GENERAL ELECTRIC

NUCLEAR POWER

SYSTEMS DIVISION

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U.S. Nuclear Regulatory Commission
Nuclear Reactor Regulation
Instrument & Control Systems Branch
Washington, D.C. 20555

RECEIVED
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U.S. NUCLEAR REGULATORY COMMISSION

Attention: Jim Knight

Gentlemen:

SUBJECT: LOW-LOW SET RELIEF LOGIC FAILURE MODE

This letter responds to your request for additional information concerning a postulated failure in the low-low set relief logic that would result in both the "low" and "mid" valve reopening a second time.

GE has evaluated the sequence of events and timing of the postulated failure and found it to have an occurrence probability of 6×10^{-7} per reactor year. For comparison, we have also calculated the probability of any 1 of 17 remaining SRV's (typical 238-sized plant), inadvertently actuating concurrent with the "low" valve and found this to be 1.3×10^{-6} per reactor year. We believe the probability of occurrence for either of these scenarios is sufficiently low and should be excluded for design purposes. This is based on the following:

1) The U.S. Nuclear Regulatory Commission's standard review plan, Sections 2.2.3, 3.5.1.5, 3.5.1.6, and Regulatory Guide 1.115 gives an acceptance criteria of 10^{-7} per year (probability of occurrence and consequences). The GE analysis for each postulated event represents probability of occurrence alone, yet is approximately within an order of magnitude of the 10^{-7} acceptance criterion.

2) The U.S. NRC standard review plan 2.2.3 also gives an alternative acceptance criterion of 10^{-6} per year for an accident (consequence) if the basis for the probability estimates can be shown to be conservative. The analysis performed by GE is believed to be sufficiently conservative for the following reasons:

   o The master and slave trip units were considered as separate contributors to the failure scenario even though their combined failure rate would have generated lower overall probabilities. This is because some components are shared with the master-to-slave configuration.

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- o The containment load definition for multiple safety/relief valve actuations is conservative by at least a factor of 2 for all frequency ranges. (This was determined as a result of 59 "Monte Carlo" simulations compared with test data taken at Caorso and is documented in GESSAR II, Appendix 3B, Attachment N. Figure 3BN-59, in combination with Figures 3BN-50 thru 3BN-58, demonstrates the conservatism of the SRV methodology in predicting Caorso test results. Figure 3BN-59 further validates the conservatism in the peak spectral valve selection process.) The most extreme loading occurs for 2 adjacent valves in which the peak pressure is twice that of a single valve. The probability of inadvertant concurrent actuation of either valve adjacent to the "low" LLS valve is only $^{2}/_{17} \times 1.3 \times 10^{-7} = 1.5 \times 10^{-8}$ per reactor year.

3) The Regulatory Staff concluded, as in the case of Brunswick (munition ship explosion), Trojan (tornado) and Shoreham (missile) that if the probability of resultant damage to the plant was sufficiently low (on the order of 10^{-6} per reactor year) that no special design features were required. The ACRS concurred in each of these assessments. In these scenarios, plant damage was assumed directly as a consequence. However, it is very unlikely that plant damage would occur from subsequent actuation of 2 SRV's.

The assumption and details for the reliability analysis are given in Attachment 1. A comparable analysis is also included for Grand Gulf (relay) logic. The FMEA analysis used as a basis for the calculations is contained in Attachment 2. Please contact Bob Strong (408) 925-1728 for additional information.

Very truly yours,

J.F. Quirk

J.F. Quirk, Manager
BWR Standardization
Nuclear Safety and Licensing Operation

Attachment

ATTACHMENT 1

PROBABILITY CALCULATIONS FOR LOW-LOW SET RELIEF LOGIC FAILURE MODES

While the Low-Low Setpoint (LLS) logic is sealed in, certain types of random single failure of some components could lead to inadvertent actuation of an additional valve. For such actuation to be coincident with the actuation of the "low" LLS valve, the failure must occur during a 1.5 second interval when the "low" valve pressure loading is at its peak. (The 1.5 second time is twice the .75 second duration of the idealized quencher bubble pressure oscillation in the suppression pool. This is taken from NEDO 22A4365, "Containment Loading Report - Mark III," and is also documented in Appendix 3B of GESSAR II.) Note that if the failure occurs before or after this 1.5 second interval, then it is of no concern (i.e., in the context of multiple subsequent actuation). The following components in both divisions are considered in this analysis:

