AC   TXV034BC
           21)  TXV035AC   TXV034BC       22)  UXV759AC   TXV035BC       23)  UHE0031L   TXV035BC       24)  UXV765AC   TXV035BC
           25)  TXV034AC   TXV035BC       26)  TXV035AC   TXV035BC       27)  TXV33--C   UXV759BC       28)  TXV33-1C   UXV759BC
           29)  TXV33--C   UHE0032L       30)  TXV33-1C   UHE0032L       31)  TXV33--C   UXV765BC       32)  TXV33-1C   UXV765BC
           33)  TXV33--C   TXV034BC       34)  TXV33-1C   TXV034BC       35)  TXV33--C   TXV035BC       36)  TXV33-1C   TXV035BC
           37)  [illegible]  485-333C      38)  485-331D   485-333C       39)  UXV766AC   485-333D       40)  UM00G31S   485-333C
           41)  UXV762AC   485-333D       42)  UPP0031S   485-333D       43)  UCV761AG   485-333D       44)  UCC0031F   485-333C



CUT SETS WITH  3 BASIC EVENTS.

            1)  UXV762CC   UXV762BC   UXV762AC         2)  UPM0033S   UXV762BC   UXV762AC         3)  UCV761CG   UXV762BC   UXV762AC
            4)  UCC0033F   UXV762BC   UXV762AC         5)  UXV762CC   UPM0032S   UXV762AC         6)  UPM0033S   UPM0032S   UXV762AC
            7)  UCV761CG   UPM0032S   UXV762AC         8)  UCC0033F   UPM0032S   UXV762AC         9)  UXV762CC   UCV761BG   UXV762AC
           10)  UPM0033S   UCV761BG   UXV762AC        11)  UCV761CG   UCV761BG   UXV762AC        12)  UCC0033F   UCV761BG   UXV762AC
           13)  UXV762CC   UCC0032F   UXV762AC        14)  UPM0033S   UCC0032F   UXV762AC        15)  UCV761CG   UCC0032F   UXV762AC
           16)  UCC0033F   UCC0032F   UXV762AC        17)  UXV762CC   UXV762BC   UPP0031S        18)  UPM0033S   UXV762BC   UPM0031S
           19)  UCV761CG   UXV762BC   UPM0031S        20)  UCC0033F   UXV762BC   UPP0031S        21)  UXV762CC   UPM0032S   UPP0031S
           22)  UPM0033S   UPM0032S   UPP0031S        23)  UCV761CG   UPM0032S   UPP0031S        24)  UCC0033F   UPM0032S   UPM0031S
           25)  UXV762CC   UCV761BG   UPM0031S        26)  UPM0033S   UCV761BG   UPP0031S        27)  UCV761CG   UCV761BG   UPM0031S
           28)  UCC0033F   UCV761BG   UPP0031S        29)  UXV762CC   UCC0032F   UPP0031S        30)  UPM0033S   UCC0032F.  UPP0031S
           31)  UCV761CG   UCC0032F   UPP0031S        32)  UCC0033F   UCC0032F   UPP0031S        33)  UXV762CC   UXV762BC   UCV761AG
           34)  UPM0033S   UXV762BC   UCV761AG        35)  UCV761CG   UXV762BC   UCV761AG        36)  UCC0033F   UXV762BC   UCV761AG
           37)  UXV762CC   UPM0032S   UCV761AG        38)  UPM0033S   UPM0032S   UCV761AG        39)  UCV761CG   UPM0032S   UCV761AG
           40)  UCC0033F   UPM0032S   UCV761AG        41)  UXV762CC   UCV761BG   UCV761AG        42)  UPM0033S   UCV761BG   UCV761AG
           43)  UCV761CG   UCV761BG   UCV761AG        44)  UCC0033F   UCV761BG   UCV761AG        45)  UXV762CC   UCC0032F   UCV761AG
           46)  UPM0033S   UCC0032F   UCV761AG        47)  UCV761CG   UCC0032F   UCV761AG        48)  UCC0033F   UCC0032F   UCV761AG
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TABLE 4 (continued)

COMPONENT COOLING WATER SYSTEM INDIAN POINT 3 MINIMAL CUTSETS
(Sheet 2 of 4)

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[illegible] FOR PHASE 1

TITLE:     COMPONENT COOLING WATER SYSTEM INDIAN POINT 3

[illegible] MINIMAL CUTSETS.

