ATTACHMENT II

JERSEY CENTRAL POWER & LIGHT COMPANY

OYSTER CREEK NUCLEAR GENERATING STATION

Docket 50-219

ECCS MODIFICATION

CORE SPRAY ELECTRICAL CROSSCONNECT

June 24, 1975

Revision 1, July 15, 1975

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Revision 1, July 15, 1975

1. INTRODUCTION

This document is submitted in compliance with condition 2.D.1 incorporated into the Oyster Creek Nuclear Generating Station Provisional Operating License as part of Amendment No. 8 dated May 24, 1975. The condition states that:

> "Within 30 days from the effective date of this amendment the licensee shall submit for NRC review and approval proposed design modifications which will enable the facility to automatically accommodate a single passive failure of the emergency diesel generator bus without adverse effect on the ability of the ECCS system to conform to the evaluation submitted to demonstrate compliance with 10 CFR 50.46 in the applications for license amendment set forth above. Such modifications shall be completed within 30 days after approval, or within such other time as may be specified in such approval."

The safety evaluation in support of issuance of Operating License Amendment Number 8 contains a section entitled "Evaluation of ECCS Performance" in which the postulated coincident occurrence of a core spray line break and a passive failure of the unbroken spray system main electric bus results in a conclusion that the design must be revised.

The Oyster Creek Core Spray System design modification proposed herein consists of interchanging the electrical feeders in one set of redundant electrically driven components for each of the core spray loops.

In addition, the design effort which produced the modification described herein was expanded to encompass a number of the potential single failures which were postulated as a result of the single failure analysis presented in conformance to license condition 2.D.2 of Amendment No. 8 to the Oyster

Creek Provisional Operating License. This is presented as Attachment I to this submittal. Section 2 presents the modification details and Section 3 indicates the system characteristics relative to the existing system with consideration given to the single failure improvements.

A safety evaluation was conducted and is presented in Section 4. Consideration has been given to the modification interface with existing safety systems, the diesel capability to accommodate the revised loading sequence and the improvement which will be experienced over previous ECCS performance analyses for the core spray line break with respect to 10 CFR 50.46. In addition, a single failure analysis for the modified system has been performed and is included in Appendix A as part of the safety evaluation.

A realistic schedule for implementation is given in Section 5 and reflects the need for approximately ninety days, subject to the availability of material and the extent and duration of the Commission review.

2. DESCRIPTION OF MODIFICATION

2.1 Objectives of the Modification

The major objective of the modification described herein is that under all conditions the ECCS modification shall enhance the system capabilities by enabling it to provide core cooling water for a postulated core spray line break (LOCA) coincident with a single failure of the diesel generator or diesel generator bus which is currently configured to power the unbroken core spray loop.

With this set of circumstances, the ECCS shall deliver to the reactor core the required quantity of coolant at the required pressure and flow rate to meet the acceptance criteria set forth in Code of Federal Regulations, Title 10, Part 50, Section 50.46 and Appendix K (effective 2/4/74).

This is accomplished by the ECCS active subsystems consisting of the spray/booster pumps and valves for each flow path being powered by separate and redundant vital power sources, under the conditions set forth above.

2.2 Modification Details

The core spray system design modifications will enable the facility to accommodate a single passive failure of either diesel generator bus without any adverse effect on the ability of the ECCS system to conform to the evaluation submitted to demonstrate compliance with 10 CFR 50.46.

The existing AC load diagram for the core spray system components is presented in Figure 2-1. The modification to the existing load diagram is presented in Figure 2-2. No change to the DC load schedule is required by the modification.

The modified load schedule enables both core spray fluid systems to function if one diesel generator bus is out of service. This was accomplished by powering redundant spray system components (i.e., components associated with a single core spray fluid system) from opposite buses. Each diesel generator can support the power requirements of two independent core spray fluid systems.

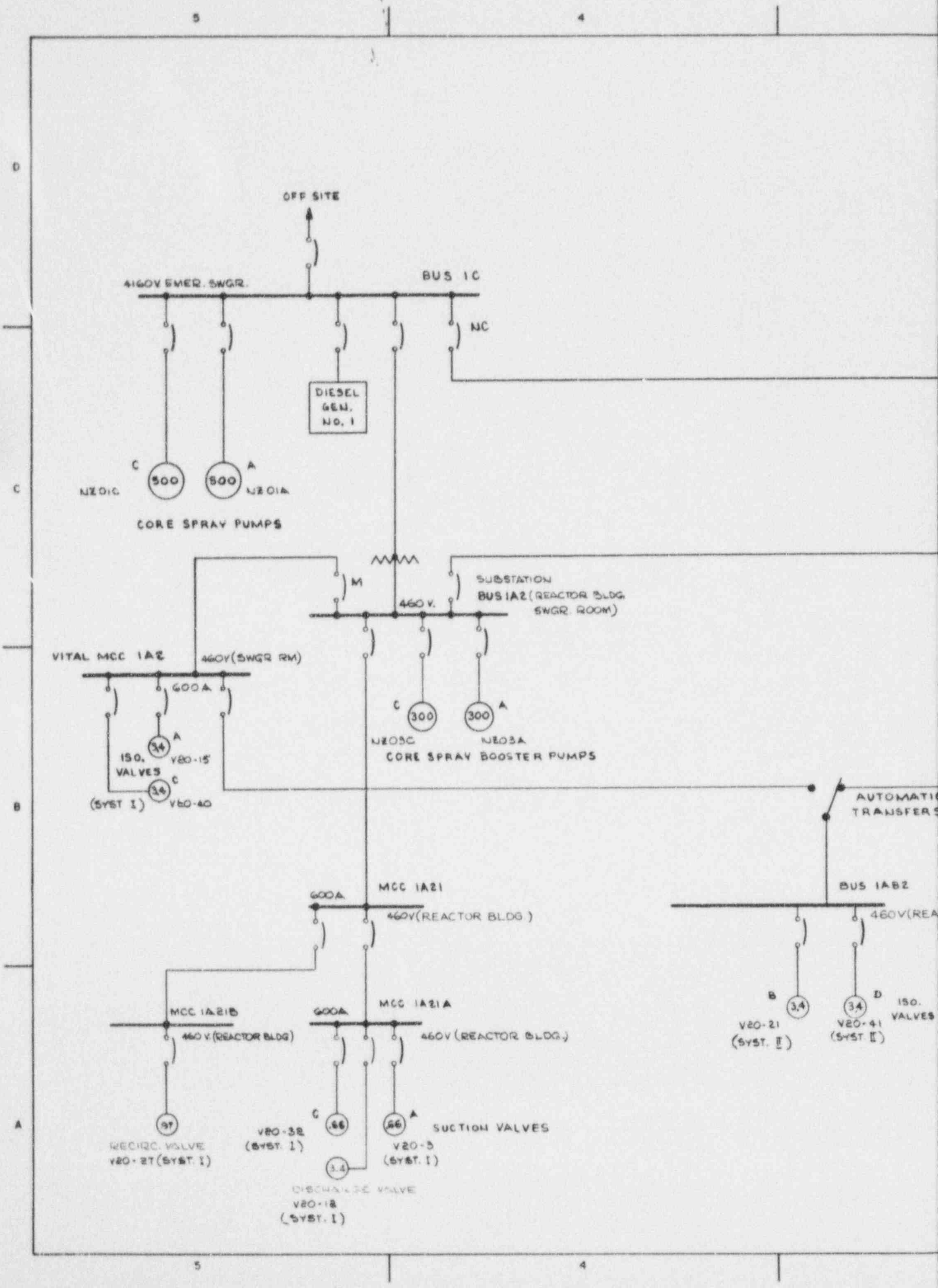
The existing core spray system actuation logic is presented in Figure 2-3. Modification of the existing logic is presented in Figure 2-4. The modification does not alter the normal core spray system start sequence. Additional constraints or conditions have been added to the start sequence logic so that one of the two existing diesel generators will not be required to support the load transient associated with the simultaneous starting of any two core spray system pumps. To assure that the control logic cannot command the simultaneous starting of two pumps on the same diesel generator bus, interlocks have been added to provide concurrent start sequences for both core spray fluid systems. The s[illegible]t sequence interlocks increase the start sequence reliability. The modification to the control system logic will automatically start both diesel generators and initiate the core spray system pump sequence in both fluid systems if either a low-low reactor level or a high drywell pressure signal is present in any one of the four core spray system logic channels.