1. Pressure Transmitters N068A, N068B
2. Master Trip Units N668A, N668B
3. Slave Trip Units N617A, N617B, N669A, and N669B
4. Voltage interfaces associated with slaves above
5. Logic gates associated with the "mid" LLS valve
6. Load drivers for all safety relief valves
7. Safety relief valve mechanical failures

The initial failure rates (λ) are assumed per the following source table:

FAILURE RATES

Component/ Failure Mode	Failure Rate λ ($\times 10^{6}$/hr)	Source	Remarks
Pressure Transmitter			
High Output	0.625	2	
Master Trip Unit			
Fail to Function	56.12	1	
Fail High	5.6	3	
Slave Trip Unit			
Fail to Function	42.48	1	
Fail High	4.2	3	
Voltage Interface (ACUI)			
Fail to Function	6.4	1	
Fail Closed	0.6	3	

Component/ Failure Mode	Failure Rate λ ($x 10^{6}$/hr)	Source	Remarks
Logic Gate			
Fail to Function	0.6		Based on a review of NSPS fail rates in Source 1
Fail Closed	0.06	3	
DC Load Driver			
Fail to Function	5.91	1	
Fail Closed	2	4	
Valve Mechanical			
Inadvertent Operation	0.42	5	Applicable for Target Rock; conservative for Crosby and Dikkers

Sources:

1. Previous analysis based on MIL-HDBK-217B.
2. IEEE Std 500-1977, Table 9.2.1
3. Assumed 10% of λ for "Fail to Function" (as in WASH-1400, Table III-4-2).
4. Assumed 33% of λ for "Fail to Function" (as in WASH-1400, Table III-4-2).
5. "Reliability Analysis of Target Rock 67F relief valve NEDM-10824-10.

During the course of 40 years, the "low" LLS valve may conservatively be expected to actuate for 106 isolation events at 15 peaks each. So there are 106/40 x 15 $\cong$ 40 of the 1.5 second intervals expected to occur during each reactor year.

Probability Calculations

1. Pressure Transmitters N068A (in Division I), N068B (in Division II). Probability of failure during any 1.5 second interval is:

$$2 \text{ transmitters} \times \frac{\lambda \text{ failures}}{\text{hr}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} \times \frac{1.5 \text{ sec}}{\text{interval}} \times \frac{40 \text{ intervals}}{\text{yr}}$$

$$= 2 \times .625 \times 10^{-6} \times \frac{60}{3600} = 0.2 \times 10^{-7} \text{ failures/yr}$$

2. Master Trip Units N668A (Division I), N668B (Division II). Probability of failure during any 1.5 second interval is:

$$2 \times 5.6 \times 10^{-6} \times \frac{60}{3600} = 1.9 \times 10^{-7} \text{ failures/yr}$$

3. Slaves N617A and N669A in Division I and N617B and N669B in Division II: Probability of failure during any of the 1.5 second intervals is:

$$= 4 \times 4.2 \times 10^{-6} \times \frac{60}{3600} = 2.8 \times 10^{-7} \text{ failures/yr}$$

4. Voltage interface associated with units above. Probability of failure during any of the 1.5 second intervals is:

$$4 \times 0.6 \times 10^{-6} \times \frac{60}{3600} = 0.4 \times 10^{-7} \text{ failures/yr}$$

5. Logic gates associated with actuation of the "mid" LLS valve: There are three gates in each division. The probability of failure of any one of the gates during any of the 1.5 second intervals is:

$$3 \times 2 \times 0.06 \times 10^{-6} \times \frac{60}{3600} = .06 \times 10^{-7} \text{ failures/yr}$$

6. DC Load Drivers. All BWR/6 plants have safety/relief valves controlled with two load drivers each (one per division per valve). The probability of each valve inadvertently actuating due to load driver failure during any of the 1.5 second intervals is:

$$\frac{2 \text{ load drivers}}{\text{valve}} \times \frac{\lambda \text{ failures}}{\text{hr}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} \times \frac{1.5 \text{ sec}}{\text{interval}} \times \frac{40 \text{ intervals}}{\text{yr}}$$

$$2 \times 2 \times 10^{-6} \times \frac{60}{3600} = 0.67 \times 10^{-7} \text{ failures/valve/yr}$$

