Duane Arnold Energy Center

Alternate Shutdown Capability Analysis

June 1980

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I. Introduction

The purpose of this analysis is to determine vulnerability of shutdown systems to fire. The previously submitted Fire Hazard Analysis addresses this issue and concludes that safe shutdown is assured, although in the case of fire in safety system control panels located in the Control Room, early detection and suppression was postulated as essential to ensure safe shutdown capability.

For the purposes of this analysis, we have assumed the possibility of some fire damage to electrical wiring in Control Room panels and thereby considered the possibility of interference with safe shutdown systems. We have also assumed that the effects of the postulated fire will not spread beyond one control panel. Extensive detection devices and increased fire fighting capability make it very unlikely that a fire would go undetected and unsuppressed before spreading into another control panel. In the control panel affected by the fire, the nature of the damage is assumed to be the combination of fused contacts (short circuits) and severed wires (open circuits) having the most severe impact on safety systems that have control circuitry in that panel. The detection and suppression capabilities are adequate to preclude an immediate and unavoidable complete exit from the Control Room. We assume that operator personnel will remain in the Control Room and operate those systems that were not impaired by the fire, while fire suppression activities are carried out. Personnel as necessary will be dispatched to locations outside the Control Room to locally control systems whose control circuits were damaged in the Control Room panel fire. In all cases, hand operated or hydraulically activated components are assumed to be in or moved to the correct position.

The current Shutdown Outside Control Room (SOCR) procedure was reviewed and the list of systems identified was categorized according to your position Safe Shutdown Capability for systems generally used for Hot and Cold Shutdown of BWR's. The shutdown process envisioned entails reactor SCRAM, reactor coolant makeup with the HPCI and RCIC systems, pressure control through both automatic and manual relief valve operation, and decay heat removal and suppression pool cooling by the RHR and RHR Service Water systems. Process monitoring and power capability are required throughout the process. We have assumed that in conjunction with the fire that off-site power is not available. If off-site power were available hot shutdown and cold shutdown are simplified.

II. Conclusions

This alternate shutdown capability analysis, with its recommended changes, and the Fire Hazard Analysis demonstrate that the Duane Arnold Energy Center may be operated and controlled in a safe manner.

This analysis indicates the need for some changes or additions to procedures and some circuit modifications. These are as follows:

1. Procedures will be revised to include checklists for RCIC, HPCI, RHR, and RHR service water motor operated valve lineups and pump operation (as applicable) and instructions on how to isolate a motor control center from spurious control room inputs that are precluding a correct lineup.

2. The control circuitry for the two safety relief valves used to manually control depressurization will be rerouted outside the Control Room to insure their operability after a Control Room fire.

3. The circuitry for RHR system flow indicators and suppression pool temperature indication will be rerouted outside the Control Room to insure the reliability of their indications.

III. Individual System Analyses

Reactivity Control

Reactor Trip Capability (SCRAM)

The reactor SCRAM system is highly diverse and the most likely result of a spurious signal caused by a fire in a control room panel would be reactor SCRAM. In the event SCRAM does not occur automatically or manually from the control room, it may be initiated from the Essential Switchgear Room and verified in the Control Rod Drive area.

Reactor Coolant Makeup

Reactor Core Isolation Cooling System (RCIC)

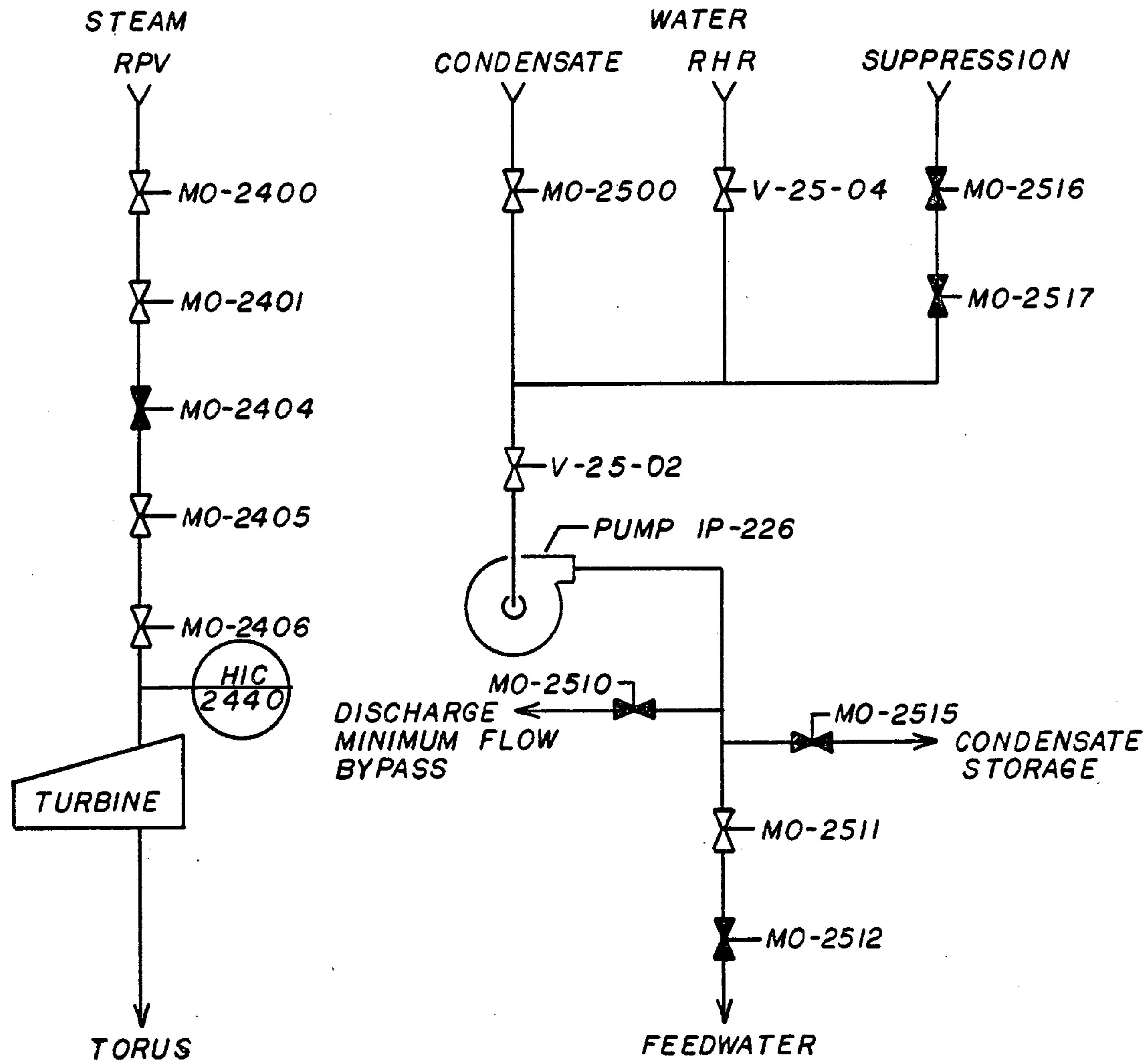
A diagram of the RCIC system showing those valves that affect the steam and water flow paths is included on the following page. The diagram shows the normal position of those valves during normal plant operation. Initiation of the RCIC system, either manually or automatically, requires the following valve positions to be achieved or maintained:

	Open	Remain Open	Close	Remain Closed	Notes
Steam Flow Path					
MO 2404	X	X			
Water Flow Path					
MO 2510	X		X*		*Should close as water flow pressure exceeds RPV pressure
MO 2512	X	X			

Continued operation of the system requires that the steam and water flow paths remain open and that system efficiency not be degraded by flow through lateral pipe branches. The source of the water flow path must also be capable of being switched from the condensate storage tank to the suppression pool. The position of the following valves (not included in system initiation) must be maintained or achieved:

	Open	Remain Open	Close	Remain Closed	Notes
Steam Flow Path					
MO 2400		X			
MO 2401		X			
MO 2405		X			
HV 2406		X			
Water Flow Path					
MO 2500		X	X*	X*	*If RCIC pump suction must switch from condensate storage tank to suppression pool.
MO 2516	X*	X*		X	
MO 2517	X*	X*		X	
MO 2510				X	
MO 2515				X	
MO 2511		X			

RCIC



REFERENCE M-124
M-125

Terminating operation of the system is accomplished by essentially reversing the changes required for system initiation. These changes are as follows:

	Open	Remain Open	Close	Remain Closed	Notes
Steam Flow Path					
MO 2404			X	X	
Water Flow Path					
MO 2512			X	X	

All of the above mentioned valves have control circuitry in the control room that would be vulnerable to a fire in a single control panel. Also, however, each of the above mentioned valves may be controlled from a location outside of the control room, that location in the case of motor operated valves is the appropriate motor control center. The purpose of the following analysis is to determine the extent to which control capability outside the control room is necessary.

Control room circuitry for motor operated valves typically consists of OPEN and CLOSE circuits. Although both circuits may use the same hand switch in the control room, they each typically have networks of relays that spread out into different control room panels. So even though both the OPEN and CLOSE circuits may be vulnerable to a fire in the control room panel containing the hand switch, they may have networks of relays whose vulnerability to control room panel fires may be completely different. Those valves that must maintain an open or closed position are vulnerable to contrary spurious signals caused by a control room panel fire. Those valves that must change positions are vulnerable to failure to receive the necessary signal. The following list includes each above mentioned valve and the type of vulnerability for which its control circuitry must be analyzed:

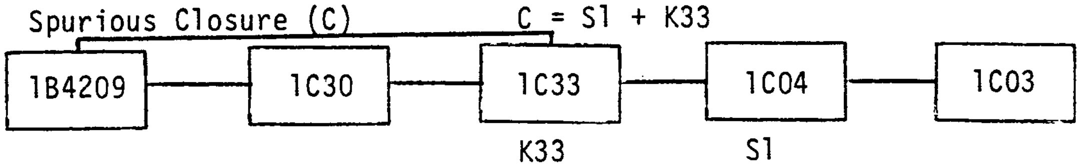
	Failure to Open ($\bar{O}$)	Spurious Closure (C)	Failure to Close ($\bar{C}$)	Spurious Opening (O)	Notes
Steam Flow Side					
MO 2400		X			
MO 2401		X			
MO 2404	X	X	X	X	
MO 2405		X			
HV 2406		X			
Water Flow Side					
MO 2500		X	X	X	
MO 2516	X	X		X	
MO 2517	X	X		X	
MO 2510	X		X	X	
MO 2515				X	
MO 2511		X			
MO 2512	X	X	X	X	

RCIC, Control Circuit Block Diagrams

and Logic Equations

MO 2400, (E51-F007) Main Steam Supply Control, Drawing E121/29

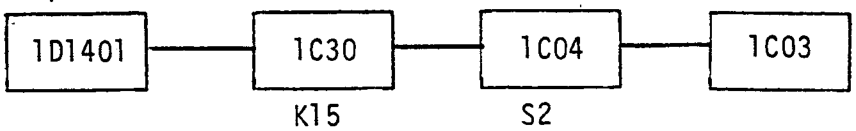
Spurious Closure (C) C = S1 + K33



Possible requirement for alternate control if fire in control room panels { 1C04, 1C30, 1C33, 1C28, 1C21

MO 2401 (E51-F008) Main Steam Supply Control, Drawing E121/30

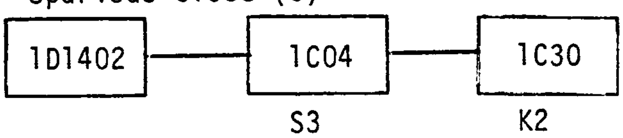
Spurious Closure (C) C = S2 + K15



Possible requirement for alternate control if fire in control room panels { 1C04, 1C30, 1C21

MO 2404 (E51-F045) Steam Supply Globe Valve, Drawing E121/32

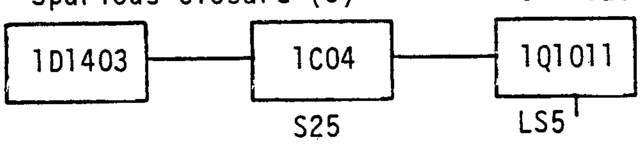
Fail to Open ($\overline{O}$) O = S3
Spurious Open (O)
Fail to Close ($\overline{C}$) C = S3 + K2
Spurious Close (C)



Possible requirement for alternate control if fire in control room panels { 1C04, 1C30, 1C32, 1C33

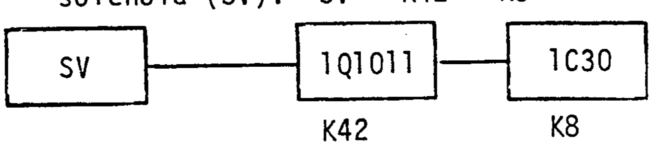
MO 2405 (N/A) Turbine Trip Throttle Gate Valve, Drawing E121/36

Spurious Closure (C) C = S25



1. Mechanical Overspeed Trip

This valve is also subject to closure from the turbine trip solenoid (SV): SV = K42 = K8



Possible requirement for alternate control if fire in control room panels { 1C04, 1C28, 1C30, 1C21, 1C33

HV 2406 (N/A) Turbine Flow Control Governing Valve, Drawing APED E51-9(6)

This valve is controlled by locally produced hydraulic signals that are not vulnerable to spurious control room signals.

