DRAFT

INDIAN POINT 3
ACCUMULATOR SYSTEM

A. SUMMARY

A.1 INTRODUCTION

The accumulator system is evaluated in the context of a large loss of coolant accident (LOCA) where the pressure in the core decreases sufficiently to allow injection due to the higher pressure nitrogen in each of the accumulator tanks. Success is defined as the injection of three accumulators into the three intact legs given a LOCA has occurred on the fourth leg.

The analysis was carried out under the following conditions:

- RWST is available
- The safeguards actuation signal is present.

The accumulator system does not depend on electric power to function, therefore, only one calculation was required for all states of electric power.

In the event trees, the accumulator system is incorporated with the low pressure injection system (LPIS). Both are required for successful emergency coolant injection.

A.2 RESULTS

Table 1 summarizes the results of this analysis and compares it to the WASH-1400 results. The mean unavailability of the system is 1.61×10^{-3}. The probability distribution for the accumulator system unavailability is shown in Figure A.

The analysis has revealed the following dominant contributors to system unavailability:

	Mean	
• Motor-operated valves	1.20×10^{-3}	(74.2%)
• Check valves	4.15×10^{-4}	(25.6%)

A.3 CONCLUSIONS

The check valves and the MOVs are the dominant contributors to accumulator unavailability on demand. The tank level, N_2 pressure, and piping failures are insignificant compared to the check valves and MOVs. The resulting mean unavailability on demand (1.61×10^{-3}) represents the loss of any one of the three intact legs, assuming the LOCA occurred on the fourth leg.

