INDIAN POINT 3
SAFEGUARDS ACTUATION SYSTEM
(Safety Injection and Containment Spray Actuation)

A. SUMMARY

A.1 INTRODUCTION

The safeguards actuation system (SAS) is evaluated for its ability to respond to various plant conditions and to deliver proper actuation signals to the designated engineered safeguards system (ESS) equipment during LOCA and other plant transient conditions.

The function of the SAS is to detect breaks in the primary or secondary system and to initiate operation of the components associated with the engineered safeguards system.

This analysis is carried out under the following assumptions:

- The system is in its normal operating mode prior to the initiating event.
- No operator action to manually initiate the system is considered in this analysis. However, action to manually initiate the essential safeguards system equipment is considered at the event tree level.

The SAS is comprised of two subsystems, safety injection actuation and containment spray actuation. Each subsystem is analyzed separately in this analysis. Failure of the safety injection actuation subsystem is defined as failure of both channels of safety injection logic or failure in the safety injection instrumentation. Failure of a single channel of safety injection logic includes failure to actuate any single equipment actuation relay.

Failure of the containment spray actuation subsystem is defined as failure of both channels of containment spray logic or failure in the containment spray instrumentation.

A.2 RESULTS

The results of this analysis are summarized in Table 1 with the following dominant contributors to safeguards actuation system failure:

Safety Injection Actuation	Mean
• Test of a single logic channel and random failure in the other logic channel (80.5%).	5.0×10^{-6}
• Random failures in both logic channels (19.5%).	1.2×10^{-6}

Containment Spray Actuation

	Mean
• Test of a single logic channel and random failure in the other logic channel (88%).	5.0×10^{-6}
• Failure of the high-high containment pressure instrumentation (6.7%).	3.8×10^{-7}

Table 1 presents a comparison of the results of this analysis to the results obtained in the WASH-1400 analysis for similar systems.

A.3 CONCLUSIONS

No single failures which completely fail the safeguards actuation system were identified. Failures in two separate logic channels or instrumentation channels will result in failure of this system; however, operator action to start the required ESS equipment is independent of this system.

B. SYSTEM DESCRIPTION

B.1 SYSTEM FUNCTION

The safeguards actuation system receives signals from various primary and secondary plant sensors, processes this input through logic matrices, and sends actuation signals to engineered safeguards system (ESS) equipment, based upon plant conditions. The system serves to limit damage in the event of breaks in the reactor coolant system (RCS) or the secondary systems (main steam, feedwater, or steam generators).

Two separate and distinct functions are performed by this system: safety injection actuation and containment spray actuation. Each of these two distinct functions causes several other actions to occur in the plant. This analysis includes all associated equipment from the process sensors (instrumentation) through the various auxiliary relays actuated by the system. Each function identified above is analyzed separately; however, the sections on system description and operation discuss both functions.

B.2 SYSTEM OPERATION

B.2.1 INITIATION SIGNALS

Table 2 identifies the signals, logic arrangement, and trip setpoints which are used to initiate the safety injection or containment spray functions of this system. Figures 1 and 2 present a simplified logic diagram for system operation. The generation of the signals used by this system and the use of these signals are presented below.

1. High Steam Line Flow in Conjunction with Low T_{avg} or Low Steam Generator Pressure.

   This condition is indicative of a steam break downstream of the main steam isolation valves (MSIV). Indications of a break in the general location are: high steam flow (to generate a signal, two of the four steam lines must indicate high steam flow) in conjunction with: a) low T_{avg} (two of four sensors), or b) low steam line pressure (two of four sensors). This signal initiates steam line isolation (closure of all four MSIVs) in addition to initiating automatic safety injection.

   To generate the high steam line flow signal, a comparison circuit is used to develop a varying setpoint signal based on turbine first stage pressure. Actual steam flow is compared with the programmed setpoint, and a trip signal is generated when actual steam flow exceeds the setpoint. To allow for startup, steam dump, and atmospheric relief valve operation when turbine first stage pressure is not a true indication of actual steam flow, the high steam line flow signal must be in coincidence with either a low T_{avg} signal (sensed by primary loop resistance temperature detectors) generated by a two of four sensing network, or a low steam generator pressure signal generated by two of four pressure sensing networks.

2. Steam Line Differential Pressure.

This condition indicates a steam break upstream of the MSIVs or a large feedwater line break. A break in this location results in the closure of the nonreturn check valve (located in each steam line). Steam pressure upstream of the check valve now decreases as the associated steam generator feeds the break directly. A comparison network is used in which this steam pressure is compared to the pressure in two of the three remaining intact steam generators. When the pressure in the steam generator feeding the break decreases to the set value below the other two steam pressures, an automatic safety injection signal is generated.

3. Low Pressurizer Pressure.

The pressurizer acts as a surge tank for the reactor coolant system. Pressurizer heaters cycle on and off to maintain RCS pressure within a certain band. Leakage from the RCS in excess of the pressurizer heater and charging pump capability for makeup results in a decrease in pressurizer pressure, and consequently RCS pressure. This signal serves to initiate automatic safety injection to protect the core from damage for RCS breaks and excessive leaks. Three channels of pressurizer pressure are monitored and an automatic safety injection signal is generated if any two of the three channels indicate low pressure. This trip is manually blocked by operator action when RCS pressure is below 1,900 psi during a plant shutdown. This block is automatically removed when RCS pressure increases above 1,900 psi and operator action would be required to reinitiate the block if it is required.

4. High Containment Pressure.

In the event of a break in the RCS, or a steam line break inside the containment building, pressure inside the containment building would increase. The rate of the increase is dependent upon the size of the break. Containment pressure is monitored by three pressure transmitters located outside of the containment building. When containment pressure exceeds the setpoint value in two of the three transmitter channels, an automatic safety injection signal is generated.

NOTE: all of the trip relays associated with the instrumentation discussed above are "deenergize to trip." That is, loss of power to an instrument channel causes the relays associated with that channel to trip, which results in one of the trip signals required for safety injection actuation.

5. High-High Containment Pressure.

A high-high containment pressure is indicative of a large loss of coolant accident (LOCA) or a major steam line break inside the containment building. Containment pressure is monitored by six pressure transmitters located outside the containment building in

the piping penetration area. The output of these transmitters is divided into two groups of three. When containment pressure exceeds the high-high setpoint, a signal is developed which energizes the relays associated with that channel. Two out of three channels in both groups are required to initiate automatic containment spray actuation. In addition to the automatic containment spray signal, a main steam line isolation signal is sent to close the MSIVs and an automatic safety injection signal is developed.

The tripping of any of the input channels described above is indicated on supervisory panel "SO" in the control room. In addition, the following channel trips will result in alarms at the locations noted:

Tripped Channels	Alarm	Location
1. High Steam Line Flow	High Steam Line Flow SI	Safeguards Panel
2. Steam Line Differential Pressure	Steam Line ΔP SI	Safeguards Panel
3. Pressurizer Pressure	Pressurizer Lo-Press Channel Trip	RCS Supervisory Panel
4. High Containment Pressure	Hi Containment Pressure SI Channel Trip	Safeguards Panel
5. High-High Containment Pressure	High-High Containment Pressure (Spray) Channel Trip	No Alarm (High Indicated)

6. Manual Initiation Signals.

In addition to the automatic signals described above, safety injection or containment spray may be initiated by the operators in the control room.

Manual safety injection is accomplished using the red manual safety injection pushbuttons on panel SB2 in the control room. Depressing one of these pushbuttons initiates the minimum required ESS equipment. Both pushbuttons must be depressed to initiate all ESS equipment. Manual spray actuation is accomplished by depressing both red manual spray actuation pushbuttons on safeguards panel SB1 in the control room. Depressing one spray actuation push button initiates one train of spray equipment.

B.2.2 ESSENTIAL SAFEGUARDS EQUIPMENT ACTUATION

All or portions of the following signals are actuated as a result of the generated signals presented above:

- Safety Injection
- Unit Trip and 69 kV Bus Transfer
- Containment Spray Actuation
- Containment Isolation Phase A
- Containment Isolation Phase B
- Containment Ventilation Isolation
- Isolation Valve Seal Water System
- Containment Cooling and Filtration
- Steam Line Isolation
- Feedwater Isolation
- Reactor Trip
- Emergency Diesels
- Service Water System
- Auxiliary Feedwater

Figure 3 presents the functional relationships between the various initiation signals and the actuated equipment. A discussion of the signals and the relationships is presented below.

1. Safety Injection Signal. The automatic safety injection signal is developed by the actuation of one of the five process input signals described previously. The automatic or manual safety injection signals cause the following actions to occur:

   a. Reactor Trip. The reactor is tripped to reduce power production and aid in minimizing the consequences of the accident.

   b. Feedwater Isolation. The feed system is isolated to minimize the severity of steam break accidents.

   c. Unit Trip and 6.9 kV Bus Transfer. The turbine is tripped to stop the demand for power. The 6.9 kV buses (1 through 4) are transferred to buses 5 and 6 to assure continued power to essential equipment.

   d. Containment Ventilation Isolation. This signal causes isolation of the pressure relief line, the purge supply line, and the purge exhaust line to eliminate leakage from the containment through these lines. (The containment purge lines are only used during cold shutdown conditions.)

   e. Containment Isolation Phase A. This signal isolates all fluid system containment penetrations which will not aid in minimizing the consequences of an accident. In addition, this signal causes operation of the isolation valve seal water system in order to provide a water seal against containment leakage and actuates containment ventilation isolation.

   f. Control Room Ventilation Isolation. This signal changes the control room air conditioner to the incident condition.

g. Safeguards Sequence. This signal causes the following actions:

(1) Commands all three diesel generators to start, provided controls are in automatic.

(2) Sends a stripping signal to all loads on the 480V buses which are not required for safety injection, and locks out all nonsafeguards loads except MCC36A, MCC36B, and MCC36C.

(3) Provides a signal to trip bus tie breakers 2AT5A and 3AT6A.

(4) Sends a starting signal to the component cooling booster pumps and sends automatic signals to allow for injection path lineup.

(5) In the absence of an undervoltage condition on the respective 480V buses, sends sequence signals to start the safeguards equipment on the four 480V buses. If outside power is lost, the sequence signal is delayed until voltage is restored to the affected 480V bus. If the SI signal is reset prior to restoring voltage to the bus, the SI equipment will not automatically start.

h. Illuminates the "Safety Injection Actuated" Lamp on Supervisory Panel SB1.

2. Containment Spray. The containment spray actuation signal is developed by the two-out-of-three-twice logic for high-high containment pressure or by depressing the two manual actuation pushbuttons. This signal causes actuation of the spray equipment and containment isolation phase B. Sodium hydroxide addition is delayed for two minutes after spray actuation to allow the operator time to cancel this addition if it is not needed. The cancel pushbutton only affects the sodium hydroxide addition system.

B.2.3 SAFEGUARDS ACTUATION MANUAL RESETS

The various actuation signals pass through memory devices that preserve the signal to allow the functions to go to completion. Manual reset pushbuttons are provided to allow for operator flexibility during recovery. The action of these pushbuttons is described below:

- Safety Injection Reset. Two manual pushbuttons are located at supervisory panel SB2. These pushbuttons, one for each logic channel, allow resetting of the equipment actuating relays. Resetting of the relays does not remove equipment from operation. These reset pushbuttons are interlocked with a timing device that prevents resetting for two minutes after actuation. Once the signal is reset, it will not be reactuated by an automatic signal until after the reactor trip breakers are reset. Manual safety injection may be reinitiated at any time.

- Containment Isolation Phase A Reset. Two manual pushbuttons located at supervisory panel SN allow resetting of this actuation signal. Once reset, reactuation will be inhibited until after the automatic safety injection signal is cleared.

- Containment Ventilation Isolation Reset. Two manual pushbuttons located at supervisory panel SN allow resetting of this actuation signal.

- Containment Isolation Phase B Reset. Two manual pushbuttons located at supervisory panel SN allow resetting of this signal. Once reset, reactuation is inhibited until after the spray initiation signal has been reset.

- Spray Reset. Two manual pushbuttons located at supervisory panel SB1 allow resetting of this signal. Once reset, automatic reactuation is inhibited until after the spray initiation signal has cleared and the reactor trip has been reset. Manual spray injection may be reinstated at any time.

B.2.4 SAFEGUARDS LOGIC CHANNELS

There are two channels of actuation logic in the safeguards actuation system. These logic channels require DC power for proper operation. The power supplies for the logic channels are presented in Section B.3 of this analysis. Table 3 identifies the logic relays and the equipment actuated by each relay.

Each logic channel contains seven master relay-slave relay sets. These relay sets are:

- SI Automatic Actuation
- SI Manual Actuation
- Containment Ventilation Actuation
- Containment Isolation Phase A (2)
- Containment Isolation Phase B
- Containment Spray Actuation

The master relays are special relays which contain operating and reset coils. The master relay is normally deenergized. When the proper logic matrix is made up, the operating coil will be energized by auxiliary contacts and demand the various safeguards equipment to operate. The master relays, via a mechanical latching mechanism, and the slave relays will remain in the actuated position until the master relay is reset (reset coil is energized). The reset signal is applied through the manual reset pushbuttons described in Section B.2.3.

The safeguards logic relays are located in relay racks behind the reactor trip logic relay panels. These relays are arranged in matrices which develop the necessary logic for safeguards initiation. A typical logic matrix and master relay-slave relay layout is shown in Figures 4 and 5. Each logic relay is fed from a safeguards actuation bistable located at the analog racks. The signal from each analog bistable feeds a safeguards logic relay in each safety injection channel.

With the exception of the high-high containment pressure relays, the logic relays are deenergized when an unsafe condition is detected.

During testing, contacts of a test relay in series with the auxiliary relays prevent the auxiliary relays from being energized. Should a safeguards actuation be called for during testing, it will be initiated by either the other safeguards actuation logic network, or that portion of the safeguards actuation logic network which is not undergoing testing. Figure 5 presents a typical test circuit arrangement for a safeguards actuation logic matrix and master relay. Note: manual SI removes the test signal that prevents the slave relays from being actuated thereby allowing the affected channel to respond to the actual SI condition.

B.3 SUPPORT SYSTEMS

Successful operation o[illegible] the safeguards actuation system is dependent upon the electric power system, primarily the DC system. Each actuation channel receives DC power from a separate battery panel and battery. Presented below are the [illegible] sources of power for the safeguards actuation system. Also [illegible]d are test power supplies for this system. DC power for [illegible] channel is monitored by two undervoltage relays which indicate on the front of the associated safeguards logic panel.

Subsystem	Power Source
Logic Channel 1 (Panels 1-1 and 1-2)	Battery 31 through Distribution Panel 31
Logic Channel 2 (Panels 2-1 and 2-2)	Battery 32 through Distribution Panel 32
Logic Channels 1 and 2 Testing	120 VAC Instrument Bus 33

B.4 INTERFACING SYSTEMS

The safeguards actuation system sends operation signals to the plant engineered safeguards system (ESS) equipment and then interfaces with all ESS systems.

In addition to the ESS systems, the safeguards actuation system sends isolation signals to other plant systems which penetrate the containment building.

B.5 TECHNICAL SPECIFICATIONS

The plant technical specifications identify:

- The maximum or minimum trip setpoints.
- The frequency of testing of the various SAS equipment.
- The number of out-of-service instrumentation or logic channels.
- Limits on the number of channel tests that may be performed at the same time.

B.6 TEST AND MAINTENANCE

The various components in the safeguards actuation system undergo periodic testing and surveillance. Maintenance is performed as required.

1. The process instrumentation channels are periodically tested to satisfy plant technical specifications as indicated below:

   a. Channel checks are performed every shift (8 hours). A channel check is a qualitative determination of acceptable operability by observation of the instrument behavior during operation.

   b. Channel functional tests are performed monthly. A channel functional test involves the injection of a simulated signal into the channel to verify operability, including alarm and/or trip initiating action.

   c. Channel calibration for most instrumentation loops is performed during refueling outages. Channel calibration is the adjustment of channel output, such that it responds, within acceptable range and accuracy, to known values of the parameters which the channel measures. Calibration encompasses the entire channel, including alarms or trips, and includes the channel functional test.

2. The safeguards actuation logic channels are periodically tested to satisfy plant technical specification requirements as indicated below:

   Logic Channel Functional Test. Logic channel functional tests are performed monthly. A logic channel functional test is the application of input signals, or the operation of relays or switch contacts, in all the combinations required to produce the required decision output, including the operation of all actuation devices. The coils for the slave relays are checked for continuity rather than actuation.

3. During refueling outages, a test safety injection signal is applied to check the operation of the engineered safety features. The breakers for the safety injection and residual heat removal pumps are made inoperable for this test. The test will be considered satisfactory if control board indication and visual observations indicate that all components have received the safety injection signal in the proper sequence; that is, the appropriate pump breakers shall have opened and closed, and the appropriate valves shall have completed their travel.

4. Testing Sequence. The general test procedure and test sequence for the logic matrices is presented below:

   a. The safeguards initiation test panel is located on the front doors of the safeguards initiation relay panels and consists of three-position pushbuttons (left, right, and push), white indicating lamps, and a red test lamp. A typical test circuit is shown in Figure 3. The white light will be illuminated whenever the proper coincident relay contacts are closed. The lamp may be tested by depressing the lens.

   b. A master test push button is provided to block actuation of the slave relays allowing the master relays to be operated without energizing safeguards equipment.

   c. When the test switch is in the left, (normal position) or right position, contact 1a in series with the logic relay are closed.

   d. With the test switch in the push position, (either right or left), contact 1a will be opened causing the logic relay to deenergize. With the proper number of logic relays tripped, the white "matrix" light associated with that safeguards function will illuminate, indicating proper operation of the logic circuit.

   e. A white master relay light is illuminated when the associated master relay is actuated. Five lights are provided as follows:

      (1) SI Master
      (2) Containment Isolation Phase A Master
      (3) Containment Isolation Phase B Master
      (4) Spray Initiation Master
      (5) Containment Ventilation Master.

   f. The operation of the individual logic relays is monitored by the status lights on supervisory panel SO and the channel trip alarms on the safeguards supervisory panel. The test reset push button removes the block signal to the slave relays, provided all master relays have been reset.

B.7 OPERATOR INTERACTION

Operator action to manually initiate the safeguards actuation system is excluded from this analysis. Operator errors during test or maintenance of this system are discussed in Section D.6 of this analysis.

B.8 COMMON CAUSE EFFECT

The logic cabinets and instrumentation cabinets associated with this system are located in the control room behind the flight panels at Indian Point 3.

Common generic components of this system are supplied by the same manufacturers, are subject to common operation and test procedures, and have common susceptibility to secondary causes of failure (grit, moisture, vibration, etc.).

Further discussion of the effects of common cause failure on system failure is presented in Section D.5 of this analysis.