With the modification, the start sequence interlock must be inhibited when a logic channel is in test to prevent test signal starting of the pumps in the loop not being tested. Four keylock switches will be used for this purpose (one for each logic channel). Only a single key will be available to assure that only one start sequence interlock circuit can be disabled. An alarm in the control room will indicate when any start sequence interlock circuit is inhibited. After logic channel test, the control room has a positive indication when the interlock circuit is restored.

Figure 2-5 presents the core spray control system pump start sequence block diagram for the modification. The diagram depicts the starting sequence associated with fluid system I. All interfaces with fluid system II have been identified. The starting sequence associated with system II may be directly translated from Figure 2-5 by substituting system II for system I and bus 1D for bus 1C. The nominal starting sequence is highlighted by the bold block outline. Figures 2-4 and 2-5 disclose that with the nominal starting sequence, each core spray fluid system is available ten seconds after the start signal sequence and power is available at the associated bus. If no power is available at one bus, both fluid systems will automatically start. The fluid system with the preferred pumps operating is available ten seconds after the start sequence signal. The other fluid system is available fifteen seconds later.

The core spray system responsiveness to valid start sequence signals has been enhanced by the modification. The existing system will initiate the start sequence for one of the two fluid systems after a single high drywell pressure signal or a low-low reactor water level signal is present in the control system logic. The modified system will initate the start sequence for both fluid systems after the first high drywell pressure signal or low-low reactor water level signal is present in the control system logic.

The modification will be designed, engineered, and installed in accordance with criteria equivalent to or better than that to which the original system was built. Present day criteria will be used where it can be reasonably and practicably applied, and will result in significant safety improvement.

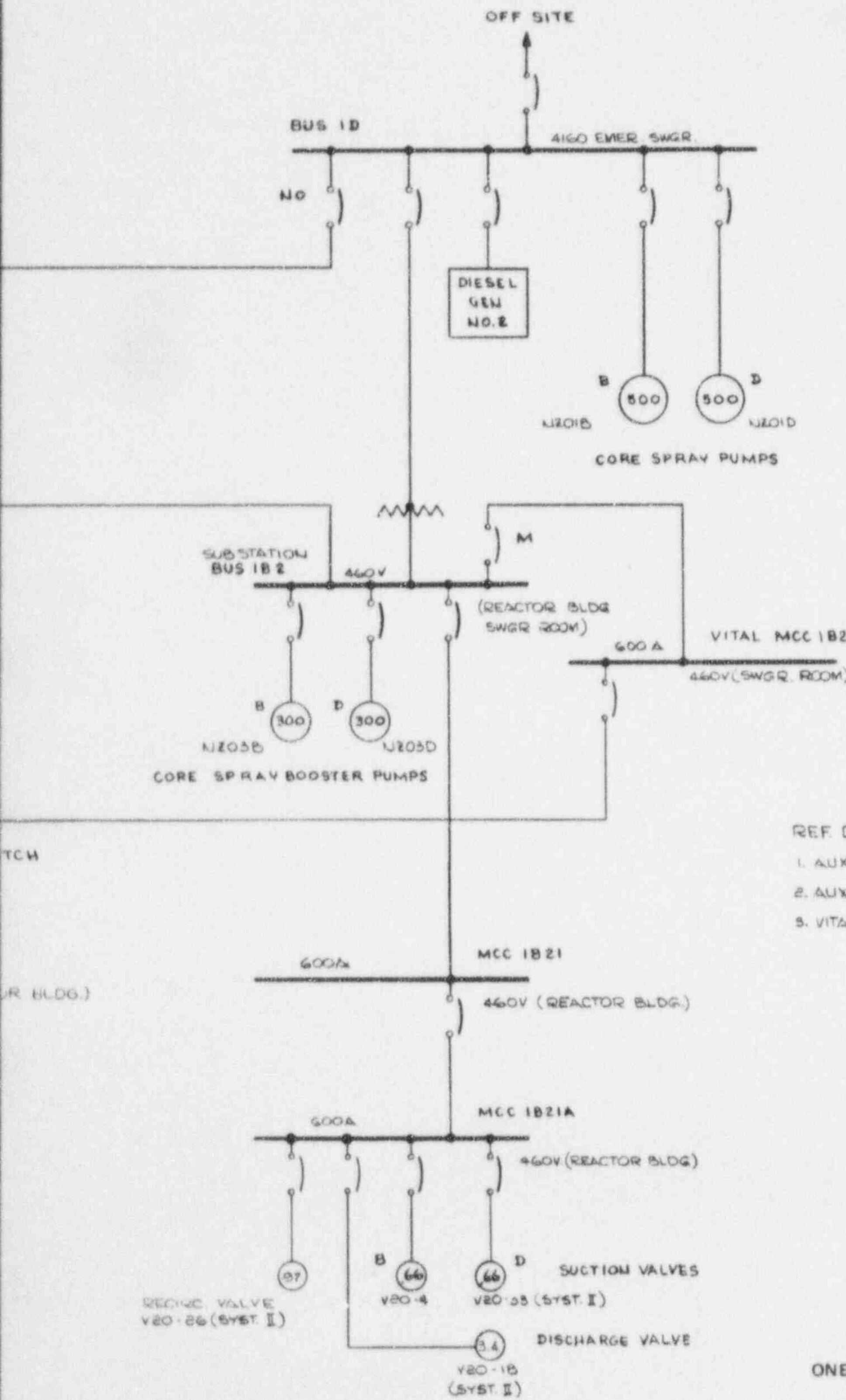

5
4
D
C
B
A
OFF SITE
4160V EMER. SWGR.
BUS 1C
NC
DIESEL GEN. NO. 1
C
500
A
500
NZ01C
NZ01A
CORE SPRAY PUMPS
M
SUBSTATION BUS 1A2 (REACTOR BLDG SWGR. ROOM)
460 V.
VITAL MCC 1A2
460V (SWGR RM)
600A
C
300
A
300
NZ03C
NZ03A
CORE SPRAY BOOSTER PUMPS
A
3,4
V20-15
150. VALVES
C
3,4
(SYST I)
V20-40
AUTOMATIC TRANSFER S
600A
MCC 1A21
460V (REACTOR BLDG.)
BUS 1AB2
460V (REA
MCC 1A21B
460 V. (REACTOR BLDG)
600A
MCC 1A21A
460V (REACTOR BLDG.)
B
3,4
D
3,4
150. VALVES
V20-21 (SYST. II)
V20-41 (SYST. II)
97
RECIRC. VALVE V20-27 (SYST. I)
C
66
A
66
SUCTION VALVES
V20-32 (SYST. I)
V20-3 (SYST. I)
3,4
DISCHARGE VALVE V20-12 (SYST. I)
5
4

PARTS LIST

REF	ITEM	DESCRIPTION	REQ'D	MATERIAL	PART NO. OR SPECIFICATION

REVISIONS

REV	DESCRIPTION



REF. DWGS.