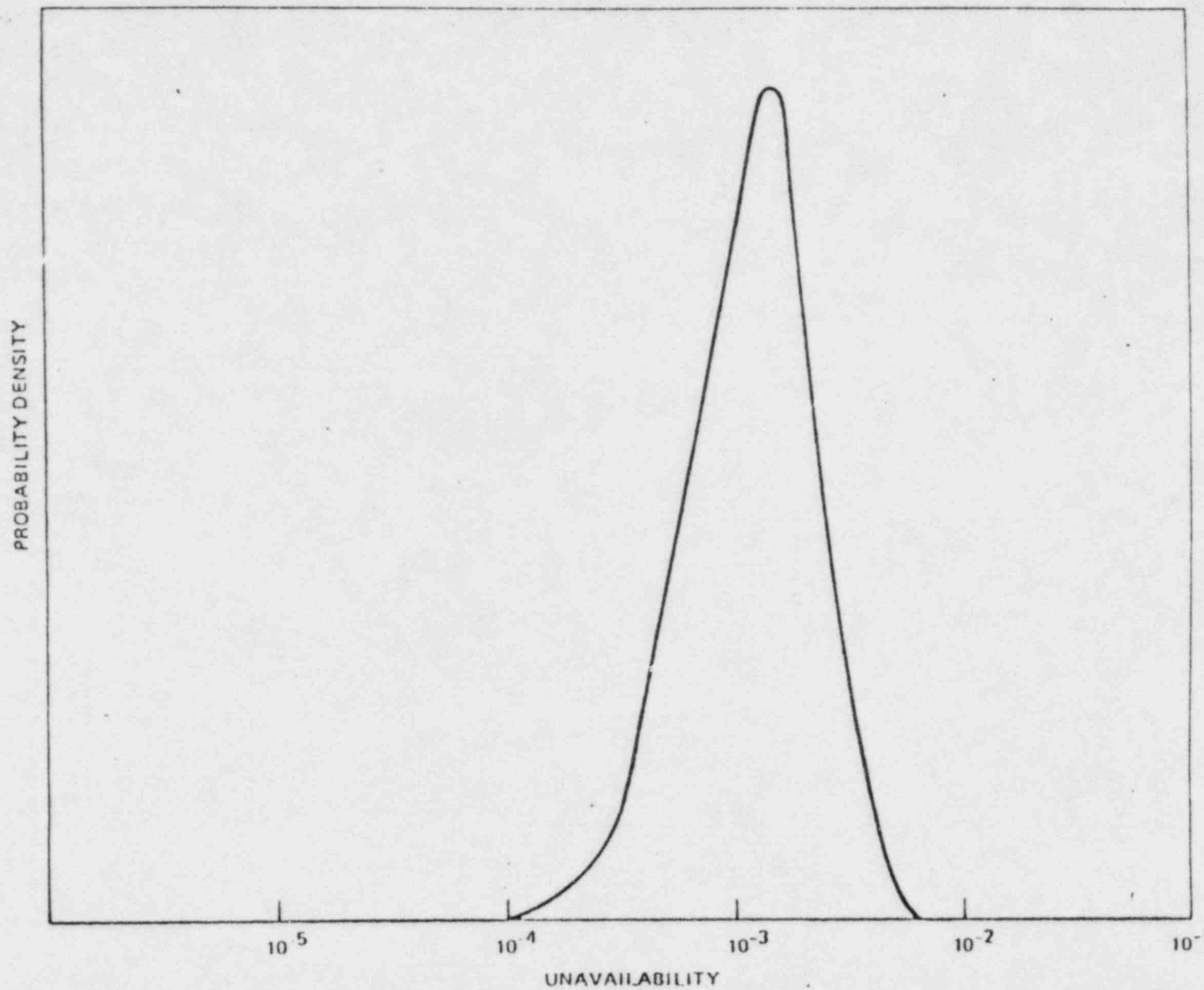

Figure A. Probability Distribution for Accumulator System Unavailability

B. SYSTEM DESCRIPTION

B.1 SYSTEM FUNCTION

For a large LOCA, the accumulator system provides enough water to initiate recovery of the core in the interval of time before the LPIS starts to provide flow, about 25 seconds after the LOCA.

B.2 SYSTEM CONFIGURATION

A block diagram and a simplified P&ID for the system are shown in Figures 1 and 2. Success of all three accumulators on the intact injection legs is required for successful initiation of core recovery.

B.3 SYSTEM OPERATION

When a medium or large break occurs in the reactor coolant system, the accumulator tanks discharge to initiate recovery of the reactor core. Unlike the previous systems which require pumps for injection, the accumulator tanks are passive, and injection occurs when the reactor coolant system pressure drops below the nitrogen gas pressure (nominally 610 to 620 psig) in the tanks. One tank is provided for each reactor coolant cold leg pipe, and all the tanks are identical.

A minimum borated water volume of 800 to 815 cubic feet is maintained in the tanks at all times. Two level sensors provide control room readouts of the level. Low and high level alarms occur when the tank level falls or rises by more than a set amount from the operating condition.

When the reactor coolant pressure falls below the accumulator pressure, the borated water flows through the motor-operated isolation valve (894A-D), which is normally deenergized open and receives an open safeguards actuation signal. These valves have redundant DC position indication in the CCR when AC power to the valves is deenergized. Flow then continues through the two check valves and into the cold leg piping of the reactor coolant system.

Nitrogen gas is nominally maintained in the tank at 610 to 620 psig and is monitored by two pressure sensors that provide a control room display of the pressure. An alarm occurs if the pressure falls or rises by more than a set amount from the normal pressure.

B.4 SUPPORT SYSTEMS

The accumulator system is a passive response system such that, at the time of injection, no other systems need to operate. Level and pressure in the accumulators are monitored during normal operation to assure the readiness of this system.

3.5 TEST, SURVEILLANCE, AND TECHNICAL SPECIFICATION REQUIREMENTS

A check valve leak test is performed during refueling outage intervals for valves 895 A, B, C, D and 897 A, B, C, D. Prior to returning to service when RCS pressure has fallen within 100 psig of the RHR system design pressure, a check is performed to verify that these valves are in the closed position. Table 2 shows the components that are tested.

One accumulator can be taken out of service for a maximum of 8 hours for hot shutdown testing.

3.6 MAINTENANCE REQUIREMENTS

The plant is not allowed to operate with any accumulator inoperable. In a case of required maintenance, the plant is shut down.

3.7 OPERATOR INTERACTION

There is no operator interaction with the accumulator system during normal operation.

3.8 COMMON CAUSE POTENTIAL

Since the system is basically a passive system requiring no actuation signals or support systems, no significant common cause potential has been identified. The only active components are the check valves, which are required to open on demand.