[illegible]    49)  UXV762CC     UXV762BC   UCC0031F      50)  UPM0033S   UXV762BC   UCC0031F      51)  UCV761CG   UXV762BC   UCC0031F
[illegible]    52)  [illegible] UXV762BC   UCC0031F      53)  UXV762CC   UPM0032S   UCC0031F      54)  UPM0033S   UPM0032S   UCC0031F
[illegible]    55)  UCV761CG     UPM0032S   UCC0031F      56)  UCC0033F   UPM0032S   UCC0031F      57)  UXV762CC   UCV761BG   UCC0031F
[illegible]    58)  UPM0033S     UCV761BG   UCC0031F      59)  UCV761CG   UCV761BG   UCC0031F      60)  UCC0033F   UCV761BG   UCC0031F
[illegible]    61)  UXV762CC     UCC0032F   UCC0031F      62)  UPM0033S   UCC0032F   UCC0031F      63)  UCV761CG   UCC0032F   UCC0031F
[illegible]    64)  UCC0033F     UCC0032F   UCC0031F      65)  UXV762CC   UXV762BC   JBS-35AD      66)  UPM0033S   UXV762BC   JBS-35AC
[illegible]    67)  UCV761CG     UXV762BC   JBS-35AD      68)  UCC0033F   UXV762BC   JBS-35AD      69)  UXV762CC   UPM0032S   JBS-35AC
[illegible]    70)  [illegible] UPM0032S   JBS-35AD      71)  UCV761CG   UPM0032S   JBS-35AD      72)  UCC0033F   UPM0032S   JBS-35AC
[illegible]    73)  UXV762CC     UCV761BG   JBS-35AD      74)  UPM0033S   UCV761BG   JBS-35AD      75)  UCV761CG   UCV761BG   JBS-35AD
[illegible]    76)  UCC0033F     UCV761CG   JBS-35AD      77)  UXV762CC   UCC0032F   JBS-35AD      78)  UPM0033S   UCC0032F   JBS-35AC
[illegible]    79)  UCV761CG     UCC0032F   JBS-35AD      80)  UCC0033F   UCC0032F   JBS-35AD      81)  UXV762CC   UXV762BC   4BS-331C
[illegible]    82)  UPM0033S     UXV762BC   4BS-331D      83)  UCV761CG   UXV762BC   4BS-331D      84)  UCC0033F   UXV762BC   4BS-331C
[illegible]    85)  UXV762CC     UPM0032S   4BS-331D      86)  UPM0033S   UPM0032S   4BS-331D      87)  UCV761CG   UPM0032S   4BS-331C
[illegible]    88)  [illegible] UPM0032S   4BS-331D      89)  UXV762CC   UCV761BG   4BS-331D      90)  UPM0033S   UCV761BG   4BS-331C
[illegible]    91)  UCV761CG     UCV761BG   4BS-331D      92)  UCC0033F   UCV761BG   4BS-331D      93)  UXV762CC   UCC0032F   4BS-331C
[illegible]    94)  UPM0033S     UCC0032F   4BS-331D      95)  UCV761CG   UCC0032F   4BS-331D      96)  UCC0033F   UCC0032F   4BS-331C
[illegible]    97)  UXV762CC     UXV762BC   UXV760AC      98)  UPM0033S   UXV762BC   UXV760AC      99)  UCV761CG   UXV762BC   UXV75CAC
[illegible]   100)  UCC0033F     UXV762BC   UXV760AC     101)  UXV762CC   UPM0032S   UXV760AC     102)  UPM0033S   UPM0032S   UXV76CAC
[illegible]   103)  UCV761CG     UPM0032S   UXV760AC     104)  UCC0033F   UPM0032S   UXV760AC     105)  UXV762CC   UCV761BG   UXV76CAC
[illegible]   106)  UPM0033S     UCV761BG   UXV760AC     107)  UCV761CG   UCV761BG   UXV760AC     108)  UCC0033F   UCV761BG   UXV76CAC
[illegible]   109)  UXV762CC     UCC0032F   UXV760AC     110)  UPM0033S   UCC0032F   UXV760AC     111)  UCV761CG   UCC0032F   UXV76CAC
[illegible]   112)  UCC0033F     UCC0032F   UXV760AC     113)  UXV762CC   UXV762BC   UMO0031S     114)  UPM0033S   UXV762BC   UMO0031S
[illegible]   115)  UCV761CG     UXV762BC   UMO0031S     116)  UCC0033F   UXV762BC   UMO0031S     117)  UXV762CC   UPM0032S   UMO0031S
[illegible]   118)  UPM0033S     UPM0032S   UMO0031S     119)  UCV761CG   UPM0032S   UMO0031S     120)  UCC0033F   UPM0032S   UMO0031S
[illegible]   121)  UXV762CC     UCV761BG   UMO0031S     122)  UPM0033S   UCV761BG   UMO0031S     123)  UCV761CG   UCV761BG   UMO0031S
[illegible]   124)  UCC0033F     UCV761BG   UMO0031S     125)  UXV762CC   UCC0032F   UMO0031S     126)  UPM0033S   UCC0032F   UMO0031S
[illegible]   127)  UCV761CG     UCC0032F   UMO0031S     128)  UCC0033F   UCC0032F   UMO0031S     129)  UXV762CC   JBS-35AC   JBS-32AC
[illegible]   130)  UPM0033S     JBS-35AD   JBS-32AD     131)  UCV761CG   JBS-35AD   JBS-32AD     132)  UCC0033F   JBS-35AD   JBS-32AC
[illegible]   133)  UXV762CC     4BS-331D   JBS-32AD     134)  UPM0033S   4BS-331D   JBS-32AD     135)  UCV761CG   4BS-331C   JBS-32AC
[illegible]   136)  UCC0033F     4BS-331D   JBS-32AD     137)  UXV762CC   UXV760AC   JBS-32AD     138)  UPM0033S   UXV760AC   JBS-32AC
[illegible]   139)  UCV761CG     UXV760AC   JBS-32AD     140)  UCC0033F   UXV760AC   JBS-32AD     141)  UXV762CC   UMO0031S   JBS-32AD
[illegible]   142)  UPM0033S     UMO0031S   JBS-32AD     143)  UCV761CG   UMO0031S   JBS-32AD     144)  UCC0033F   UMO0031S   JBS-32AC
[illegible]   145)  UXV762CC     JBS-35AD   UXV760BC     146)  UPM0033S   JBS-35AD   UXV760BC     147)  UCV761CG   JBS-35AD   UXV76CBC
[illegible]   148)  UCC0033F     JBS-35AD   UXV760BC     149)  UXV762CC   4BS-331D   UXV760BC     150)  UPM0033S   4BS-331D   UXV76CBC
[illegible]   151)  UCV761CG     4BS-331D   UXV760BC     152)  UCC0033F   4BS-331D   UXV760BC     153)  UXV762CC   UXV760AC   UXV76CBC
[illegible]   154)  UPM0033S     UXV760AC   UXV760BC     155)  UCV761CG   UXV760AC   UXV760BC     156)  UCC0033F   UXV760AC   UXV76CBC
[illegible]   157)  UXV762CC     UMO0031S   UXV760BC     158)  UPM0033S   UMO0031S   UXV760BC     159)  UCV761CG   UMO0031S   UXV76CBC
[illegible]   160)  UCC0033F     UMO0031S   UXV760BC     161)  UXV762CC   JBS-35AD   UMO0032S     162)  UPM0033S   JBS-35AC   UMO0032S
[illegible]   163)  UCV761CG     JBS-35AD   UMO0032S     164)  UCC0033F   JBS-35AD   UMO0032S     165)  UXV762CC   4BS-331D   UMO0032S
[illegible]   166)  UPM0033S     4BS-331D   UMO0032S     167)  UCV761CG   4BS-331D   UMO0032S     168)  UCC0033F   4BS-331D   UMO0032S
[illegible]   169)  UXV762CC     UXV760AC   UMO0032S     170)  UPM0033S   UXV760AC   UMO0032S     171)  UCV761CG   UXV760AC   UMO0032S
[illegible]   172)  UCC0033F     UXV760AC   UMO0032S     173)  UXV762CC   UMO0031S   UMO0032S     174)  UPM0033S   UMO0031S   UMO0032S
[illegible]   175)  UCV761CG     UMO0031S   UMO0032S     176)  UCC0033F   UMO0031S   UMO0032S     177)  JBS-35AD   JBS-32AD   JBS-33AD
[illegible]   178)  4BS-331D     JBS-32AD   JBS-33AD     179)  UXV760AC   JBS-32AD   JBS-33AD     180)  UMO0031S   JBS-32AD   JBS-33AC
[illegible]   181)  JBS-35AD     UXV760BC   JBS-33AD     182)  4BS-331D   UXV760BC   JBS-33AD     183)  UXV76CAC   UXV760BC   JBS-33AC
[illegible]   184)  UPM0033S     UXV760BC   JBS-33AD     185)  JBS-25AD   UMO0032S   JBS-33AD     186)  4BS-331D   UMO0032S   JBS-33AC
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TABLE 4 (continued)

COMPONENT COOLING WATER SYSTEM INDIAN POINT 3 MINIMAL CUTSETS
(Sheet 3 of 4)

[illegible] PHASE 1

TITLE: COMPONENT COOLING WATER SYSTEM INDIAN POINT 3

CUT SETS WITH 3 BASIC EVENTS.