MO 2500 (E51-F010) Suction From Condensate Storage, Drawing E121/31

Spurious Closure (C) — $C = S4 + (K14)(K21)$

Fail to Close ($\overline{C}$)

Spurious Opening (0) — $0 = S4 + (K2)(\overline{K14} + \overline{K21})$

[1D1405] — [1C04] — [1C30]

1C04: S4

1C30: K2, K14, K21

Possible requirement for alternate control if fire in control room panels { 1C04, 1C32, 1C30, 1C33

MO 2516/2517 (E51-F031/E51-F029) Suction from Suppression Pool, Drawing E121/33

Fail to Open ($\overline{0}$) — $0 = S10 / S22$

Spurious Open (0)

Spurious Closure (C) — $C = S10 / S22$

[1C1410] — [1C04]

1C04: S10/S22

Possible requirement for alternate control if fire in control room panel { 1C04

MO 2510 (E51-F019) RCIC Pump Discharge Minimum Flow Bypass, Drawing E121/34

Fail to Open ($\overline{0}$) — $0 = S9 + (K19)(N020)$

Spurious Open (0)

Fail to Close ($\overline{C}$) — $C = S9 + K20 + \overline{K9} + N002$

[1D1406] — [1C04] — [1C30] — [1C128]

1C04: S9

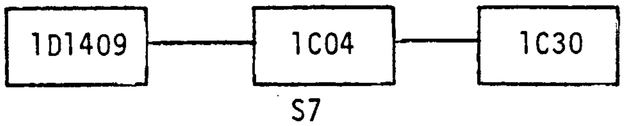
1C30: K9, K19, K20

1C128: N020 (PS2520), N002 (FS2508)

Possible requirement for alternate control if fire in control room panels { 1C04, 1C30

MO 2515 (E51-F022) Test Line to Condensate Storage, Drawing E121/35

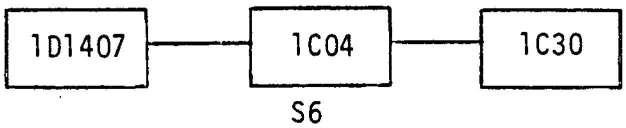
Spurious Open (O) O = S7



Possible requirement for alternate control if fire in control room panel { 1C04

MO 2511 (E51-F012) Downstream Gate Valve, Drawing E121/32

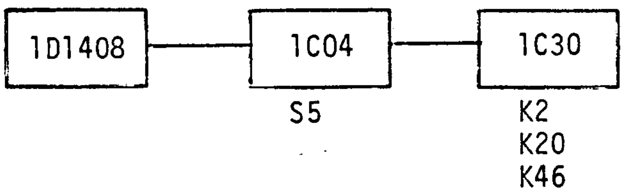
Spurious Close (C) C = S6



Possible requirement for alternate control if fire in control room panel { 1C04

MO 2512 (E51-F013) Downstream Gate Valve, Drawing E121/40

Fail to Open ($\overline{O}$) $O = S5 + (K2)(\overline{K20})(\overline{K46})$
Spurious Open ($\underline{O}$)
Fail to Close ($\overline{C}$) $C = S5 + K20 + K46$
Spurious Close (C)



Possible requirement for alternate control if fire in control room panels { 1C04 1C32
1C30 1C33

RCIC, Relay Development

The following relays are those relays included in RCIC component control circuits. The input logic and input signals are shown as a Boolean logic equation. The location of each relay or contact is shown. The relays are grouped into levels. Those relays in the first level appear in the previously described control circuits. Relays in the second level appear in the supporting logic for relays in the first level, etc. The listed relays are all on drawings APED-E51-9(2) and E51-9(3).

1st Level

Relay/ Contacts	Location	Input Logic/Signal
E51-K2	1C30	= (E11A-K79A + E11A-K80A) (E11A-K79B + E11A-K80B)
E51-K8	1C30	= S17 + K6 + K7 + (K48) (LS2) (B21-N017A) + K33
E51-S17	1C04	normally open, Turbine Trip
LS2	local	closes when valve MO 2404 fully open
B21-N017A	local	closes on high reactor water level
E51-K9	1C30	= Limit Switch 15
LS15	local	closes when valve MO 2404 not fully closed
E51-K14	1C30	= Limit Switch 2
LS2	local	closes when valve MO 2517 fully open
E51-K15	1C30	= (S23) (K2) + (B21B-S5A) (B21B-K3A) via 1C21 + K12 + (N019A) (N019C) via 1C121 + K29 + (S16) (K15)
E51-S23	1C04	normally open, manual isolation (HS2481)
B21B-S5A	1C21	normally open, manual isolation
E51-N019A	local	close on low RPV steam pressure
E51-N019C	local	close on low RPV steam pressure
E51-S16	1C04	normally closed, manual reset
E51-K19	1C30	= N002
E51-N002	local	closes on low RCIC pump discharge flow
E51-K20	1C30	= C002 via 1Q1011
E51-C002	local	closes when turbine trip & throttle valve fully closed
E51-K21	1C30	= Limit Switch 2
LS2	local	closes when valve MO 2516 fully open
E51-K46	1C30	= Limit Switch 6
LS6	local	closes when valve MO 2404 fully closed

2nd Level

Relay/ Contacts	Location	Input Logic/Signal
E11A-K79A	1C32	= B21-N031A
B21-N031A	local	closes on RPV low level
E11A-K80A	1C32	= B21-N031C
B21-N031C	local	closes on RPV low level
E11A-K79B	1C33	= B21-N031B
B21-N031B	local	closes on RPV low level
E11A-K80B	1C33	= B21-N031D
B21-N031D	local	closes on RPV low level
E51-K6	1C30	= N009A + N009B via 1C128
E51-N009A	local	close on high RCIC turbine exhaust pressure
E51-N009B	local	close on high RCIC turbine exhaust pressure
E51-K7	1C30	= N006
E51-N006	local	close on low pump suction pressure
E51-K48	1C33	= B21-N017C via 1C55A
B21-N017C	local	closes on high RPV level
E51-K33	1C33	= K39 + (B21B-S5B) (B21B-K3B) via 1C21 + K32 + (N019B) (N019C) via 1C57 + (S26) (K33)
B21B-S5B	1C21	normally open, manual isolation
E51-N019B	local	close on low RPV steam pressure
E51-N019C	local	close on low RPV steam pressure
B21B-K3A	1C21	= closes on high ambient or differential temperature
E51-K12	1C30	= N017 via 1C121
E51-N017	local	closes on high steam line differential pressure
E51-K29	1C30	= (N012A) (N012C) via 1C128
E51-N012A	local	close on high turbine exhaust diaphragm pressure
E51-N012C	local	close on high turbine exhaust diaphragm pressure

3rd Level

Relay/ Contacts	Location	Input Logic/Signal
E51-K39	1C33	= (N012B) (N012D) via 1C28
E51-N012B	local	close on high turbine exhaust diaphragm pressure (PS2420B)
E51-N012D	local	close on high turbine exhaust diaphragm pressure (PS2420D)
B21B-K3B	1C21	closes on high ambient or differential pressure
E51-K32	1C33	= N018 via 1C57
E51-N018	local	closes on high steam line differential pressure
E51-S26	1C04	normally closed, reset

<u>Reactor Coolant Makeup</u>

High Pressure Coolant Injection System (HPCI)

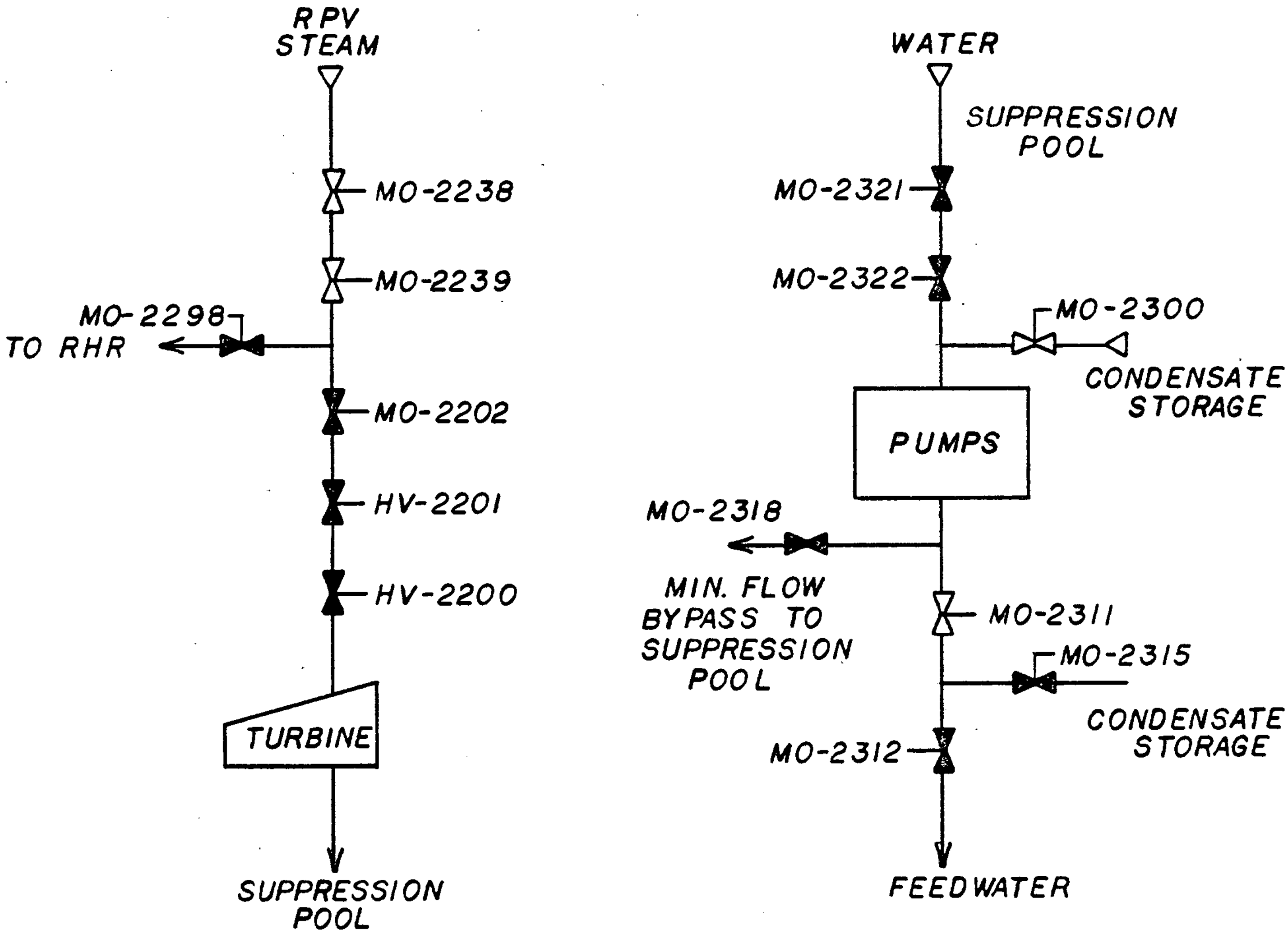
A diagram of the HPCI system showing those valves that affect the steam and water flow paths is included on the following page. The diagram shows the normal position of those valves during normal plant operation. Initiation of the HPCI system, either manually or automatically, requires the following valve positions to be achieved or maintained:

	Open	Remain Open	Close	Remain Closed	Notes
Steam Flow Path					
MO 2202	X	X			
HV 2201	X	X			
HV 2200	X	X			
Water Flow Path					
MO 2318	X	X	X	X	Should close as water flow pressure exceeds RPV pressure
MO 2312	X	X			

Continued operation of the system requires that the steam and water flow paths remain open and that system efficiency not be degraded by flow through lateral pipe branches. The source of the water flow path must also be capable of being switched from the condensate storage tank to the suppression pool. The position of the following valves (not included in system initiation) must be maintained or achieved:

	Open	Remain Open	Close	Remain Closed	Notes
Steam Flow Path					
MO 2238		X			
MO 2239		X			
MO 2298				X	
Water Flow Path					
MO 2300		X	X*	X*	*If HPCI pump suction must switch from condensate storage tank to suppression pool.
MO 2321	X*	X*		X	
MO 2322	X*	X*		X	
MO 2311		X			
MO 2315				X	

HPCI



REFERENCE M-122
M-123

Terminating operation of the system is accomplished by essentially reversing the changes required for system initiation. These changes are as follows:

	Open	Remain Open	Close	Remain Closed	Notes
Steam Flow Path					
MO 2202			X	X	
Water Flow Path					
MO 2312			X	X	

All of the above mentioned valves have control circuitry in the control room that would be vulnerable to a fire in a single control panel. Also, however, each of the above mentioned valves may be controlled from a location outside of the control room, that location in the case of motor operated valves is the appropriate motor control center. The purpose of the following analysis is to determine the extent to which control capability outside the control room is necessary.