C. LOGIC MODEL

C.1 EVENT TREE

This system is input to the event trees developed for the LOCA, steam break, and loss of offsite power transients. Failure of this system is defined as failure to send an actuation signal to the actuated equipment. In the event tree, questions concerning the state of this system are asked following questions on electric power and before the actuated systems status.

C.2 SYSTEM FAULT TREE

Figure 4 presents the fault trees developed for the safeguards actuation system. Discussion of the events and the quantification of the tree is presented in Section D of this analysis. Manual actuation of this system is always possible; however, this analysis does not include the probability of manual actuation.

The fault tree is developed for a LOCA condition in the plant. The fault tree logic for the steam line break and the loss of offsite power transients is similar.

C.3 FAULT TREE CODING

Table 4 identifies the basic events, their failure modes, and the failure rates associated with these modes.

D. QUANTIFICATION

D.1 SINGLE HARDWARE FAILURES

No single hardware failures were identified in either the safety injection actuation or containment spray actuation systems.

D.2 DOUBLE HARDWARE FAILURES

The doubles contribution to system failure consist of random hardware failures in one logic channel, coupled with random hardware failures in the other logic channel.

D.2.1 SAFETY INJECTION ACTUATION

Channel 1 of safety injection consists of the following basic components:

- Actuation Relay A-1
- Manual Actuation Relay M-2
- Reset Relay and Pushbutton RS-1
- Normal Defeat Switch -1
- DC Power fuses 2-1 and 3-1
- Equipment Actuation Relays 10-15X
- Steam Line Isolation Relay S-1
- Containment High-High Pressure Relay AS1

The mean times to repair, MTTR, for the DC power fuse, the reset relay and the normal defeat switch are based upon the following:

- DC power fuse - Indication of a failed fuse is available on the front of the affected safeguards actuation panel. These panels are located in the control room and are under operator surveillance. Every shift (8 hours) the status of the panels is verified. The MTTR, 4 hours, is based upon one half of the interval between visual inspections.

- Normal Defeat Switch and Reset Relay - The failure mode of interest is the shorting across of normally open contacts. Failures of this type are only detectable during the monthly logic channel testing or upon a system demand. The MTTR assigned, 360 hours, is based upon one half of the interval between tests.

Channel 2 contains similar components.

The following equation defines the probability of failure on demand for a single safety injection logic channel:

$$Q = 2(V1 + V4) + V2 + 6V3$$

where

V1 = probability of occurrence of a single short around open contacts.

V2 = probability of failure of a single master relay.

V3 = probability of failure of a single auxiliary relay.

V4 = probability of failure of a single fuse.

Q = channel unavailability on demand.

Using the failure data presented in Table 4 and the fault tree constructed for the event "No Safeguards Actuation Signal (SAS) from Channel 1," we obtain a distribution for the probability of failure on demand characterized by the following mean and variance:

Mean 3.64×10^{-4}

Variance 1.02×10^{-6}.

Using the fault tree and discrete probability distribution (DPD) arithmetic, we obtain for the probability of "No Safeguards Actuation Signal" (LOCA), a distribution represented by the following mean and variance:

Mean 1.19×10^{-6}

Variance 2.34×10^{-11}.

D.2.2 CONTAINMENT SPRAY ACTUATION

Containment spray actuation channel 1 consists of the following components:

- Containment Spray Master Relay S1-O
- Containment Spray Reset Relay S1-R
- Containment Spray Auxiliary Relay S11X
- DC Power Fuses 2-1 and 3-1
- Containment Spray Relay AS-1.

The MTTR for the DC power fuses and the reset relay are based upon the following:

- DC power fuse - 4 hours based upon the discussion in Section D.2.1.
- Reset Relay - 360 hours based upon the discussion in Section D.2.1.

Channel 2 contains similar components.

The following equation defines the probability of failure on demand for a single containment spray logic channel:

$$Q = V1 + V2 + 2(V3 + V4)$$

where

V1 = probability of occurrence of a single short around open contacts.

V2 = probability of failure of a single master relay.

V3 = probability of failure of a single auxiliary relay.

V4 = probability of failure of a single fuse.

Q = channel unavailability on demand.

For the event "No Spray Signal Generated Channel 1" we obtain, using the failure data presented in Table and the fault tree constructed for this event, a distribution for the probability of failure characterized by the following mean and variance:

Mean 1.85×10^{-4}

Variance 2.54×10^{-7}.

For the event "No Containment Spray Actuation Signal," DPD arithmetic yields a probability distribution characterized with the following mean and variance:

Mean 2.99×10^{-7}

Variance 1.46×10^{-12}.

D.3 INSTRUMENT LOOP FAILURES

Two groups of instruments are considered; those which initiate SI and those which initiate CS.

D.3.1 INSTRUMENT LOOP FAILURES, SI

The instrumentation of interest for the LOCA transient is: pressurizer low pressure (3 channels, 2 of 3 required); and containment high and high-high pressure (high 2 of 3; high-high 2 of 3, twice). A basic instrumentation loop consists of a sensor, transmitter, test device, test-operate switches, bistable, power supply, and logic relays. Referring to the instrumentation fault trees, the sensor and transmitter are grouped in the transmitter block, and the bistable and logic relays are grouped in the bistable block. Note, upon a loss of power to the instrument loop, the logic relays associated with the loop change state to close their logic matrix contacts. This is true for all SI instrumentation except high-high containment pressure where the relays must be energized to close the logic matrix contacts.

The MTTR for the pressurizer and containment pressure transmitter networks are based upon the following:

- Pressurizer pressure transmitters - Although these transmitters are only calibrated during plant refueling outages, the output of these transmitters is under continuous observation during plant operation. Any deviation of a single channel will be detected

during the normal channel checks performed every shift. For this reason, four hours (one half of the normal shift cycle) is defined as the MTTR for these transmitters.

- Containment pressure transmitters - These transmitters are also calibrated during refueling outages and routinely monitored in the control room; however, containment pressure does not vary significantly over the course of a single shift. Drift or other malfunctions in a single transmitter network will be detected during plant operation due to the normal pressure buildup that occurs inside the containment over several days. Based upon engineering judgment, the MTTR for the transmitter network is defined to be one half of a weekly cycle (84 hours).

The following equation defines the probability of failure on demand for the safety injection instrumentation:

$$Q = (9V3^2)(V1 + V2)^2$$

where

V1 = the probability of failure of a single presurrizer transmitter network.

V2 = the probability of failure of a single bistable/logic relay channel.

V3 = the probability of failure of a single containment pressure transmitter network.

Q = safety injection instrumentation unavailability on demand.

Based upon the above equation, we have the following distribution for the failure of instrumentation to provide automatic trip signals to SIS:

Mean 1.56×10^{-16}

Variance 2.59×10^{-30}.

D.3.2 INSTRUMENT LOOP FAILURES, CS

The instrumentation which initiates containment spray consists of the containment high-high pressure transmitters and bistables. The six containment pressure transmitters are arranged in two groups of three with 2 of 3 high-high pressure signals required from each group for containment spray to be actuated. The instrumentation loops fail with no trip signal if power is lost to the instrument loop.

The MTTR for the high-high containment pressure transmitters is defined as 84 hours for the reasons noted in Section D.3.1.

The following equation defines the probability of failure o
the containment spray instrumentation.

$$Q = 6\ (V2 + V3)^2$$

where

V2 = the probability of failure of a single bistable,
channel.

V3 = the probability of failure of a single containme
transmitter network.

Q = containment spray instrumentation unavailability

Based upon the above equation, the probability of failure fo
containment high-high pressure signal is characterized by th
mean and variance:

Mean 4.24×10^{-3}

Variance 1.55×10^{-4}.

D.4 SYSTEM FAILURE DUE TO TEST AND MAINTENANCE

D.4.1 TESTING

During system logic channel functional testing, the master SI
prevented from energizing by open contacts operated by the te
This testing is performed monthly and normally requires four
hours for completion. The master SI relay is not blocked for
duration of the testing; however, for the purposes of this an
is assumed that the channel under test cannot perform its fun
the entire duration of the test. The mean test act duration
hours with a variance of one hour. Using the test act durati
data developed in Section D.2.1 for a single SAS channel, we
the contribution to system failure for a single SAS channel u
and random failures in the other channel, the following mean
variance:

Mean $\frac{5\ \text{hrs}}{\text{month}} \times \frac{1\ \text{month}}{720\ \text{hrs}}\ 3.58 \times 10^{-4} = 2.53 \times 10^{-6}$

Variance 4.97×10^{-11}.

For the system total contribution to failure due to this testi
must add the contribution to failure while testing of the othe
channel. This results in the following failure probability fo
during test.

Mean 5.05×10^{-6}

Variance 1.99×10^{-10}.

D.4.2 MAINTENANCE

Maintenance upon certain portions of this system is allowable under the plant technical specifications. This maintenance is limited to the instrumentation which supplies the trip signals. Prior to performing the maintenance, the other channels of instrumentation which sense the same parameter are tested to ensure their operability. Upon completion of this testing, the failed instrument is placed in the tripped position which, in effect, gives one part of the signal necessary for system actuation. Maintenance for these cases does not affect system unavailablity.

Maintenance is not performed on other portions of the safeguards acutuation system during plant operation.

D.5 QUANTIFICATION OF COMMON CAUSE - INSTRUMENT CHANNEL MISCALIBRATION

There is a potential for common miscalibration errors to be applied to all instruments of a particular set. During the periodic calibrations, a single technician or group of technicians perform the tests necessary to ensure instrument accuracy. These tests are usually performed sequentially among identical channels. This leads to a close coupling between the acts. However, most calibration activities, even if performed in error do not result in an instrument that fails to provide a trip. In addition, the diversity in the types of instruments that provide trip signals limits the effect of these potential common cause miscalibrations. If we take the value of a single instrument channel failing (the sum of bistable, logic relays, and transmitter network failures) as the probability of common cause miscalibration of a set of instruments, failure of two sets of instrumentation due to miscalibration of this type would result in a mean and variance of:

Mean 2.94×10^{-10}

Variance 9.13×10^{-19}.

This value is used as the probability of common cause miscalibration of instrumentation.

During the monthly logic channel testing, it can be seen from the fault tree that a single logic channel failure can cause failure of the safeguards actuation system. Both trains of logic are tested sequentially which in principle could introduce some common cause coupling between the channels. However, the logic testing does not involve the changing of trip set points or logic arrangements. For this reason, these testing failures are treated as independent events which do not affect system unavailability.

D.6 QUANTIFICATION OF HUMAN ERROR

The human error of failing to actuate this system given an initiating event is outside of the boundary of this analysis, but is included in the initiating event trees.

Human errors during instrumentation calibration are discussed in the common cause section, Section D.5.

There are potential candidates for human errors quantification during the monthly logic channel functional testing. These potential candidates are discussed below:

1. Failure to return "Normal-Defeat" switch to "Normal" after testing.

   This switch prevents the master SI relay from being energized. Failure to return this switch to normal defeats one entire channel of safety injection/containment spray actuation.

   This switch is annunciated in the control room and this error, if made, is immediately detectable. For this reason, this potential human error is not quantified in this analysis.

2. Failure to return individual test switches to "Normal."

   These switches allow testing of the individual logic relays. All test switches are the push-turn type. All switches are annunciated at the individual safeguards panel and each relay being tested is annunciated in the control room. Failure to return a switch to normal results in that particular channel of instrumentation being unable to provide a trip signal.

   Because these switches have indication when they are in the test position, and because the individual channels are annunciated when testing, no human error quantification is performed for this condition.

D.7 SYSTEM QUANTIFICATION

D.7.1 SAFETY INJECTION ACTUATION

Failure of the safety injection actuation subsystem is caused by failures in the individual logic channels, failures in the instrumentation, failure during test and maintenance, and common cause failures.

The probability of safety injection actuation signal failure on demand is now:

$$Q_{SI} = \alpha_{SI\ logic} + \alpha_{Inst} + \alpha_{TM} + \alpha_{CC}$$

$$= 6.24 \times 10^{-6}$$

$$\beta^2_{SI} = 2.20 \times 10^{-10}.$$

D.7.2 CONTAINMENT SPRAY ACTUATION

Failure of the containment spray actuation subsystem is caused by failures in the individual logic channels, failures in the instrumentation, failures during test and maintenance, and common cause failures.

The probability of containment spray actuation signal failure on demand is now:

$$Q_{CS} = \alpha_{CS\ logic} + \alpha_{Inst} + \alpha_{TM} + \alpha_{CC}$$

$$= 5.66 \times 10^{-6}$$

$$\beta^2_{CS} = 1.49 \times 10^{-10}.$$

D.7.2 CONTAINMENT SPRAY ACTUATION

Failure of the containment spray actuation subsystem is caused by failures in the individual logic channels, failures in the instrumentation, failures during test and maintenance, and common cause failures.

The probability of containment spray actuation signal failure on demand is now:

$$Q_{CS} = \alpha_{CS\ logic} + \alpha_{test} + \alpha_{TM} + \alpha_{CC}$$

$$= 5.66 \times 10^{-6}$$

$$\beta^2_{CS} = 1.49 \times 10^{-10}.$$

TABLE 1

INDIAN POINT 3 SUMMARY OF RESULTS SAFEGUARDS ACTUATION SYSTEM

	Mean	Variance	5th Percentile	95th Percentile	Median	WASH-1400 (Median Values)
A. Safety Injection Actuation						
1. Logic Channels	1.2×10^{-6}	2.3×10^{-11}	1.8×10^{-8}	4.6×10^{-6}	2.8×10^{-7}	9.0×10^{-6}
2. Instrumenation	1.6×10^{-16}	2.6×10^{-30}	4.3×10^{-19}	5.3×10^{-16}	1.5×10^{-17}	-
3. Test and Maintenance	5.0×10^{-6}	2.0×10^{-10}	1.5×10^{-7}	1.9×10^{-5}	1.7×10^{-6}	1.3×10^{-5}
4. Common Cause	2.9×10^{-10}	9.1×10^{-19}	6.6×10^{-12}	1.1×10^{-9}	8.7×10^{-11}	4.5×10^{-5}
5. System Failure on Demand	6.2×10^{-6}	2.2×10^{-10}	2.3×10^{-7}	2.5×10^{-5}	2.4×10^{-6}	9.9×10^{-5}
B. Containment Spray Actuation						
1. Logic Channels	3.0×10^{-7}	1.5×10^{-12}	4.5×10^{-9}	1.2×10^{-6}	7.2×10^{-8}	6.5×10^{-5}
2. Instrumentation	3.8×10^{-7}	4.9×10^{-12}	2.8×10^{-9}	1.4×10^{-6}	6.3×10^{-8}	-
3. Test and Maintenance	5.0×10^{-6}	2.0×10^{-10}	1.5×10^{-7}	1.9×10^{-5}	1.7×10^{-6}	2.0×10^{-5}
4. Common Cause	2.9×10^{-10}	9.1×10^{-19}	6.6×10^{-12}	1.1×10^{-9}	8.7×10^{-11}	1.0×10^{-3}
5. System Failu on Demand	5.7×10^{-6}	1.5×10^{-10}	2.7×10^{-7}	2.1×10^{-5}	2.4×10^{-6}	1.1×10^{-3}

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TABLE 2

INDIAN POINT 3 - SAFEGUARDS ACTUATION SYSTEM SIGNALS AND LOGIC

Parameter	Logic Arrangement	Setpoint*	Actuates	Remarks
1. SAFETY INJECTION ACTUATION				
a. Manual Safety Injection	One out of two pushbuttons	N/A	Equivalent to Auto SI.	One pushbutton only starts minimum required equipment. Both must be depressed to ensure all necessary equipment receives a start signal.
b. High Steam Line Flow in Conjunction with Low T_{avg} or Low Steam Line Pressure.	a. Two out of four High Steam Flow (one out of two signals for two out of four loops) in conjunction with: b. Two out of four Low T_{avg} or c. Two out of four Low Steam Line Pressure.	a. Programmed based on turbine first stage pressure. b. ≥540°F c. ≥600 psig	1. Auto SI a. Feedwater Isolation b. Reactor Trip c. Safeguards Sequence 1. Aux. Feedwater 2. Safety Injection 3. Fan Cooling 4. Service Water d. Containment Isolation Phase A e. Containment Ventilation Isolation f. Isolation Valve Seal Water System g. Control Room Ventilation Isolation 2. Steam Line Isolation	a. Two flow transmitters per steam line. One of two high generates high flow signal. Two of four signals required. b. Any two of four. c. Any two of four.
c. Steam Line Differential Pressure	One out of four channels of two out of three pressure comparison networks.	≤150 psid	Auto SI (see 1b. above)	
d. Low Pressurizer Pressure	Two out of three channels of pressurizer pressure.	≥1700 psig	Auto SI (see 1b. above)	Blocked by operation action during shutdown.
e. High Containment Pressure	Two out of three channels of containment pressure.	≤3.5 psig	Auto SI (see 1b. above)	
2. CONTAINMENT SPRAY ACTUATION				
a. Manual Spray	Two out of two pushbuttons.	N/A	a. Spray Actuation b. Containment Isolation Phase B (CIB) c. Containment Ventilation Isolation	

* Technical specification limit, actual setpoints may vary.

TABLE 2 (continued)

INDIAN POINT 3 - SAFEGUARDS ACTUATION SYSTEM SIGNALS AND LOGIC

Parameter	Logic Arrangement	Setpoint*	Actuates	Remarks
h. High-High Containment Pressure	Two sets of two out of three pressure signals (two out of three twice).	≤23 psig	a. Spray Actuation b. CIB c. Containment Ventilation Isolation d. Steam Line Isolation (through high steam flow relay)	1. The only automatic safeguards actuation signal which requires power at the trip bistable to trip (i.e., energized to trip).
3. MISCELLANEOUS SAFEGUARDS CIRCUITS				
a. Manual Steam Line Isolation	One pushbutton per loop (four loops).	N/A	None	Closes MSIVs only
b. Manual Containment Isolation	One out of two pushbuttons	N/A	a. CIA b. Isolation Valve Seal Water c. Containment Ventilation Isolation	
c. High Containment Activity	One of two (air particulate or radiogas)	Variable Setpoint	Containment Ventilation Isolation	Setpoint depends upon background radiation.
d. Safety Injection Manual Reset	Manual pushbuttons and timer	N/A	Resets Automatic Safety Injection Logic	Locked out by timer for two minutes. One reset for each train.
e. Containment Ventilation Isolation Reset	N/A	N/A	N/A	Resets signal
f. Containment Isolation Phase A Reset	N/A	N/A	N/A	Resets signal
g. Spray Actuation Reset	N/A	N/A	N/A	Resets signal
h. Containment Isolation Phase B Reset	N/A	N/A	N/A	Resets signal

* Technical specification limit, actual setpoint may vary.