7. Valve Mechanical Failure: The probability of each valve inadvertently actuating due to its own mechanical failure during any of the 1.5 second intervals is:

$$0.42 \times 10^{-6} \times \frac{60}{3600} = 0.07 \times 10^{-7} \text{ failures/valve/yr}$$

Conclusion

The probability of both the "low" and "mid" valve actuating during the Low-Low Set seal-in mode (second pop) is totalled as follows:

1. Pressure Transmitters (2 as calculated):	0.2×10^{-7}/yr
2. Master Trip Units (2 as calculated):	1.9×10^{-7}/yr
3. Slave Trip Units (4 as calculated):	2.8×10^{-7}/yr
4. Voltage Interfaces (4 as calculated):	0.4×10^{-7}/yr
5. Logic Gates (6 as calculated):	0.06×10^{-7}/yr
6. DC Load Drivers (2 as calculated):	0.67×10^{-7}/yr
7. Valve Mechanical Failure (1 as calculated):	0.07×10^{-7}/yr
Total "Mid" Valve Failure Probability:	6×10^{-7}/yr

The average BWR/6 plant (238-size) contains 19 safety/relief valves. With the "low" valve actuating and the "mid" valve accounted for above, the probability of any one of the remaining 17 valves actuating concurrent with any of the 1.5 second intervals of the "low" valve is totalled as follows:

1. Logic Gates (34 gates for 17 valves) = $\frac{34}{6}$ x .06 x 10^{-7} = .34 x 10^{-7}/yr
2. DC Load Drivers (34 LDs for 17 valves) = $\frac{34}{2}$ x .67 x 10^{-7} = 11.4 x 10^{-7}/yr
3. Mechanical Failure (17 valves) = 17 x .07 x 10^{-7} = 1.2 x 10^{-7}/yr

Total One-of-17-Valves Failure Probability: 1.3 x 10^{-6}/yr

Grand Gulf Relay Logic Probability Comparison

The probability analysis for a relay plant (Grand Gulf) is based on the following comparison with solid-state plant data just calculated:

1. Pressure Transmitters: Same as solid state
2. Master Trip Units: Same as solid state
3. Slave Trip Units: Only N617A or N617B can singly actuate "mid" valve
4. Voltage Interfaces: Non-existent for relay plants
5. Logic Gates: Non-existent for relay plants
6. DC Load Drivers: Non-existent for relay plants
7. Valve Mechanical Failures: Same as solid state
8. Relay Logic: Every valve requires either "2-out-of-2" or "1-out-of-2 twice" relays to actuate. Therefore, no single failing relay can actuate any valves.

The probability of coincident subsequent actuation of both the "low" and "mid" LLS valves for a relay plant is therefore summarized as follows:

1. Pressure Transmitters:	.2 x 10^{-7}/yr
2. Master Trip Units:	1.9 x 10^{-7}/yr
3. Slave Trip Units: 2/4 x (solid state):	1.4 x 10^{-7}/yr
4. Valve Mechanical Failure:	.07 x 10^{-7}/yr
Total Probability for Coincident "Mid" Valve Failure (Relay Plant):	3.6 x 10^{-7}/yr

Grand Gulf is a 251-size plant with 20 safety/relief valves. "Mechanical Valve Failures" is the only remaining function for a relay plant which can singly actuate any valves (other than the "low" or "mid" valve after low-low set seal in). With the "low" valve actuating and the "mid" valve already accounted for above, the probability of any one of the remaining 18 valves actuating in coincidence with the "low" valve is

$$18 \times .07 \times 10^{-7}/yr = 1.26 \times 10^{-7}/yr.$$

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FAILURE MODES AND EFFECTS ANALYSIS