190)	4BS-331D	JBS-32AD	UXV760CC	191)	UXV760AC	JBS-32AD	UXV760CC	192)	UMOOC31S	JBS-32AD	UXV760CC
193)	JBS-35AD	UXV760BC	UXV760CC	194)	4BS-331D	UXV760BC	UXV760CC	195)	UXV760AC	UXV760BC	UXV760CC
196)	UPMOC31S	UXV760BC	UXV760CC	197)	JBS-35AD	UMOOC32S	UXV760CC	198)	4BS-331D	UMOOC32S	UXV760CC
199)	UXV760AC	UMOOC32S	UXV760CC	200)	UPMOC31S	UMOOC32S	UXV760CC	201)	JBS-35AD	JBS-32AD	UMOOC33S
202)	4BS-331D	JBS-32AD	UMOOC33S	203)	UXV760AC	JBS-32AD	UMOOC33S	204)	UPMOC31S	JBS-32AD	UMOOC33S
205)	JBS-35AD	UXV760BC	UMOOC33S	206)	4BS-331D	UXV760BC	UMOOC33S	207)	UXV760AC	UXV760BC	UMOOC33S
208)	UPMOC31S	UXV760BC	UMOOC33S	209)	JBS-35AD	UMOOC32S	UMOOC33S	210)	4BS-331D	UMOOC32S	UMOOC33S
211)	UXV760AC	UMOOC32S	UMOOC33S	212)	UPMOC31S	UMOOC32S	UMOOC33S	213)	UXV762BC	JBS-35AD	JBS-33AD
214)	UPMOC32S	JBS-35AD	JBS-33AD	215)	UCV761BQ	JBS-35AD	JBS-33AD	216)	UCCOC32F	JBS-35AD	JBS-33AD
217)	UXV762BC	4BS-331D	JBS-33AD	218)	UPMOC32S	4BS-331D	JBS-33AD	219)	UCV761BQ	4BS-331D	JBS-33AD
220)	UCCOC32F	4BS-331D	JBS-33AD	221)	UXV762BC	UXV760AC	JBS-33AD	222)	UPMOC32S	UXV760AC	JBS-33AD
223)	UCV761BQ	UXV760AC	JBS-33AD	224)	UCCOC32F	UXV760AC	JBS-33AD	225)	UXV762BC	UMOOC31S	JBS-33AD
226)	UPMOC32S	UMOOC31S	JBS-33AD	227)	UCV761BQ	UMOOC31S	JBS-33AD	228)	UCCOC32F	UMOOC31S	JBS-33AD
229)	UXV762BC	JBS-35AD	UXV760CC	230)	UPMOC32S	JBS-35AD	UXV760CC	231)	UCV761BQ	JBS-35AD	UXV760CC
232)	UCCOC32F	JBS-35AD	UXV760CC	233)	UXV762BC	4BS-331D	UXV760CC	234)	UPMOC32S	4BS-331D	UXV760CC
235)	UCV761BQ	4BS-331D	UXV760CC	236)	UCCOC32F	4BS-331D	UXV760CC	237)	UXV762BC	UXV760AC	UXV760CC
238)	UPMOC32S	UXV760AC	UXV760CC	239)	UCV761BQ	UXV760AC	UXV760CC	240)	UCCOC32F	UXV760AC	UXV760CC
241)	UXV762BC	UMOOC31S	UXV760CC	242)	UPMOC32S	UMOOC31S	UXV760CC	243)	UCV761BQ	UMOOC31S	UXV760CC
244)	UCCOC32F	UMOOC31S	UXV760CC	245)	UXV762BC	JBS-35AD	UMOOC33S	246)	UPMOC32S	JBS-35AD	UMOOC33S
247)	UCV761BQ	JBS-35AD	UMOOC33S	248)	UCCOC32F	JBS-35AD	UMOOC33S	249)	UXV762BC	4BS-331D	UMOOC33S
250)	UPMOC32S	4BS-331D	UMOOC33S	251)	UCV761BQ	4BS-331D	UMOOC33S	252)	UCCOC32F	4BS-331D	UMOOC33S
253)	UXV762BC	UXV760AC	UMOOC33S	254)	UPMOC32S	UXV760AC	UMOOC33S	255)	UCV761BQ	UXV760AC	UMOOC33S
256)	UCCOC32F	UXV760AC	UMOOC33S	257)	UXV762BC	UPMOC31S	UMOOC33S	258)	UPMOC32S	UMOOC31S	UMOOC33S
259)	UCV761BQ	UMOOC31S	UMOOC33S	260)	UCCOC32F	UMOOC31S	UMOOC33S	261)	UXV762CC	UXV762AC	JBS-32AD
262)	UPMOC33S	UXV762AC	JBS-32AD	263)	UCV761CQ	UXV762AC	JBS-32AD	264)	UCCOC33F	UXV762AC	JBS-32AD
265)	UXV762CC	UPMOC31S	JBS-32AD	266)	UPMOC33S	UPMOC31S	JBS-32AD	267)	UCV761CQ	UPMOC31S	JBS-32AD
268)	UCCOC33F	UPMOC31S	JBS-32AD	269)	UXV762CC	UCV761AQ	JBS-32AD	270)	UPMOC33S	UCV761AQ	JBS-32AD
271)	UCV761CQ	UCV761AQ	JBS-32AD	272)	UCCOC33F	UCV761AQ	JBS-32AD	273)	UXV762CC	UCCOC31F	JBS-32AD
274)	UPMOC33S	UCCOC31F	JBS-32AD	275)	UCV761CQ	UCCOC31F	JBS-32AD	276)	UCCOC33F	UCCOC31F	JBS-32AD
277)	UXV762CC	UXV762AC	UXV760BC	278)	UPMOC33S	UXV762AC	UXV760BC	279)	UCV761CQ	UXV762AC	UXV760BC
280)	UCCOC33F	UXV762AC	UXV760BC	281)	UXV762CC	UPMOC31S	UXV760BC	282)	UPMOC33S	UPMOC31S	UXV760BC
283)	UCV761CQ	UPMOC31S	UXV760BC	284)	UCCOC33F	UPMOC31S	UXV760BC	285)	UXV762CC	UCV761AQ	UXV760BC
286)	UPMOC33S	UCV761AQ	UXV760BC	287)	UCV761CQ	UCV761AQ	UXV760BC	288)	UCCOC33F	UCV761AQ	UXV760BC
289)	UXV762CC	UCCOC31F	UXV760BC	290)	UPMOC33S	UCCOC31F	UXV760BC	291)	UCV761CQ	UCCOC31F	UXV760BC
292)	UCCOC33F	UCCOC31F	UXV760BC	293)	UXV762CC	UXV762AC	UMOOC32S	294)	UPMOC33S	UXV762AC	UMOOC32S
295)	UCV761CQ	UXV762AC	UMOOC32S	296)	UCCOC33F	UXV762AC	UMOOC32S	297)	UXV762CC	UPMOC31S	UMOOC32S
298)	UPMOC33S	UPMOC31S	UMOOC32S	299)	UCV761CQ	UPMOC31S	UMOOC32S	300)	UCCOC33F	UPMOC31S	UMOOC32S
301)	UXV762CC	UCV761AQ	UMOOC32S	302)	UPMOC33S	UCV761AQ	UMOOC32S	303)	UCV761CQ	UCV761AQ	UMOOC32S
304)	UCCOC33F	UCV761AQ	UMOOC32S	305)	UXV762CC	UCCOC31F	UMOOC32S	306)	UPMOC33S	UCCOC31F	UMOOC32S
307)	UCV761CQ	UCCOC31F	UMOOC32S	308)	UCCOC33F	UCCOC31F	UMOOC32S	309)	UXV762AC	JBS-32AD	JBS-33AD
310)	UPMOC31S	JBS-32AD	JBS-33AD	311)	UCV761AQ	JBS-32AD	JBS-33AD	312)	UCCOC31F	JBS-32AD	JBS-33AD
313)	UXV762AC	UXV760BC	JBS-33AD	314)	UPMOC31S	UXV760BC	JBS-33AD	315)	UCV761AQ	UXV760BC	JBS-33AD
316)	UCCOC31F	UXV760BC	JBS-33AD	317)	UXV762AC	UMOOC32S	JBS-33AD	318)	UPMOC31S	UMOOC32S	JBS-33AD
319)	UCV761AQ	UMOOC32S	JBS-33AD	320)	UCCOC31F	UMOOC32S	JBS-33AD	321)	UXV762AC	JBS-32AD	UXV760CC
322)	UPMOC31S	JBS-32AD	UXV760CC	323)	UCV761AQ	JBS-32AD	UXV760CC	324)	UCCOC31F	JBS-32AD	UXV760CC
325)	UXV762AC	UXV760BC	UXV760CC	326)	UPMOC31S	UXV760BC	UXV760CC	327)	UCV761AQ	UXV760BC	UXV760CC
328)	UCCOC31F	UXV760BC	UXV760CC	329)	UXV762AC	UMOOC32S	UXV760CC	330)	UPMOC31S	UMOOC32S	UXV760CC

TABLE 4 (continued)

COMPONENT COOLING WATER SYSTEM INDIAN POINT 3 MINIMAL CUTSETS

(Sheet 4 of 4)

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[illegible] MINIMAL CUT SETS FOR PHASE 1

TITLE:  COMPONENT COOLING WATER SYSTEM INDIAN POINT 3

CUT SETS WITH 3 BASIC EVENTS.