TABLE 3

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
Logic Channel 1			
1. SI Automatic Actuation Relay SIA-1	a. C-A1		a. Containment Isolation Phase A
	b. 2SI01		b. Safeguards Sequencing
	c. SI-10X		c. Equipment Actuation Relays
	d. SI-11X		d. Equipment Actuation Relays
	e. SI-12X		e. Equipment Actuation Relays
	f. SI-13X		f. Equipment Actuation Relays
	g. SI-14X		g. Equipment Actuation Relays
	h. SI-15X		h. Equipment Actuation Relays
	i. VI		i. Vent Isolation Relay
2. SI Manual Actuation Relay SIM-1	a. VI		a. Vent Isolation Relay
	b. 2SI01		b. Safeguards Sequencing
	c. SI-10X		c. Equipment Actuation Relays (see below)
	d. SI-11X		d. Equipment Actuation Relays (see below)
	e. SI-12X		e. Equipment Actuation Relays (see below)
	f. SI-13X		f. Equipment Actuation Relays (see below)
	g. SI-14X		g. Equipment Actuation Relays (see below)
	h. SI-15X		h. Equipment Actuation Relays (see below)

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TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
3. Equipment Actuation Relay SI-10X	a. F1X		a. Feedwater Isolation Relay
	b. F2X		b. Feedwater Isolation Relay
	c. F3X		c. Feedwater Isolation Relay
	d. F4X		d. Feedwater Isolation Relay
		e. 42/CCBP31	e. Aux. CC Booster Pump 21
		f. 42/CCBP33	f. Aux. CC Booster Pump 33
		g. Valve 851B	g. High Head SIS Pump 32 Stop Valve
		h. Valve 746	h. RHR Loop Discharge Stop Valve
		i. Valve 822A	i. CCW Outlet from RHR Hx
		j. Valve 856A	j. High Head Branch Line Stop Valve
		k. Valve 856C	k. High Head Branch Line Stop Valve
		l. Valve 894A	l. Accumulator Discharge Stop
		m. Valve 894C	m. Accumulator Discharge Stop
4. Equipment Actuation Relay SI-11X		a. Valve 1835A	a. BIT Discharge Valve
		b. Valve 1825A	b. BIT Inlet Valve
		c. Valve SOV-1111	c. Nuclear Header SW to Conventional Pl nt
		d. Valve SOV-1112	d. Conventional Header SW to Conventional Plant
		e. 52/2AT5A	e. Bus 2A-5A Tie Breaker
5. Equipment Actuation Relay SI-12X		a. Reactor Trip	
		b. Valve SOV-1170	b. Containment Cooling Water (SW)
		c. Valve SOV-1276	c. Diesel Generator Cooling Water (SW)

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TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
5. continued		d. 12/CCWF	d. Containment cooling water low flow alarms
		e. Diesel Start (3)	e. 31, 33 Primary Auto Start, 32 Backup Auto Start
		f. Containment Recirculation Air Units Flow Control Valves	f. All FCVs
6. Equipment Actuation Relay SI-13X		a. 52/AF1 b. 52/AF3 c. BFBP Relay d. Reactor Trip e. BFPB3 Relay	a. Auxiliary Feedwater Pump 31 b. Auxiliary Feedwater Pump 33 c. AFW Pump Automatic Start Relay e. Block Automatic, Start AFW Pump 32
7. Equipment Actuation Relay SI-14X		a. Diesel Generator 31 Lockout ckt b. Diesel Generator 32 Lockout ckt c. Diesel Generator 33 Lockout ckt d. Air Conditioning, Control Room	
8. Equipment Actuation Relay SI-15X	a. SI-15AX	b. RHR Pumps (Bypass Trip Switch)	a. Auxiliary Relay (SI Pumps)
9. Steam Line Isolation Relay SLI	a. SIA-1 b. MS1 c. MS2 d. MS3 e. MS4		a. SI Actuation Relay b. MSIV 31 c. MSIV 32 d. MSIV 33 e. MSIV 34

TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
10. High Containment Pressure ASI	a. SLI b. SI		a. Steam Line Isolation Relay b. Containment Spray Relay
11. Containment Spray Relay SI	a. C-BI b. VI c. SI-IX		a. Containment Isolation Phase Phase B Relay b. Vent Isolation Relay c. CS Auxiliary Relay
12. Containment Spray Auxiliary Relay SI-IX		a. 52/CSI b. Valve 876A c. Valve 866A	a. Containment Spray Pump 31 b. Additive Tank Outlet c. CS Pump 31 Discharge
13. Containment Isolation Phase B Relay C-BI	a. C-B-11X		a. Containment Isolation Phase B Auxiliary Relay
14. Containment Phase B Auxiliary Relay C-B-11X		a. Valve 222 b. Valve PCV 1229 c. Valve 797 d. Valve 784 e. Valve FCV625	a. RCS Pump 1 Seal Return b. SJAE to Containment c. CC to RCS Pumps d. CC From RCP Motor Bearings e. CC From RCP Thermal Barrier
15. Containment Ventilation Isolation Relay VI		a. Containment Purge Valves b. Containment Pressure Relief Valves	a. To/From (All valves) b. To/From (All valves)

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TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
16. Containment Isolation Phase A Relay C-A1	a. C-A11X		a. Phase A Equipment Actuation Relays
	b. C-A12X		b. Phase A Equipment Actuation Relays
	c. C-A13X		c. Phase A Equipment Actuation Relays
	d. C-A14X		d. Phase A Equipment Actuation Relays
17. Phase A Equipment Actuation Relay C-A11X		a. Valve 200A	a. Letdown Flow control, 75 GPM oriface
		b. Valve 200B	b. Letdown Flow Control, 45 GPM oriface
		c. Valve 200C	c. Letdown Flow Control, 75 GPM oriface
		d. Valve 201	d. Letdown From Regenerative Hx
		e. H_2 Recombiner System Isolation Valve	
		f. Valve 519	f. Makeup to Pressurizer Relief Tank
		g. Valve 548	g. Gas Analyzer - Pressurizer Relief Tank
		h. Valve 791	h. CC to Excess Letdown Hx
		i. Valve 793	i. CC From Excess Letdown Hx
		j. PCV-1229	j. SJAE Containment Isolation
18. Phase A Equipment Actuation Relay C-A12X		a. Valve 4505	a. Seal Water for S/G Blowdown Sample
		b. Valve 956A	b. Sample - Pressurizer Steam
		c. Valve 956C	c. Sample - Pressurizer Liquid

TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
18. continued		d. Valve 956E	d. Sample - RCS
		e. H_2 Recombiner System Isolation Valve	
		f. Valve 1410 (open)	f. IVSW Isolation Valve (opens)
		g. Valve 956G	g. Accumulator Sample
		h. Valve 1702	h. RC Drain Tank to WDS Holdup Tank
		i. Valve 1723	i. Containment Sump Pumps to WDS Holdup Tank
19. Phase A Equipment Actuation Relay C-A13X		a. Valve 1785	a. Vent Header From RC Drain Tank
		b. Valve 1788	b. Gas Analyzer - RC Drain Tank
		c. S/G Blowdown and Sample Isolation Valves	c. (17 Valves)
		d. Containment RAD Monitor Sol Valve	d. SOV 1534 (C), 1538 (O), 1536 (C), 1540 (O)
		e. Inst. Air Valve	e. PCV-1228
20. Phase A Equipment Actuation Relay C-A14X		a. Valve 956J	a. Gross Failed Fuel Det. System
		b. Pers Lock Valve	
		c. Equipment Hatch Lock Valve	
Logic Channel Z			
1. SI Automatic Actuation Relay SIA-2	a. C-A2		a. Containment Isolation Phase A Relay
	b. 2SID2		b. Safeguards Sequencing
	c. SI-20X		c. Equipment Actuation Relays
	d. SI-21X		d. Equipment Actuation Relays

TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
1. continued	e. SI-22X		e. Equipment Actuation Relays
	f. SI-23X		f. Equipment Actuation Relays
	g. SI-24X		g. Equipment Actuation Relays
	h. SI-25X		h. Equipment Actuation Relays
	i. V2		i. Vent Isolation Relay
2. SI Manual Actuation SIM-2	a. V2		a. Vent Isolation Relay
	b. 2SID2		b. Safeguards Sequencing
	c. SI-20X		c. Equipment Actuation Relays
	d. SI-21X		d. Equipment Actuation Relays
	e. SI-22X		e. Equipment Actuation Relays
	f. SI-23X		f. Equipment Actuation Relays
	g. SI-24X		g. Equipment Actuation Relays
	h. SI-25X		h. Equipment Actuation Relays
3. Equipment Actuation Relay SI-20X	a. F11X		a. Feedwater Isolation Relay
	b. F12X		b. Feedwater Isolation Relay
	c. F13X		c. Feedwater Isolation Relay
	d. F14X		d. Feedwater Isolation Relay
		e. 42/CCBP32	e. Auxiliary CC Booster Pump 32
		f. 42/CCBP34	f. Aux. CC Booster Pump 34
		g. Valve 851A	g. High Head SIS Pump 32 Stop Valve
		h. Valve 747	h. RHR Loop Discharge Stop Valve
		i. Valve 822B	i. CCW Outlet From RHR Hx
		j. Valve 856B	j. High Head Branch Line Stop Valve
		k. Valve 856D	k. High Head Branch Line Stop Valve
		l. Valve 894B	l. Accumulator Discharge Stop
		m. Valve 894D	m. Accumulator Discharge Stop

TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
4. Equipment Actuation Relay SI-21X		a. Valve 1835B	a. BIT Discharge Valve
		b. Valve 1852B	b. BIT Inlet Valve
		c. Valve SOV-1111	c. Nuclear Header SW to Conventional Plant
		d. Valve SOV-1112	d. Conventional Header SW to Conventional Plant
		e. 52/3AT6A	e. Bus 3A-6A Tie Breaker
5. Equipment Actuation Relay SI-22X		a. Reactor Trip	
		b. Valve SOV-1171	b. Containment Cooling Water (SW)
		c. Valve SOV-1276A	c. Diesel Generator Cooling Water (SW)
		d. 12/CCWF	d. Containment cooling water low flow alarm
		e. Diesel Start (3)	e. 31, 33 Backup Auto Start, 32 Primary Auto Start
		f. Containment Recirculation Air Units Flow Control Valves	f. All FCVs
6. Equipment Actuation Relay SI-23X		a. 52/AF1	a. Auxiliary Feedwater Pump 31
		b. 52/AF3	b. Auxiliary Feedwater Pump 33
		c. BFPD Relay	c. AFW Pump Auto Start Relay
		d. Reactor Trip	
		e. BFPD3 Relay	e. Block Auto Start AFW Pump 32
7. Equipment Actuation Relay SI-24X		a. Diesel Generator 31 Lockout ckt	
		b. Diesel Generator 32 Lockout ckt	
		c. Diesel Generator 33 Lockout ckt	
		d. Air Conditioning, Control Room	

TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
8. Equipment Actuation Relay SI-25X	a. SI-25A	b. RHR Pumps (Bypass Trip Switch)	a. Auxiliary Relay (SI Pumps)
9. Steam Line Isolation Relay SL2	a. SIA-2 b. MS11 c. MI12 d. MS13 e. MS14		a. SI Actuation Relay b. MSIV 31 c. MSIV 32 d. MSIV 33 e. MSIV 34
10. High Contain-ment Pressure Relay AS2	a. SL2 b. S2		a. Steam Line Isolation Relay b. Containment Spray Relay
11. Containment Spray Relay S2	a. C-B2 b. V2 c. S2-1X		a. Containment Isolation Phase B Relay b. Vent Isolation Relay c. CS Auxiliary Relay
12. Containment Spray Auxiliary Relay S2-1X		a. 52/CS2 b. Valve 876B c. Valve 866B	a. Containment Spray Pump 32 b. Additive Tank Outlet c. CS Pump 32 Discharge
13. Containment Isolation Phase B Relay C-B2	a. C-B-21X		a. Containment Isolation Phase B Auxiliary Relay

TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
14. Containment Isolation Phase B Auxiliary Relay C-B-21X		a. Valve 222	a. RCS Pump 1 Seal Return
		b. Valve PCV 1230	b. SJAE to Containment
		c. Valve 769	c. CC to RCS Pumps
		d. Valve 786	d. CC From RCP Motor Bearings
		e. Valve 789	e. CC From RCP Thermal Barrier
15. Containment Ventilation Isolation Relay V2		a. Containment Purge Valves	a. To/From (All valves)
		b. Containment Pressure Relief Valves	b. To/From (All valves)
16. Containment Isolation Phase A Relay C-A2	a. C-A21X		a. Phase A Equipment Actuation Relays
	b. C-A22X		b. Phase A Equipment Actuation Relays
	c. C-A23X		c. Phase A Equipment Actuation Relays
	d. C-A24X		d. Phase A Equipment Actuation Relays
17. Phase A Equipment Actuation Relay C-A21X		a. Valve 202	a. Letdown From Regenerative Hx
		b. H_2 Recombiner System Isolation Valve	
		c. Valve 552	c. Makeup to Pressurizer Relief Tank
		d. Valve 549	d. Gas Analyzer - Pressurizer Relief Tank
		e. Valve 796	e. CC From Excess Letdown Hx
		f. Valve 798	f. CC to Excess Letdown Hx

TABLE 3 (continued)

INDIAN POINT 3 SAFEGUARDS ACTUATION RELAYS/ACTUATED EQUIPMENT

Logic Channel and Relay	Device Actuated	Equipment Actuated	Remarks
18. Phase A Equipment Actuation Relay C-A22X		a. Valve 4506	a. Seal water for S/G Blowdown Sample
		b. Valve 956B	b. Sample - Pressurizer Sample
		c. Valve 956D	c. Sample - Pressurizer Liquid
		d. Valve 956F	d. Sample - RCS
		e. H_2 Recombiner System Isolation Valve	
		f. Valve 1413 (open)	f. IVSW Isolation Valve (opens)
		g. Valve 956H	g. Accumulator Sample
		h. Valve 1705	h. RC Drain Tank to WDS Holdup Tank
		i. Valve 1728	i. Containment Sump Pumps to WDS Holdup Tank
19. Phase A Equipment Actuation Relay C-A23X		a. Valve 1787	a. Vent Header from RC Drain Tank
		b. Valve 1789	b. Gas Analyzer RC Drain Tank
		c. S/G Blowdown and Sample Isolation Valves	c. (17 Valves)
		d. Containment RAD Monitor Sol Valve	d. SOV 1537 (C), 1541 (O), 1535 (C), 1539 (O)
		e. Instrument Air Valve	e. PCV-1228
20. Phase A Equipment Actuation Relay C-A24X		a. Valve 956K	a. Gross Failed Fuel Det. System Isolation Valve
		b. Pers. Lock Valve	
		c. Equipment Hatch Lock Valve	

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TABLE 4

SAFEGUARDS ACTUATION SYSTEM BASIC EVENT DATA

Event Description and Failure Mode	Fault Tree Coding	Failure Data					Comments
		Mean	H/D	Variance	MTTR	Reference*	
1. No output from DC Bus No. 31	4BS--31D	N/A	-	-	-	-	See E. P. analysis
2. No output from DC Bus No. 32	4BS--32D	N/A	-	-	-	-	See E. P. analysis
3. No output from AC Instrument Bus No. 31	JBSAC31D	N/A	-	-	-	-	See E. P. analysis
4. No output from AC Instrument Bus No. 32	JBSAC32D	N/A	-	-	-	-	See E. P. analysis
5. No output from AC Instrument Bus No. 34	JBSAC34D	N/A	-	-	-	-	See E. P. analysis
6. No operator initiation of safety injection	MHOOPACT	1.0	-	0	-	-	Quantified in text
7. Safeguards Relay, A-1, fails to close	MRESIA1S	1.15×10^{-5}	D	3.38×10^{-9}	-	37	
8. Safeguards Relay, A-2, fails to close	MRESIA2S	1.15×10^{-5}	D	3.38×10^{-9}	-	37	
9. SI Manual Relay, M[illegible] fails to close	MRESIM1S	1.15×10^{-5}	D	3.38×10^{-9}	-	37	
10. SI Manual Relay, [illegible], fails to close	MRESIM2S	1.15×10^{-5}	D	3.38×10^{-9}	-	37	
11. Short across Reset, [illegible]	MPBRS1-F	4.28×10^{-7}	H	3.36×10^{-10}	360 hours	41	
12. Short across Reset, [illegible]-2	MPBRS2-F	4.28×10^{-7}	H	3.36×10^{-10}	360 hours	41	
13. Short across Norm[illegible] Defeat Switch 1	MSWNODF1	4.28×10^{-7}	H	3.36×10^{-10}	360 hours	41	
14. Short across Normal Defeat Switch 2	MSWNODF2	4.28×10^{-7}	H	3.36×10^{-10}	360 hours	41	
15. DC fuse 2-1, opens prematurely	MFU02-1K	8.32×10^{-7}	H	1.08×10^{-9}	1 hour	36	
16. DC fuse 3-1, opens prematurely	MFU03-1K	8.32×10^{-7}	H	1.08×10^{-9}	1 hour	36	
17. DC fuse 2-2, opens prematurely	MFU02-2K	8.32×10^{-7}	H	1.08×10^{-9}	1 hour	36	
18. DC fuse 3-2, opens prematurely	MFU03-2K	8.32×10^{-7}	H	1.08×10^{-9}	1 hour	36	
19. Equipment Actuation Relay, 10x, fails to close	MRE10X-S	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
20. Equipment Actuation Relay, 20x, fails to close	MRE20X-S	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
21. Equipment Actuation Relay, 11x, fails to close	MRE11X-S	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
22. Equipment Actuation Relay, 21x, fails to close	MRE21X-S	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
23. Equipment Actuation Relay, 12x, fails to close	MRE12X-S	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
24. Equipment Actuation Relay, 22x, fails to close	MRE22X-S	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
25. Equipment Actuation Relay, 13x, fails to close	MRE13X-S	6.28×10^{-6}	D	2.49×10^{-11}	-	46	

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

TABLE 4 (continued)