LEGEND:
P=PROBABILITY
S=SIGNIFICANCE
L=LOW
M=MEDIUM

SHEET NO. 1
CONT ON SHEET 2

SYSTEM/SUBSYSTEM: BWR/6 Low-Low Set Logic Design

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY (L=LOW) POTENTIAL EFFECT	COMP. PROVISIONS	P	S	CAUSE OF FAILURE MODE	P	COMMENTS
Press XMTR (N068A) (N068E)	Fails Low (no output)	None	Gross Failure Detector	Fails to arm one channel on demand. Disables one Division.	Division II	L	L	Electrical	M	
	Fails High (Shows High Press)	None	(Same as above)	Arms one channel during normal operation. *Actuates 'mid' LLS valve if the failure occurs after arming the LLS logic. (*N068A only)	Second channel (Both channels have to be armed for valve actuation).	L L*	L M	Electrical	M	
	Drifts Low & Drifts High	Similar to Fails High & Fails Low Respectively								
Master Trip Unit N668A (N668E)	Fails Low (0 at output)	None	Self Testing Feature	Fails to arm one channel for SRV actuation & LL set arming.	Division II	L	L	Electrical	M	
	Fails High (1 at output)	None	"	Arms one channel for SRV actuation & LL set arming when not reqd. *Actuates 'mid' LLS valve if the failure occurs after arming the LLS logic. (*N668A only)	Second Channel	L *L	L M	Electrical	M M	
	Drifts Low & Drifts High	Similar to Fails High & Fails Low Respectively								
Slave Trip Unit N669A* (N669E)	Fails Low (0 at output)	None	Self Testing Feature	Fails to arm one channel for SRV's set at 1113 psig & fails to arm one channel of LL set Logic.	Division II	L	L	Electrical	M	
	Fails High (1 at output)	None	" "	Inadvertent Arming of one channel for SRV's set at 1113 psig & one channel of LL set Logic *(N669A only) Failure coinciding with LL set valve opening following LLset arming can cause multiple subsequent relief valve actuation	Second Channel	L	L	Electrical	M	
	Drifts Low & Drifts High	Similar to Fails High & Fails Low Respectively								

ATTACHMENT 2

GENERAL ELECTRIC

FAILURE MODES AND EFFECTS ANALYSIS

SHEET NO 2

CONT ON SHEET 3

SYSTEM/SUBSYSTEM: BWR/6 Low-Low Set Logic

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY: POTENTIAL EFFECT	COMP. PROVISIONS	P	S	CAUSE OF FAILURE MODE	P	COMMENTS
Voltage Interface A1 (E1)	Fails Low Fails High*	Same as for N669A (E) Slave XMTR *See Sh. 1								
Slave Trip Unit N618A (N618E)	Fails Low (0 at output) (also drifts high)	None	Self Testing Module	Will fail to lower the setpoint of high LLS valves in one Division	Division II	L	L	Electrical	M	
	Fails High (1 at output) (also drifts low)	None	"	Will cause inadvertent partial arming of one channel to reduce closing set pt of High LLS Valves.	Other Channel	L	L	Electrical	M	
Voltage Interface A2 (E2)	Fails Low Fails High	Same as for Slave XMTR N618A(E)								
Switch S38A (S38E)	Open Contact	None	Self Testing Module	Will not seal in LLSet signal i.e. will not arm LLSet logic in one Division	Division II	L	L	Dust, Rust	L	
	Short	None	"	Cannot reset LLSet through one channel.	Other Channel	L	L	Short Circuit	L	

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FAILURE MODES AND EFFECTS ANALYSIS

SHEET NO. 3

CONT ON SHEET 4

SYSTEM/SUBSYSTEM: BWR/6 Low-Low Sel Logic

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY: POTENTIAL EFFECT	OVERALL EFFECT ON SAFETY: COMP. PROVISIONS	P	S	CAUSE OF FAILURE MODE	P	COMMENTS
Voltage Interface A3 (E3)	Fail Low Fails High	Similar to Fail Open & Fail Short for Switch S38A (S38E).								
Slave Trip Unit N617A	Fails Low (0 at output)	None	Self Testing Module	Fails to Arm Mid Low Lowset valve logic in Division I (i.e. Back up to Low LLS valve will not function in Division I).	Division II	L	L	Electrical	M	
	Fails High (1 at output)	None	(Same as above)	- None during normal plant operation.		H	L	Electrical	M	
				- If failure occurs during a transient during initial valve opening, the mid range LLS valve will stick open.	None	L	L		L	
				- If failure occurs during repressurization following the initial valve openings, there is a potential for mid LLS valve to open simulataneously with low LLS valve.	None	L	M		VL	