[illegible]  [illegible]  [illegible]  UMCOG32S   UXV760CC      3321)  UCCOG31F   UMLOG32S   UXV760CC      3331)  UXV762AC   JBS-32AD   UMLOG33S
[illegible]  [illegible]  [illegible]  JBS-32AD   UMLOG33S      3351)  UCV761AG   JBS-32AD   UMLOC33S      3361)  UCCOC31F   JBS-32AD   UMLOG33S
[illegible]  [illegible]  [illegible]  UXV76O2C   UZLOG33S      3381)  UPMOG31S   UXV760BC   UMLOC33S      3391)  UCV761AG   UXV760BC   UMOOC33S
[illegible]  [illegible]  [illegible]  UXV760BC   U1000033S     3411)  UXV762AC   UMOOO32S   UMLOC33S      3421)  UPMOC31S   UMOOC32S   UMOCC33S
[illegible]  [illegible]  [illegible]  UMCOG32S   UMCOG33S      3441)  UCCOO31F   UMOOO32S   UMOOO33S      3451)  UXV762BC   UXV762AC   JBS-33AG
[illegible]  [illegible]  [illegible]  UXV762AC   JBS-33AD      3471)  UCV761BG   UXV762AC   JBS-33AD      3481)  UCCOC32F   UXV762AC   JBS-33AF
[illegible]  [illegible]  [illegible]  UPPCG31S   JBS-333D      3501)  UPMOO32S   UPMOG31S   JBS-33AD      3511)  UCV761EG   UPMOC31S   JBS-33AC
[illegible]  [illegible]  [illegible]  UPPOG31S   JBS-33AD      3531)  UXV762BC   UCV761AG   JBS-33AD      3541)  UPMOG32S   UCV761AG   JBS-33AC
[illegible]  [illegible]  [illegible]  UCV761EG   JBS-33AD      3561)  UCCOG32F   UCV761AG   JBS-33AD      3571)  UXV762EC   UCCOG31F   JBS-33AC
[illegible]  [illegible]  [illegible]  UCCOG31F   JBS-33AD      3591)  UCV761BG   UCCOO31F   JBS-33AD      3601)  UCCOC32F   UCCOG31F   JBS-33AC
[illegible]  [illegible]  [illegible]  UXV762AC   UXV760CC      3621)  UPMOG32S   UXV762AC   UXV760CC      3631)  UCV761EG   UXV762AC   UXV760CC
[illegible]  [illegible]  [illegible]  UXV762AC   UXV760CC      3651)  UXV762BC   UPMOO31S   UXV760CC      3661)  UPMOC32S   UPMOC31S   UXV760CC
[illegible]  [illegible]  [illegible]  UPPOG31S   UXV760CC      3681)  UCCOO32F   UPMOO31S   UXV760CC      3691)  UXV762EC   UCV761AC   UXV760CC
[illegible]  [illegible]  [illegible]  UCV761AG   UXV760CC      3711)  UCV761BG   UCV761AG   UXV760CC      3721)  UCCOC32F   UCV761AG   UXV760CC
[illegible]  [illegible]  [illegible]  UCCOC31F   UXV760CC      3741)  UPMOG32S   UCCOC31F   UXV760CC      3751)  UCV761EG   UCCOG31F   UXV760CC
[illegible]  [illegible]  [illegible]  UCCOG31F   UXV760CC      3771)  UXV762BC   UXV762AC   UMLOO33S      3781)  UPMOC32S   UXV762AC   UMLOC33S
[illegible]  [illegible]  [illegible]  UXV762AC   UMLOO33S      3801)  UCCOG32F   UXV762AC   UMOJO33S      3811)  UXV762EC   UPMOO[illegible]S   UMLCC33S
[illegible]  [illegible]  [illegible]  UPMOC31S   UMOOG33S      3831)  UCV761EG   UPMOG31S   UMCOG33S      3841)  UCCOC32F   UPMO[illegible]S   UMOOG33S
[illegible]  [illegible]  [illegible]  UCV761AG   UMCOO33S      3861)  UPMOG32S   UCV761AG   UMOOC33S      3871)  UCV761EG   UCV761AG   UMLOO33S
[illegible]  [illegible]  [illegible]  UCV761AG   UMLOG33S      3891)  UXV762BC   UCCOO31F   UMOOC33S      3901)  UPMOG32S   UCCOC31F   UMOOG33S
[illegible]  [illegible]  [illegible]  UCCOG31I   UZGCC33S      3921)  UCCOO32F   UCCOO31F   UMOOC33S
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TABLE 5

SYSTEM EFFECTS OF PIPE FAILURE - INDIAN POINT 3 COMPONENT COOLING SYSTEM

Pipe Section	Diameter (Inches)	System Failure	Potential for Other Systems Impact	Comments
1. #199 CC Pump Discharge Header to Heat Exchanger 31	14	Yes	Systems Cooled by CC System Fail	May split the system and recover one half of system. (Operator action)
2. #211 CC Pump Discharge Header to Heat Exchanger 32	14	Yes	Systems Cooled by CC System Fail	Same As 1 Above
3. #209 CC Pumps Discharge Cross-Tie Header	14	Yes	Systems Cooled by CC System Fail	Same As 1 Above
4. #53 CC Heat Exchangers Cross-Tie Header	12	Yes	Systems Cooled by CC System Fail	Same As 1 Above
5. #53 Supply Header from Heat Exchanger 31 (Three Sections)	16 14 12	Yes	Systems Cooled by CC System Fail	Same As 1 Above
6. #53A Supply Header from Heat Exchanger 32 (Three Sections)	16 14 12		Systems Cooled by CC System Fail	Same As 1 Above
7. #52 Return Header from RHR Heat Exchanger 31 (Three Sections)	12 14 16	Yes	Systems Cooled by CC System Fail	Same As 1 Above
8. #52 Return Header from RHR Heat Exchanger 32 (Three Sections)	12 14 16	Yes	Systems Cooled by CC System Fail	Same As 1 Above
9. #197 CC Pumps Suction Cross-Tie Header	12	Yes	Systems Cooled by CC	Same As 1 Above

TABLE 6

INDIAN POINT 3 COMPONENT COOLING SYSTEM - CAUSE TABLE

Basic Events	Failure Data				System Effect	Failure Data (t = 24 hours)	
	Hourly		Demand			Mean	Variance
	Mean	Variance	Mean	Variance			
CASE 1 BOUNDARY CONDITION: POWER AT ALL BUSES							
1. Single Events							
a. Manual Valve	9.15×10^{-8}	1.01×10^{-14}	-	-			
b. Service Water Supply Fails*	-	-	-	-			
c. Piping Failure (17)	1.46×10^{-8}	1.24×10^{-13}	-	-			
TOTAL	1.06×10^{-7}	1.53×10^{-14}			System Failure	1.06×10^{-7}	1.53×10^{-14}
2. Heat Exchanger Trains							
a. Train D	1.34×10^{-6}	$.84 \times 10^{-12}$	-	-			
b. Train E	$1.52 \times 10^{-}$	3.01×10^{-12}	-	-			
TOTAL					System Failure	3.52×10^{-9}	2.91×10^{-16}
3. Pump Trains							
a. Operating Pump	3.44×10^{-6}	2.13×10^{-11}	-	-			
b. Standby Pump	-	-	1.44×10^{-3}	1.13×10^{-6}			
c. Previously Operating Pump	-	-	1.43×10^{-3}	1.13×10^{-6}			
TOTAL					System Failure	9.15×10^{-10}	7.99×10^{-18}
4. Test and Maintenance		(with pump trains)					
5. Human Error	-						
6. Common Cause	-						
7. Other	-						
SYSTEM TOTAL						1.11×10^{-7}	1.54×10^{-14}

* Service water shown for completeness only, quantified at the event tree level.

TABLE 6 (continued)

INDIAN POINT 3 COMPONENT COOLING SYSTEM - CAUSE TABLE

Basic Events	Failure Data				System Effect	Failure Data (t = 24 hours)	
	Hourly		Demand				
	Mean	Variance	Mean	Variance		Mean	Variance
CASE I BOUNDARY CONDITION: POWER AT TWO BUSES							
1. Single Events							
a. Manual Valve	9.15×10^{-8}	1.01×10^{-14}	-	-			
b. Service Water Supply Fails*	-	-	-	-			
c. Piping Failure (17)	1.46×10^{-8}	1.24×10^{-13}	-	-			
TOTAL	1.06×10^{-7}	1.53×10^{-14}			System Failure	1.06×10^{-7}	1.53×10^{-14}
2. Heat Exchanger Trains							
a. Train D	1.34×10^{-6}	2.84×10^{-12}	-	-			
b. Train E	1.52×10^{-6}	3.01×10^{-12}	-	-			
TOTAL					System Failure	3.52×10^{-9}	2.91×10^{-16}
3. Pump Trains							
a. Operating Pump	3.44×10^{-6}	2.13×10^{-11}	-	-			
b. Standby Pump	-	-	1.44×10^{-3}	1.13×10^{-6}			
c. Previously Operating Pump	-	-	1.43×10^{-3}	1.13×10^{-6}			
TOTAL					System Failure	1.64×10^{-6}	5.72×10^{-12}
4. Test and Maintenance		(with pump trains)					
5. Human Error	-						
6. Common Cause	-						
7. Other	-						
SYSTEM TOTAL						1.75×10^{-6}	5.72×10^{-12}

* Service water shown for completeness only, quantified at the event tree level.