SAFEGUARDS ACTUATION SYSTEM BASIC EVENT DATA

Event Description and Failure Mode	Fault Tree Coding	Failure Data					Comments
		Mean	H/D	Variance	MTTR	Reference*	
26. Equipment Actuation Relay, 23x, fails to close	MRE23X-S	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
27. Equipment Actuation Relay, 14x, fails to close	MRE14X-S	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
28. Equipment Actuation Relay, 24x, fails to close	MRE24X-S	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
29. Equipment Actuation Relay, 15x, fails to close	MRE15X-S	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
30. Equipment Actuation Relay, 25x, fails to close	MRE25X-S	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
31. Steam Line Isolation Relay SL1, fails to close	MRESL1-S	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
32. Steam Line Isolation Relay SL2, fails to close	MRESL2-S	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
33. Containment Spray Relay, AS1, fails to close	MREAS1-S	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
34. Containment Spray Relay, AS2, fails to close	MREAS2-S	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
35. Pressurizer Pressure Transmitter Network 455, fails to provide a trip signal	MPT455-S	1.66 x 10^{-6}	H	6.28 x 10^{-12}	4 hours	40	
36. Pressurizer Pressure Transmitter Network 456, fails to provide a trip signal	MPT456-S	1.66 x 10^{-6}	H	6.28 x 10^{-12}	4 hours	40	
37. Pressurizer Pressure Transmitter Network 457, fails to provide a trip signal	MPT457-S	1.66 x 10^{-6}	H	6.28 x 10^{-12}	4 hours	40	
38. Containment Pressure Transmitter Network 948A, fails to provide a trip signal	MPT948AS	1.66 x 10^{-6}	H	6.28 x 10^{-12}	84 hours	40	
39. Containment Pressure Transmitter Network 948B, fails to provide a trip signal	MPT948BS	1.66 x 10^{-6}	H	6.28 x 10^{-12}	84 hours	40	
40. Containment Pressure Transmitter Network 948C, fails to provide a trip signal	MPT948CS	1.66 x 10^{-6}	H	6.28 x 10^{-12}	84 hours	40	
41. No trip signal from Pressurizer Low Pressure Network, 455D	MPC455DS	6.67 x 10^{-6}	D	2.50 x 10^{-11}	-		Made up of logic relay and bistable
- logic relay	-	6.28 x 10^{-6}	D	2.49 x 10^{-11}	-	46	
- bistable	-	3.88 x 10^{-7}	D	1.47 x 10^{-13}	-	39	

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

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TABLE 4 (continued)

SAFEGUARDS ACTUATION SYSTEM BASIC EVENT DATA

Event Description and Failure Mode	Fault Tree Coding	Failure Data					Comments
		Mean	H/D	Variance	MTTR	Reference*	
42. No trip signal from Pressurizer Low Pressure Network, 456D	MPC456DS	6.67×10^{-6}	D	2.50×10^{-11}	-		Made up of logic relay and bistable
- logic relay	-	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
- bistable	-	3.88×10^{-7}	D	1.47×10^{-13}	-	39	
43. No trip signal from Pressurizer Low Pressure Network, 457D	MPC457DS	6.67×10^{-6}	D	2.50×10^{-11}	-		Made up of logic relay and bistable
- logic relay	-	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
- bistable	-	3.88×10^{-7}	D	1.47×10^{-13}	-	39	
44. No trip signal from Containment High Pressure Network, 948D	MPC948DS	6.67×10^{-6}	D	2.50×10^{-11}	-		Made up of logic relay and bistable
- logic relay	-	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
- bistable	-	3.88×10^{-7}	D	1.47×10^{-13}	-	39	
45. No trip signal from Containment High Pressure Network, 948E	MPC948ES	6.67×10^{-6}	D	2.50×10^{-11}	-		Made up of logic relay and bistable
- logic relay	-	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
- bistable	-	3.88×10^{-7}	D	1.47×10^{-13}	-	39	
46. No trip signal from Containment High Pressure Network, 948F	MPC948FS	6.67×10^{-6}	D	2.50×10^{-11}	-		Made up of logic relay and bistable
- logic relay	-	6.28×10^{-6}	D	2.49×10^{-11}	-	46	
- bistable	-	3.88×10^{-7}	D	1.47×10^{-13}	-	39	
47. No operator initiation of Containment Spray	MMANCSSS	1.0	-	0	-	-	Quantified in text
48. Containment Spray Relay, S1-0, fails to close	MRES1--S	1.15×10^{-5}	D	3.38×10^{-9}	-	37	
49. Containment Spray Relay, S2-0, fails to close	MRES2--S	1.15×10^{-5}	D	3.38×10^{-9}	-	37	
50. Containment Spray Auxiliary Relay, S11X, fails to close	MRES11XS	6.28×10^{-6}	D	2.49×10^{-4}	-	46	
51. Containment Spray Auxiliary Relay, S21X, fails to close	MRES21XS	6.28×10^{-6}	D	2.49×10^{-4}	-	46	

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

TABLE 4 (continued)

SAFEGUARDS ACTUATION SYSTEM BASIC EVENT DATA

	Event Description and Failure Mode	Fault Tree Coding	Failure Data					Comments
			Mean	H/D	Variance	MTTR	Reference*	
52.	Short across Containment Spray Reset Relay, S1-R	MRECS1RE	4.28×10^{-7}	H	3.36×10^{-10}	360 hours	41	
53.	Short across Containment Spray Reset Relay, S2-R	MRECS2RE	4.28×10^{-7}	H	3.36×10^{-10}	360 hours	41	
54.	Containment Presure Transmitter Network 949A, fails to provide a trip signal	MPT949AS	1.66×10^{-6}	H	6.28×10^{-12}	84 hours	40	
55	Containment Presure Transmitter Network 949B, fails to provide a trip signal	MPT949BS	1.66×10^{-6}	H	6.28×10^{-12}	84 hours	40	
56.	Containment Presure Transmitter Network 949C, fails to provide a trip signal	MPT949CS	1.66×10^{-6}	H	6.28×10^{-12}	84 hours	40	
57.	No trip signal from Containment Hi-Hi Pressure Network, 948A	MPC948AS	6.67×10^{-6}	D	2.50×10^{-11}	-	-	Made up of logic relay and bistable
	- logic relay		6.28×10^{-6}	D	2.49×10^{-11}	-	46	
	- bistable		3.88×10^{-7}	D	1.47×10^{-13}	-	39	
58.	No trip signal from Containment Hi-Hi Pressure Network, 948B	MPC948BS	6.67×10^{-6}	D	2.50×10^{-11}	-	-	Made up of logic relay and bistable
	- logic relay		6.28×10^{-6}	D	2.49×10^{-11}	-	46	
	- bistable		3.88×10^{-7}	D	1.47×10^{-13}	-	39	
59.	No trip signal from Containment Hi-Hi Pressure Network, 948C	MPC948CS	6.67×10^{-6}	D	2.50×10^{-11}	-	-	Made up of logic relay and bistable
	- logic relay		6.28×10^{-6}	D	2.49×10^{-11}	-	46	
	- bistable		3.88×10^{-7}	D	1.47×10^{-13}	-	39	
60.	No trip signal from Containment Hi-Hi Pressure Network, 949A	MPC949AS	6.67×10^{-6}	D	2.50×10^{-11}	-	-	Made up of logic relay and bistable
	- logic relay		6.28×10^{-6}	D	2.49×10^{-11}	-	46	
	- bistable		3.88×10^{-7}	D	1.47×10^{-13}	-	39	

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

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TABLE 4 (continued)

SAFEGUARDS ACTUATION SYSTEM BASIC EVENT DATA

Event Description and Failure Mode	Fault Tree Coding	Failure Data: Mean	H/D	Variance	MTTR	Reference*	Comments
61. No trip signal from Containment Hi-Hi Pressure Network, 949B	MPC949BS	6.67×10^{-6}	D	2.50×10^{-11}	-	-	Made up of logic relay and bistable
- logic relay		6.28×10^{-6}	D	2.49×10^{-11}	-	46	
- bistable		3.88×10^{-7}	D	1.47×10^{-13}	-	39	
62. No trip signal from Containment Hi-Hi Pressure Network, 949C	MPC949CS	6.67×10^{-6}	D	2.50×10^{-11}	-	-	Made up of logic relay and bistable
- logic relay		6.28×10^{-6}	D	2.49×10^{-11}	-	46	
- bistable		3.88×10^{-7}	D	1.47×10^{-13}	-	39	

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

TABLE 5

INDIAN POINT 3 RESULTS TABLE - SAFEGUARDS ACTUATION SYSTEM

Event Description	Mean	Variance	Effect on System	Mean	Variance
A. SAFETY INJECTION ACTUATION					
1. SI Channel Logic	3.64×10^{-4}	1.02×10^{-6}	Loss of a single channel, no effect on system.	--	--
2. SI Logic--Two Channels	1.19×10^{-6}	2.34×10^{-11}	System failure.	1.19×10^{-6}	2.34×10^{-11}
3. Instrumentation Failure	1.56×10^{-16}	2.59×10^{-30}	No signal to SI - system failure.	1.56×10^{-16}	2.59×10^{-30}
4. Test and Maintenance and Random Failures	5.05×10^{-6}	1.99×10^{-10}	System failure.	5.05×10^{-6}	1.99×10^{-10}
5. Common Cause Miscalibration of Sensors	2.94×10^{-10}	9.13×10^{-19}	No signal to SI - system failure.	2.94×10^{-10}	9.13×10^{-19}
6. System Failure on Demand (SI)	--	--	--	6.24×10^{-6}	2.20×10^{-10}
B. CONTAINMENT SPRAY ACTUATION					
1. CS Channel Logic	1.85×10^{-4}	2.54×10^{-7}	Loss of single channel; loss of 1/2 CS pumps.	--	--
2. CS Logic--Two Channels	2.49×10^{-7}	1.46×10^{-12}	System failure.	2.99×10^{-7}	1.46×10^{-12}
3. Instrumentation Failure	3.75×10^{-7}	4.85×10^{-12}	No signal to CS - sy 'em failure.	3.75×10^{-7}	4.85×10^{-12}
4. Test and Maintenance and Random Failures.	5.05×10^{-6}	1.99×10^{-10}	System Failure.	5.05×10^{-6}	1.99×10^{-10}
5. Common Cause Miscalculation of Sensors	2.94×10^{-10}	9.13×10^{-19}	No signal to CS - system failure.	2.94×10^{-10}	9.13×10^{-19}
6. System Failure on Demand (CS)	--	--		5.66×10^{-6}	1.49×10^{-10}

0713A

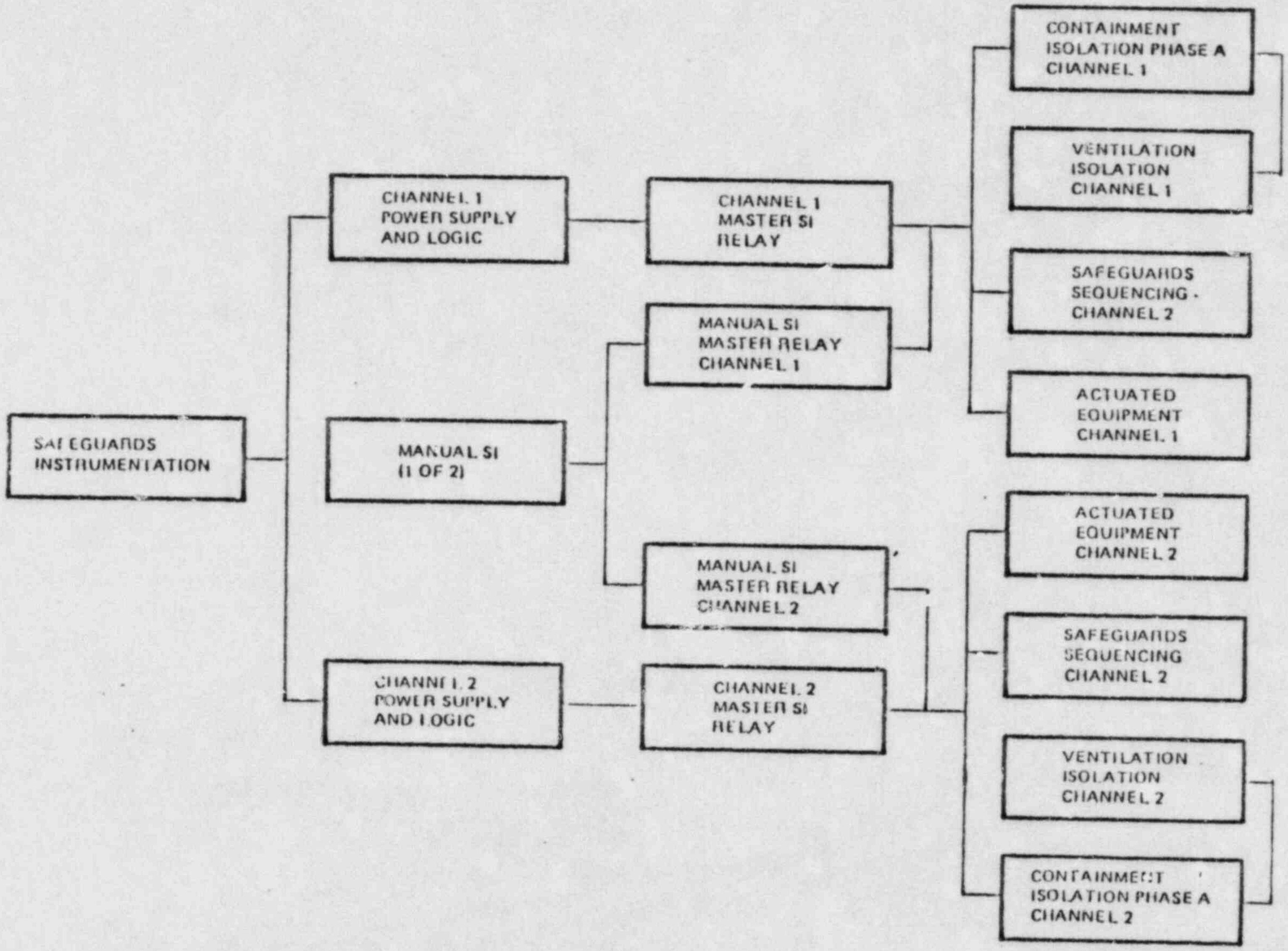


Figure 1. Indian Point 3 Safeguards Actuation Safety Injection Subsystem

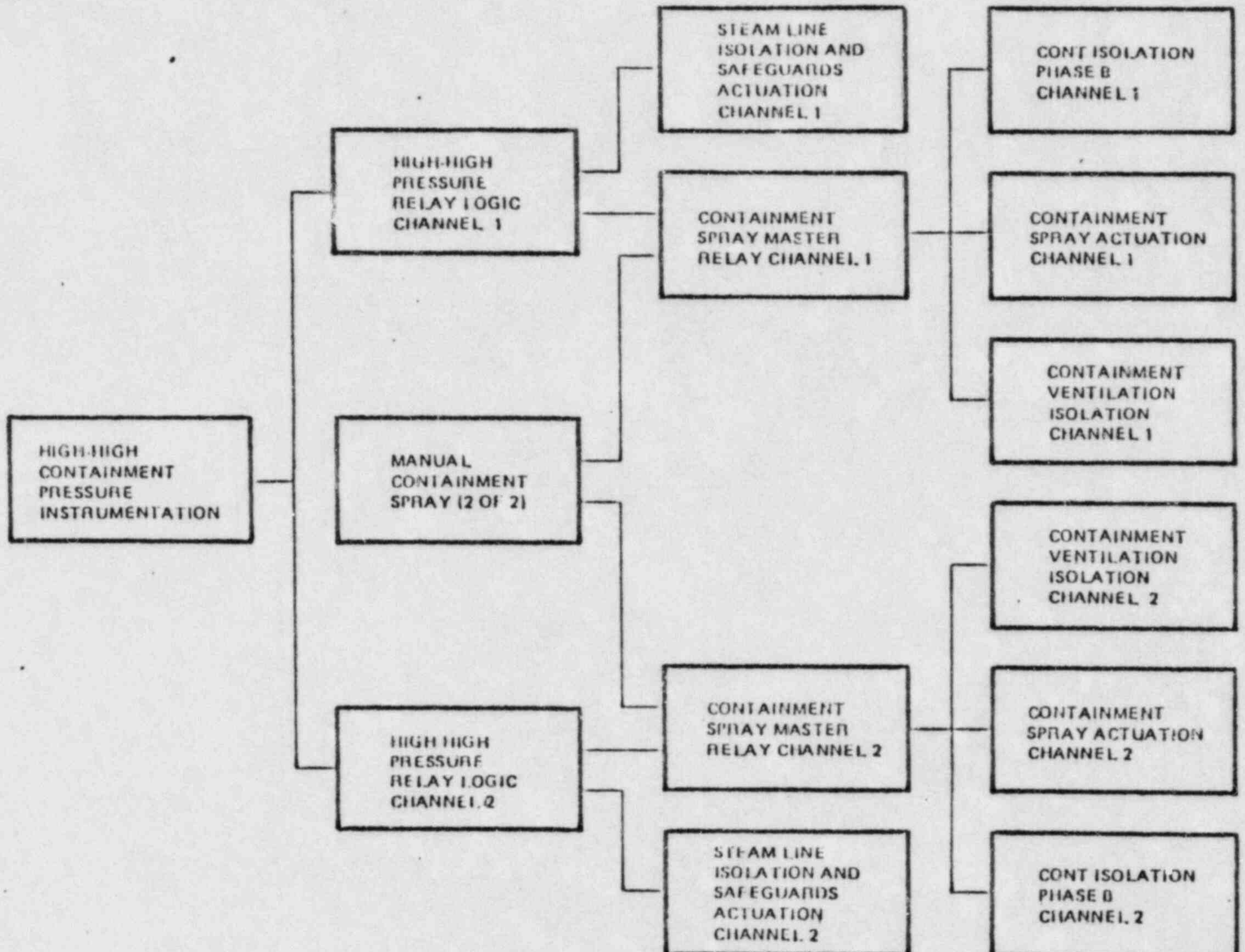


Figure 2. Indian Point 3 Safeguards Actuation Containment Spray Subsystem

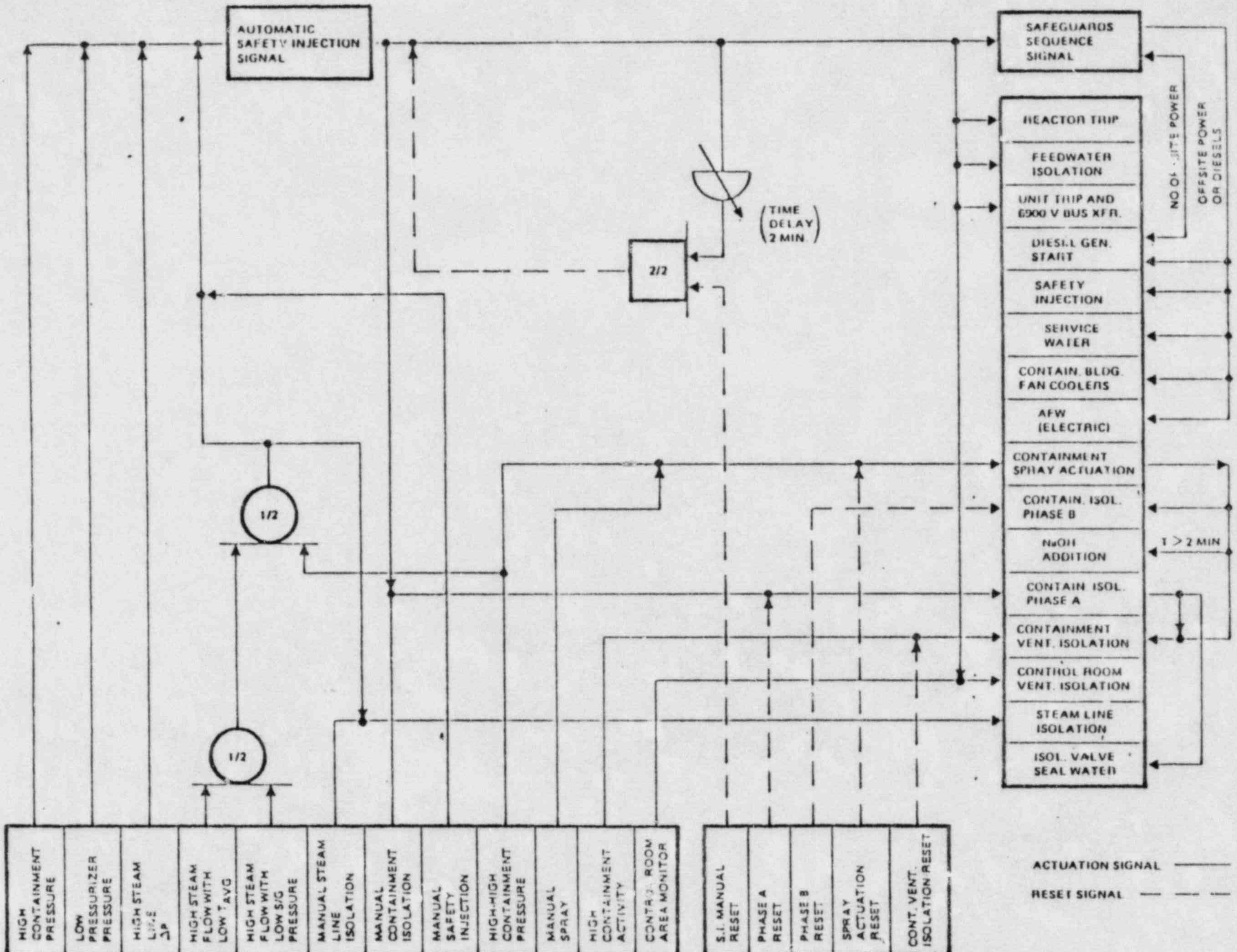


Figure 3. Indian Point 3 Safeguards Actuation System Functional Block Diagram Relationships