1. AUX. 1 LINE DIAGRAM SH. 1 GE-3002
2. AUX. 1 LINE DIAGRAM SH. 3 GE-3004
3. VITAL ONE LINE DIAGRAM GE-3013

FIGURE 2–1

ONE LINE POWER DIAGRAM EXISTING SCHEME

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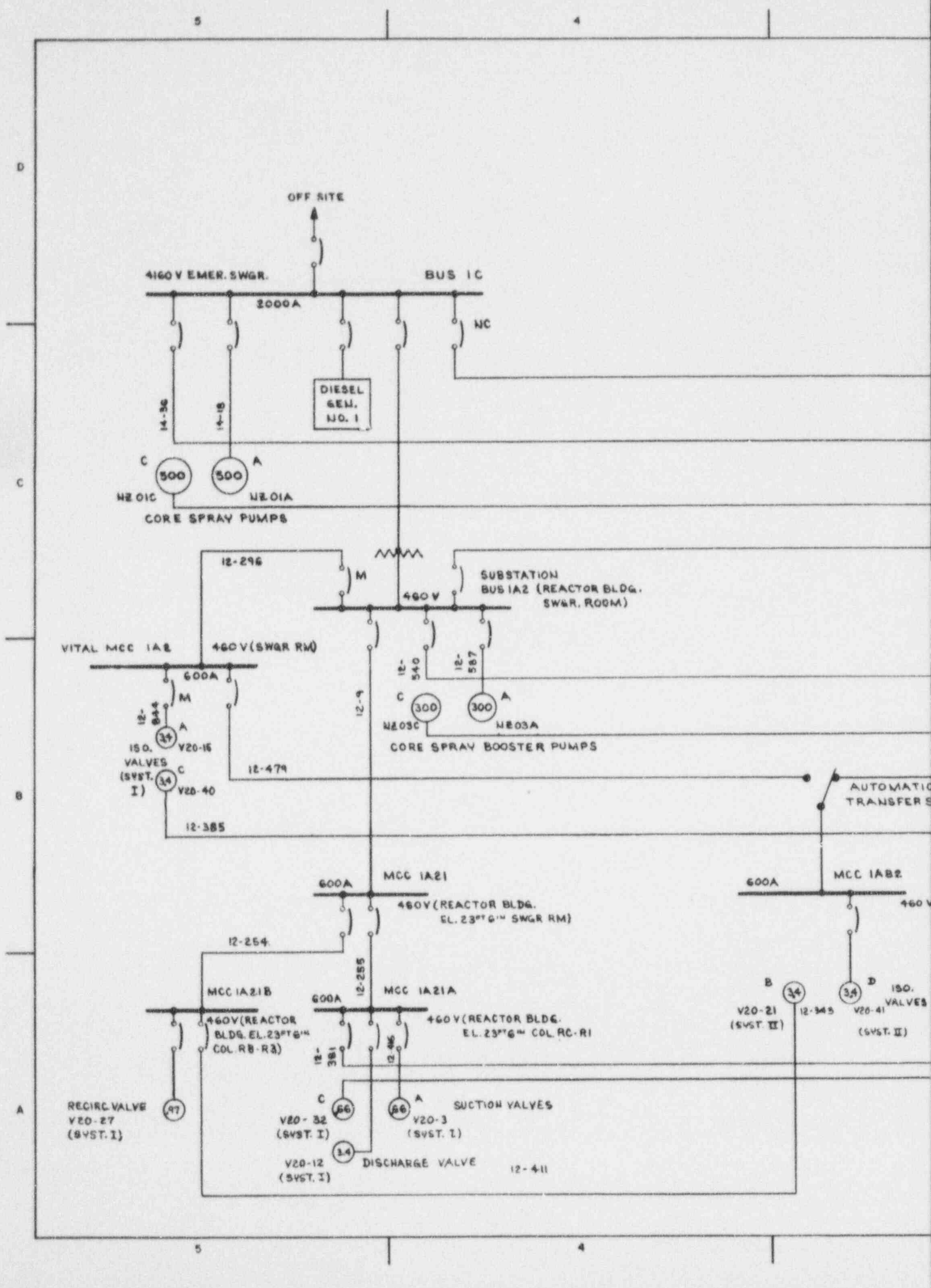


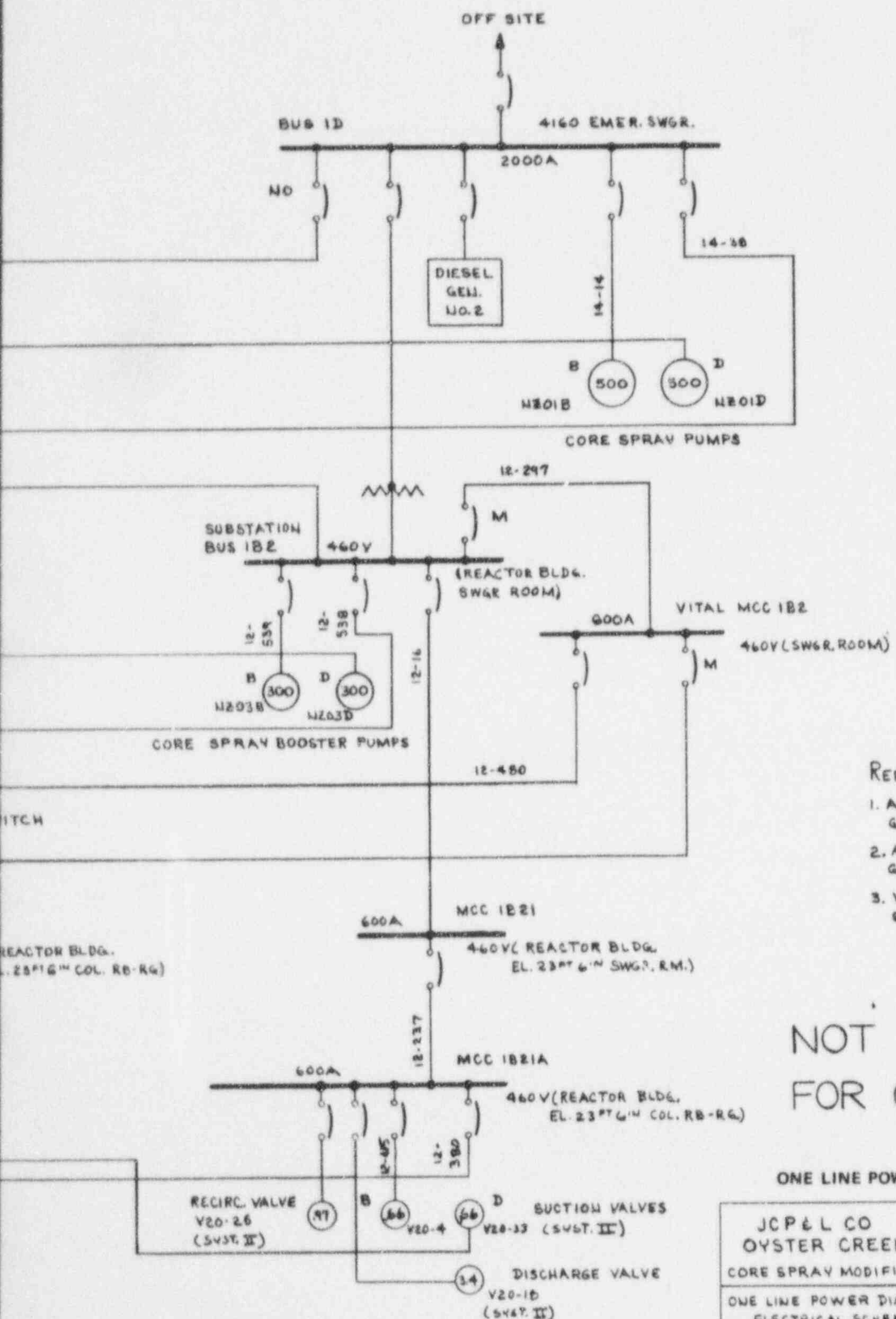
5
4
D
C
B
A
OFF SITE
4160 V EMER. SWGR.
BUS 1C
2000A
NC
DIESEL GEN. NO. 1
14-36
14-18
C
A
500
500
NZ01C
NZ01A
CORE SPRAY PUMPS
12-296
M
SUBSTATION BUS 1A2 (REACTOR BLDG. SWGR. ROOM)
460 V
VITAL MCC 1A2
460 V (SWGR RM)
600A
M
12-344
A
34
ISO. VALVES (SYST. I)
V20-15
C
34
V20-40
12-9
12-540
12-587
C
A
300
300
NZ03C
NZ03A
CORE SPRAY BOOSTER PUMPS
12-479
AUTOMATIC TRANSFER S
12-385
600A
MCC 1A21
460V (REACTOR BLDG. EL. 23FT 6IN SWGR RM)
600A
MCC 1AB2
460 V
12-254
12-255
MCC 1A21B
460V (REACTOR BLDG. EL. 23FT 6IN COL. RB-R3)
600A
MCC 1A21A
460 V (REACTOR BLDG. EL. 23FT 6IN COL. RC-R1)
B
34
V20-21 (SYST. II)
12-345
34
D
V20-41 (SYST. II)
ISO. VALVES
12-381
12-416
RECIRC. VALVE V20-27 (SYST. I)
47
C
66
V20-32 (SYST. I)
A
66
V20-3 (SYST. I)
SUCTION VALVES
34
V20-12 (SYST. I)
DISCHARGE VALVE
12-411
5
4

PARTS LIST						
			REQ'D		IDENTIFICATION	
REF	ITEM	DESCRIPTION			MATERIAL	PART NO OR SPECIFICATION

REVISIONS	
REV	DESCRIPTION

ANSTEC APERTURE CARD

Also Available on Aperture Card



Ref. Dwgs.