TABLE 6 (continued)

INDIAN POINT 3 COMPONENT COOLING SYSTEM - CAUSE TABLE

Basic Events	Failure Data				System Effect	Failure Data (t = 24 hours)	
	Hourly		Demand				
	Mean	Variance	Mean	Variance		Mean	Variance
CASE 1 BOUNDARY CONDITION: POWER AT ONE BUS							
.. Single Events							
a. Manual Valve	9.15×10^{-8}	1.01×10^{-14}	-	-			
b. Service Water Supply Fails*	-	-	-	-			
c. Piping Failure (17)	1.46×10^{-8}	1.24×10^{-13}	-	-			
TOTAL	1.06×10^{-7}	1.53×10^{-14}			System Failure	1.06×10^{-7}	1.53×10^{-14}
2. Heat Exchanger Trains							
a. Train D	1.34×10^{-6}	2.84×10^{-12}	-	-			
b. Train E	1.52×10^{-6}	3.01×10^{-12}	-	-			
TOTAL					System Failure	3.52×10^{-9}	2.91×10^{-16}
3. Pump Trains							
a. Operating Pump	3.44×10^{-6}	2.13×10^{-11}	-	-			
b. Standby Pump	-	-	1.44×10^{-3}	1.13×10^{-6}			
c. Previously Operating Pump	-	-	1.43×10^{-3}	1.13×10^{-6}			
TOTAL					System Failure	8.26×10^{-5}	1.23×10^{-8}
4. Test and Maintenance		(with pump trains)					
5. Human Error	-						
6. Common Cause	-						
7. Other	-						
SYSTEM TOTAL						8.27×10^{-5}	1.22×10^{-8}

* Service water shown for completeness only, quantified at the event tree level.

TABLE 6 (continued)

INDIAN POINT 3 COMPONENT COOLING SYSTEM - CAUSE TABLE

Basic Events	Failure Data				System Effect	Failure Data (t = 24 hours)	
	Hourly		Demand				
	Mean	Variance	Mean	Variance		Mean	Variance
CASE 2 BOUNDARY CONDITION: POWER AT ALL BUSES							
1. Single Events							
a. Manual Valve	9.15×10^{-8}	1.01×10^{-14}	-	-			
b. Service Water Supply Fails*	-	-	-	-			
c. Piping Failure (17)	1.46×10^{-8}	1.24×10^{-13}	-	-			
TOTAL	1.06×10^{-7}	1.53×10^{-14}			System Failure	1.06×10^{-7}	1.53×10^{-14}
2. Heat Exchanger Trains							
a. Train D	1.34×10^{-6}	2.84×10^{-12}	-	-			
b. Train E	1.52×10^{-6}	3.01×10^{-12}	-	-			
TOTAL					System Failure	3.52×10^{-9}	2.91×10^{-16}
3. Pump Trains							
a. Operating Pump	3.44×10^{-6}	2.13×10^{-11}	-	-			
b. Standby Pump	-	-	1.44×10^{-3}	1.13×10^{-6}			
c. Previously Operating Pump	-	-	1.43×10^{-3}	1.13×10^{-6}			
TOTAL					System Failure	1.87×10^{-7}	1.21×10^{-13}
4. Test and Maintenance		(with pump trains)					
5. Human Error	-						
6. Common Cause	-						
7. Other	-						
SYSTEM TOTAL						2.97×10^{-7}	1.34×10^{-13}

* Service water shown for completeness only, quantified at the event tree level.

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TABLE 6 (continued)

INDIAN POINT 3 COMPONENT COOLING SYSTEM - CAUSE TABLE

Basic Events	Failure Data				System Effect	Failure Data (t = 24 hours)	
	Hourly		Demand				
	Mean	Variance	Mean	Variance		Mean	Variance
CASE 2 BOUNDARY CONDITION: POWER AT TWO BUSES							
1. Single Events							
a. Manual Valve	9.15×10^{-8}	1.01×10^{-14}	-	-			
b. Service Water Supply Fails*	-	-	-	-			
c. Piping Failure (17)	1.46×10^{-8}	1.24×10^{-13}	-	-			
TOTAL	1.06×10^{-7}	1.53×10^{-14}			System Failure	1.06×10^{-7}	1.53×10^{-14}
2. Heat Exchanger Trains							
a. Train D	1.34×10^{-6}	2.84×10^{-12}	-	-			
b. Train E	1.52×10^{-6}	3.01×10^{-12}	-	-			
TOTAL					System Failure	3.51×10^{-9}	2.91×10^{-16}
3. Pump Trains							
a. Operating Pump	3.44×10^{-6}	2.13×10^{-11}	-	-			
b. Standby Pump	-	-	1.44×10^{-3}	1.13×10^{-6}			
c. Previously Operating Pump	-	-	1.43×10^{-3}	1.13×10^{-6}			
TOTAL					System Failure	3.01×10^{-5}	8.38×10^{-10}
4. Test and Maintenance		(with pump trains)					
5. Human Error	-						
6. Common Cause	-						
7. Other	-						
SYSTEM TOTAL						3.02×10^{-5}	8.37×10^{-10}

* Service water shown for completeness only, quantified at the event tree level.

TABLE 6 (continued)

INDIAN POINT 3 COMPONENT COOLING SYSTEM - CAUSE TABLE

Basic Events	Failure Data				System Effect	Failure Data (t = 24 hours)	
	Hourly		Demand				
	Mean	Variance	Mean	Variance		Mean	Variance
CASE 2 BOUNDARY CONDITION: POWER AT ONE BUS							
1. Single Events							
a. Manual Valve	9.15×10^{-8}	1.01×10^{-14}	-	-			
b. Service Water Supply Fails*	-	-	-	-			
c. Piping Failure (17)	1.46×10^{-8}	1.24×10^{-13}	-	-			
TOTAL	1.06×10^{-7}	1.53×10^{-14}			System Failure	1.06×10^{-7}	1.53×10^{-14}
2. Heat Exchanger Trains							
a. Train D	1.34×10^{-6}	2.84×10^{-12}	-	-			
b. Train E	1.52×10^{-6}	3.01×10^{-12}	-	-			
TOTAL					System Failure	3.52×10^{-9}	2.91×10^{-16}
3. Pump Trains							
a. Operating Pump	3.44×10^{-6}	2.13×10^{-11}	-	-			
b. Standby Pump	-	-	1.44×10^{-3}	1.13×10^{-6}			
c. Previously Operating Pump	-	-	1.43×10^{-3}	1.13×10^{-6}			
TOTAL					System Failure	1.51×10^{-3}	1.03×10^{-6}
4. Test and Maintenance		(with pump trains)					
5. Human Error	-						
6. Common Cause	-						
7. Other	-						
SYSTEM TOTAL						1.51×10^{-3}	1.03×10^{-6}

* Service water shown for completeness only, quantified at the event tree level.