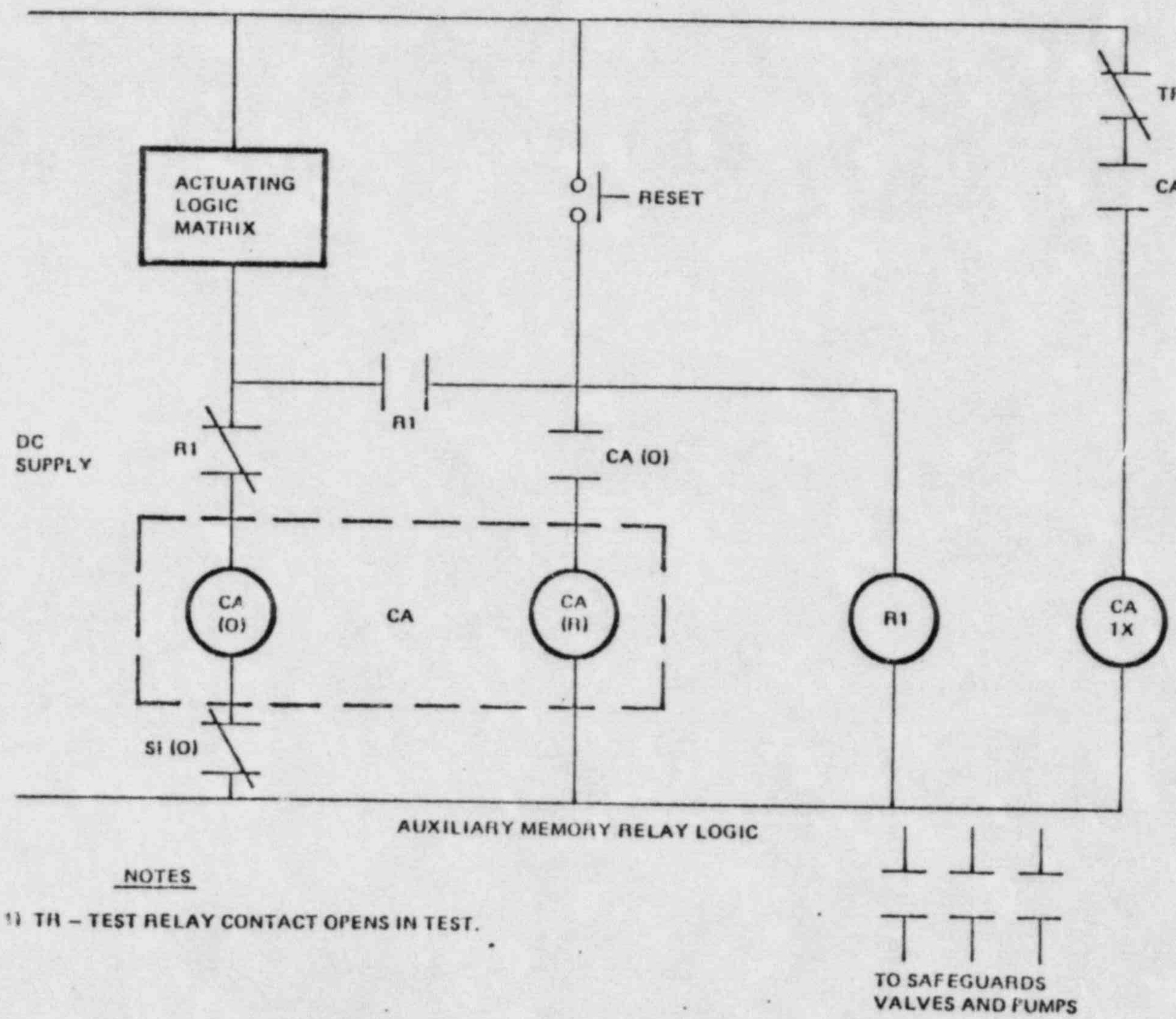


Figure 4. Indian Point 3 Safeguards Actuation Logic Arrangement - Master/Reset Relay

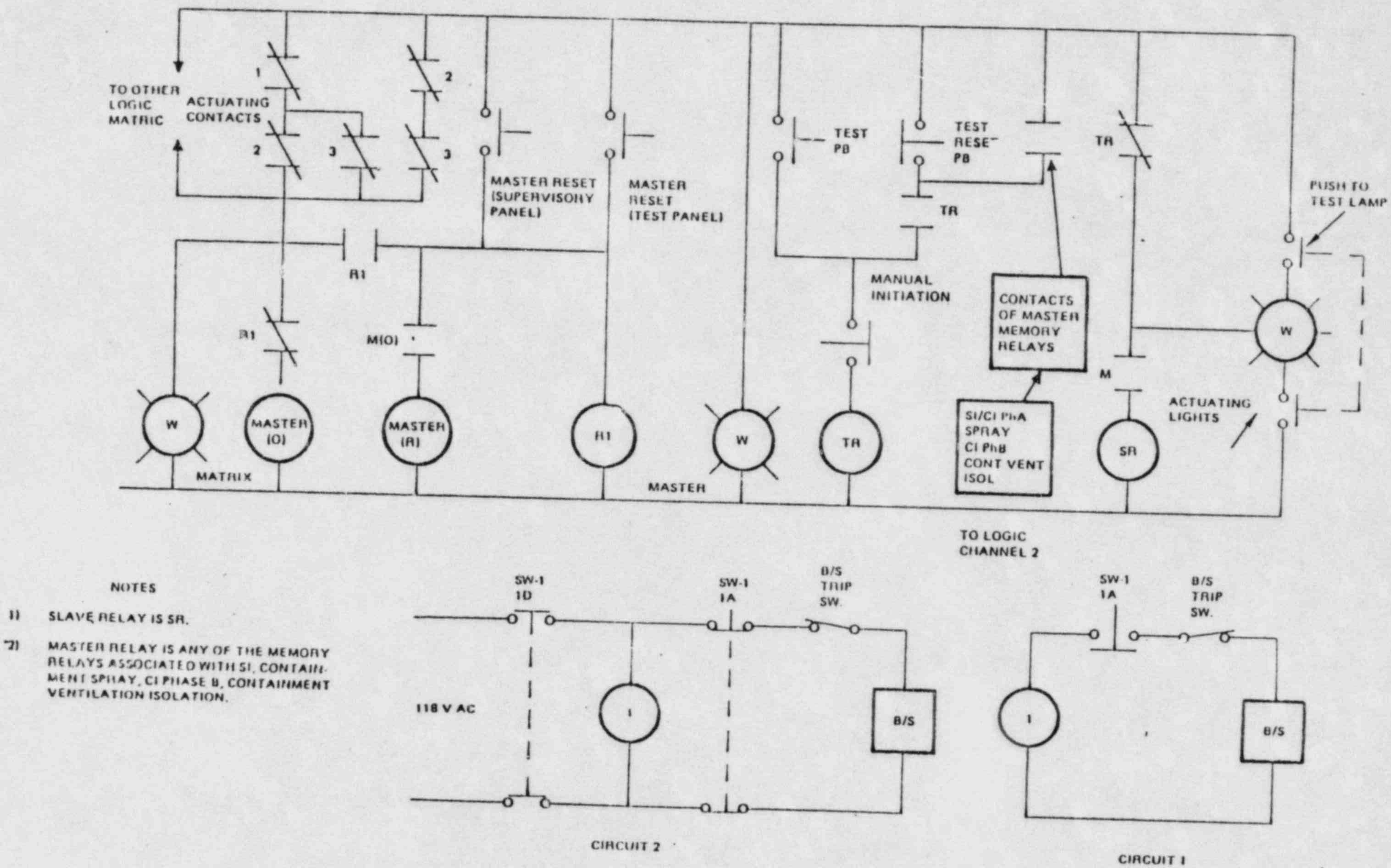
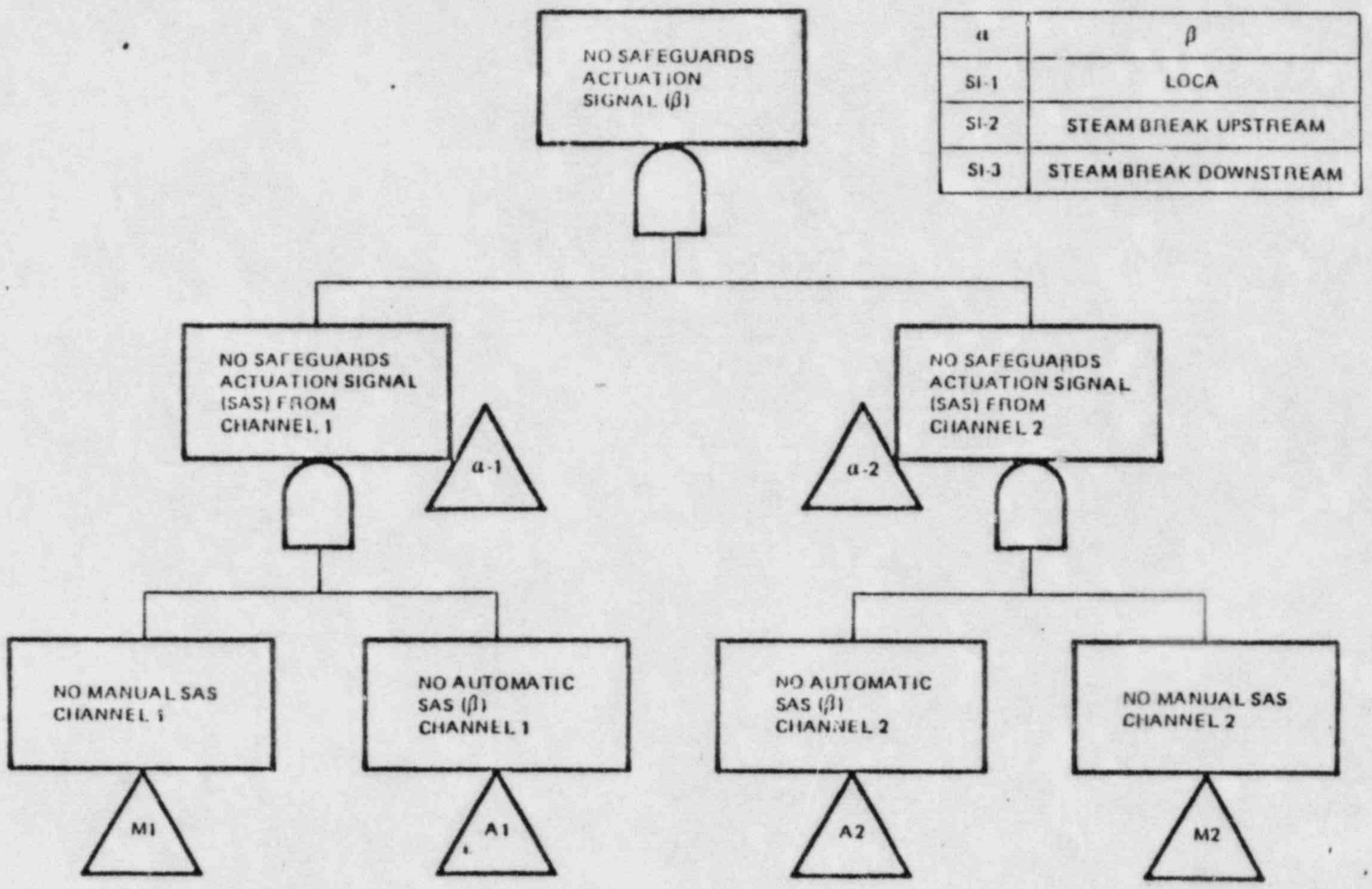
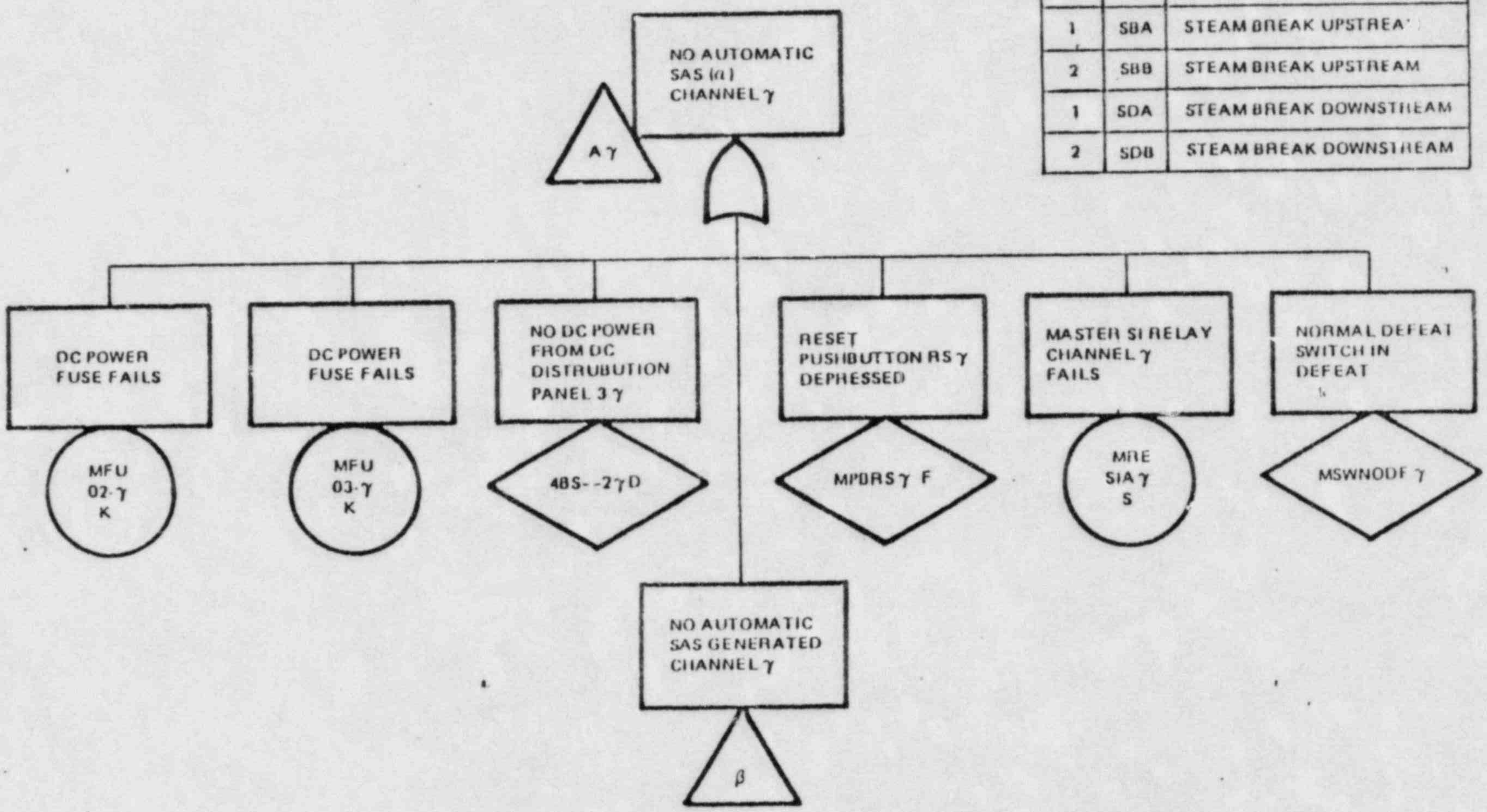


Figure 5. Indian Point 3 Safeguards Actuation Test Circuits



α	β
SI-1	LOCA
SI-2	STEAM BREAK UPSTREAM
SI-3	STEAM BREAK DOWNSTREAM

Figure 6. Indian Point 3 Safeguards Actuation System Fault Tree (Sheet 1 of 19)



γ	β	α
1	LOA	LOCA
2	LOB	LOCA
1	SBA	STEAM BREAK UPSTREAM
2	SBB	STEAM BREAK UPSTREAM
1	SDA	STEAM BREAK DOWNSTREAM
2	SDB	STEAM BREAK DOWNSTREAM

Figure 6. (Sheet 2 of 19)