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GENERAL ELECTRIC

FAILURE MODES AND EFFECTS ANALYSIS

SHEET NO. 4
CONT ON SHEET 5

SYSTEM/SUBSYSTEM: BWR/6 Low-Low Set Logic Design

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY				CAUSE OF FAILURE MODE		COMMENTS
				POTENTIAL EFFECT	COMP. PROVISIONS	P	S		P	
Slave Trip Unit N616E	Fails Low	None	Self Testing	- Fails to open 'low' LLS valve initially as well as in the LL Set Mode, in Division I.	Division II	L	L	Electrical	L	
	Fails High	None	(Same as above)	- None during normal plant operation						
				- Following a transient in which LL Set is armed, this failure will result in the 'low' LLS valve sticking open.	None	L	M	Electrical	L	
Voltage Interface E4	Fails Low Fails High	Similar to Slave Trip Unit N616E Fails High & Low respectively.								

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GENERAL ELECTRIC

FAILURE MODES AND EFFECTS ANALYSIS

SHEET NO. 5
CONT ON SHEET 6

SYSTEM/SUBSYSTEM: BWR/6 LL Set Logic

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY: POTENTIAL EFFECT	OVERALL EFFECT ON SAFETY: COMP. PROVISIONS	P	S	CAUSE OF FAILURE MODE	P	COMMENTS
Slave Trip Unit N617A (N617E) (contd)	Drifts Low & Drifts High	Similar to Fails High & Fails Low Respectively								
Voltage Interface A4 (E4)	Fails Low & Fails High	Same as Slave Trip Unit N617A								
Voltage Interface A5 (E5)	Fails Low	None	Self Testing	Will not open the lowest LLS valve either during initial opening or during subsequent opening, in Div. I	Division II	L	L	Electrical	M	
	Fails High	None	(Same as above)	Arms one channel for lowest LLS Valve actuation (Both channels needed)	Other Channel	L	L	Electrical	M	
Logic Gate AG1 (EG1)	Fails Open (0 in output)	None	(Same as above)	- None during Normal Operation - Will not reduce reclose setpoints of high LL Set valve following a transient, (in Div. I).	Division II	L	L	Electrical	M	
	Fails Closed (1 in output)	None	(Same as above)	-Arms one channel for reduced reclose setpoint of high LL Set valves.	Other Channel	L	L	Electrical	M	

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GENERAL ELECTRIC

FAILURE MODES AND EFFECTS ANALYSIS

SHEET NO 6

CONT ON SHEET 7

SYSTEM/SUBSYSTEM: BWR/6 Low-Low Set Logic Design

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY				CAUSE OF FAILURE MODE		COMMENTS
				POTENTIAL EFFECT	COMP. PROVISIONS	P	S		P	
Logic Gate AGE	Fails Open	None	Self Testing	Cannot open 'low' LLS valve initially No impact on subsequent opening following LL Set Logic arming	Division II	L	L	Electrical	M	
	Fails Closed	None	Valve Activates	- Causes inadvertent opening of 'low' LLS valve	None	L	L	Electrical	M	
Logic Gate AG3	Fails Open	None	Self Testing	Fails 'mid' LLS SRV actuation in the LLS mode. Normal actuation in non-LLS mode is not affected.	This is a back-up for 'low' LLS valve actuation function	L	L	Electrical	M	
	Fails Closed	None	Self Testing	None during normal operation following a transient in which the LLS logic is armed, this failure causes immediate actuation of 'mid' LLS valve.	None	L	L	Electrical	M	

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GENERAL ELECTRIC

FAILURE MODES AND EFFECTS ANALYSIS

SHEET NO 7
CONT ON SHEET 8

SYSTEM/SUBSYSTEM: BWR/6 Low-Low Set Logic

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY: POTENTIAL EFFECT	COMP. PROVISIONS	P	S	CAUSE OF FAILURE MODE	P	COMMENTS
Time Delay TDA (TDE)	Fails Open	None	Self Testing	Will not arm LL Set Logic in Div. I	Division II	L	L	Electrical	M	
	Fails Closed	None	(Same as above)	None						
Logic Gate AG2 (EG2)	Fails Open	None	(Same as above)	Will not arm Low-Low set logic in Division I	Division II	L	L	Electrical	M	
	Fails Closed	None	(Same as above)	Cannot reset LL Set logic through one channel	Other Channel	L	L	Electrical	M	
Logic Gate ARI (ERI)	Fails Open	None	(Same as above)	- cannot open certain SRV's through Division I also LL Set is not in effect for these valves.	Division II	L	L	Electrical	M	
	Fails Closed	None	(Same as above	- Sends signal through one channel for opening certain SRV's Need other channel also for valve actuation.	Other Channel	L	L	Electrical	M	