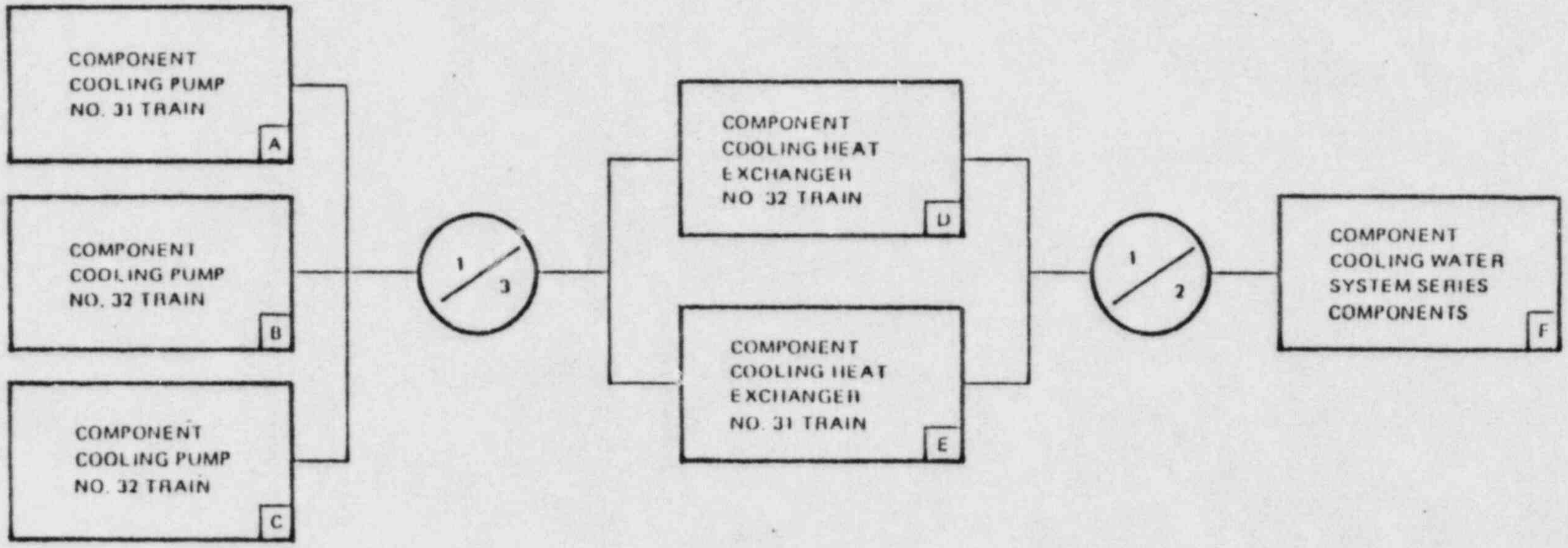


Figure 1. Indian Point 3 Component Cooling Water System Block Diagram

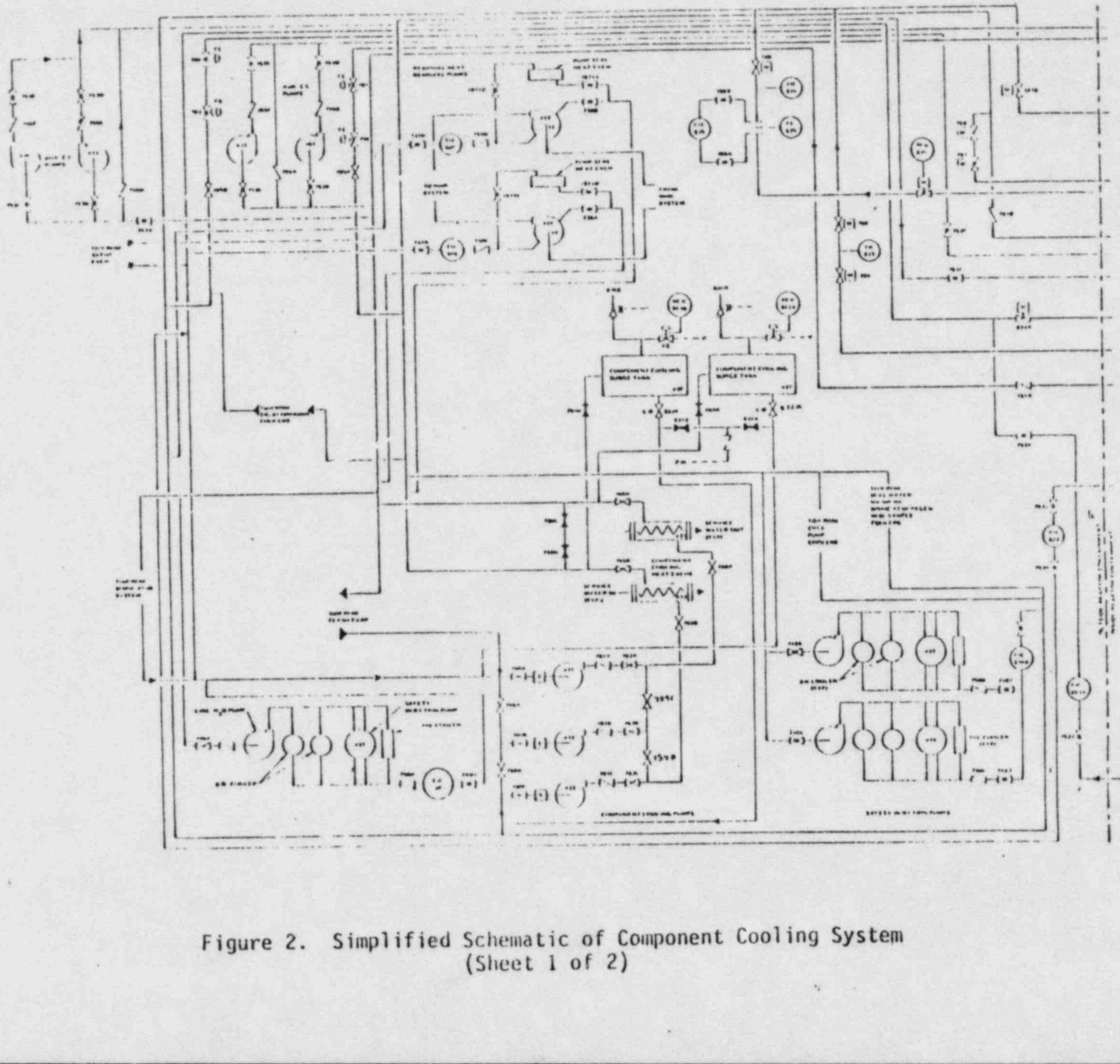


Figure 2. Simplified Schematic of Component Cooling System
(Sheet 1 of 2)