C. LOGIC MODEL

C.1 TOP EVENTS

The event of "Insufficient Flow From the Accumulator" is defined in the event tree and must be positive before LPIS is requested. Since the MOVs are deenergized open, there is no power requirement for these systems.

C.2 SYSTEM FAULT TREE

The tree for each accumulator, shown in Figure 3, is an OR gate with two check valves and an MOV that is normally deenergized open and also receives a safeguards actuation signal to open in case it has been energized and closed. For a large LOCA, all three accumulators on good legs must provide flow to successfully initiate recovery of the core. Therefore, any of the nine valves that fails to allow flow will cause a "failure of the accumulator system." Other failures of low tank level, low tank pressure, and pipe failure, are also shown. Their contribution will be discussed in the quantification section.

C.2 FAULT TREE CODING AND BASIC EVENTS

The basic events are listed in Table 3 with the failure mode and mean failure rate indicated. Each of these is a single element cutset since any one failure fails the system. The result is nine single event failures that result in top event failure.

D. QUANTIFICATION

D.1 SINGLE FAILURES

D.1.1 HARDWARE CONTRIBUTION

Each single-event minimal cutset is analyzed using plant-specific data. Since all intact legs must provide flow to assure success of the accumulators, the two check valve and one deenergized open MOV must allow flow on each intact leg. Therefore, the following data was used with six check valves and three MOVs having the unavailability values shown here for this plant.

- Check valve fails to open (6)

  Mean: 5.91×10^{-5}

- MOV fails closed (deenergized open) (3)

  Mean: $9.15 \times 10^{-3} \times \frac{8760^{*}}{2} = 4.00 \times 10^{-4}$

- Pipes. Table 4 shows the pipe sections that constitute single failures of the accumulators. We estimate that the pipe contributions are less than 10^{-10} per hour as discussed in the methods section.

- N^2 Pressure. Each accumulator has two redundant pressure sensors to detect inadequate pressure on each accumulator on a continuous basis. We estimate undetected low pressure in an accumulator to be no worse than 10^{-5}.

- Water Level. Each accumulator has two redundant level sensors to detect inadequate water level in each accumulator on a continuous basis. We estimate that undetected low level in an accumulator will be no worse than 10^{-5}.

The hardware contribution to the mean system unavailability is then

Mean = 6 check valve failures + 3 MOV failures

$= 6(5.91 \times 10^{-5}) + 3(4.00 \times 10^{-4})$

$= 1.61 \times 10^{-3}$.

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*Based on a 12-month refueling cycle, one half of the test cycle (12 months or 8760 hours) was considered the mean time to repair. Even though the valve stem is deenergized open, the flowpath may be blocked if the gate has parted from the valve stem. Only a flow test will verify that the gate is open. The 12 months is an assumption and may be longer, in which case the mean value becomes larger based on longer times between flow checks.

D.1.2 TEST AND MAINTENANCE CONTRIBUTION

As discussed in Section B.4, tests on the system are done at refueling. Any maintenance on the system during operation calls for a plant shutdown, therefore, no unavailability contribution is considered from test and maintenance.

D.1.3 HUMAN ERROR CONTRIBUTION

Since this is a passive system, no human interaction occurs during normal operation. Therefore, no contribution is allowed to overall system unavailability due to human error.

TABLE 1

ACCUMULATOR UNAVAILABILITY--INDIAN POINT 3

	Mean	Variance	5th Percentile	Median	95th Percentile
This Analysis	1.6×10^{-3}	1.7×10^{-6}	3.6×10^{-4}	1.2×10^{-3}	4.1×10^{-3}
WASH-1400	Not Given	Not Given	6.2×10^{-4}	9.5×10^{-4}	1.4×10^{-3}

TABLE 2

TESTING REQUIREMENTS--INDIAN POINT 3

Component	Testing
Check Valves 897A, B, C, D	Cycled every RCS depressurization*
Check Valves 895A, B, C, D	Leak tested every RCS depressurization*
MOV 894A, B, C, D	Cycled every RCS depressurization

*Tested for leakage every refueling; tested to assure closure every RCS repressurization.