1. Aux. 1 Line Diagram Sh. 1 GE-3002
2. Aux. 1 Line Diagram Sh. 2 GE-3004
3. Vital One Line Diagram GE-3013

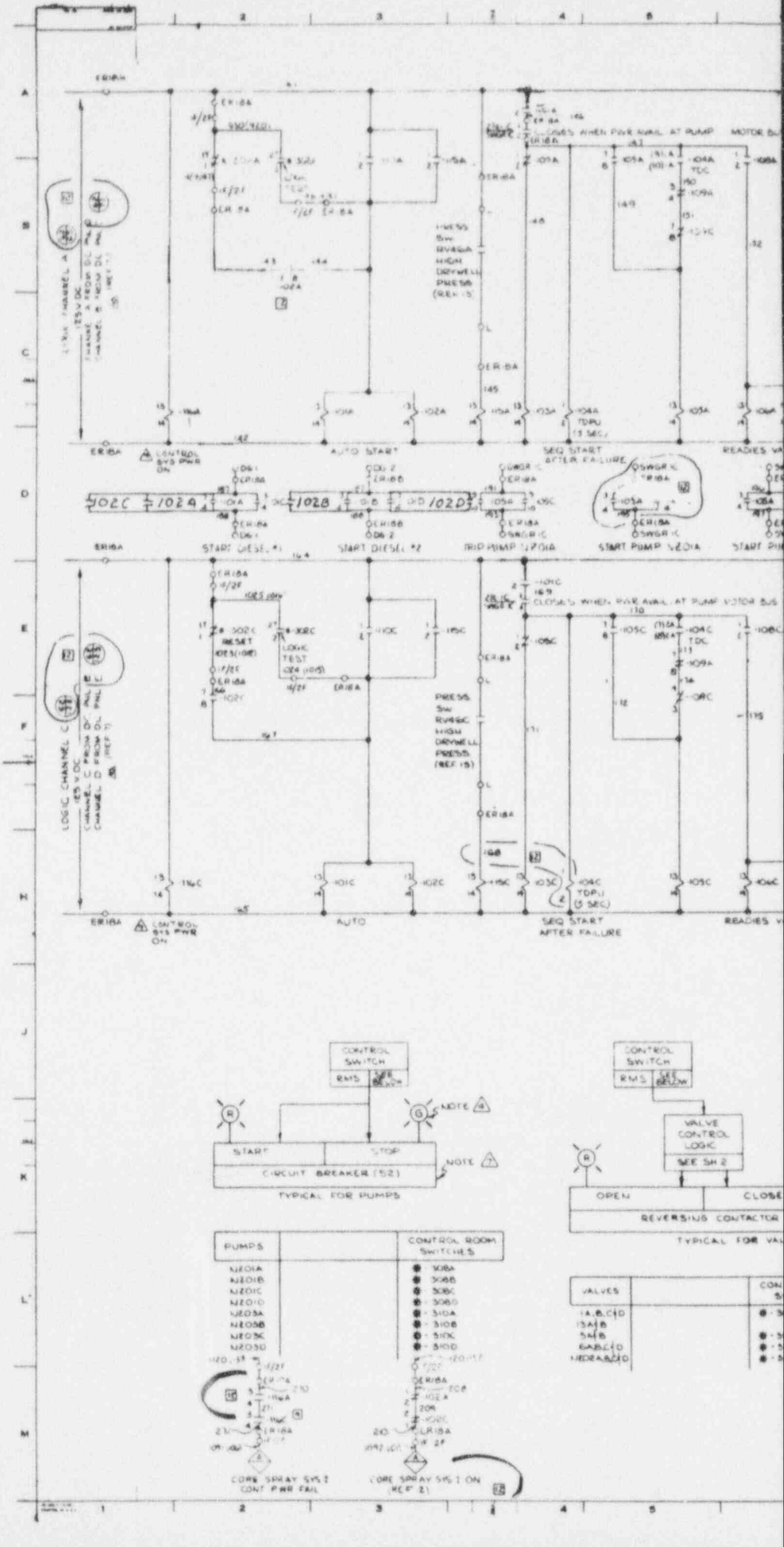
NOT APPROVED FOR CONSTRUCTION

FIGURE 2–2

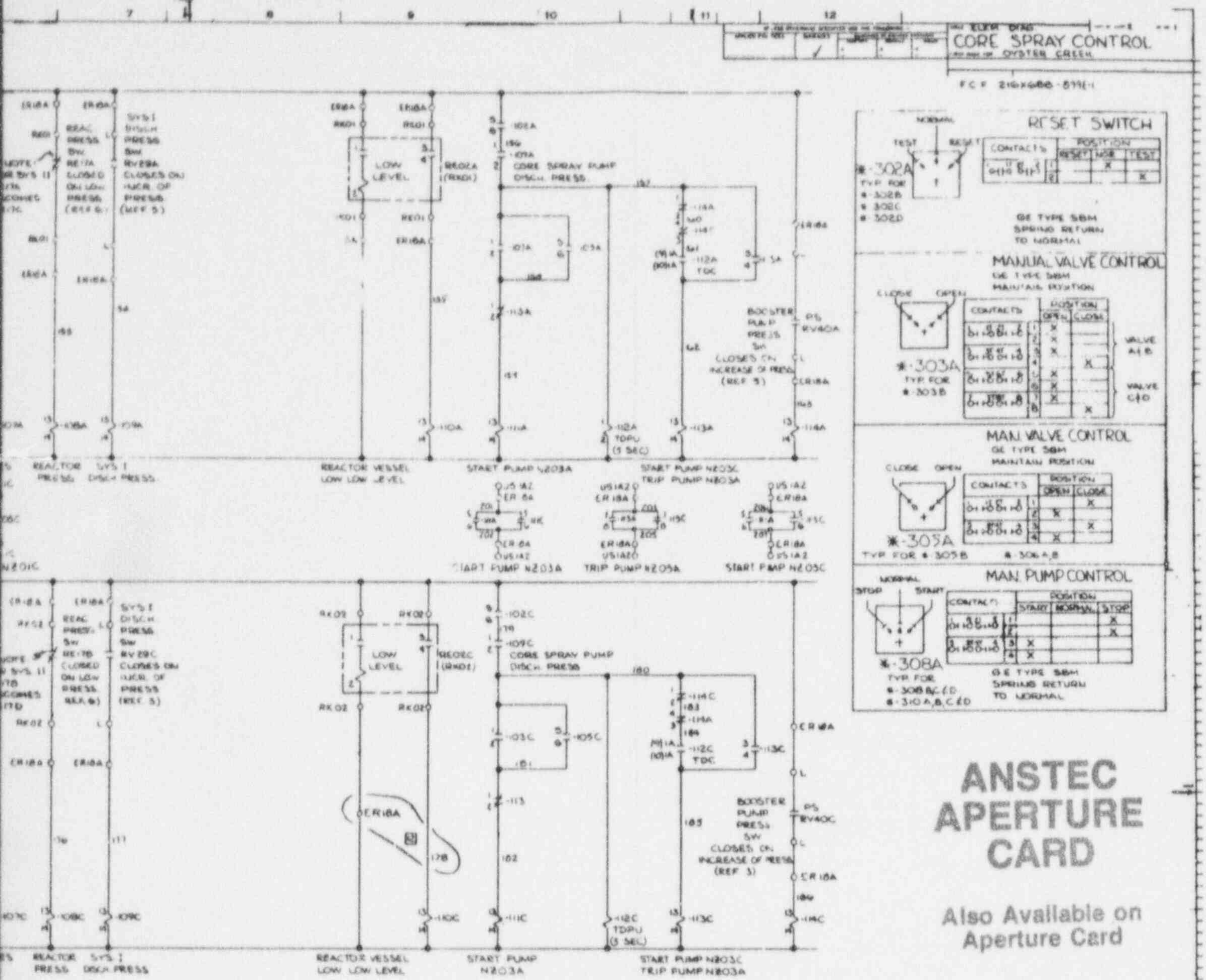
ONE LINE POWER DIAGRAM ELECTRICAL SCHEME