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FAILURE MODES AND EFFECTS ANALYSIS

SHEET NO. 8

CONT ON SHEET 9

SYSTEM/SUBSYSTEM:

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY: POTENTIAL EFFECT	COMP. PROVISIONS	P	S	CAUSE OF FAILURE MODE	P	COMMENTS
Logic Gate AR2 (ER2)	Fails Open	None	Self Testing	Disables Low-Low set logic in Div. I	Division II	L	L	Electrical	M	
	Fails Closed	None	(Same as above)	-LL Set Logic is continuously armed in one channel		L	L	Electrical	M	
Logic Gate AR3 (ER3)	Fails Open	None	(Same as above)	-Cannot open 'mid' LLS valve through Division I	Division II	L	L	Electrical	M	
	Fails Closed	None	(Same as above	-Arms one channel for mid LLS valve actuation.	Other Channel	L	L	Electrical	M	
				- If failure occurs after a transient in which LL Set is armed, this failure will cause instantaneous openings of "mid" LLS valve. If this occurs simultaneously with the opening of low LLS valve, the design objective of LLS logic is not met.	None	L	M	Electrical	VL	

FAILURE MODES AND EFFECTS ANALYSIS

SYSTEM/SUBSYSTEM: BWR/6 Low-Low Set Logic Design

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY: POTENTIAL EFFECT	COMP PROVISIONS	P	S	CAUSE OF FAILURE MODE	P	COMMENTS
Logic Gate ER4	Fails Open	None	Self Testing	Cannot open 'low' LL Set valve thru Division I	Division II	L	L	Electrical	M	
	Fails Closed	None	Valve Activates	-Will cause inadvertent opening of 'low' LLS valve.	None	L	L	Electrical	M	
Logic Gate AG4, AG5, AG6	Fails Open	None	Self Testing	Cannot open certain SRV's through Division I.	Division II	L	L	Electrical	M	
	Fails Closed	None	Valve Activates	- Causes inadvertent actuation of certain SRV's.	None	L	M	Electrical	M	
				If failure occurs simultaneously with the actuation of 'low' LL Set valve, design objectives are not met.					VL	
Logic Gate EG4	Fails Open	None	Self Testing	Cannot open 'mid' LL Set Valve	Division II	L	L	Electrical	M	
	Fails Closed	None	Valve Activates	- Causes inadvertent actuation of mid LL Set valve.		L	L	Electrical	M	
				If this failure occurs simultaneously with the actuation of 'low' LL Set valve, design objective of LL Set will not be met.					VL	

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FAILURE MODES AND EFFECTS ANALYSIS

SHEET NO. 10
CONT ON SHEET F

SYSTEM/SUBSYSTEM:

ITEM	MODE OF FAILURE	SPECIFIC LOCAL EFFECT OF FAILURE	HOW DETECTED	OVERALL EFFECT ON SAFETY: POTENTIAL EFFECT	COMP. PROVISIONS	P	S	CAUSE OF FAILURE MODE	P	COMMENTS
Logic Gate EG5	Fails Open	None	Self Testing	Prevents Opening of 'low' LL Set valve on demand thru Div I.	Division II	L	L	Electrical	M	
	Fails Closed	None	Valve Actuation	In advertent actuation of low LL Set valve	None	L	M	Electrical	M	
Load Driver D1,02,03	Same as Logic Gates AG4, AG5, AG6									
Load Driver D4	Same as Logic Gate EG4									
Load Driver D5	Same as Logic Gate EG5									
Solenoid S1, S2, S3	Fail Open Fail Short	None	Not Detected	Cannot open SR valve on demand	Division II	L	L	Electrical	M	
Solenoid S4	Fail Open Fail Short	None	Not Detected	Cannot open SR valve on demand	Division II	L	L	Electrical	M	
Solenoid S5	Fail Open Fail Short	None	Not Detected	Cannot open SR valve on demand	Division II	L	L	Electrical	M	