Control room circuitry for motor operated valves typically consists of OPEN and CLOSE circuits. Although both circuits may use the same hand switch in the control room, they each typically have networks of relays that spread out into different control room panels. So even though both the OPEN and CLOSE circuits may be vulnerable to a fire in the control room panel containing the hand switch, they may have networks of relays whose vulnerability to control room panel fires may be completely different. Those valves that must maintain an open or closed position are vulnerable to contrary spurious signals caused by a control room panel fire. Those valves that must change positions are vulnerable to failure to receive the necessary signal. The following list includes each above mentioned valve and the type of vulnerability for which its control circuitry must be analyzed:

	Failure to Open ($\bar{O}$)	Spurious Closure (C)	Failure to Close ($\bar{C}$)	Spurious Opening (O)	Notes
Steam Flow Path					
MO 2238		X			
MO 2239		X			
MO 2298				X	
MO 2202	X	X	X	X	
HV 2201	X	X			
HV 2200	X	X			
Water Flow Path					
MO 2321	X	X		X	
MO 2322	X	X		X	
MO 2300		X	X	X	
MO 2318	X	X	X	X	

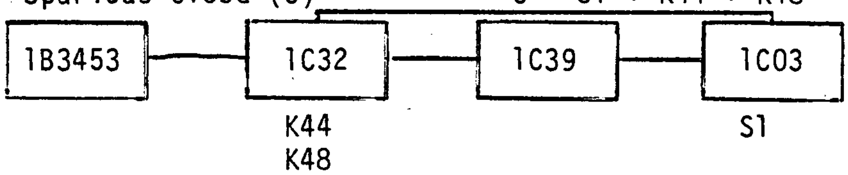
	Failure to Open ($\overline{O}$)	Spurious Closure (C)	Failure to Close ($\overline{C}$)	Spurious Opening (O)	Notes
Water Flow Path					
MO 2311		X			
MO 2315				X	
MO 2312	X	X	X	X	

HPCI, Control Circuit Block Diagrams

and Logic Equations

MO 2238 (E41-F002) Main Steam to HPCI Turbine, Drawing E121/14

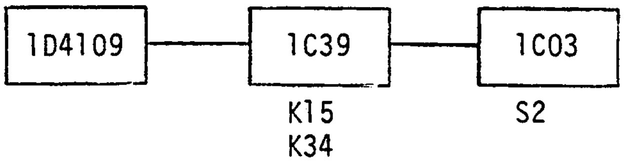
Spurious Close (C) $C = S1 + K44 + K48$



Possible requirement for alternate control if fire in control room panel { 1C03 1C21 1C32

MO 2239 (E41-F003) Main Steam to HPCI Turbine, Drawing E121/15

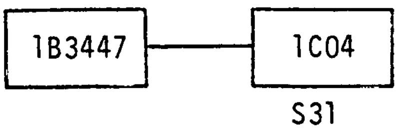
Spurious Closure (C) $C = S2 + K15 + K34$



Possible requirement for alternate control if fire in control room panel { 1C03 1C21 1C39

MO 2298 (E41-F066) Main Steam to RHR System, Drawing E121/44A

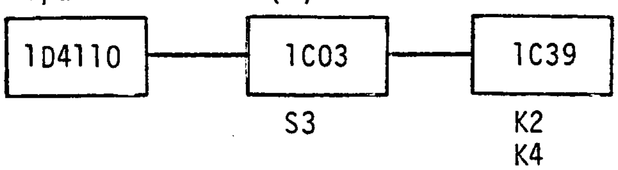
Spurious Opening (O) $O = S31$



Possible requirement for alternate control if fire in control room panel { 1C04

MO 2202 (E41-F001) Main Steam Supply Control, Drawing E121/16

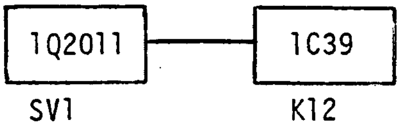
Failure to Open $(\overline{O})$ $O = S3 + K2 + K4$
Spurious Open (O)
Failure to Close $(\overline{C})$ $C = S3$
Spurious Close (C)



Possible requirement for alternate control if fire in control room panel { 1C03 1C43 1C39 1C44 1C32

HV 2201 (N/A) Turbine Stop Valve, Drawing APED E41-6(3)

This valve is normally controlled by locally produced hydraulic signals that are not vulnerable to spurious control room signals, however, it is subject to closure from the turbine trip solenoid (SV): SV1 = K12



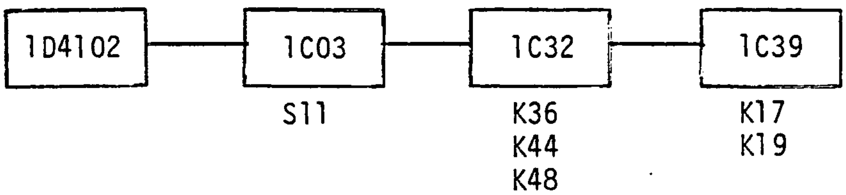
Possible requirement for alternate control if fire in control room panels { 1C39 1C32 1C03 1C21

HV 2200 (N/A) Turbine Control Valve

This valve is controlled by locally produced hydraulic signals that are not vulnerable to spurious control room signals.

MO 2321 (E41-F042) Suppression Pool Outlet, Drawing E121/23

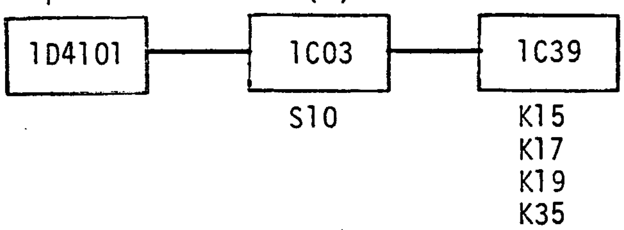
Failure to Open ($\overline{0}$) $0 = (\overline{K36})(\overline{K48})(S11 + \overline{K17} + K19)$
Spurious Open (0)
Spurious Close (C) $C = S11 + K44 + K48$



Possible requirement for alternate control if fire in control room panels { 1C03 1C39 1C32 1C21

MO 2322 (E41-F041) Suppression Pool Pump Suction, Drawing E122/22

Failure to Open ($\overline{0}$) $0 = (\overline{K35})(\overline{K15})(S10 + \overline{K17} + K19)$
Spurious Open (0)
Spurious Closure (C) $C = S10 + K15 + K35$



Possible requirement for alternate control if fire in control room panels { 1C03 1C21 1C39

MO 2300 (E41-F004) Condensate Storage Tank Supply to Pump Suction, Drawing E121/17

Spurious Close (C) $C = S4 + (K20)(K18)$
Failure to Close ($\overline{C}$)
Spurious Open (O) $O = S4 + (\overline{K18} + \overline{K20})(K2 + K4)$

1D4108	1C03	1C39
	S4	K2 K4 K18 K20

Possible requirement for alternate control if fire in control room panel { 1C03, 1C39, 1C32, 1C43, 1C44

MO 2318 (E41-F005) Minimum Flow Bypass to Suppression Chamber, Drawing E121/21

Failure to Open ($\overline{O}$) $O = S8 + (K10)(PS2324)$
Spurious Opening (O)
Failure to Close ($\overline{C}$) $C = S8 + K51 + K13 + FS2310$
Spurious Closing (C)

1D4103	1C03	1C39	1C120
	S8	K10 K13 K51	PS2324 FS2310

Possible requirement for alternate control if fire in control room panel { 1C03, 1C39

MO 2311 (E41-F007) HPCI Condensate Flow, Drawing E121/16

Spurious Closure (C) $C = S6$

1D4107	1C03	1C39
	S6	

Possible requirement for alternate control if fire in control room panel { 1C03

MO 2315 (E41-F008) HPCI Condensate Recirculation to Storage Tank, Drawing E121/19

Spurious Opening (O) $O = S7$

1D4105	1C03	1C39
	S7	

Possible requirement for alternate control if fire in control room panel { 1C03

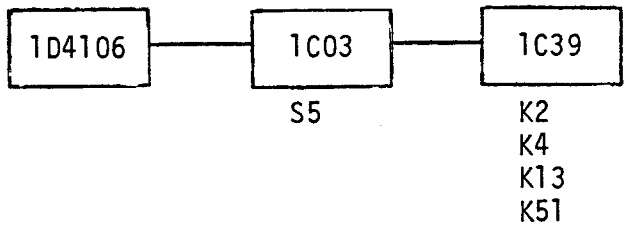
MO 2312 (E41-F006) HPCI Condensate Flow, Drawing E121/18

Failure to Open ($\overline{O}$) — $O = S5 + (\overline{K13})(\overline{K51})(K2 + K4)$

Spurious Open (O)

Failure to Close ($\overline{C}$) — $C = S5 + K13 + K51$

Spurious Close (C)



Possible requirement for alternate control if fire in control room panel:

1C03	1C43
1C39	1C44
1C32	

HPCI, Relay Development

The following relays are those relays included in RCIC component control circuits. The input logic and input signals are shown as a Boolean logic equation. The location of each relay or control is shown. The relays are grouped into levels. Those relays in the first level appear in the previously described control circuits. Relays in the second level appear in the supporting logic for relays in the first level. The listed relays are on drawings APED E41-6(3) and E41-6(4).