JCP&L CO OYSTER CREEK CORE SPRAY MODIFICATION	NUS CORPORATION ROCKVILLE, MARYLAND
ONE LINE POWER DIAGRAM ELECTRICAL SCHEME	
DRAWN / CHECKED / APPROVED	DRAWING NO. 5060D031 REV. 1
	SCALE NONE SHEET 1 OF 1

9604220407-02



LOGIC CHANNEL A
125 V DC
CHANNEL A FROM DC PNL
CHANNEL B FROM DC PNL
LOGIC CHANNEL C
125 V DC
CHANNEL C FROM DC PNL
CHANNEL D FROM DC PNL
CLOSES WHEN PWR AVAIL AT PUMP
PRESS SW RV46A HIGH DRYWELL PRESS
PRESS SW RV46C HIGH DRYWELL PRESS (REF 15)
RESET
LOGIC TEST
TDPU (5 SEC)
CONTROL SYS PWR ON
AUTO START
AUTO
SEQ START AFTER FAILURE
READIES VA
START DIESEL #1
START DIESEL #2
TRIP PUMP NZ01A
START PUMP NZ01A
CONTROL SWITCH
RMS
SEE BELOW
NOTE
START
STOP
CIRCUIT BREAKER (52)
TYPICAL FOR PUMPS
VALVE CONTROL LOGIC
SEE SH 2
OPEN
CLOSE
REVERSING CONTACTOR
TYPICAL FOR VA
PUMPS
CONTROL ROOM SWITCHES
NZ01A 308A
NZ01B 308B
NZ01C 308C
NZ01D 308D
NZ03A 310A
NZ03B 310B
NZ03C 310C
NZ03D 310D
VALVES
1A,B,C,D
13A,B
5A,B
6A,B,C,D
NZ02A,B,C,D
CORE SPRAY SYS I CONT PWR FAIL
CORE SPRAY SYS I ON (REF 2)

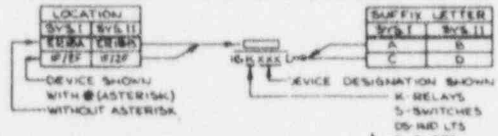


REFERENCE DWGS.

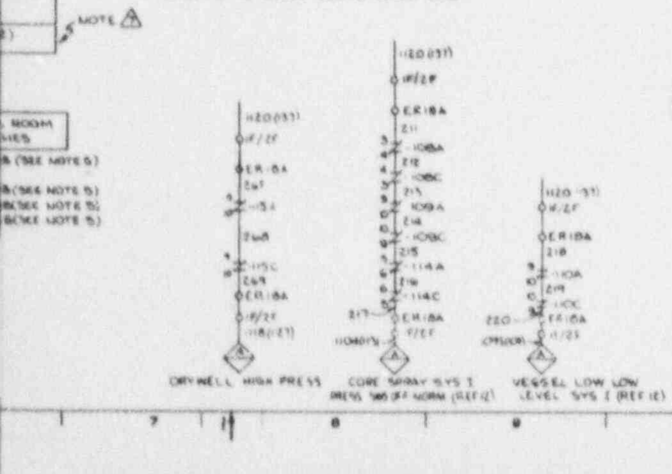
1. 175A7106 TABULATION OF CONTROL RELAYS
2. 237E901 CONTAINMENT SPRAY SYS. ELEM. DIAG.
3. 885D781 CORE SPRAY SYSTEM P&ID
4. 148F902 ANNUNCIATOR "C" ELEM. DIAG.
5. 148F912 PROCESS INSTRUMENTATION ELEM. DIAG.
6. 148F712 REACTOR VESSEL PRESS./LEVEL TEMP INST. P&ID
7. B&R DWG 3028 125VDC ONE LINE DIAG.
8. 919D687 PANEL 18B
9. 886D447 PANEL 18A
10. 729E182 AUTO DEPRESSURIZATION ELEM. DIAG.
11. AEF 12044 4160V SWGR ELEM. CORE SPRAY PUMP CONTROL
12. 161F271 ANNUNCIATOR "B" ELEM. DIAG.
13. 237E726 DRYWELL & SUPPRESSION SYSTEM P&ID
14. B&R DWGS 3029 DC CONTROL ELEM. DIAGS
15. AEF 24319 DIESEL GEN #1 SCHEM DIAG
16. AEF 24316 DIESEL GEN #2 SCHEM DIAG

NOTES

1. UNLESS OTHERWISE NOTED, THE DEVICE DESIGNATION SHOWN (i.e. 101) IS AN ABBREVIATION OF THE COMPLETE DEVICE DESIGNATION WHICH IS:



3. VALVE CONTROL VOLTAGE SHALL BE TAKEN FROM SAME BUS SUPPLYING POWER TO VALVE MOTOR, VALVES A&C FROM 'A' BUS, VALVES B&D FROM B BUS.
4. RED LIGHT TO BE ON FOR PUMP RUNNING GREEN LIGHT ON WHEN PUMP IS STOPPED EXCEPT FOR MANUAL SHUTDOWN WHEN ALL LIGHTS ARE TO BE DE-ENERGIZED (DARK).
5. RED LIGHT TO BE ON FOR VALVE FULLY OPEN. GREEN LIGHT ON WHEN VALVE FULLY CLOSED. BOTH LIGHTS TO BE ON WHEN VALVE IS IN INTERMEDIATE POSITIONS.
6. PUMP MOTOR CIRCUITS SHALL PROVIDE FOR OVERLOAD & UNDER VOLTAGE TRIPS. VALVE MOTOR SHALL BE PROTECTED BY OVERLOAD TRIPS.
7. MOTOR CONTROL BY A.E.
8. MOUNT TERM. BOX OUTSIDE CONTAINMENT WALL, IDENTIFY WIRES FROM SWITCHES INSIDE TERM BOX.
9. RELAYS & DEVICES SUFFIXED BY 'A' & 'C' SYS I WILL BECOME 'B&D' FOR SYS II UNLESS OTHERWISE SPECIFIED.
10. PROVIDE SEPARATE POWER SUPPLY FOR EACH CHANNEL.