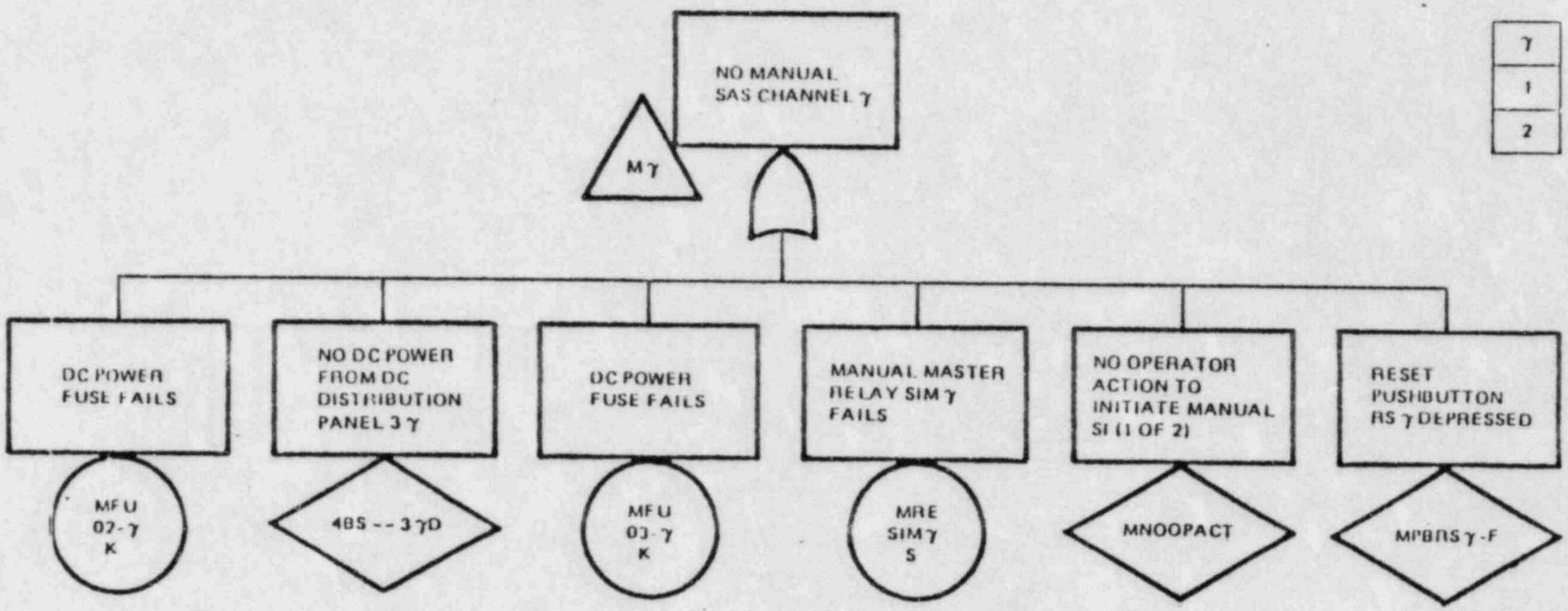


Figure 6. (Sheet 3 of 19)

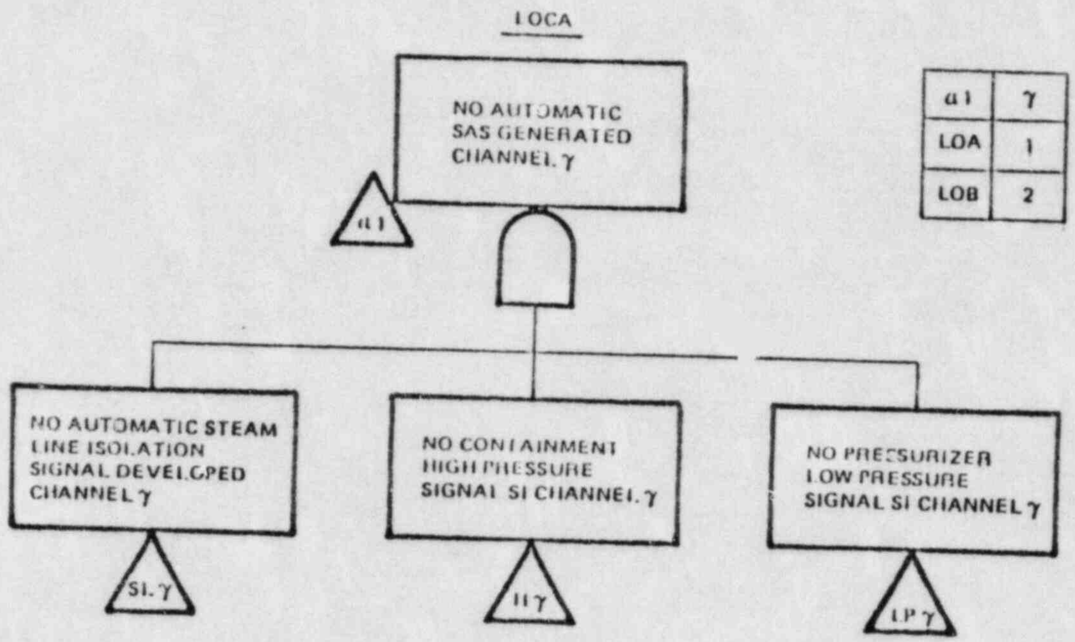


Figure 6. (Sheet 4 of 19)

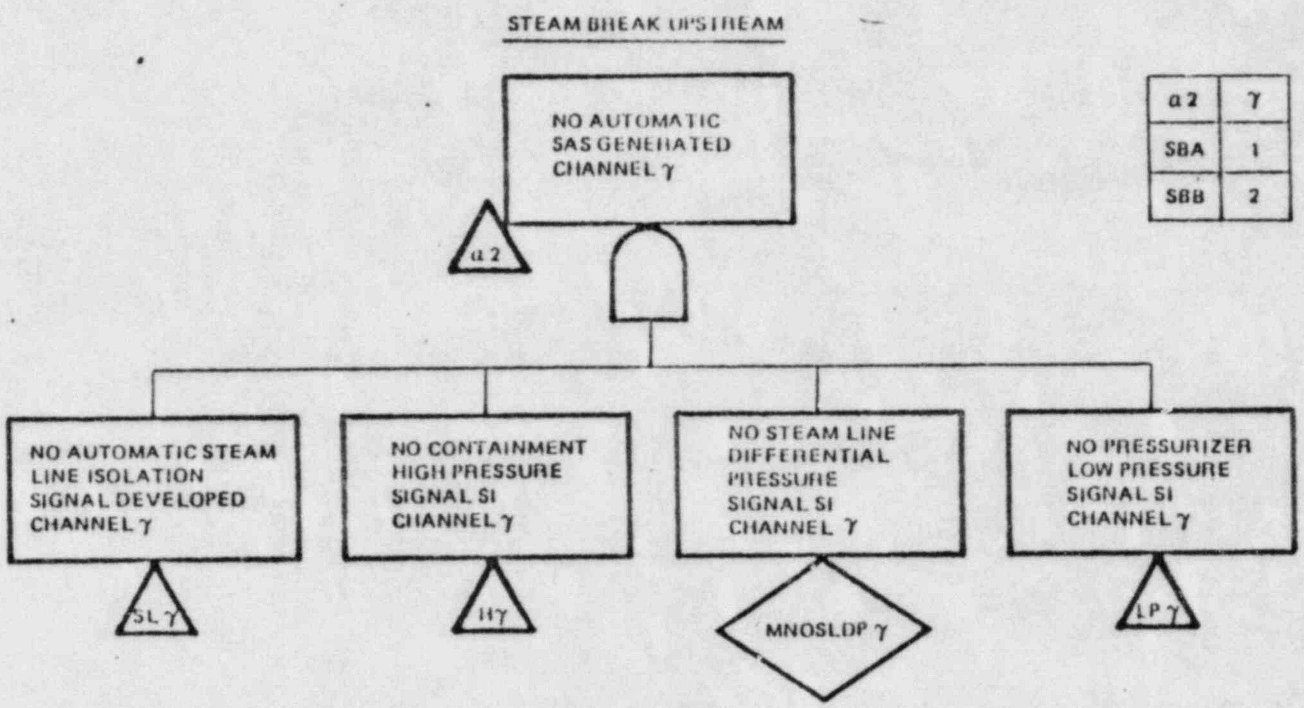


Figure 6. (Sheet 5 of 19)

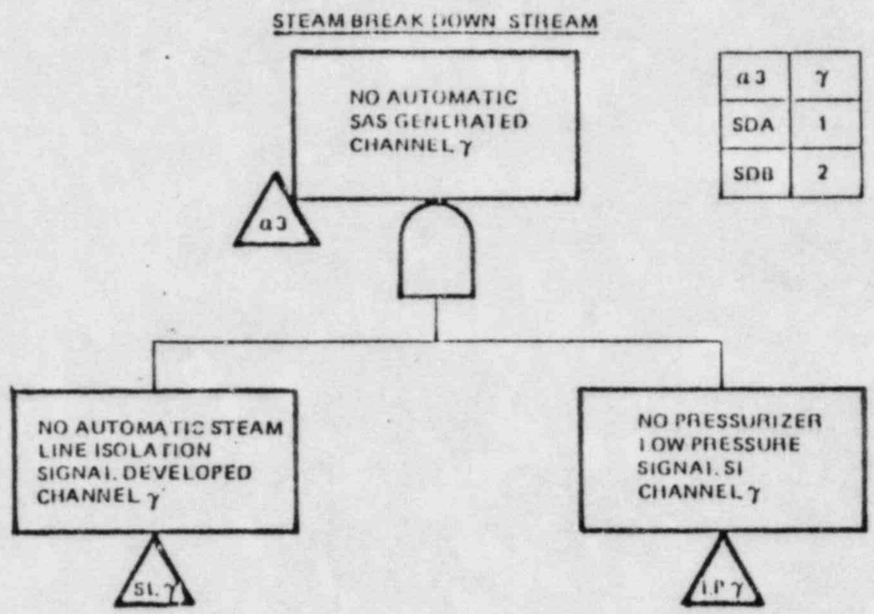
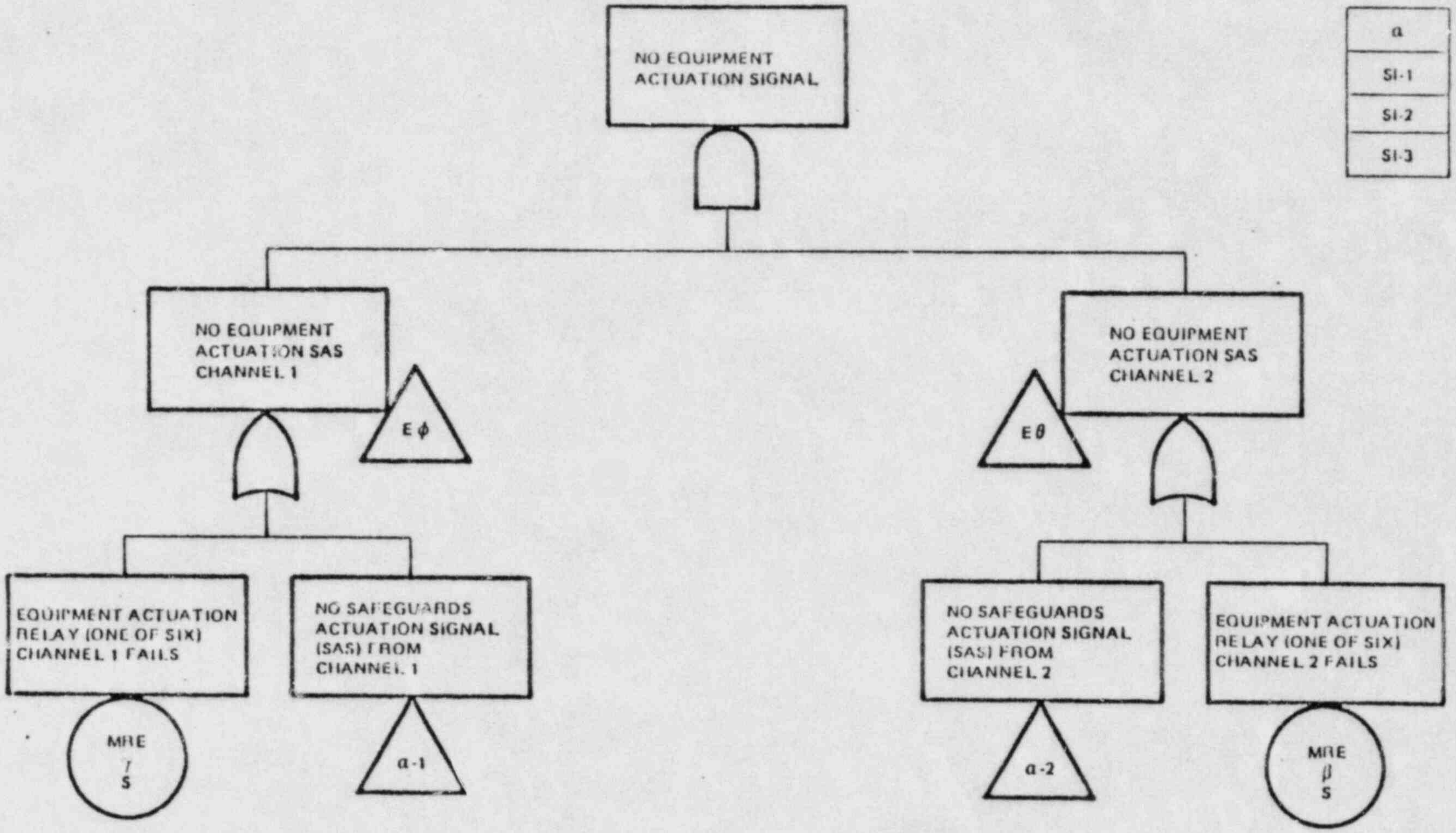


Figure 6. (Sheet 6 of 19)



a
SI-1
SI-2
SI-3

Eφ	γ	6 RELAYS	
E10	10X-	SI-10X	NOTE: SEE TABLE 3 FOR ACTUATED EQUIPMENT
E11	11X-	SI-11X	
E12	12X-	SI-12X	
E13	13X-	SI-13X	
E14	14X-	SI-14X	
E15	15X-	SI-15X	

Eθ	β	6 RELAYS	
E20	20X-	SI-20X	NOTE: SEE TABLE 3 FOR ACTUATED EQUIPMENT
E21	21X-	SI-21X	
E22	22X-	SI-22X	
E23	23X-	SI-23X	
E24	24X-	SI-24X	
E25	25X-	SI-25X	

Figure 6. (Sheet 7 of 19)

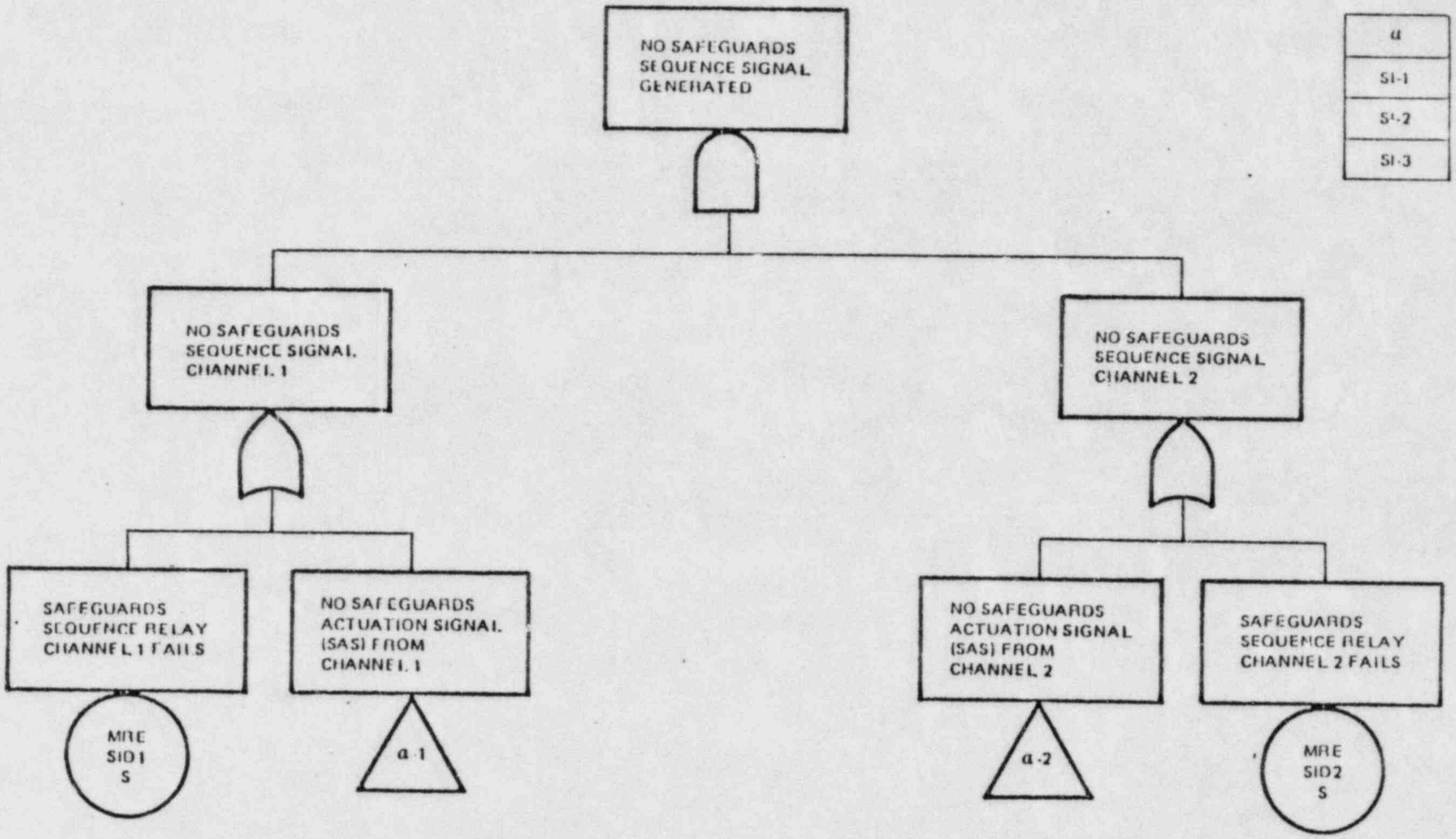


Figure 6. (Sheet 8 of 19)