1st Level

Relay/ Contacts	Location	Input Logic/Signal
E41-K2	1C39	= } (K41 + B21-N031B) (K42 + B21-N031D), B21's via 1C55
E41-K3	1C39	= }
B21-N031B	local	close on RPV low water level
B21-N031D	local	close on RPV low water level
E41-K4	1C39	= } (E21A-K5A + E21A-K5B) (E21A-K6A + E21-K6B)
E41-K53	1C39	= }
E41-K12	1C39	= S19 + K8 + K9 + K11 + K15 + K44 + K35
E41-S19	1C03	normally open, manual turbine trip
E41-K13	1C39	= LS4
LS4	local	closes when turbine stop valve HV2201 fully closed
E41-K15	1C39	= (N001B) (N001D) via 1C122
E41-N001B	local	closes on low HPCI steam supply pressure
E41-N001D	local	closes on low HPCI steam supply pressure
E41-K17	1C39	= (LS5218) (LS5219) via 1C215
LS5218	local	open on condensate storage tank low water level
LS5219	local	open on condensate storage tank low water level
E41-K18	1C39	= LS2
LS2	local	closed when valve MO 2322 fully open
E41-K19	1C39	= N015A + N015B
E41-N015A	local	close on suppression chamber high water (LS2319)
E41-N015B	local	close on suppression chamber high water (LS2320)
E41-K20	1C39	= LS2
LS2	local	closes when valve MO 2321 fully open
E41-K34	1C39	= K35 + (K53 + K3) (S32)
E41-S32	1C03	normally open, HPCI manual isolation (HS 2242)
E41-K35	1C39	= (B21B-S6B) (B21B-K4B) + K28 + K33 + (S18) (K35)
B21-S6B	1C21	normally open, manual isolation
E41-S18	1C03	normally closed, HPCI reset (HS2240)
E41-K36	1C32	= } (B21B-S6A) (B21B-K4A) + K43 + K46 + (S30) (K36)
E41-K44	1C32	= }
B21-S6A	1C21	normally open, manual isolation
E41-S30	1C03	normally closed, HPCI reset (HS2241)

Relay/ Contacts	Location	Input Logic/Signal
E41-K48	1C32	= (N001A) (N001C) via 1C126B
E41-N001A	local	close on low HPCI steam supply pressure
E41-N001C	local	close on low HPCI steam supply pressure
E41-K51	1C39	= LS6
LS6	local	closes when valve MO 2202 fully closed
		2nd Level
E41-K8	1C39	= N017A + N017B via 1C120
E41-N017A	local	closes on high HPCI turbine exhaust
E41-N017B	local	closes on high HPCI turbine exhaust
E41-K9	1C39	= N010
E41-N010	local	closes on low suction pump pressure
E41-K10	1C39	= N006 via 1C120
E41-N006	local	closes on low HPCI pump discharge flow
E41-K11	1C39	= (K45) (B21-N017D) via 1C55A
B21-N017D	local	closes on reactor high water level (LIS 4592D)
E41-K28	1C39	= (N012B) (N012D) via 1C120
E41-N012B	local	closes on high HPCI turbine exhaust pressure (PS 2215B)
E41-N012D	local	closes on high HPCI turbine exhaust pressure (PS 2215D)
E41-K33	1C39	= N005 via 1C126B
E41-N005	local	closes on high differential pressure
E41-K41	1C32	= B21-N031A via 1C56
B21-N031A	local	closes on RPV low level
E41-K42	1C32	= B21-N031C via 1C56
B21-N031C	local	closes on RPV low level
E41-K43	1C32	= N004 via 1C122
E41-N004	local	close on steam line high differential pressure
E41-K46	1C32	= (N012A) (N012C) via 1C120
E41-N012A	local	close on HPCI turbine exhaust diaphragm high pressure (PS2215A)
E41-N012C	local	close on HPCI turbine exhaust diaphragm high pressure (PS2215C)
E41-K45	1C32	= B21-N017B via 1C56A
B21-N017B	local	closes on RPV high level
E21A-K5A	1C43	= N011A
E11-N011A	local	close on high drywell pressure

Relay/ Contacts	Location	Input Logic/Signal
E21A-K5B	1C44	= N011B
E11-N011B	local	close on high drywell pressure
E21A-K6A	1C43	= N011C
E11-N011C	local	close on high drywell pressure
E21A-K6B	1C44	= N011D
E11-N011D	local	close on high drywell pressure
B21B-K4B	1C21	close on high ambient or differential pressure
B21B-K4A	1C21	close on high ambient or differential pressure

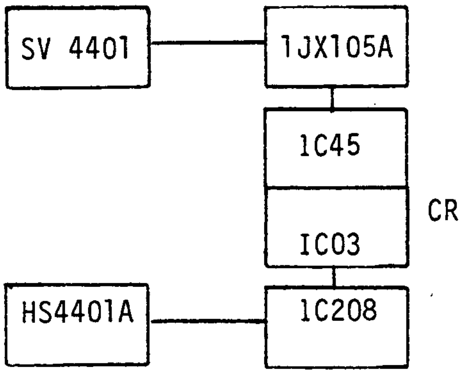
Reactor Pressure Control

Manual Relief Valve Operation

Manual relief valve operation is permitted from local panel IC208. Two relief valves may be operated from that local panel.

Valve (GE #)	Local Panel 1C208 Hand Switch	Valve Setpoint
SV 4401 (B21-F013B)	HS 4401A	1090 PSIG
SV 4407 (B21-F013F)	HS 4407A	1100 PSIG

The following block diagram, derived from drawing E-121/2, and GE Drawing B21-18, shows the electrical cable routing:



The routing of the cable through panels IC03 & IC45 in the control room makes control of SV 4401 from HS 4401A at local panel 1C208, vulnerable to fire in either of the panels in the control room.

The same routing was used for SV 4407 and HS 4407A.

Reactor Decay Heat Removal and Suppression Pool Cooling

Residual Heat Removal System (RHR)

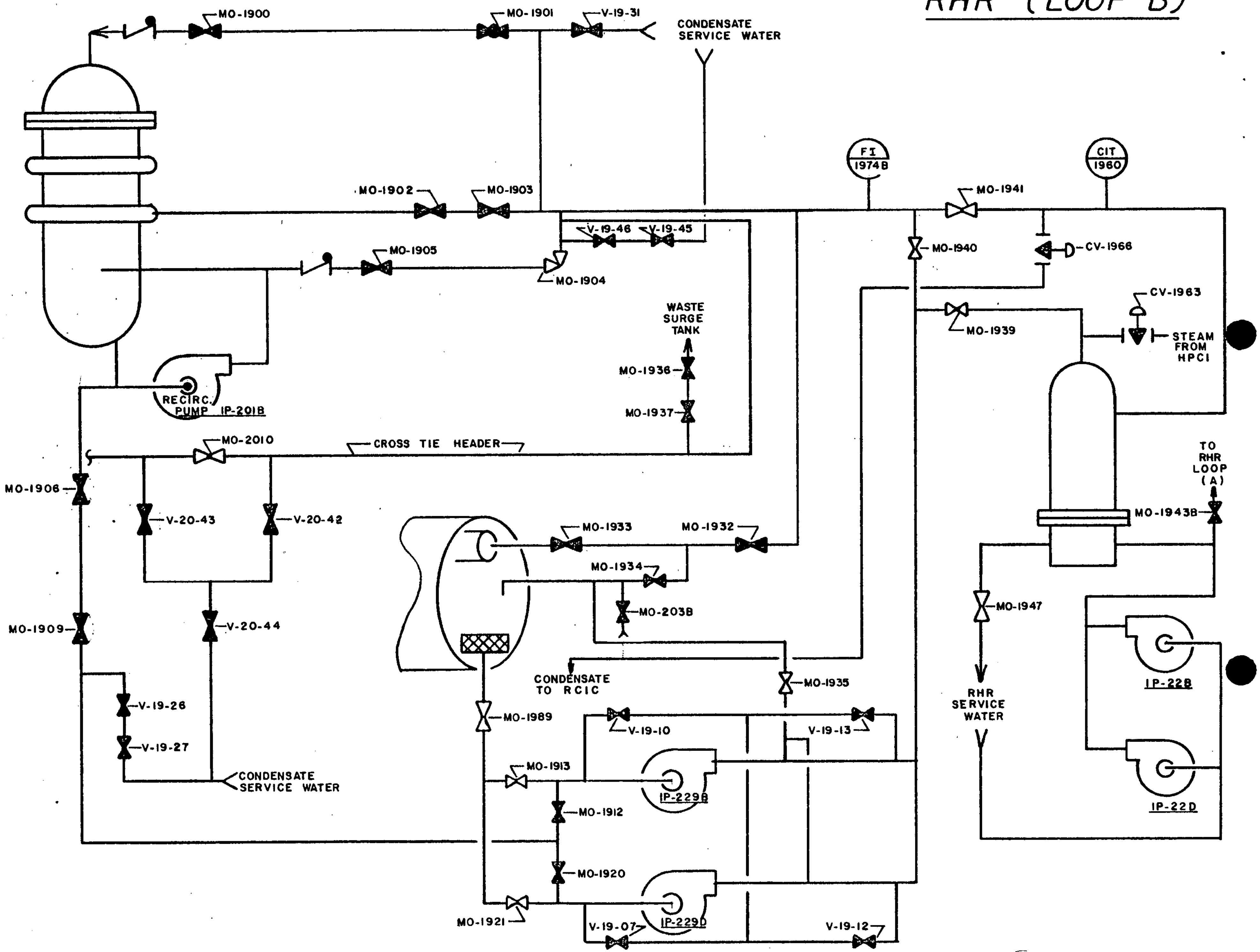
A diagram of the RHR system showing those valves that affect the water flow paths is included on the following page. The diagram shows the normal position of those valves during normal plant operation. The RHR system is composed of two similar loops, identified as Loop A and Loop B. Both loops may be used for either suppression pool cooling or in the shutdown cooling mode for decay heat removal. Use of the RHR would typically take place in three stages. The first stage would be use in the suppression pool cooling mode. The second stage would be an intermediate phase involving flushing the system. The third stage would be using the system in the shutdown cooling mode. The mode of operation of a loop is independent of the mode of operation of the other loop. As can be seen from the system diagram, the two loops are symmetrical. Corresponding components are listed in a table following the diagram. Although only Loop B is analyzed here, similar conclusions about Loop A can be drawn using the table of corresponding components. Operation of the RHR service water system for RHR Heat Exchanger operation is discussed separately.

Initiation of the RHR (Loop B) system in the suppression pool cooling mode requires the following valve positions to be achieved or maintained, the pumps to operate, and reliable indication on the instrument identified (In all cases, valves operated locally by hand are not included since they will not be vulnerable to interference from spurious control room signals):

	Open	Remain Open	Close	Remain Closed	Notes
MO 2010			X	X	
1P-229B					Start
MO 1932	X	X			
MO 1934	X	X			
FI 1974B					Indicates Flow Rate
MO 1935			X	X	
MO 1940			X	X	

Continued operation of the RHR (Loop B) system in the suppression pool cooling mode requires that the water flow path remains open and that system efficiency is not degraded by flow through lateral pipe branches. The position of the following valves (not included in system initiation) must be maintained:

RHR (LOOP B)


MO-1900
MO-1901
V-19-31
CONDENSATE SERVICE WATER
FI 1974B
CIT 1960
MO-1902
MO-1903
MO-1941
V-19-46
V-19-45
MO-1905
MO-1904
MO-1940
CV-1966
CV-1963
MO-1939
STEAM FROM HPCI
WASTE SURGE TANK
MO-1936
MO-1937
RECIRC. PUMP IP-201B
MO-2010
CROSS TIE HEADER
MO-1906
V-20-43
V-20-42
TO RHR LOOP (A)
MO-1943B
MO-1933
MO-1932
MO-1934
MO-2038
MO-1947
MO-1909
V-20-44
IP-22B
CONDENSATE TO RCIC
MO-1935
RHR SERVICE WATER
V-19-26
V-19-27
MO-1989
V-19-10
V-19-13
CONDENSATE SERVICE WATER
MO-1913
IP-229B
IP-22D
MO-1912
MO-1920
MO-1921
V-19-07
IP-229D
V-19-12

	Open	Remain Open	Close	Remain Closed	Notes
MO 1989		X			
MO 1913		X			
MO 1912				X	
MO 1939		X			
MO 1941		X			
MO 1901				X	
MO 1903				X	
MO 1905				X	
MO 1937				X	
MO 1933				X	
MO 2038				X	

Terminating use of the RHR (Loop B) system in the suppression pool cooling mode and initiating the flushing sequence requires the following changes:

	Open	Remain Open	Close	Remain Closed	Notes
1P-229B					Stop
MO 1934			X	X	
MO 1932			X	X	
MO 1913			X	X	
MO 1921			X	X	
MO 1935	X	X			
CIS 1960					Indicates conductivity of water to insure adequate flush process
MO 1940	X	X			
MO 1912	X	X			
MO 1920	X	X			

(The RHR (Loop B) system is flushed by condensate water originating through valves V-19-46 and V-20-42 and passing back through the system pumps and valves V-19-10, V-19-13, V-19-7, and V-19-12 into the suppression pool)

Continued operation of the flush mode requires that the valve line-up remain as in the suppression pool cooling mode except as modified for initiation of the flushing operation.