TABLE 3

LIST OF COMPONENTS--INDIAN POINT 3

Component	Failure Mode	Fault Tree Coding	Mean Failure Rate	Variance	Data Source
Check Valves					
897 (A, B, C, D)	Fails to open	ACV 897 (A,B,C,D)Q	6.91×10^{-5}	1.03×10^{-8}	Item 3
895 (A, B, C, D)	Fails to open	ACV 895 (A,B,C,D)Q	6.91×10^{-5}	1.03×10^{-8}	Item 3
Motor-Operated Valves					
894 (A, B, C, D)	Transfers closed (Deenergized open)	AMV 894 (A,B,C,D)Q	9.15×10^{-8}	1.01×10^{-14}	Item 1

TABLE 4

SYSTEM EFFECTS OF PIPE FAILURE

Pipe Section	Dia.	System Failure	Potential for Other Systems Impact	Initiating Event	Comments
<u>Accumulator No. 31</u>					
Outlet upstream of check valve 895A	10"	Yes under analysis assumptions	None	No	Loss of a single accumulator
Downstream of check valve 895A to check valve 897A	10"	Yes under analysis assumptions	Yes - Loss of one injection path for low pressure injection and one injection path for high pressure injection.	No	Loss of a single accumulator
<u>Accumulator No. 33</u>					
Outlet upstream of check valve 895C	10"	Yes under analysis assumptions	None	No	Loss of a single accumulator
Downstream of check valve 895C to check valve 897C	10"	Yes under analysis assumptions	Yes - Loss of one injection path for low pressure injection and one injection path for high pressure injection.	No	Loss of a single accumulator
<u>Accumulator No. 32</u>					
Outlet upstream of check valve 895B	10"	Yes under analysis	None	No	Loss of a single accumulator
Downstream of check valve 895B to check valve 897B	10"	Yes under analysis assumptions	Yes - Loss of one injection path for low pressure injection and one single injection path for high pressure injection.	No	Loss of a single accumulator
<u>Accumulator No. 34</u>					
Outlet upstream of check valve 895D	10"	Yes under analysis assumption	None	No	Loss of a single accumulator
Downstream of check valve 895D to check valve 897D	10"	Yes under analysis assumptions	Yes - Loss of one injection path for low pressure injection and one single injection path for high pressure injection.	No	Loss of a single accumulator