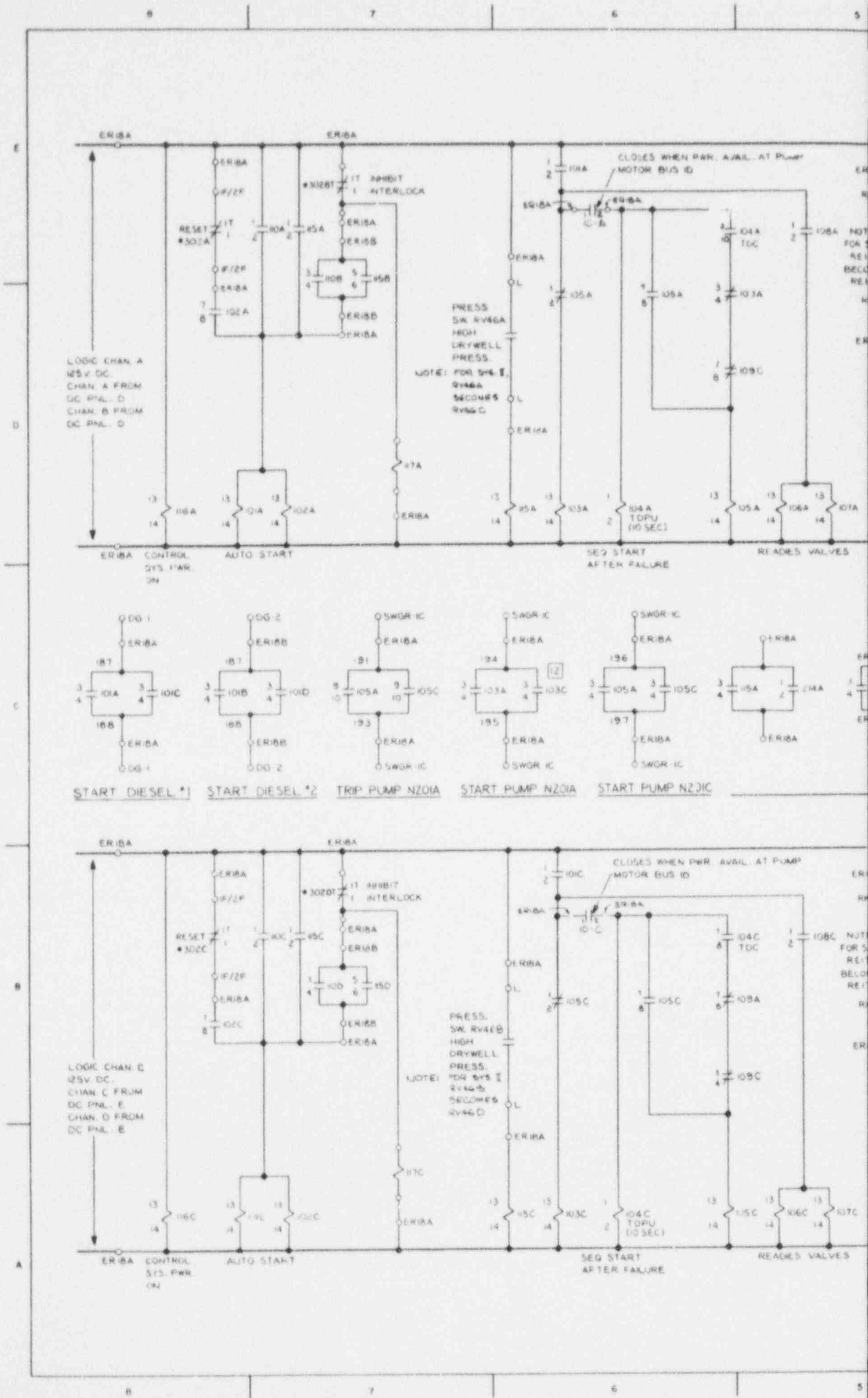


EQUIP PWR SOURCE	
SYS I	SYS II
US1A2	US1B2
SWGR 1C	SWGR 1D
DG-1	DG-1

FIGURE 2-3

CORE SPRAY SYSTEM
ELEMENTARY DIAGRAM EXISTING SCHEME
(SHEET 1)

9604220407-03



ER18A
CLOSES WHEN PWR. AVAIL. AT PUMP MOTOR BUS 1D
IT INHIBIT INTERLOCK
RESET
PRESS SW. RV46A HIGH DRYWELL PRESS.
NOTE: FOR SYS. II, RV46A BECOMES RV46C
LOGIC CHAN. A 125 V. DC. CHAN. A FROM DC PNL. D CHAN. B FROM DC PNL. D
TDPU (10 SEC)
CONTROL SYS. PWR. ON
AUTO START
SEQ START AFTER FAILURE
READIES VALVES
START DIESEL #1
START DIESEL #2
TRIP PUMP NZ01A
START PUMP NZ01A
START PUMP NZ01C
PRESS. SW. RV46B HIGH DRYWELL PRESS.
NOTE: FOR SYS II RV46B BECOMES RV46D
LOGIC CHAN. C 125V. DC. CHAN. C FROM DC PNL. E CHAN. D FROM DC PNL. E

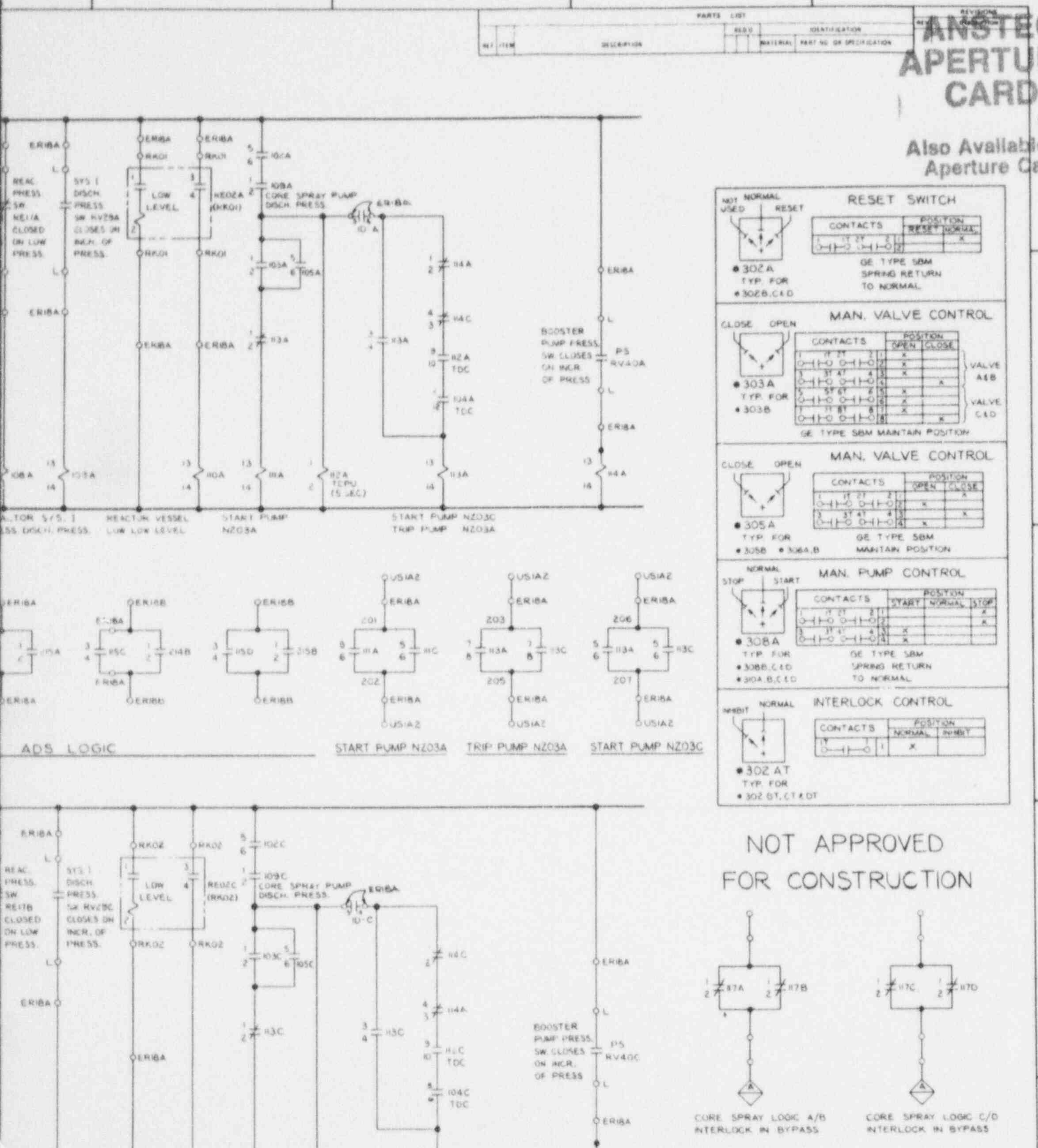
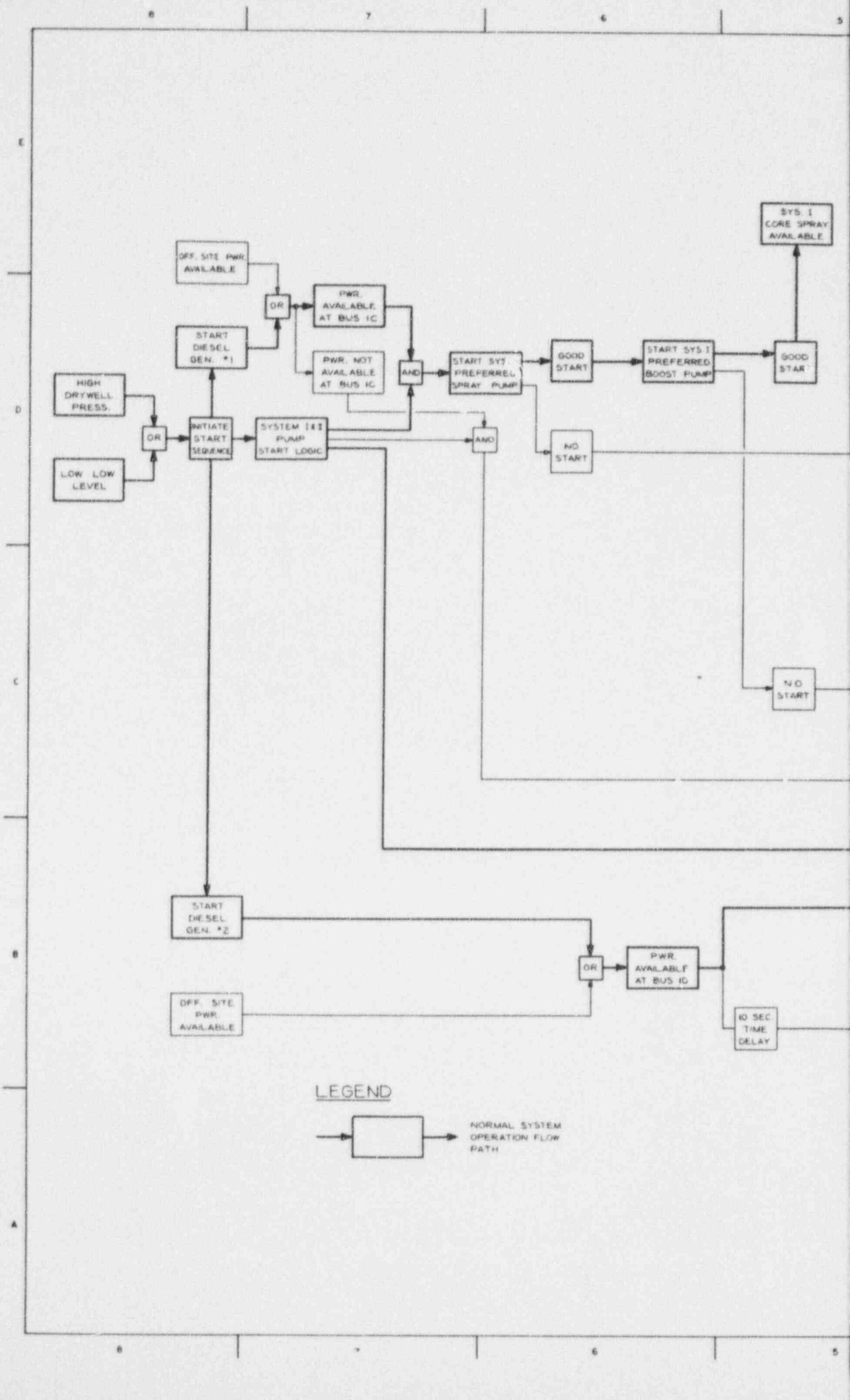