Initiation of the RHR (Loop B) system in the shutdown cooling mode after completion of the flushing operation requires the following valves, pumps, and indicators to function as indicated:

	Open	Remain Open	Close	Remain Closed	Notes
MO 1908	X	X			
MO 1909	X	X			
1P-229B					Start
MO 1905	X	X			
MO 1904					Throttle to intermediate position

	Open	Remain Open	Close	Remain Closed	Notes
FI 1974B					Indicates Flow Rate
MO 1935			X	X	

Continued operation of the RHR (Loop B) system in the shutdown cooling mode requires that the water flow path remains open and that system efficiency is not degraded by flow through lateral pipe branches. The position of the following valves (not included in system initiation) must be maintained:

	Open	Remain Open	Close	Remain Closed	Notes
MO 1912		X			
MO 1939		X			
MO 1941		X			
MO 1901				X	
MO 1903				X	
MO 1937				X	
MO 2010				X	
MO 1932				X	

The RHR (Loop B) system can be operated in the shutdown cooling mode essentially indefinitely.

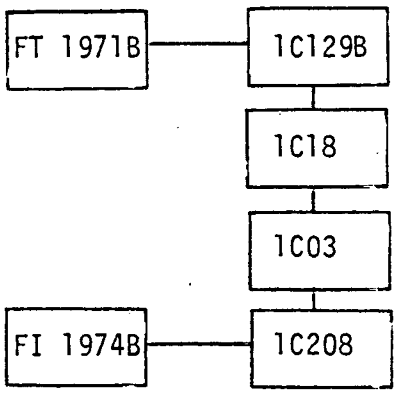
All of the above mentioned valves have control circuitry in the control room that would be vulnerable to a fire in a single control panel. Also, however, each of the above mentioned valves may be controlled from a location outside of the control room, that location in the case of motor operated valves is the appropriate motor control center. The purpose of the following analysis is to determine the extent to which control capability outside the control room is necessary.

Control room circuitry for motor operated valves typically consists of OPEN and CLOSE circuits. Although both circuits may use the same hand switch in the control room, they each typically have networks of relays that spread out into different control room panels. So even though both the OPEN and CLOSE circuits may be vulnerable to a fire in the control room panel containing the hand switch, they may have networks of relays whose vulnerability to control room panel fires may be completely different. Those valves that must maintain an open or closed position are vulnerable to contrary spurious signals caused by a control room panel fire. Those valves that must change positions are vulnerable to failure to receive the necessary signal. The following list includes each above mentioned valve and the type of vulnerability for which its control circuitry must be analyzed:

	Failure to Open ($\overline{O}$)	Spurious Closure (C)	Failure to Close ($\overline{C}$)	Spurious Opening (O)	Notes
MO 1901				X	
MO 1903				X	
MO 1904	X	X	X	X	Throttle to intermediate position
MO 1905	X	X		X	
MO 1908	X	X			
MO 1909	X	X			
MO 1912	X	X		X	
MO 1913		X	X	X	
MO 1920	X	X			
MO 1921			X	X	
MO 1932	X	X	X	X	
MO 1933				X	
MO 1934	X	X	X	X	
MO 1935	X	X	X	X	
MO 1937				X	
MO 1939		X			
MO 1940	X	X	X	X	
MO 1941		X			
MO 1989		X			
MO 2010			X	X	
MO 2038				X	

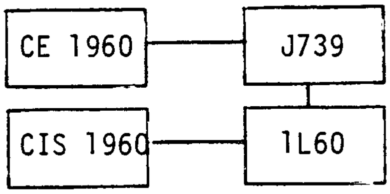
RHR, Indication

1. RHR (Loop B) System Flow Indication is provided at local panel 1C208 by instrument FI 1974B, the source of the signal is FT 1971B. The block diagram derived from drawing E121/57 shows the electrical cable routing.



The routing of the cable through panels 1C18 and 1C03 in the control room makes the local panel (1C208) instrument reading vulnerable to a fire in either of those control panels.

2. RHR (Loop B) System Heat Exchanger B Conductivity used during the flush mode is provided by conductivity indicator CIS 1960 located locally at 1L60. The source of the signal is CE 1960. The signal is transmitted directly to the indicator. The block diagram derived from drawing E121/57 shows the cable routing. The conductivity reading will not be affected by a control room fire.



RHR, Pump B Control Circuit

1P-229B RHR Pump B   Drawing E121/41

The control circuitry for a pump is different from that of a valve in that there are CLOSE (C) and TRIP (T) circuits for pump operation and cease of operation. Interferring signals from a control room panel fire can still be bypassed by operating the pump from its motor control center or the essential switchgear room.

Failure to close ($\overline{C}$)	C = S + K18B + CLOSE
Spurious Trip (T)	T = S + K19B + TRIP

1M405	1A405	1C03	1C33
	CLOSE	S	K18B
	TRIP		K19B

Possible requirement for alternate control if fire in control room panel { 1C03 1C32 / 1C33 1C31 }

Relay Development

1st Level

Relay Contact	Location	Input Logic/Signal
E11-K18B	1C33	= (K78B) (K72B) (K2B + K70B)
E11-K19B	1C33	= (LS3/M01913) (LS3/M01912 + K15B + K15A)
LS3/M01913	local	closed except when valve M01913 fully open
LS3/M01912	local	closed except when valve M01912 fully open

2nd Level

E11-K78B	1C33	= (K9B) (K3B + K4B)
E11-K72B	1C33	= S3B + (K72B) (K78B) (K2B + K70B)
E11-K2B	1C33	= closed when normal auxilliary power available,signal via 1C31
E11-K70B	1C33	= K78B
E11-K15B	1C33	= LS11 closes when valve M01909 not fully open
E11-K15A	1C32	= LS16 closes when valve M01908 not fully open

3rd Level

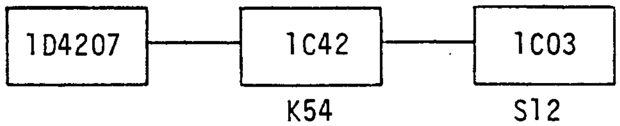
E11-K9B	1C33	= closes on high drywell pressure and reactor low level, signal via 1C32
E11-K3B	1C33	= closed when standby power available, signal via 1C31
E11-K4B	1C33	=

RHR, Control Circuit Block Diagram

and Logic Equations

<u>MO 1901</u> (E11-F023) Reactor Head Spray   Drawing E122/6

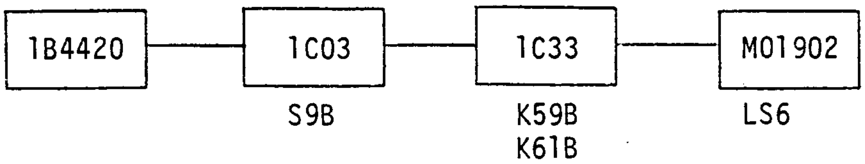
Spurious Open (0) $0 = (S12)\ (K54)$



Possible requirement for alternate control if fire in control room panels { 1C42

<u>MO 1903</u> (E11-F016B) Containment Cooling   Drawing E121/60

Spurious Open (0) $0 = S9B\ [K59B + LS6\ (\overline{K61B})]$



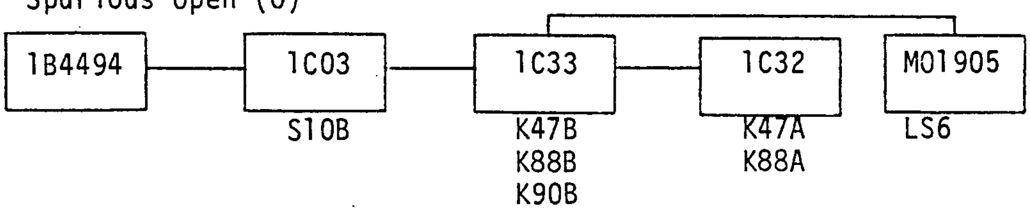
Possible requirement for alternate control if fire in control room panels { 1C03

<u>MO 1904</u> (E11-F017B) Discharge to LPCI   Drawing E121/53

Failure to Close ($\overline{C}$)
Spurious Close (C)
Failure to Open ($\overline{0}$)
Spurious Open (0)

$C = (\overline{K47B})\ (\overline{K47A})\ [S10B + K88B + K88A]$

$0 = (S10B)\ (LS6 + K90B) + K47B + K47A$



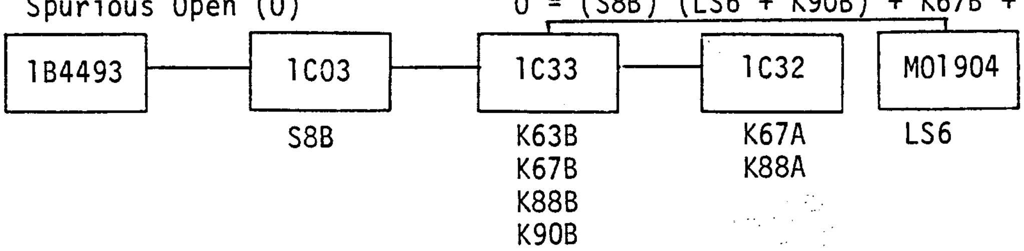
Possible requirement for alternate control if fire in control room panels { 1C03 1C33

<u>MO 1905</u> (F015B) Discharge to LPCI   Drawing E121/52

Spurious Close (C)
Failure to Open ($\overline{0}$)
Spurious Open (0)

$C = (\overline{K67B})\ (S8B + K63B + K88B + K88A)$

$0 = (S8B)\ (LS6 + K90B) + K67B + K67A$

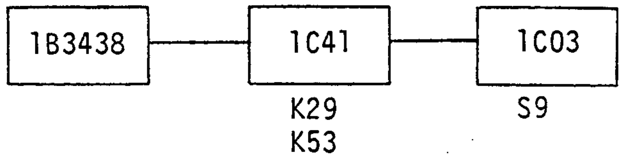


Possible requirement for alternate control if fire in control room panels { 1C03 1C32 1C33

<u>MO 1908</u> (E11-F009), Shutdown Cooling Drawing E122/2

Spurious Close (C) $C = S9 + \overline{K29}$

Failure to Open $(\overline{O})$ $0 + (S9)(K53) + K29$

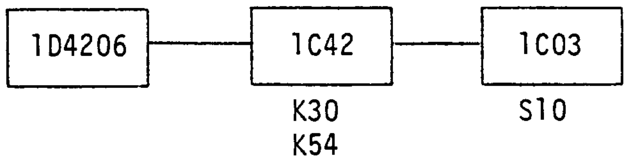


Possible requirement for alternate control if fire in control room panels { 1C03 1C41

<u>MO 1909</u> (E11-F008) Drawing E122/4

Spurious Close (C) $C = S10 + \overline{K30}$

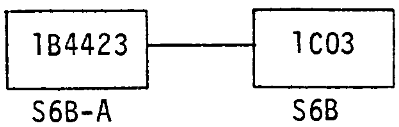
Failure to Open $(\overline{O})$ $0 = (S10)(K54) + K30$



Possible requirement for alternate control if fire in control room panels { 1C03 1C42

<u>MO 1912</u> (E11-F006B) Shutdown Cooling Valve B, Drawing E121/44

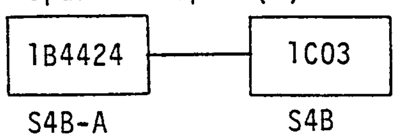
Spurious Close (C) $C = (S6B)(S6B\text{-}A)$
Failure to Open $(\overline{O})$
Spurious Open (O) $O = S6B + S6B\text{-}A$



Possible requirement for alternate control if fire in control room panels { 1C03

<u>MO 1913</u> (E11-F004B) Pump B Suction Drawing E121/43A

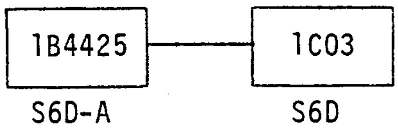
Spurious Close (C) $C = S4B + S4B\text{-}A$
Failure to Close $(\overline{C})$
Spurious Open (O) $O = (S4B)(S4B\text{-}A)$



Possible requirement for alternate control if fire in control room panels { 1C03

MO 1920 (E11-F006D) Shutdown Cooling Valve D — Drawing E121/44

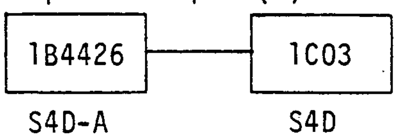
Spurious Close (C) — $C = (S6D)\ (S6D\text{-}A)$
Failure to Open ($\overline{O}$) — $\overline{O} = S6D + S6D\text{-}A$