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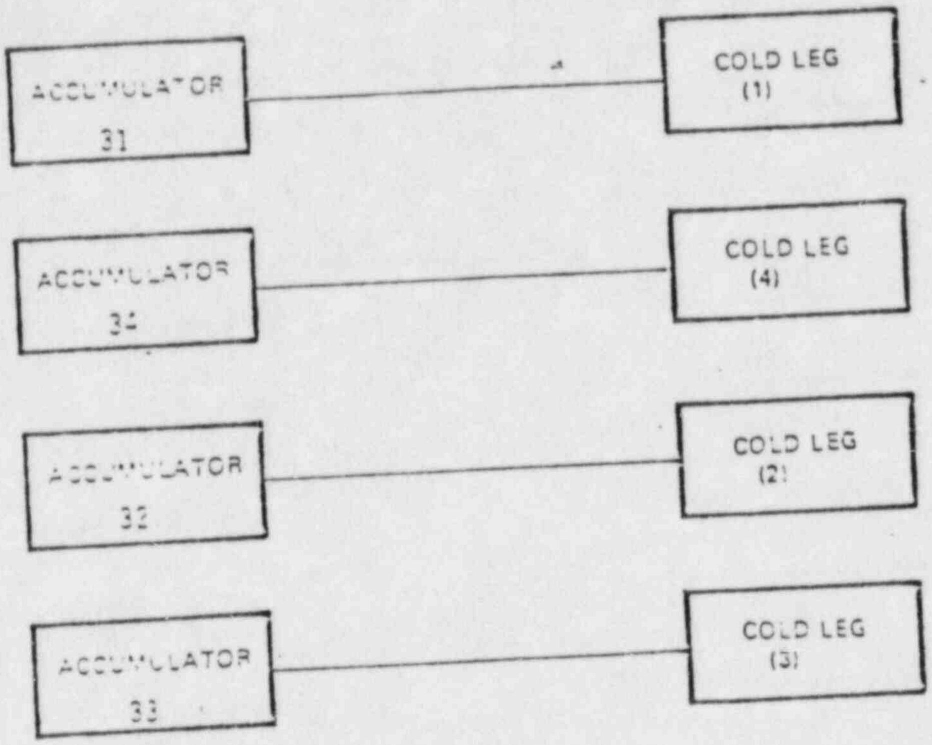
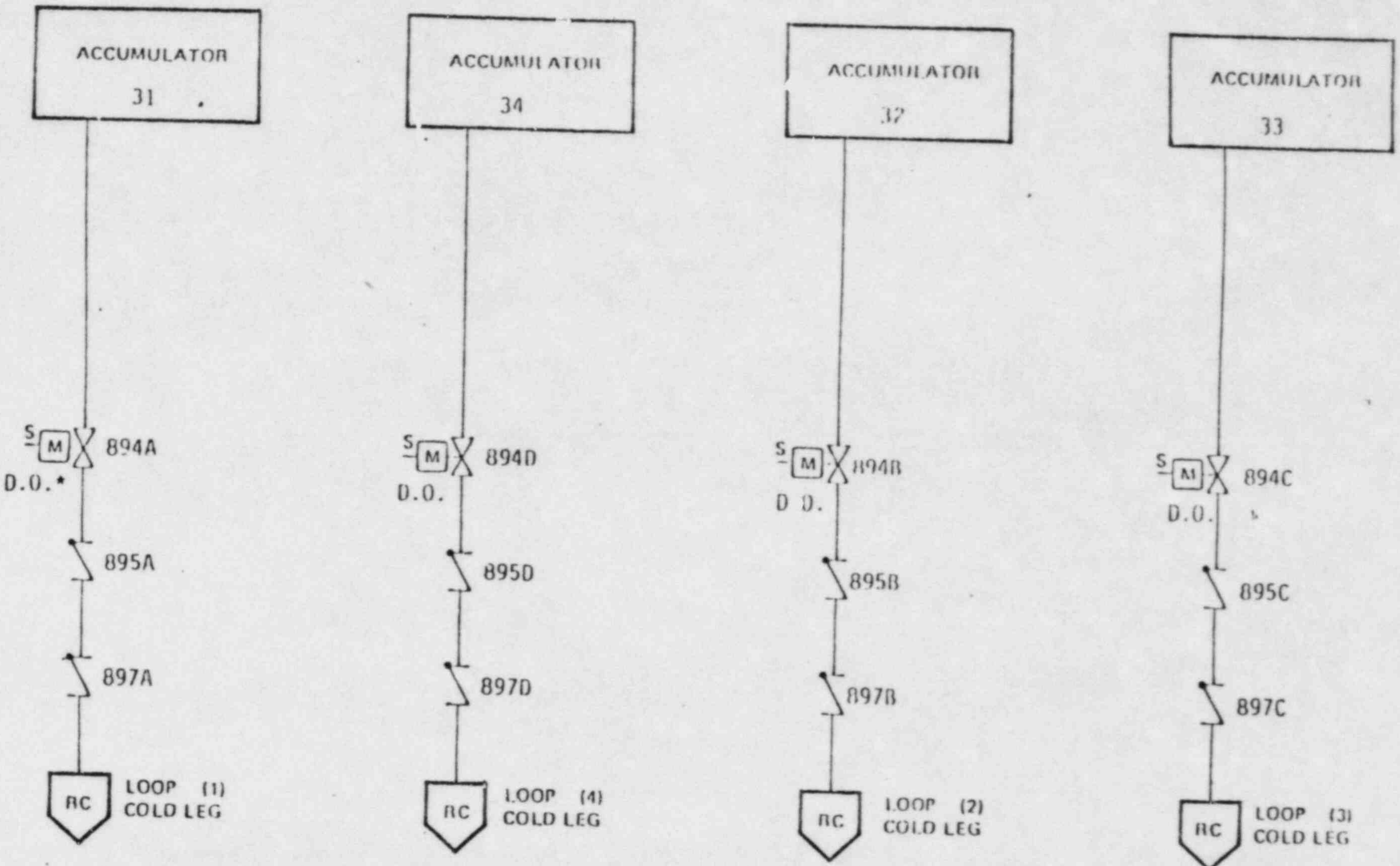


Figure 1. Accumulator Block Diagram



*D.O. ⇒ Deenergized open.