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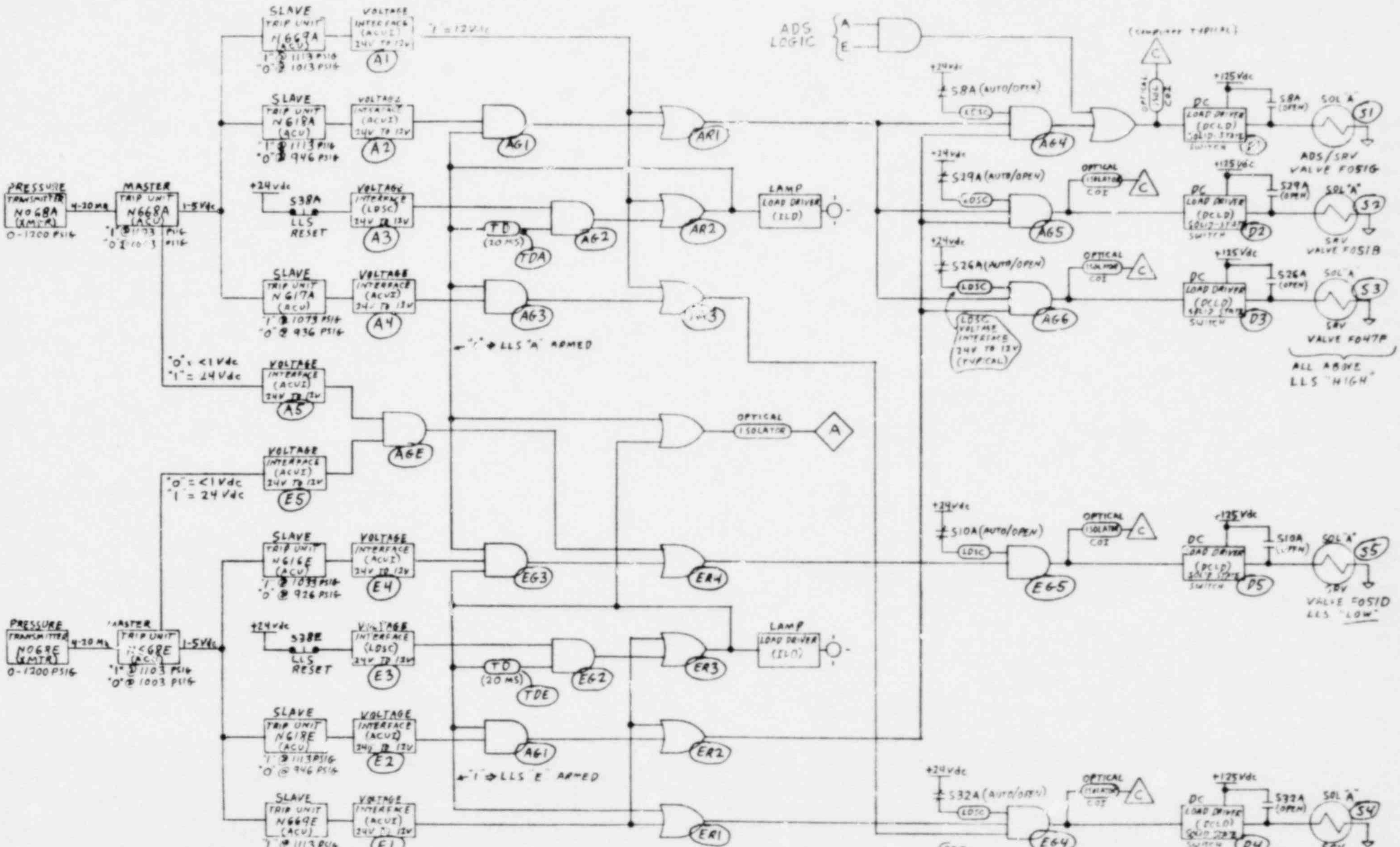

CLINTON LOW-LOW SETPOINT LOGIC (PER 851E713 REV 7)

(DIV 1 ONLY SHOWN. TYPICAL FOR DIV 2 EXCEPT A→B AND E→F)