Possible requirement for alternate control if fire in control room panels — 1C03

MO 1921 (E11-F004D) Pump D Suction — Drawing E121/43A

Failure to Close ($\overline{C}$) — $\overline{C} = S4D + S4D\text{-}A$
Spurious Open (O) — $O = (S4D)\ (S4D\text{-}A)$



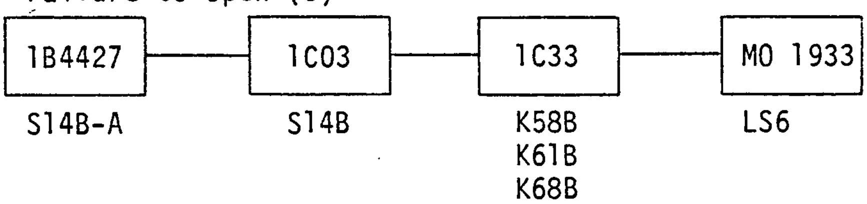
Possible requirement for alternate control if fire in control room panels — 1C03

MO 1932 (E11-F028B) Test Isolation Valve — Drawing E121/49

Spurious Close (C)
Failure to Close ($\overline{C}$)
Spurious Open (O)
Failure to Open ($\overline{O}$)

$C = (S14B\text{-}A)\ [(S14B + \overline{K58B})\ (K61B)]$

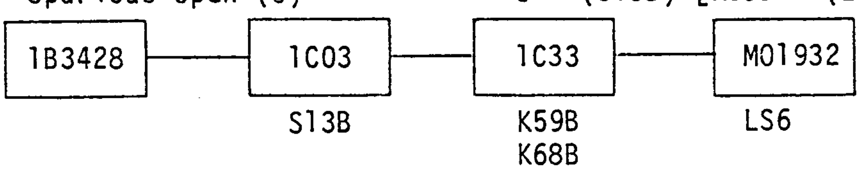
$O = S14B\text{-}A + (S14B)\ [K58B + (LS6)\ (\overline{K68B})]$



Possible requirement for alternate control if fire in control room panels — 1C03, 1C32, 1C33

MO 1933 (E11-F027B) Test to Torus Valve — Drawing E121/59A

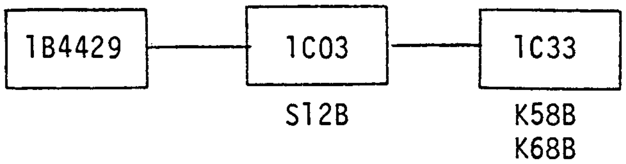
Spurious Open (O) — $O = (S13B)\ [K59B + (LS6)\ (\overline{K68B})]$



Possible requirement for alternate control if fire in control room panels — 1C03

MO 1934 (E11-F024B) Test to Torus Valve Drawing E121/59

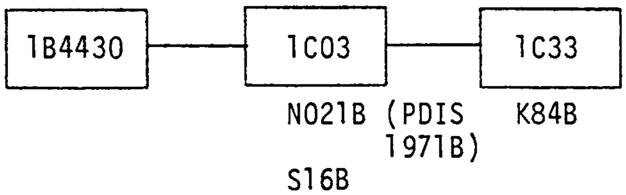
Spurious Close (C) $C = S12B + (K68B)(\overline{K58B})$
Failure to Close ($\overline{C}$)
Spurious Open (O) $O + (S12B)(K58B + \overline{K68B})$
Failure to Open ($\overline{O}$)



Possible requirement for alternate control if fire in control room panels { 1C03 1C33

MO 1935 (E11-F007B) Minimum Flow Bypass Drawing E121/54

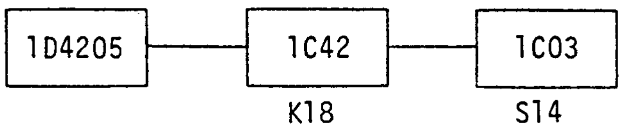
Spurious Close (C) $C = S16B + (N021B)$
Failure to Close ($\overline{C}$)
Spurious Open (O) $O = S16B + K84B$
Failure to Open ($\overline{O}$)



Possible requirement for alternate control if fire in control room panels { 1C03 1C33

MO 1937 (E11-F049) RHR Discharge to Waste Surge Tank, Drawing E122/15

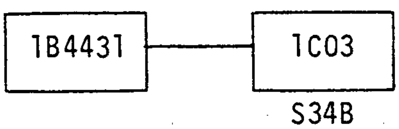
Spurious Opening (O) $O = (S14)(K18)$



Possible requirement for alternate control if fire in control room panels { 1C42 1C15 1C17

MO 1939 (E11-F047B) Heat Exchanger Shell Inlet, Drawing E121/43

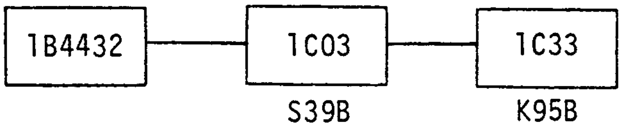
Spurious Close (C) $C = S34B$



Possible requirement for alternate control if fire in control room panels { 1C03

<u>MO 1940</u> (E11-F048B) Heat Exchanger Bypass Drawing E121/51

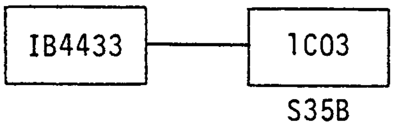
Spurious Close (C) — $C = S39B + K95B$
Failure to Close ($\overline{C}$)
Spurious Open (0) — $0 = (S39B)(\overline{K95B})$
Failure to Open ($\overline{0}$)



Possible requirement for alternate control if fire in control room panels — 1C03, 1C32, 1C33

<u>MO 1941</u> (E11-F003B) Heat Exchanger Shell Outlet, Drawing E121/43

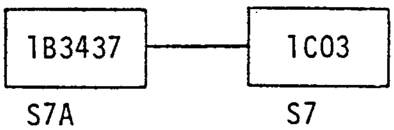
Spurious Close (C) — $C = S35B$



Possible requirement for alternate control if fire in control room panels — 1C03

<u>MO 2010</u> (E11-F010) Cross Loop Header Drawing E121/45A

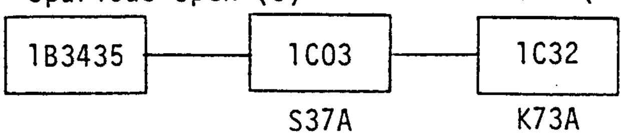
Failure to Close ($\overline{C}$) — $C = S7 + S7A$
Spurious Open (0) — $0 = (S7)(S7A)$



Possible requirement for alternate control if fire in control room panels — 1C03

<u>MO 2038</u> (E11-F011A) Drain to Torus Drawing E121/50

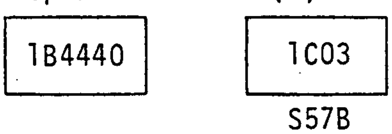
Spurious Open (0) — $0 = (S37A)(\overline{K73A})$



Possible requirement for alternate control if fire in control room panels — 1C03

<u>MO 1989</u> (N/A) Suppression Pool Outlet, Drawing E121/45

Spurious Close (C) — $C = S57B$



Possible requirement for alternate control if fire in control room panels — 1C03

RHR, Relay Development

The following relays are those relays included in RHR (Loop B) component control circuits. The input logic and input signals are shown as a Boolean logic equation. The location of each relay or contact is shown. The relays are grouped into levels. Those relays in the first level appear in the previously described control circuits. Relays in the second level appear in the supporting logic for relays in the first level, etc. The listed relays are found primarily in three groups of drawings. Relays in the A71-series are on drawings APED A71-3(5), A71-3(6), A71-3(7), A71-3(9) and A71-3(13). Drawings in the E11-series with an "A" suffix, ie, E11-K47A, are on drawings APED E11-7(4), E11-7(5), and E11-7(6). Drawings in the E11-series with a "B" suffix, ie E11-K47B, are on drawings APED E11-7(7), E11-7(8) and E11-7(9).

1st Level

Relay/ Contact	Loca- tion	Input Logic/Signal
A71-K29	1C41	= (K17) (K28) (K29 + K11)
A71-K53	1C41	=
A71-K30	1C42	= (K18) (K50) (K30 + K12)
A71-K44	1C42	=
E11-K47A	1C32	= ($\overline{\text{K45A}}$) (K44A) (K43A)
E11-K67A	1C32	= ($\overline{\text{K63A}}$) (K44A) (K43A)
E11-K73A	1C32	= K9A + K10A + (K7A + K7B) (K8A + K8B)
E11-K88A	1C32	= (K39A) ($\overline{\text{K86A}}$)
E11-K47B	1C33	= (K43B) (K44B) ($\overline{\text{K45B}}$)
E11-K58B	1C33	= [S18B + (K61B) (K14B)] [(K107A + K107B) (K106A + K106B)] X
E11-K59B	1C33	= [S17B + S17B(K69B)]
E11-S18B	1C03	normally open, for containment spray valves
E11-S17B	1C03	normally open, E11-F024B, 28B, 16B, 21B, 27B
E11-K61B	1C33	= K9B
E11-K68B	1C33	=
E11-K63B	1C33	= (K65A + K65B) (K16A) (K16B) (A71B-K60)
E11-K67B	1C33	= ($\overline{\text{K63B}}$) (K43B) (K44B)
E11-K84B	1C33	= (N021B) (520/1A405 + 52a/A406)
E11-N021B	local	closes on low flow (PDIS 1971B)
S2a	1A405	closes when breaker for pump 1P-229B is closed
S2a	1A406	closes when breaker for pump 1P-229D is closed

Relay/ Contact	Loca- tion	Input Logic/Signal
E11-K88B	1C33	= K39B
E11-K90B	1C33	= B21-N021B via 1C55
B21-N021B	local	closes on low reactor pressure (PS 4548)
E11-K95B	1C33	= ($\overline{K93B}$) (K94B)

2nd Level

A71-K11	1C41	= S32
A71-S32	1C05	normally open, isolation valves reset
A71-K12	1C42	= S33
A71-S33	1C05	normally open, isolation valves reset
A71-K17	1C41	= [($\overline{S22B}$) (K5B) + ($\overline{S22A}$) (K5A)] (K17 + K47)
E11-S22B	1C17	normally closed
E11-S22A	1C15	normally closed
E11-K18	1C42	= [($\overline{S22D}$) (K5D) + ($\overline{S22C}$) (K5C)] (K18 + K48)
E11-S22D	1C17	normally closed
E11-S22C	1C15	normally closed
E11-K28	1C41	= B31-N018A via 1C122
B31-N018A	local	opens on high reactor pressure
E11-K50	1C42	= B31-N018B2 via 1C58
B31-N018B2	local	opens on high reactor pressure
E11-K7A	1C32	= E21-K7A
E11-K8A	1C32	= E21-K8A
E11-K9A	1C32	= K10A + (K7A + K7B) (K8A + K8B)
E11-K10A	1C32	= (K5A + K5B) (K6A + K6B)
E11-K16A	1C32	= LS15
LS15	local	= closed when MO 1908 not fully closed
E11-K39A	1C32	= (K37A) ($\overline{K43A}$) + (K35A + K35B) (K36A + K36B) (K34A)
E11-K43A	1C32	= (K40A) ($\overline{K37A}$)
E11-K44A	1C32	= (K90A + K90B) (K105A + K105B) (K43A + K39A)
E11-K65A	1C32	= B31-N018A via 1C122
B31-N018A	local	closes on low RPV pressure
E11-K106A	1C32	= E11-N019A via 1C122
E11-N019A	local	closes on high drywell pressure
E11-K107A	1C32	= E11-N019C via 1C126B
E11-N019C	local	closes on high drywell pressure
E11-K7B	1C33	= E21-K7B
E11-K8B	1C33	= E21-K8B
E11-K14B	1C33	= B21-N037
B21-N037	1C121	closed above RPV low level trip