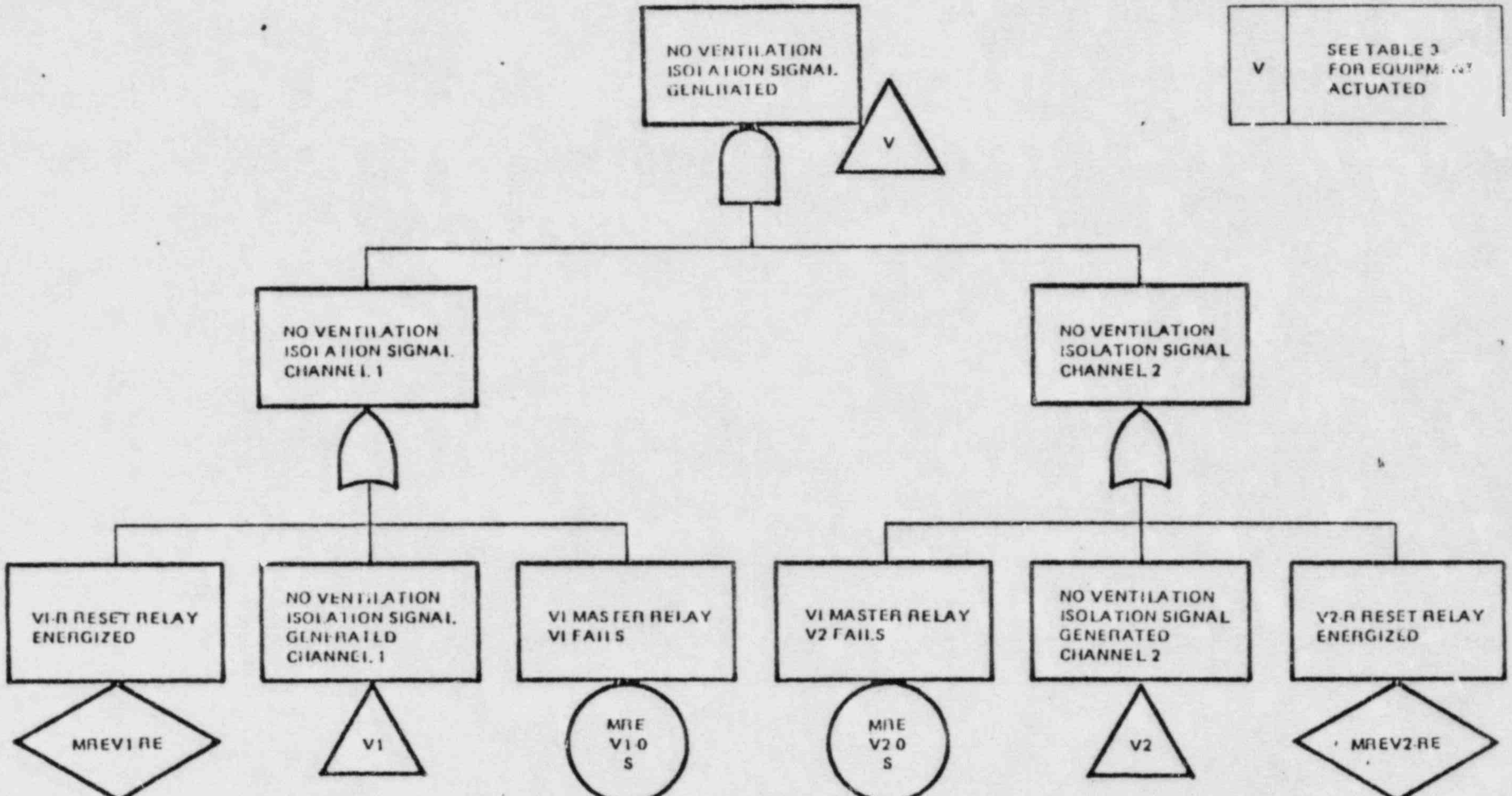


Figure 6. (Sheet 9 of 19)

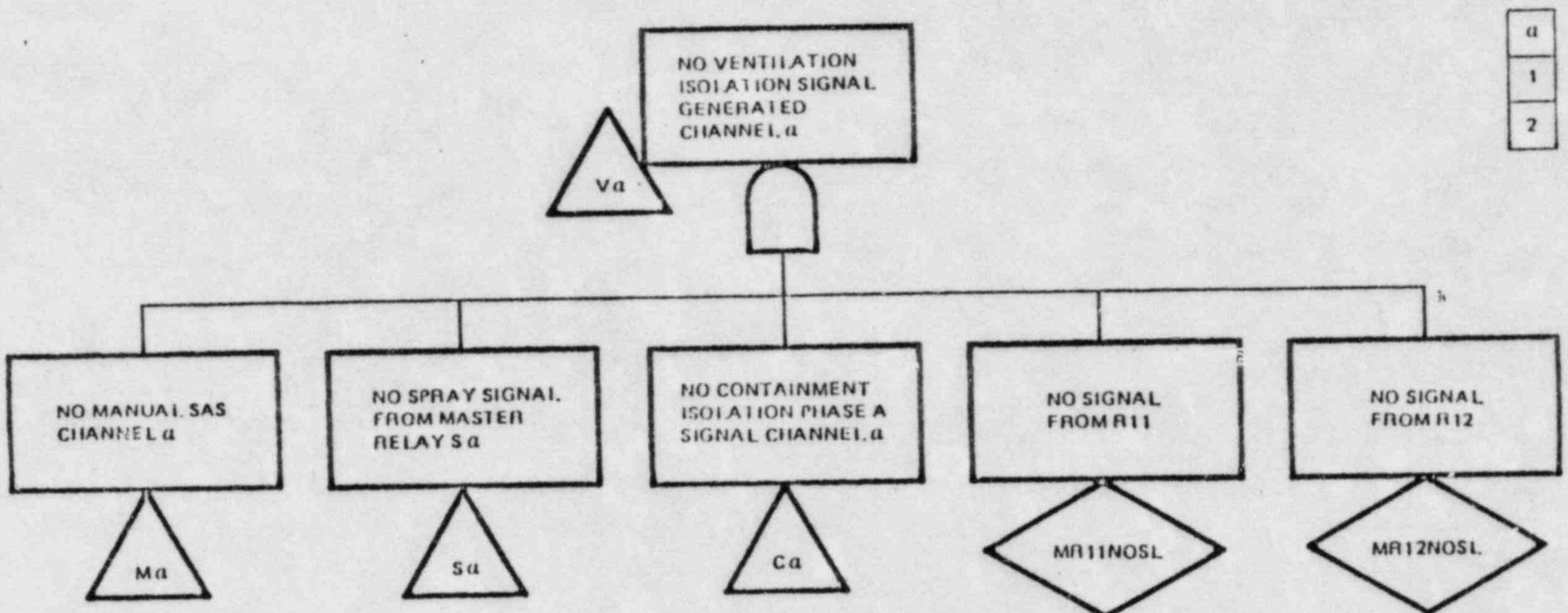


Figure 6. (Sheet 10 of 19)

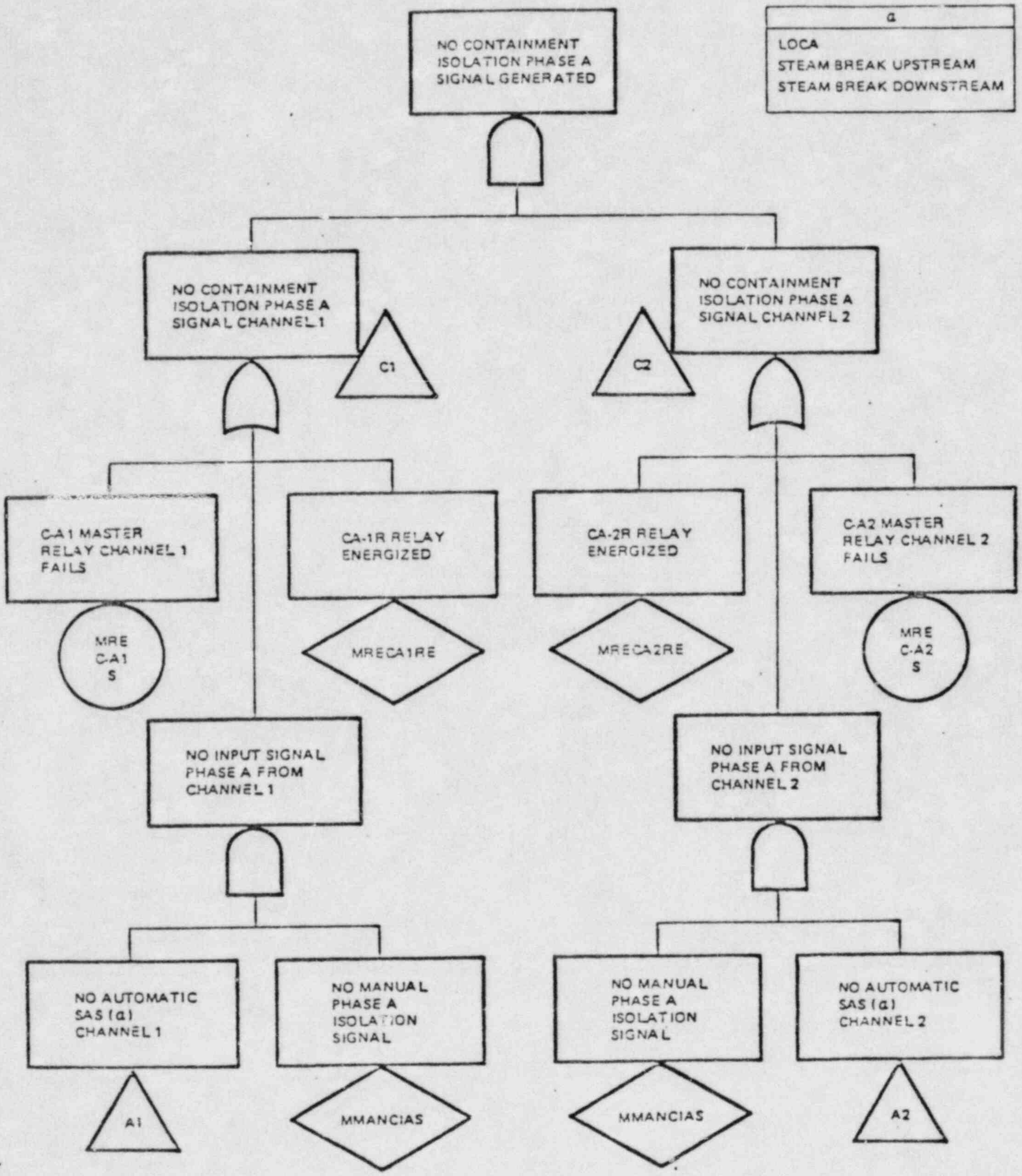


Figure 6. (Sheet 11 of 19)

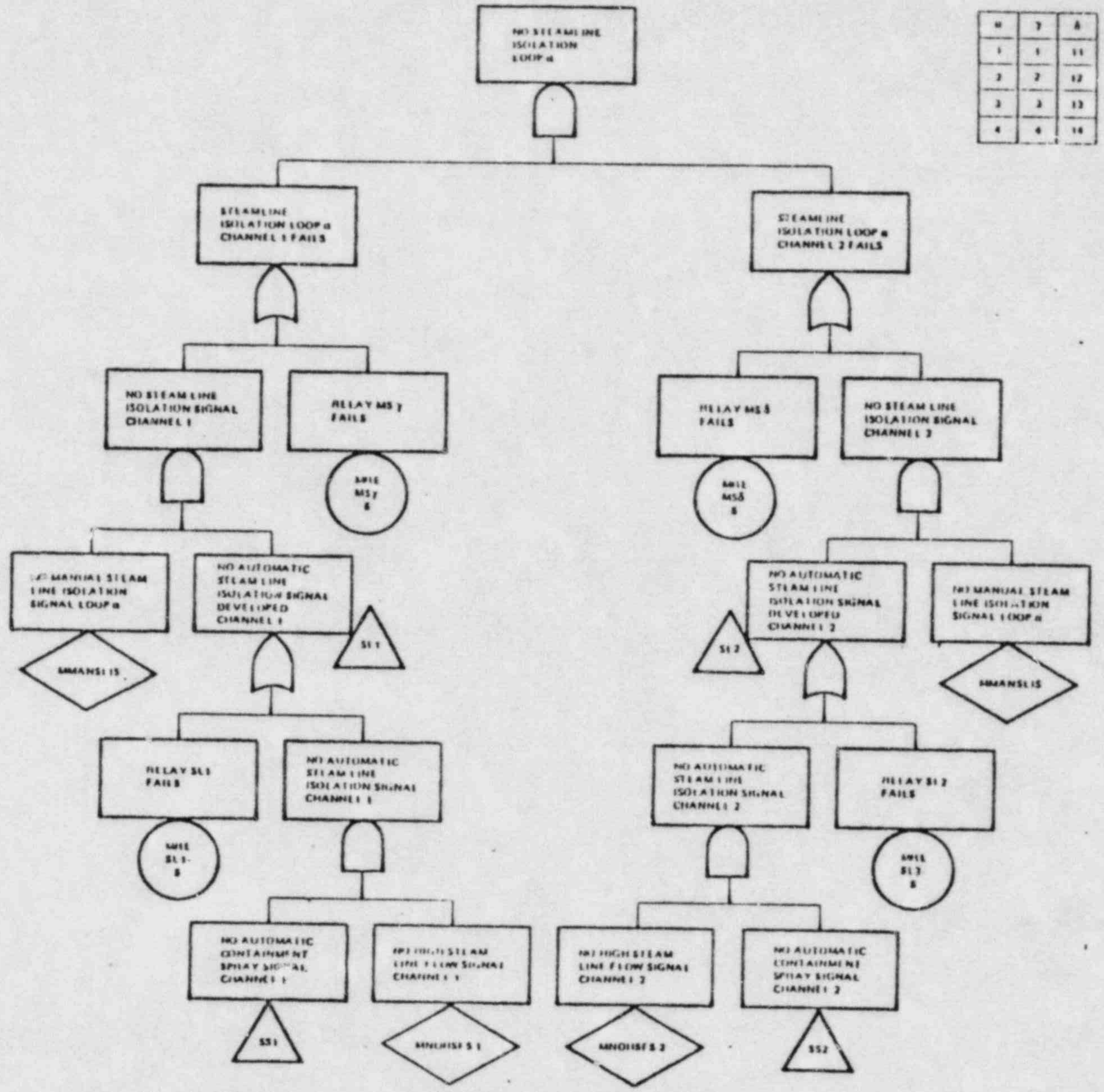


Figure 6. (Sheet 12 of 19)

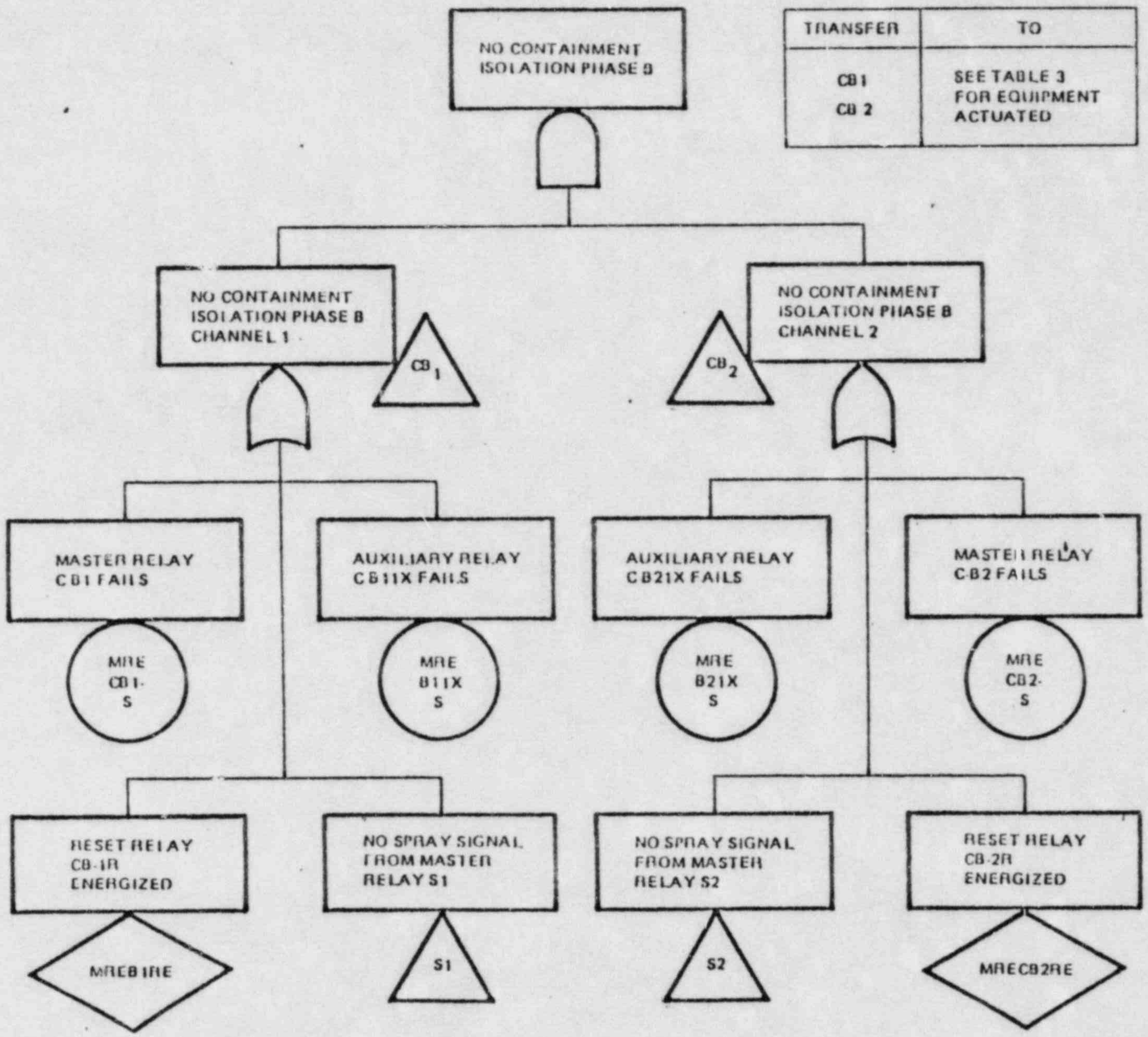


Figure 6. (Sheet 13 of 19)