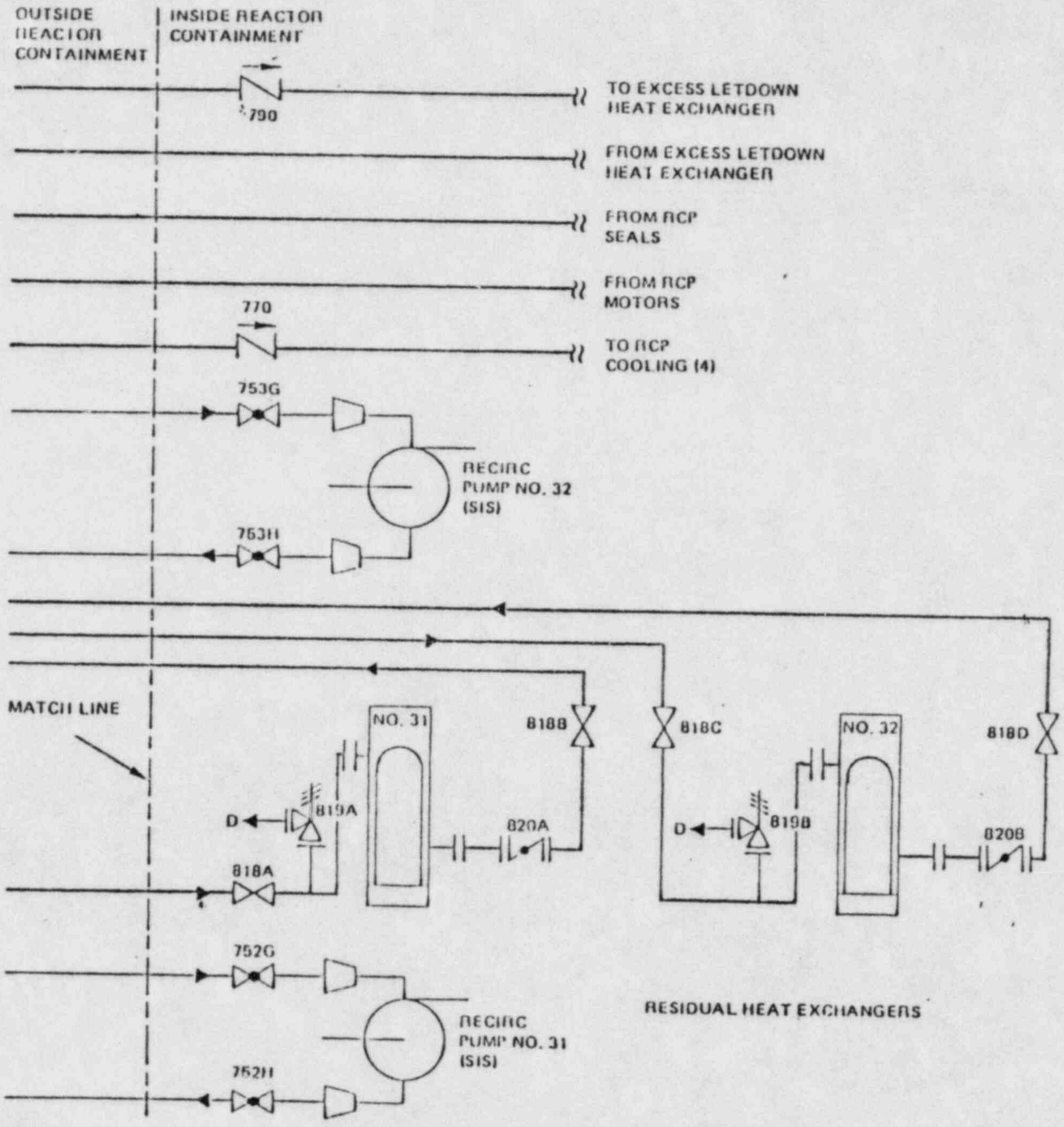
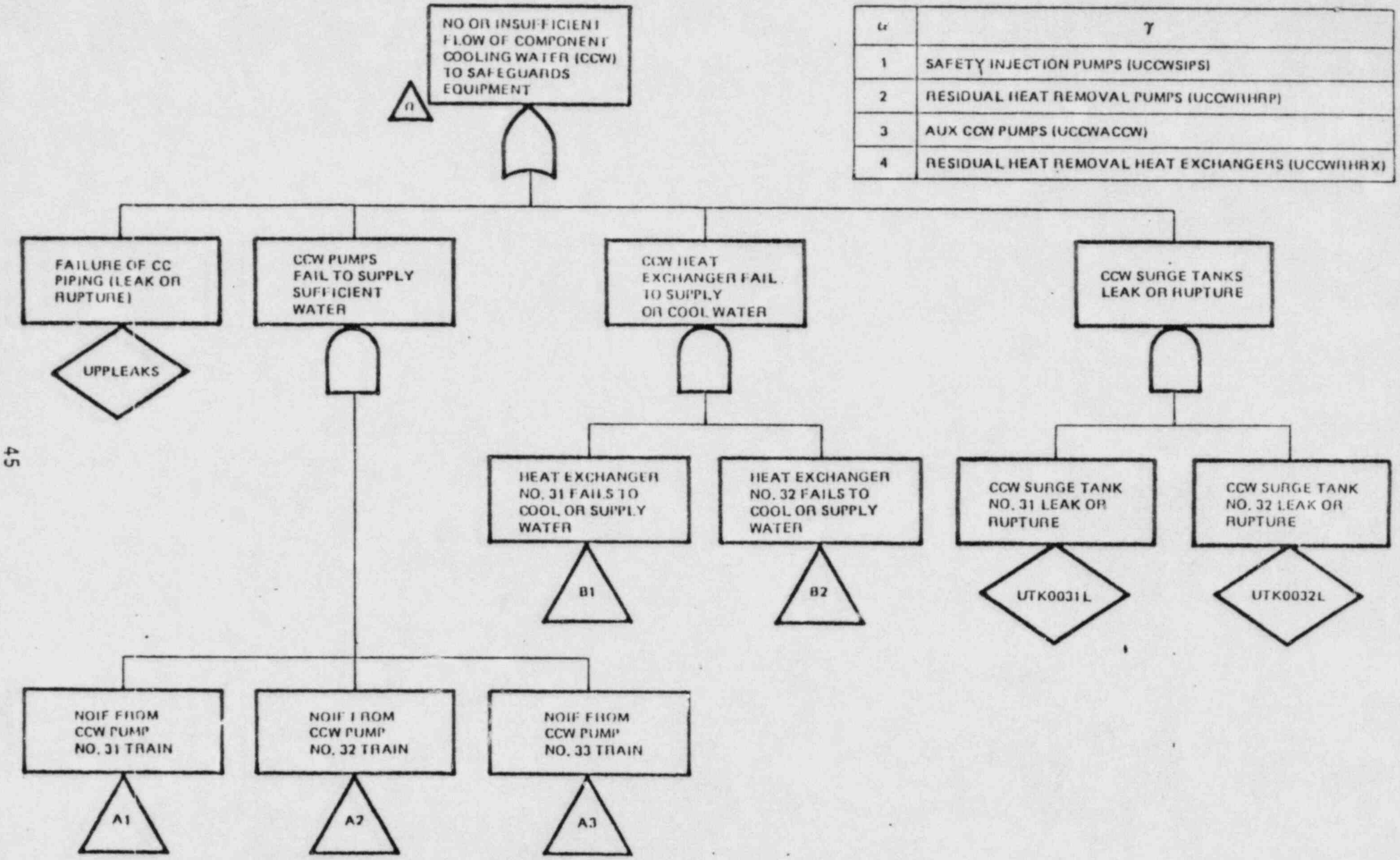
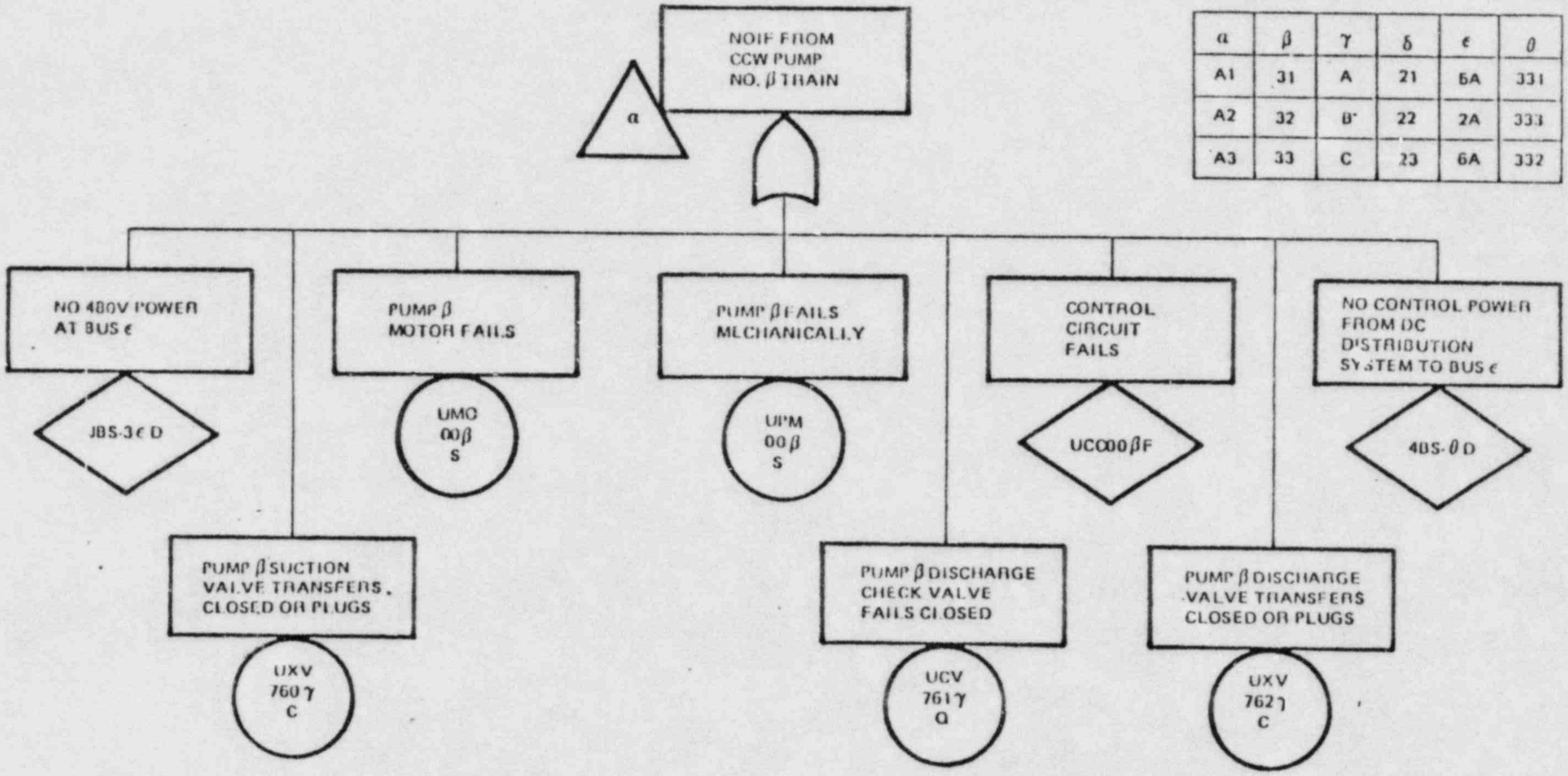