FIGURE 2-4

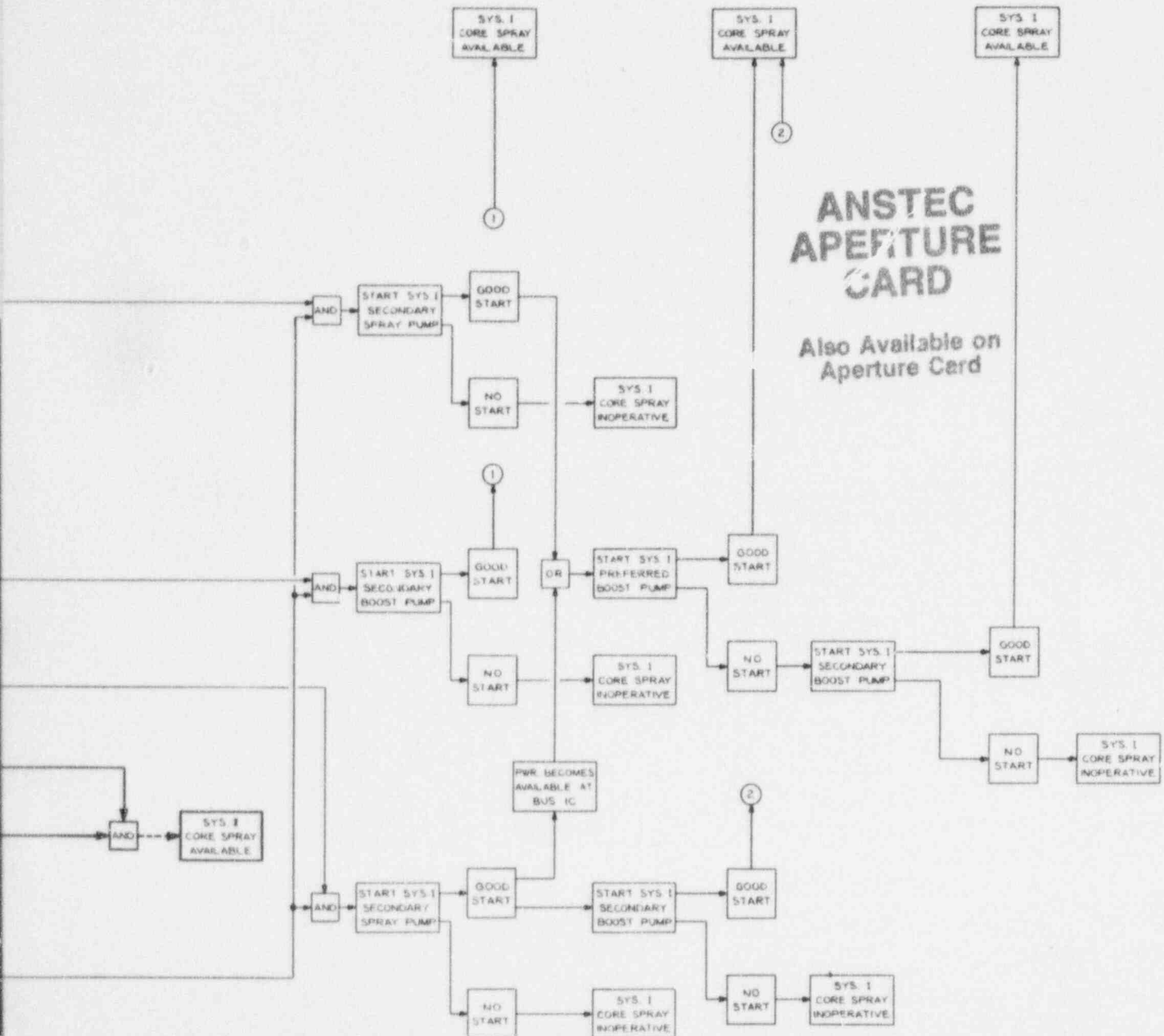
ELEMENTARY DIAGRAM ELECTRICAL SCHEME

JCP&L CO. OYSTER CREEK CORE SPRAY MOD.	NUS CORPORATION ROCKVILLE, MARYLAND
ELEMENTARY DIAGRAM ELECTRICAL SCHEME	DRAWING NO. 5060F032 REV 1

9604220407-04



OFF. SITE PWR. AVAILABLE
OR
PWR. AVAILABLE AT BUS 1C
START DIESEL GEN. #1
PWR. NOT AVAILABLE AT BUS 1C
HIGH DRYWELL PRESS.
OR
LOW LOW LEVEL
INITIATE START SEQUENCE
SYSTEM I & II PUMP START LOGIC
AND
START SYS. I PREFERRED SPRAY PUMP
GOOD START
START SYS. I PREFERRED BOOST PUMP
GOOD START
SYS. I CORE SPRAY AVAILABLE
AND
NO START
NO START
START DIESEL GEN. #2
OR
PWR. AVAILABLE AT BUS 1D
OFF. SITE PWR. AVAILABLE
10 SEC TIME DELAY
LEGEND
NORMAL SYSTEM OPERATION FLOW PATH



ANSTEC APERTURE CARD

Also Available on Aperture Card

NOT APPROVED FOR CONSTRUCTION

FIGURE 2–5

SYSTEM BLOCK DIAGRAM

JCP & L CO.
OYSTER CREEK
CORE SPRAY MOD.