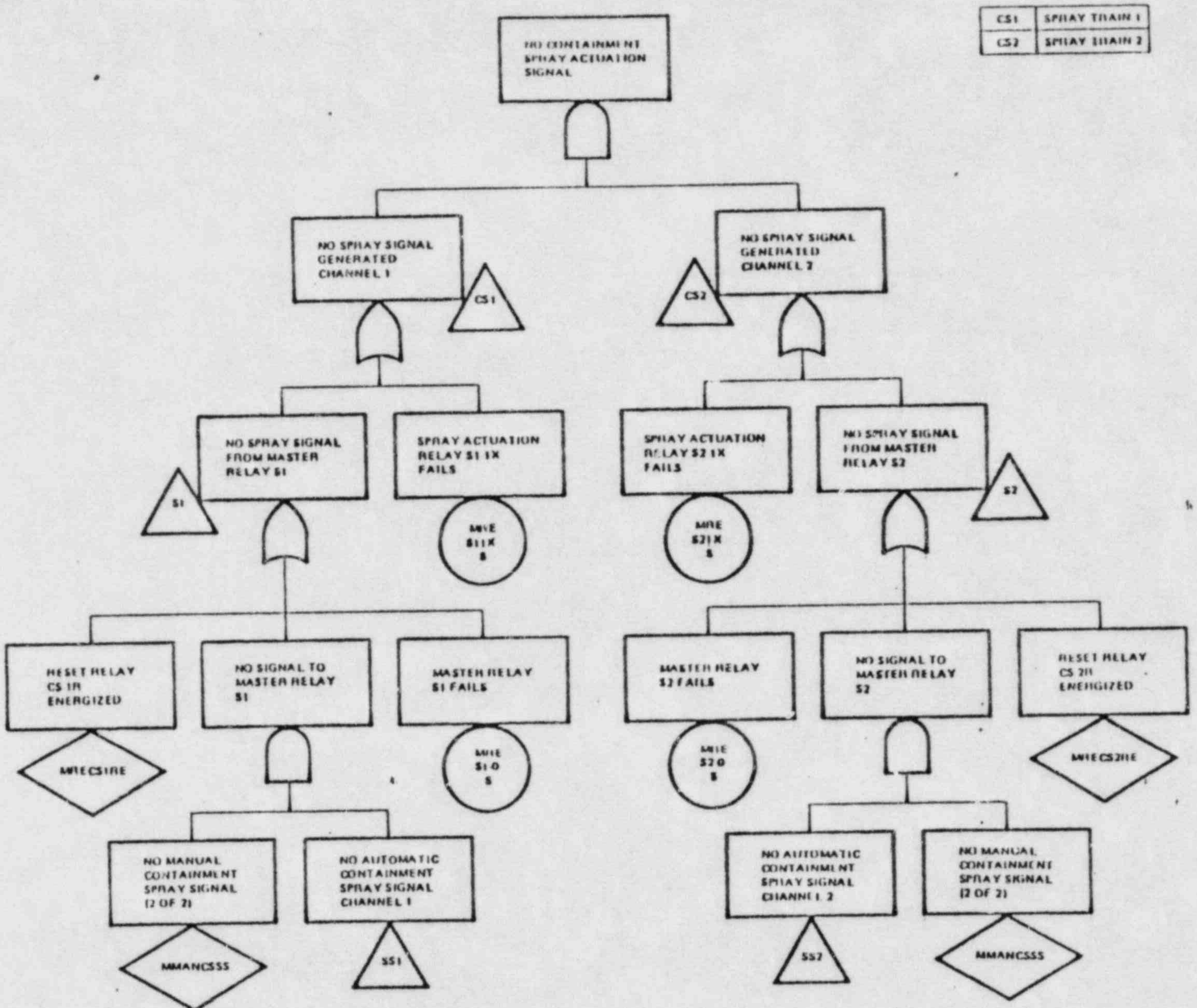
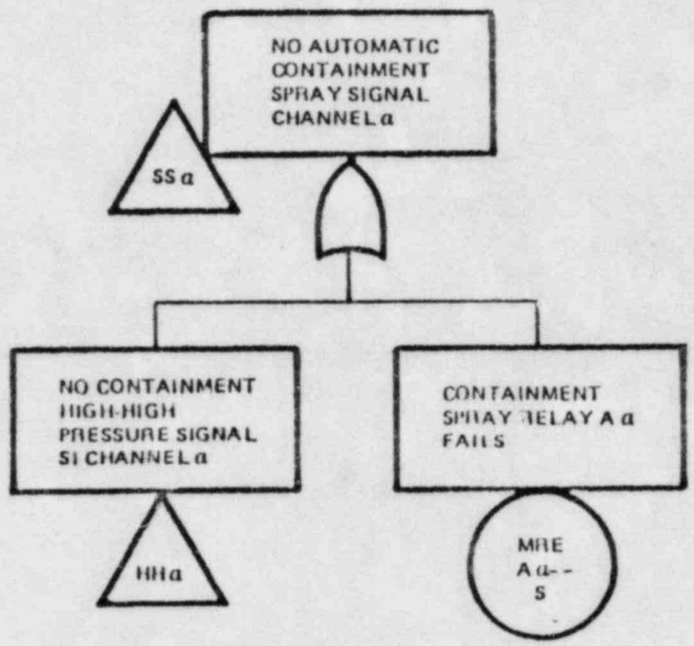


Figure 6. (Sheet 14 of 19)



α	γ
1	13
2	23

Figure 6. (Sheet 15 of 19)

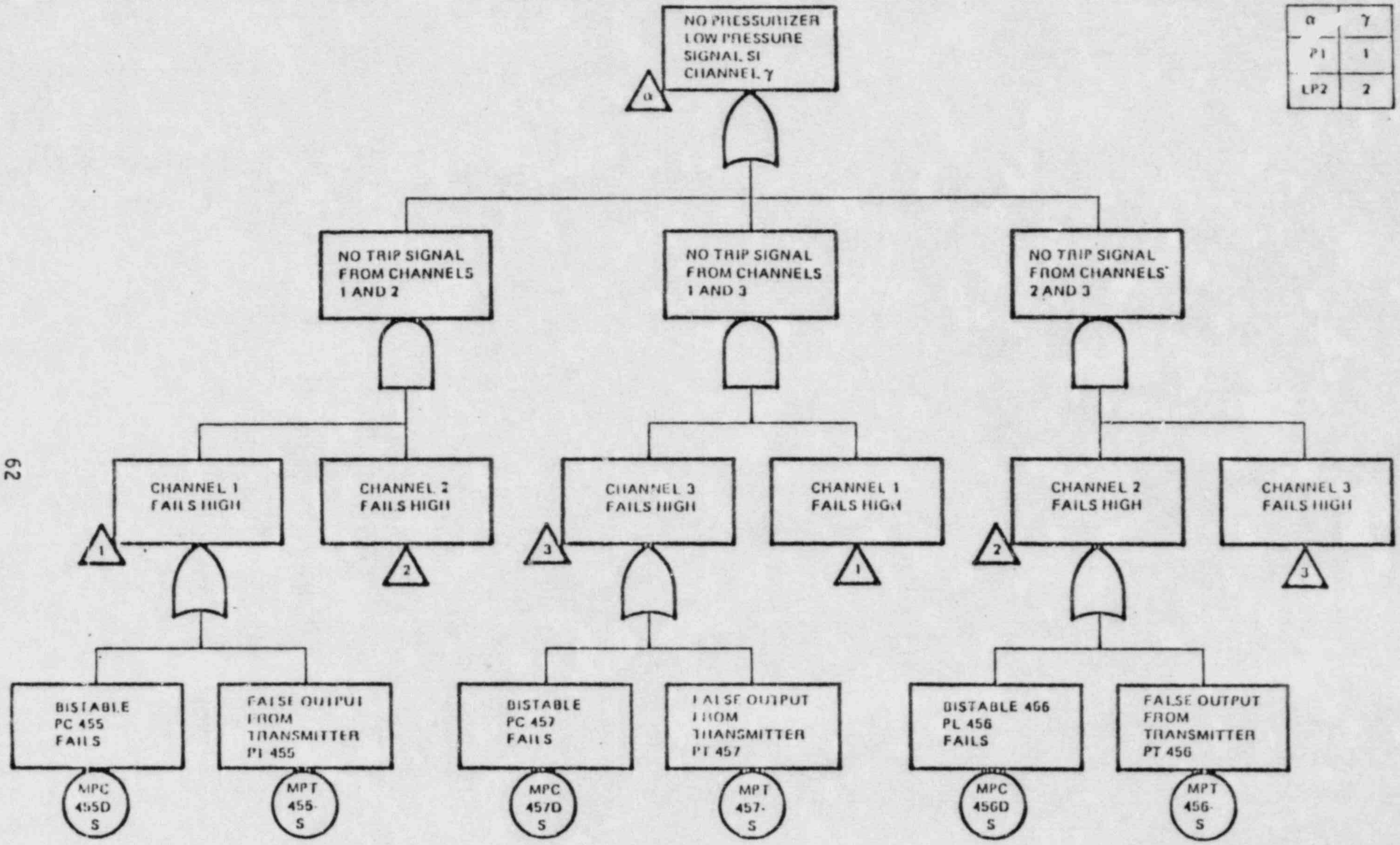
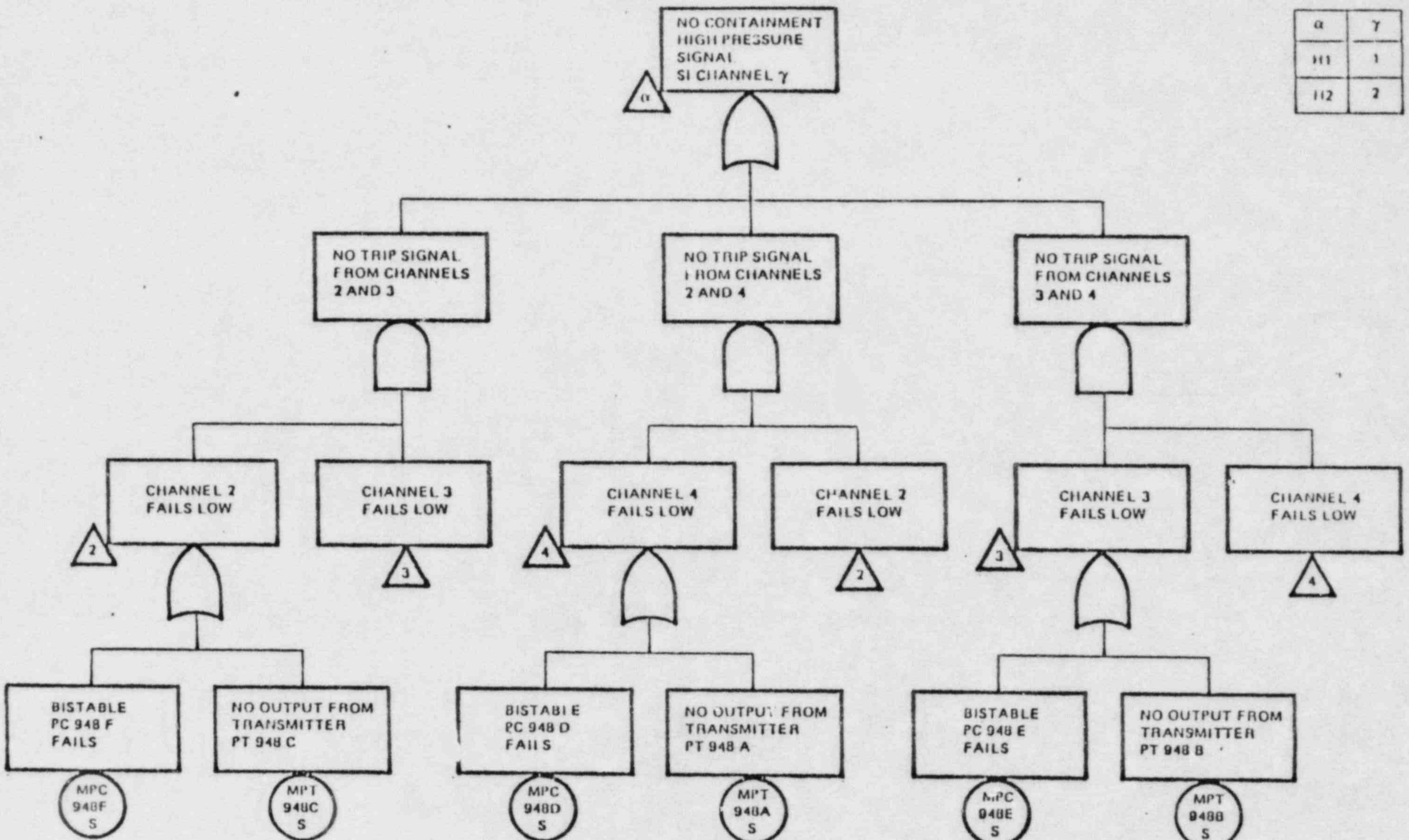


Figure 6. (Sheet 16 of 19)



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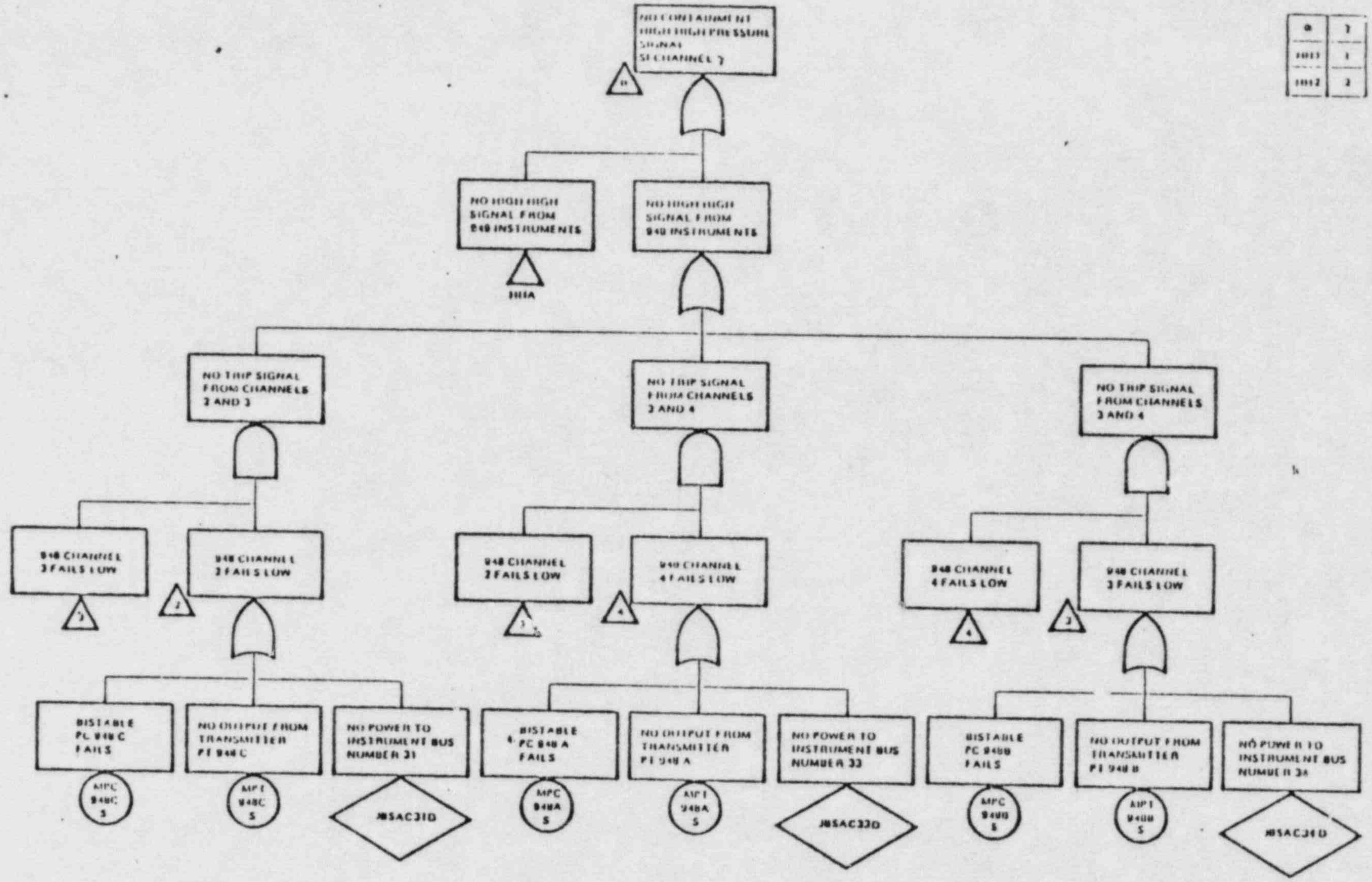

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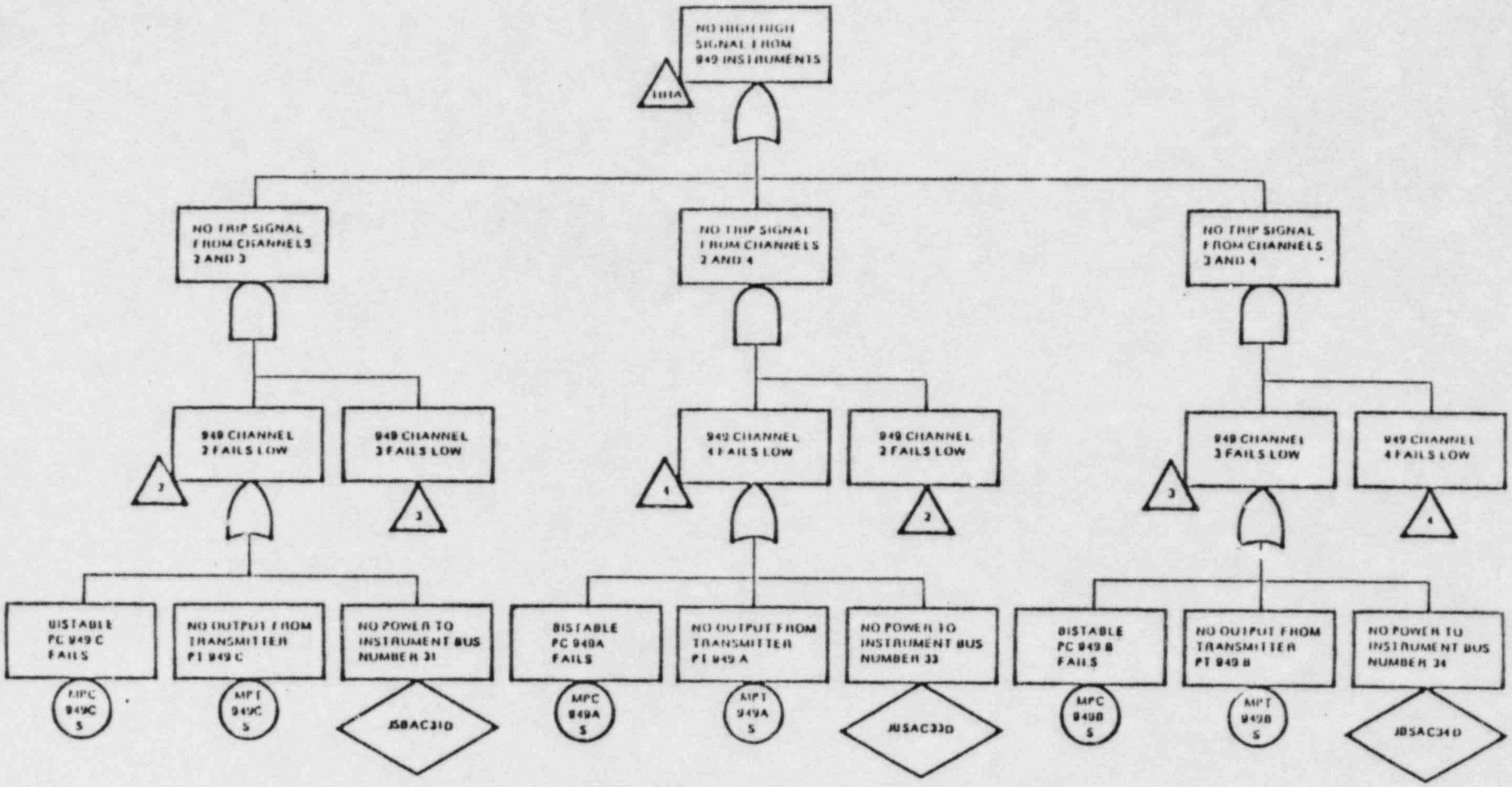

Figure 6. (Sheet 19 of 19)