Figure 2. (Sheet 2 of 2)



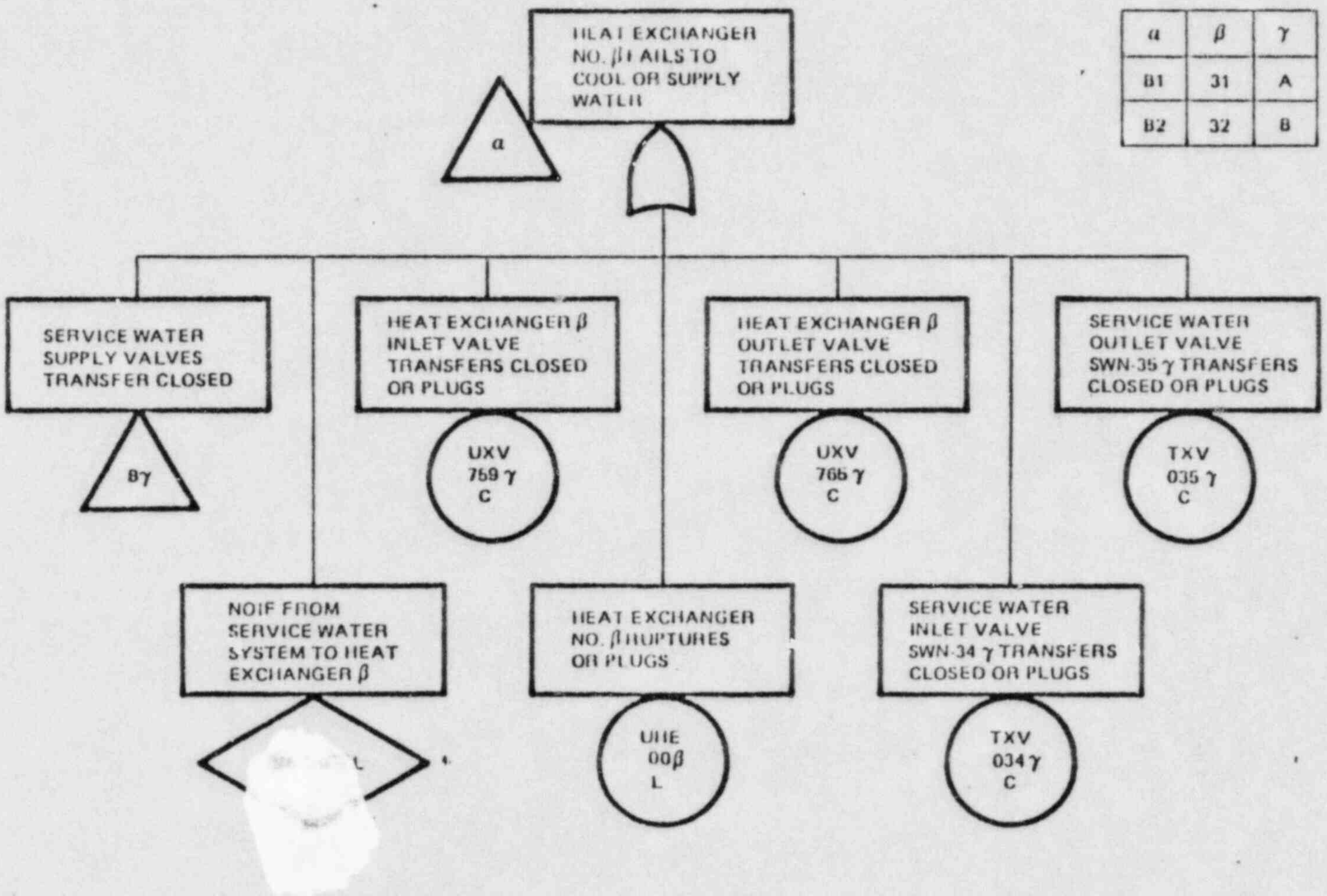
α	γ
1	SAFETY INJECTION PUMPS (UCCWSIPS)
2	RESIDUAL HEAT REMOVAL PUMPS (UCCWRHRP)
3	AUX CCW PUMPS (UCCWACCW)
4	RESIDUAL HEAT REMOVAL HEAT EXCHANGERS (UCCWRHRX)

Figure 3. Indian Point 3 Component Cooling System Fault Tree
(Sheet 1 of 4)



α	β	γ	δ	ϵ	θ
A1	31	A	21	6A	331
A2	32	B	22	2A	333
A3	33	C	23	6A	332

Figure 3. (Sheet 2 of 4)



α	β	γ
B1	31	A
B2	32	B

Figure 3. (Sheet 3 of 4)

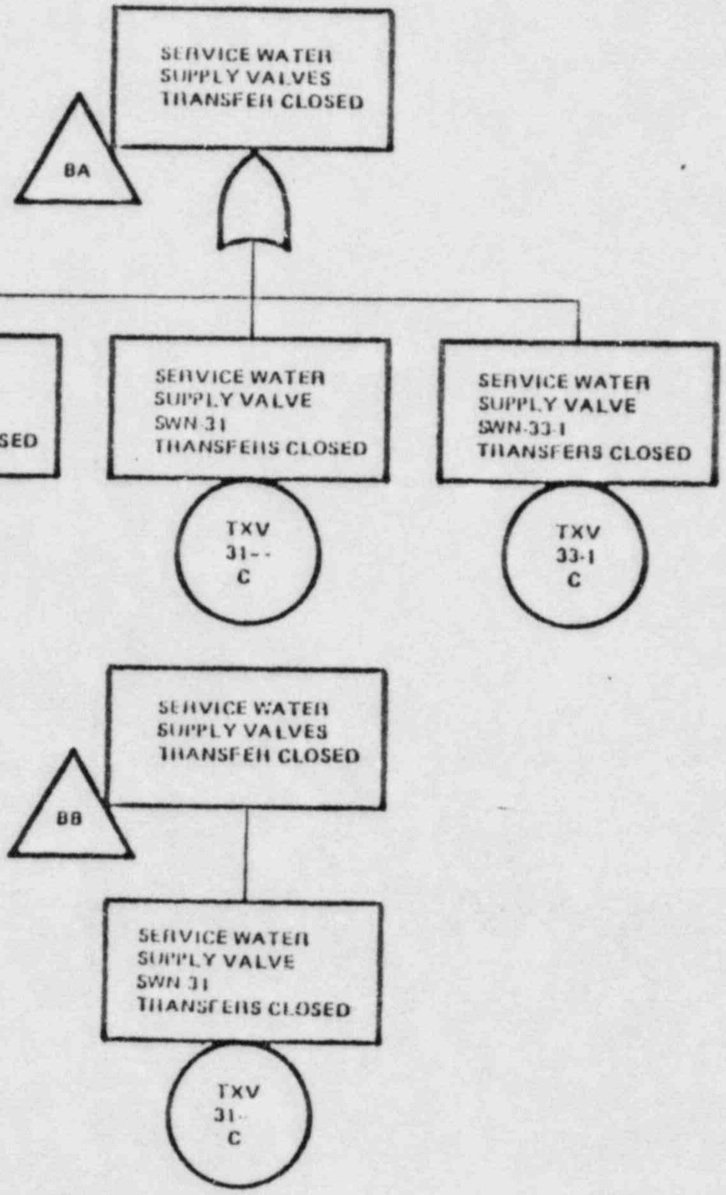


Figure 3. (Sheet 4 of 4)