Relay/ Contact	Location	Input Logic/Signal
E11-K16B	1C33	= LS15
LS15	local	closed when MO 1909 not fully closed
E11-K39B	1C33	= ($\overline{\text{K43B}}$) [K37B + K11B ($\overline{\text{K40A}}$) (K36A + K36B) (K35A + K35B) K34B]
E11-K43B	1C33	= (K40B) ($\overline{\text{K37B}}$)
E11-K44B	1C33	= (K43B + K39B) (K105A + K105B) (K90A + K90B)
E11-K45B	1C33	= K44B
E11-K63B	1C33	= (K65A + K65B) (K16A) (K16B) (A71B-K60)
E11-K65B	1C33	= B31-N018B-1 via 1C58
B31-N018B-1	local	closes on low RPV pressure
E11-K69B	1C33	= [(K61B) (K14B) + S18B] (K107A + K107B) (K106A + K106B) (S17B)
E11-K86B	1C33	= K39B
E11-K93B	1C33	= K94B
E11-K94B	1C33	= K10B + (K7A + K7B) (K8A + K8B)
E11-K106B	1C33	= E11-N019B via 1C58
E11-N019B	local	closes on high drywell pressure
E11-K107B	1C33	= E11-N019D via 1C121
E11-N019D	local	closes on high drywell pressure
A71B-K60	1C42	closes on reactor low level or high drywell pressure

3rd Level

Relay/ Contact	Location	Input Logic/Signal
A71-K5A	1C15	= (C71A-K6A) (C71A-K4A)
A71-K5C	1C15	= (C71A-K6C) (C71A-K4C)
A71-K5B	1C17	= (C71A-K6B) (C71A-K4B)
A71-K5D	1C17	= (C71A-K6D) (C71A-K4D)
A71-K47	1C41	= S32
A71-K48	1C42	= S33
E11-K5A	1C32	= N011A via 1C122
E11-N011A	local	closes on high drywell pressure
E11-K6A	1C32	N011C via 1C126B
E11-N011C	local	closes on high drywell pressure
E11-K34A	1C32	= K33A + [K27A + (K31A + K31B) (K32A + K32B) (K100A)] $\overline{\text{K11A}}$
E11-K35A	1C32	= B31-N016A via 1C122
B31-N016A	local	closes when riser differential pressure "A" is greater than "B"
E11-K36A	1C32	= B31-N016C via 1C22
B31-N016C	local	closes when riser differential pressure "A" is greater than "B"
E11-K40A	1C32	= (K34A) ($\overline{\text{K37B}}$)
E11-K90A	1C32	= B21-N021A via 1C56
B21-N021A	local	closes on low reactor pressure

Relay/ Contact	Loca- tion	Input Logic/Signal
E11-K105A	1C32	= B21-N021C via 1C122
E11-K5B	1C33	= E11-N011B via 1C58
E11-N011B	local	closes on high drywell pressure
E11-K6B	1C33	= E11-N011D via 1C121
E11-N011D	local	closes on high drywell pressure
E11-K11B	1C33	= S1B
E11-S1B	1C03	normally open, reset break detection
E11-K34B	1C33	= K33B + $\overline{\text{K11B}}$ [K27B + (K32A + K32B) (K31A + K31B) K100B]
E11-K35B	1C33	= B31-N016B via 1C121
B31-N016B	local	closes when riser differential pressure "A" is greater than "B"
E11-K36B	1C33	= B31-N016D via 1C121
B31-N016D	local	closes when riser differential pressure "A" is greater than "B"
E11-K37B	1C33	= ($\overline{\text{K40A}}$) (K36A + K36B) (K35A + K35B) (K34B)
E11-K40B	1C33	= ($\overline{\text{K37A}}$) (K34B)
E11-K61B	1C33	= K9B
E11-K90B	1C33	B21-N021B via 1C55
B21-N021B	local	closes on low RPV pressure
E11-K105B	1C33	= B21-N021D via 1C121
B21-N021D	local	closes on low RPV pressure
E21-K7A	1C43	= B21-N031A via 1C56
B21-N031A	local	closes on low RPV level
E21-K7B	1C44	= B21-N031B via 1C55
B21-N031B	local	closes on low RPV level
E21-K8A	1C43	= B21-N031C via 1C56
B21-N031C	local	closes on low RPV level
E21-K8B	1C44	= B21-N031D via 1C55
B21-N031D	local	closes on low RPV level

4th Level

E11-K31A	1C32	= B21-N039A via 1C56
B21-N039A	local	closes below reactor setpoint
E11-K32A	1C32	= B21-N039C via 1C56
B21-N039C	local	closes below reactor setpoint
E11-K34A	1C32	= K33A + ($\overline{\text{K11A}}$) [K27A + K100A (K31A + K31B) (K32A + K32B)]
E11-K27B	1C33	= (K77B) (K23A + K23B) (K24A + K24B) (K25A + K25B) (K26A + K26B)
E11-K31B	1C33	= B21-N039B via 1C55
B21-N039B	local	closes below reactor setpoint
E11-K32B	1C33	= B21-N039B via 1C55
B21-N039D	local	closes below reactor setpoint
E11-K33B	1C33	= K27B + (K100B) (K31A + K31B) (K32A + K32B)

Relay/ Contact	Location	Input Logic/Signal
E11-K100B	1C33	= K28B
C71A-K6A	1C15	close on low RPV level
C71A-K6B	1C17	close on low RPV level
C71A-K6C	1C15	close on low RPV level
C71A-K6D	1C17	close on low RPV level
C71A-K4A	1C15	close on drywell high pressure
C71A-K4B	1C17	close on drywell high pressure
C71A-K4C	1C15	close on drywell high pressure
C71A-K4D	1C17	close on drywell high pressure

5th Level

Relay/ Contact	Location	Input Logic/Signal
E11-K11A	1C32	= S1A
E11-S1A	1C03	normally closed, reset break detection
E11-K23A	1C32	= (K77A) (B31-N019A) via 1C57
B31-N019A	local	closes when pump "A" runs differential pressure over setpoint
E11-K24A	1C32	= (K77A) (B31-N020A) via 1C57
B31-N020A	local	closes when pump "A" runs differential pressure over setpoint
E11-K25A	1C32	= (K77A) (B31-N021B) via 1C58
B31-N021B	local	closes when pump "B" runs differential pressure over setpoint
E11-K26A	1C32	= (K77A) (B31-N022B) via 1C58
B31-N022B	local	closes when pump "B" runs differential pressure over setpoint
E11-K27A	1C32	= (K77A) (K23A + K23B) (K24A + K24B) (K25A + K25B) (K26A + K26B)
E11-K33A	1C32	= K27A + [(K100A) (K31A + K31B) (K32A + K32B)]
E11-K100A	1C32	= K28A
E11-K23B	1C33	= (K77B) (B31-N021A) via 1C57
B31-N021A	local	closes when pump "A" runs differential pressure over setpoint
E11-K24B	1C33	= (K77B) (B31-N022A) via 1C57
B31-N022A	local	closes when pump "A" runs differential pressure over setpoint
E11-K25B	1C33	= (K77B) (B31-N019B) via 1C58
B31-N019B	local	closes when pump "B" runs differential pressure over setpoint
E11-K26B	1C33	= (K77B) (B31-N020B) via 1C58
B31-N020B	local	closes when pump "B" runs differential pressure over setpoint
E11-K28B	1C33	= K77B

6th Level

Relay/ Contact	Location	Input Logic/Signal
E11-K28A	1C32	= K77A
E11-K77A	1C32	= (K10A) + (K79A + K79B) (K80A + K80B)
E11-K77B	1C33	= (K10B) + (K79A + K79B) (K80A + K80B)

7th Level

Relay/ Contact	Location	Input Logic/Signal
E11-K10A	1C32	= (K5A + K5B) (K6A + K6B)
E11-K79A	1C32	= B21-N031A via 1C56
B21-N031A	local	closes on RPV low level
E11-K80A	1C32	= B21-N031C via 1C56
B21-N031C	local	closes on RPV low level
E11-K79B	1C33	= B21-N031B via 1C55
B21-N031B	local	closes on RPV low level
E11-K80B	1C33	= B21-N031D via 1C55
B21-N031D	local	closes on RPV low level

Reactor Decay Heat Removal and Suppression Pool Cooling

RHR Service Water

A diagram of the RHR Service water system for the RHR (Loop B) heat exchanger showing those valves that affect the water flow path is included on the following page. The diagram shows the normal position of those valves during normal plant operation. Pump (1P-22B, 1P-22D) startup is all that is required to initiate the RHR Service Water system. The valves are normally in the correct lineup and for continued operation must maintain their position as follows:

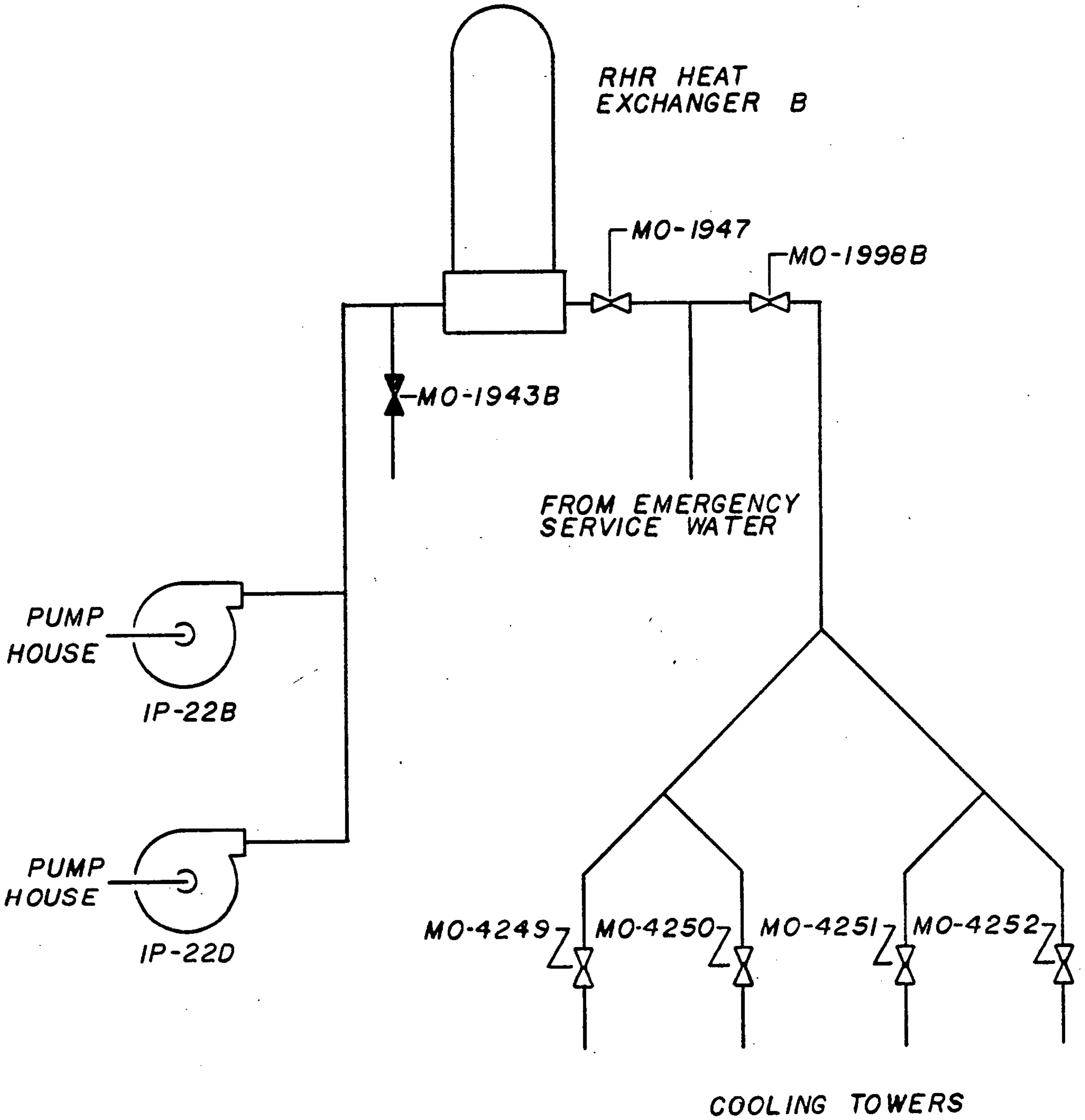
	Remain Open	Remain Closed	Notes
MO 1943B		X	
MO 1947	X		
MO 1998B	X		
MO 4249	X		
MO 4250	X		
MO 4251	X		
MO 4252	X		

Terminating use of the RHR Service Water system for RHR (Loop B) requires only that the pumps be stopped.

All of the above mentioned valves have control circuitry in the control room that would be vulnerable to a fire in a single control panel. Also, however, each of the above mentioned valves may be controlled from a location outside of the control room, that location in the case of motor operated valves is the appropriate motor control center. The purpose of the following analysis is to determine the extent to which control capability outside the control room is necessary.