Figure 2. Accumulator Simplified P&ID

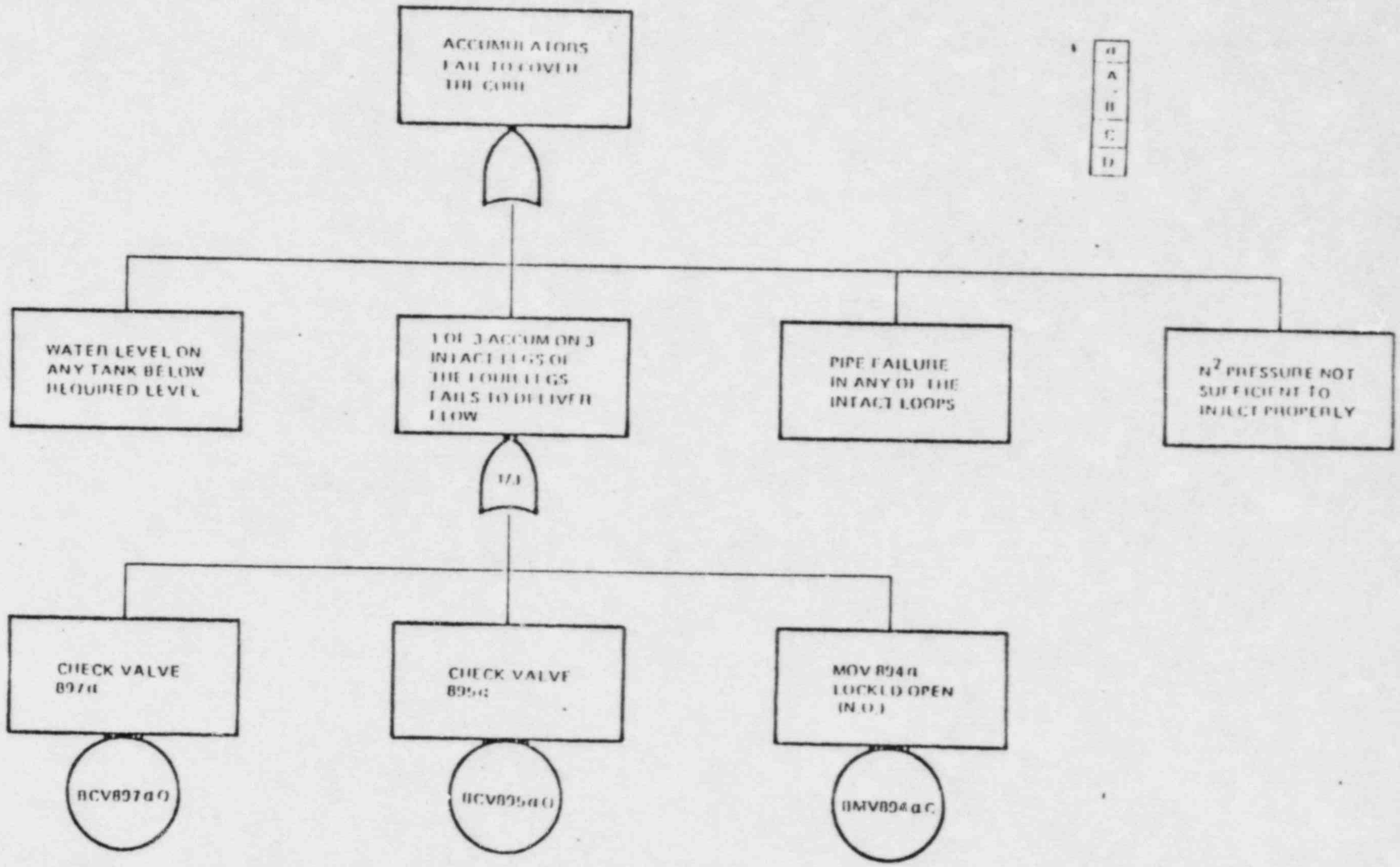


Figure 3. Accumulator System Fault Tree