Control room circuitry for motor operated valves typically consists of OPEN and CLOSE circuits. Although both circuits may use the same hand switch in the control room, they each typically have networks of relays that spread out into different control room panels. So even though both the OPEN and CLOSE circuits may be vulnerable to a fire in the control room panel containing the hand switch, they may have networks of relays whose vulnerability to control room panel fires may be completely different. Those valves that must maintain an open or closed position are vulnerable to contrary spurious signals caused by a control room panel fire. Those valves that must change positions are vulnerable to failure to receive the necessary signal. The following list includes each above mentioned valve and the type of vulnerability for which its control circuitry must be analyzed:

RHR (LOOP B) SERVICE WATER



REFERENCE M-113

	Failure to Open ($\overline{O}$)	Spurious Closure (C)	Failure to Close ($\overline{C}$)	Spurious Opening	Notes
MO 1943				X	
MO 1947		X			
MO 1998B		X			
MO 4249		X			
MO 4250		X			
MO 4251		X			
MO 4252		X			

RHR Service Water

Pumps B & D Control Circuitry

1P-22B & D RHR (Loop B) Service Water Pumps   Drawings E121/42

The control circuitry for a pump is different from that of a valve in that there are CLOSE (C) and TRIP (T) circuits for pump operation and cease of operation. Interferring signals from a control room panel fire can still be bypassed by operating the pump from its motor control center or the essential switchgear room.

Failure to Close ($\bar{C}$)   C = S + CLOSE

Spurious Trip (T)   T = S + TRIP + K62B + 194-41 + 197-41

1M407	1A407	1C03	1C33	1C31
	CLOSE TRIP 194-41	S	K62B	197-41

Possible requirement for alternate control if fire in control room panel: 1C03 1C33 1C31

Relay Development

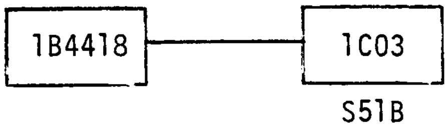
Relay/ Contact	Location	Input Logic/Signal
194-41	1A407	= } load shedding signals from panel 1C31
197-41	1C31	= }
K62B	1C33	= (S19B) (K9B)
S19B	1C03	normally open, RHR Service Water Pump Control
K9B	1C33	close on high drywell pressure and reactor low level, signals via 1C32

RHR Service Water, Control Circuit

Block Diagrams and Logic Equations

<u>MO 1943B</u> (E11-F073B) RHR Service Water Cross Tie Loop B, Drawing E121/45

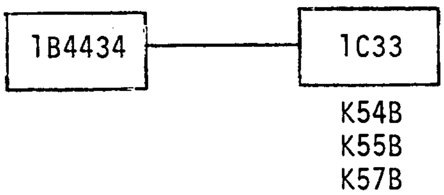
Spurious Opening (O) $O = S51B$



Possible requirement for alternate control if fire in control room panel { 1C03

<u>MO 1947</u> (E11-F068B) RHR Heat Exchanger B, Service Water Outlet, Drawing E121/55

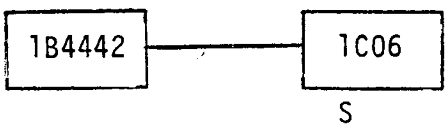
Spurious Closure (C) $C = K57B + (K54B)(K55B)$



Possible requirement for alternate control if fire in control room panel { 1C33, 1C1B

<u>MO 1998B</u> (N/A) RHR Heat Exchanger B Discharge to Radwaste, Drawing E111/6

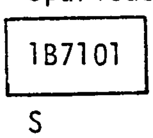
Spurious Closure (C) $C = S$



Possible requirement for alternate control if fire in control room panel { 1C06

<u>MO 4249</u> (N/A) Cooling Tower Cooling Water Inlet, Drawing E110/11

Spurious Closure (C) $C = S$



Possible requirement for alternate control if fire in control room panel { None

<u>MO 4250</u>, <u>MO 4251</u>, and <u>MO 4252</u>, all have circuitry identical to <u>MO 4249</u>, independent of the control room.

RHR Service Water, Relay Development

1st Level

Relay/ Contact	Location	Input Logic/Signal
E11-K54B	1C33	= 52b/1A407
E11-K55B	1C33	= 52b/1A408
E11-K57B	1C33	= S600B

2nd Level

52b	1A407	closes if service water pump not running
52b	1A408	closes if service water pump not running
E11-S600B	1C18	closes when valve MO 1947 E11-F068B closed

Process Monitoring

Reactor Vessel Level and Pressure

Suppression Pool Temperature

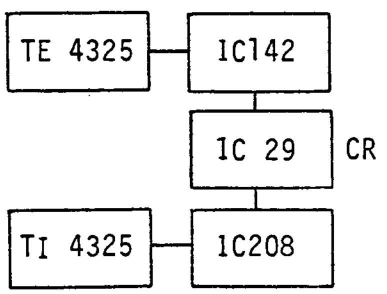
1. Reactor vessel level indication is provided at local panel IC55 by the following instruments:

Instrument (GE #)	GE drawing #
LIS 4532 (B21-N031B)	B21-145C-30-30
LIS 4534 (B21-N031D)	B21-145C-30-30
LIS 4536 (B21-N025A)	B21-145C-30-30
LIS 4538 (B21-N025B)	B21-145C-30-30
LIS 4540 (B21-N026B)	B21-145C-30-30
LIS 4562 (B21-N024B)	B21-145C-30-33

An examination of the GE drawings shows that the instrument reading is independent of any signal emanating from or passing through the control room.

2. Reactor pressure indication is provided at local panel IC55 by instrument PI 4554 (GE #B21-R004B), GE drawing # B21-3(2). An examination of the GE drawing shows that the instrument reading is independent of any signal emanating from or passing through the control room.

3. Suppression pool temperature indication is provided at local panel IC208 by instrument TI 4325 (N/A), the source of the signal is TE 4325 (N/A), the following block diagram derived from drawing E-122/19 shows the electrical cable routing:



The routing of the cable through panel IC29 in the control room makes the local panel (IC208) instrument reading vulnerable to a fire in the control room panel.

Support

Onsite Power Source and Distribution System

The onsite power sources and distribution networks for AC and DC power are located outside the control room. The impact of fire on these systems and their ability to supply power to plant safety system has been previously examined in the Fire Hazard Analysis and found to be unimpaired by fire in a single plant area.

Appendix A

Sample Component Analysis

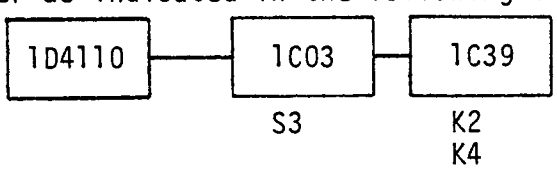
Each system analyzed in the Alternate Shutdown Capability Analysis has been broken into components that are then individually analyzed for vulnerability to control room panel fires. This analysis can be accomplished based on a block diagram showing key component locations, and as required, a Boolean Logic equation showing the relation between key components and a development of the supporting relays. For the purpose of exposition, a typical component, MO 2202, the motor operated main steam supply control valve for the High Pressure Coolant Injection (HPCI) system is analyzed.

The role of the main steam supply control valve, MO 2202, is determined by examining the P & ID M-120. From that P & ID, it is determined that proper operation of the valve requires that it not be subjected to the following conditions:

Failure to Open ($\overline{O}$)
Spurious Open (O)
Failure to Close ($\overline{C}$)
Spurious Close (C)

If MO 2202 is subjected to any of the above conditions at the wrong time, proper operation of the HPCI system will be precluded.

The vulnerability of the valve to spurious electrical signals is determined by examining the appropriate electrical schematics. The electrical schematic for MO 2202 is drawing E121/16. Three electrical components, Switch S3 and Relays K2 and K4, have contacts in the open/close circuits for the motor operator. These components are located with respect to each other as indicated in the following block diagram:



The relation between these components for circuit control purposes is illustrated by two Boolean equations, one for Open (O) and one for Close (C):

$$O = S3 + K2 + K4$$

$$C = S3$$

The above Boolean notation implies that energizing switch S3 in the open position or relays K2 or K4 will result in an open signal to the motor operator. Energizing switch S3 in the close position will result in a close signal to the motor operator.

A fire in panel 1C03 may electrically short the wiring in such a manner that the open or close circuit may be energized, or it might break the wiring and preclude receipt of an open or close signal from the switch S3. A fire in panel 1C39 affecting relay contacts for relays K2 and K4 might similarly cause spurious opening or failure to open when normally called for by automatic signals.

Relays K2 and K4 are the ends of chains of relays that propogate signals from various points through the plant and in the control room. As a result of this linkage, fires in other control room panels may propogate spurious signals by damaging relays. Relay K2 is driven by the following combination of signals (see HPCI, Relay Development 1st Level):

K2 = (K41 + B21-N031B) (K42 + B21-N031D)

B21-N031B and D are local switches that close on RPV low water level and are connected via panel 1C55, located outside the control room, to relay K2 in control room panel 1C39. Relays K41 and K42 are located in control room panel 1C32 and are driven by the following signals (see HPCI, Relay Development 2nd Level):

K41 = B21-N031A
K42 = B21-N031C

B21-N031A and C are local switches like B21-N031B and C except they are connected via panel 1C56 located outside the control room, to relays K41 and K42 in control room panel 1C32. Should a fire develop in control room panel 1C32 that shorted out relays K41 and K42, the logic for K2 would result in the energizing of K2 and a spurious opening signal. Similarly, a fire in panel 1C32 could preclude receipt of a desirable automatic signal.

Relay K4 is driven by the following combination of signals (see HPCI, Relay Development 1st Level):

K4 = (E21A-K5A + E21A-K5B) (E21A-K6A + E21-K6B)

E21A-K5A and K6A are located at control room panel 1C43 and E21A-K5B and K6B are located at control room panel 1C44. These relays are driven by local switches E11-N011A, B, C and D that close on high drywell pressure (see HPCI, Relay Development 2nd Level). Should a fire develop in control room panel 1C43 that shorted out relays -K5A and -K6A or in control room panel 1C44 that shorted out relays -K5B and -K6B, the logic for K4 would result in the energizing of K4 and a spurious opening signal. Similarly, a fire in either panel 1C43 or 1C44 could preclude receipt of a desirable automatic signal.

From this sample analysis, one can see how the limits of vulnerability of a component to spurious control room signals can be determined. In all cases of components involving a motor control center, regardless of the extent of vulnerability to spurious control room signals, the motor operator can be controlled locally at the motor control center and isolated from the spurious signals. The breakers actuated by the close/open circuitry are located in the motor control center (MCC), and isolated from the control room circuitry. Power for the motor operator is supplied via the MCC and controlled by the breakers there. This arrangement allows local control of the motor operator from the MCC when the external control circuitry in the control room is disrupted. To insure the most reliable local operation of the motor control center, instructions should be included in procedures describing the necessary local actions.

Appendix B

List of Drawings

APED A71-3(5)
APED A71-3(6)
APED A71-3(7)
APED A71-3(9)
APED A71-3(13)
APED B21-3(2)
APED B21-18 (2)
APED B21-18 (3)
APED B21-145C-30-30-1
APED B21-145C-30-33-1
APED E41-6(3)
APED E41-6(4)
APED E51-9(2)
APED E51-9(3)
APED E51-9(6)
APED E11-7(4)
APED E11-7(5)
APED E11-7(6)
APED E11-7(8)
APED E11-7(9)
E110/11
E111/6
E-121/2
E-121/14
E-121/15
E-121/16
E-121/17
E-121/18
E-121/19
E-121/21
E-121/23
E-121/29
E-121/30
E-121/31
E-121/32
E-121/33
E-121/34
E-121/35
E-121/36
E-121/40
E-121/41
E-121/42
E-121/43
E-121/43A
E-121/44
E-121/44A
E-121/45
E-121/45A
E-121/49
E-121/50
E-121/51
E-121/52
E-121/53
E-121/54
E-121/55
E-121/57
E-121/59
E-121/59A
E-121/60
E-122/2
E-122/4
E-122/15
E-122/16
E-122/19
E-122/22
M-113
M-119
M-120
M-122
M-123
M-124
M-125