NUS CORPORATION
ROCKVILLE, MARYLAND

SYSTEM
BLOCK DIAGRAM

DRAWN J. C. LEE

DRAWING NO. 5060F033 REV. 1

SCALE NONE SHEET 1 OF 1

9604220407-05

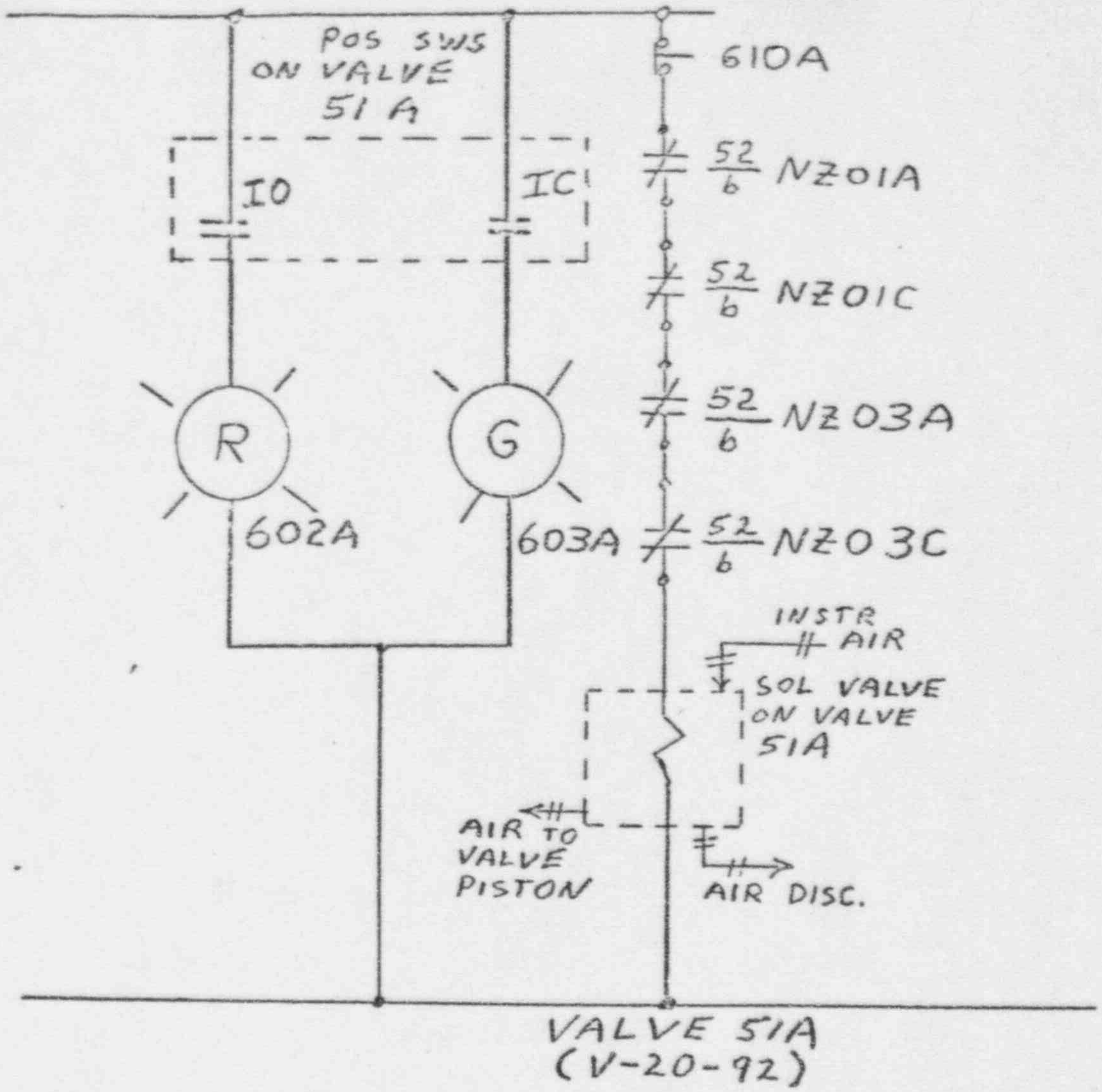
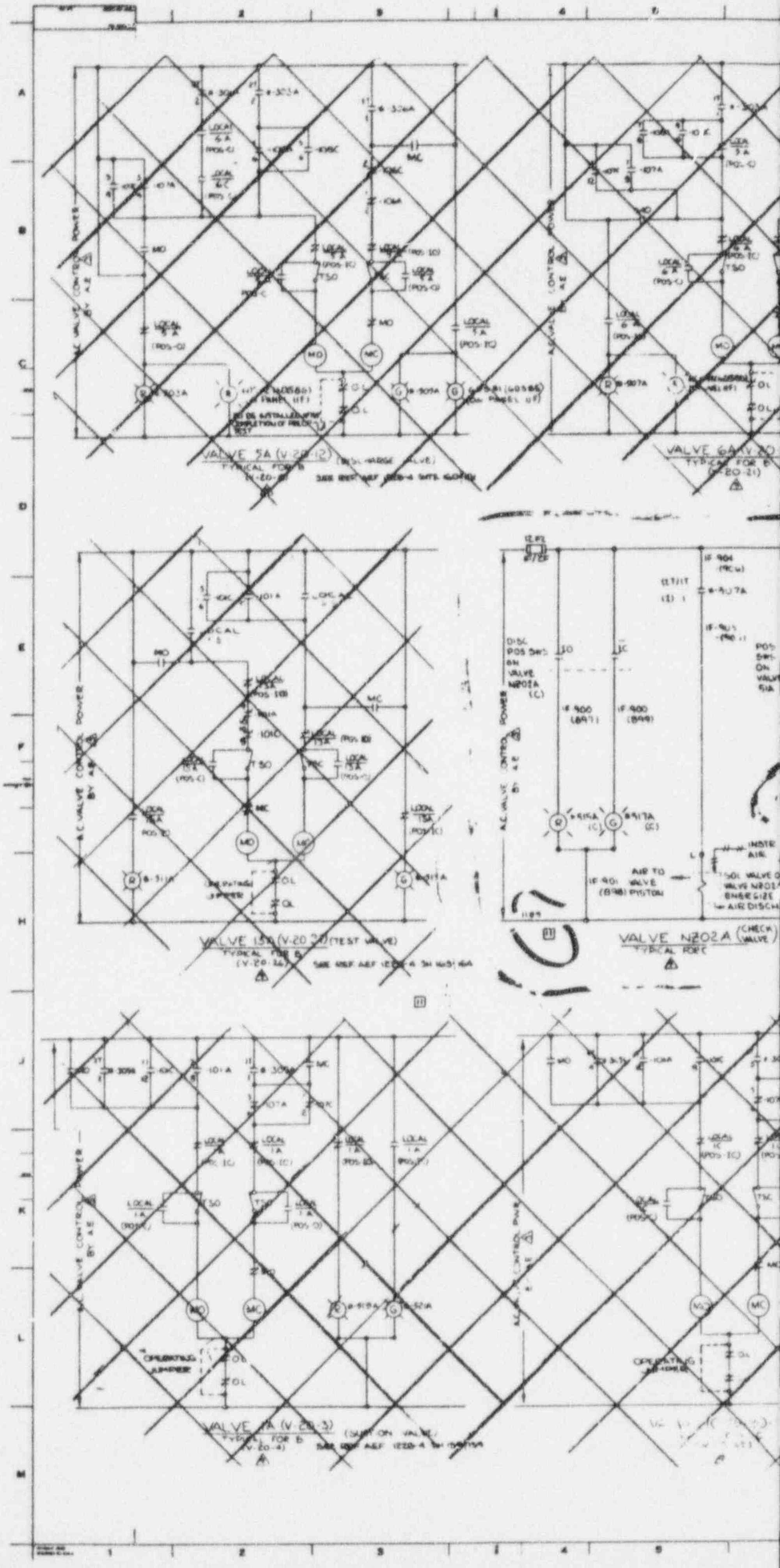


FIGURE 2–6

EXISTING ELECTRICAL
SCHEME MINIFLOW VALVE
(REF. FIGURE 2–6A)

Revision 1 dated 7–15–75


VALVE 5A (V-20-12) (DISCHARGE VALVE)
TYPICAL FOR B
VALVE 6A (V-20
VALVE 15A (V-20-27) (TEST VALVE)
TYPICAL FOR B
VALVE N202A (CHECK VALVE)
TYPICAL FOR C
VALVE 7A (V-20-3) (SHUT ON VALVE)
TYPICAL FOR B
(V-20-4)
A.C. VALVE CONTROL POWER BY A.E.
OPERATING JUMPER

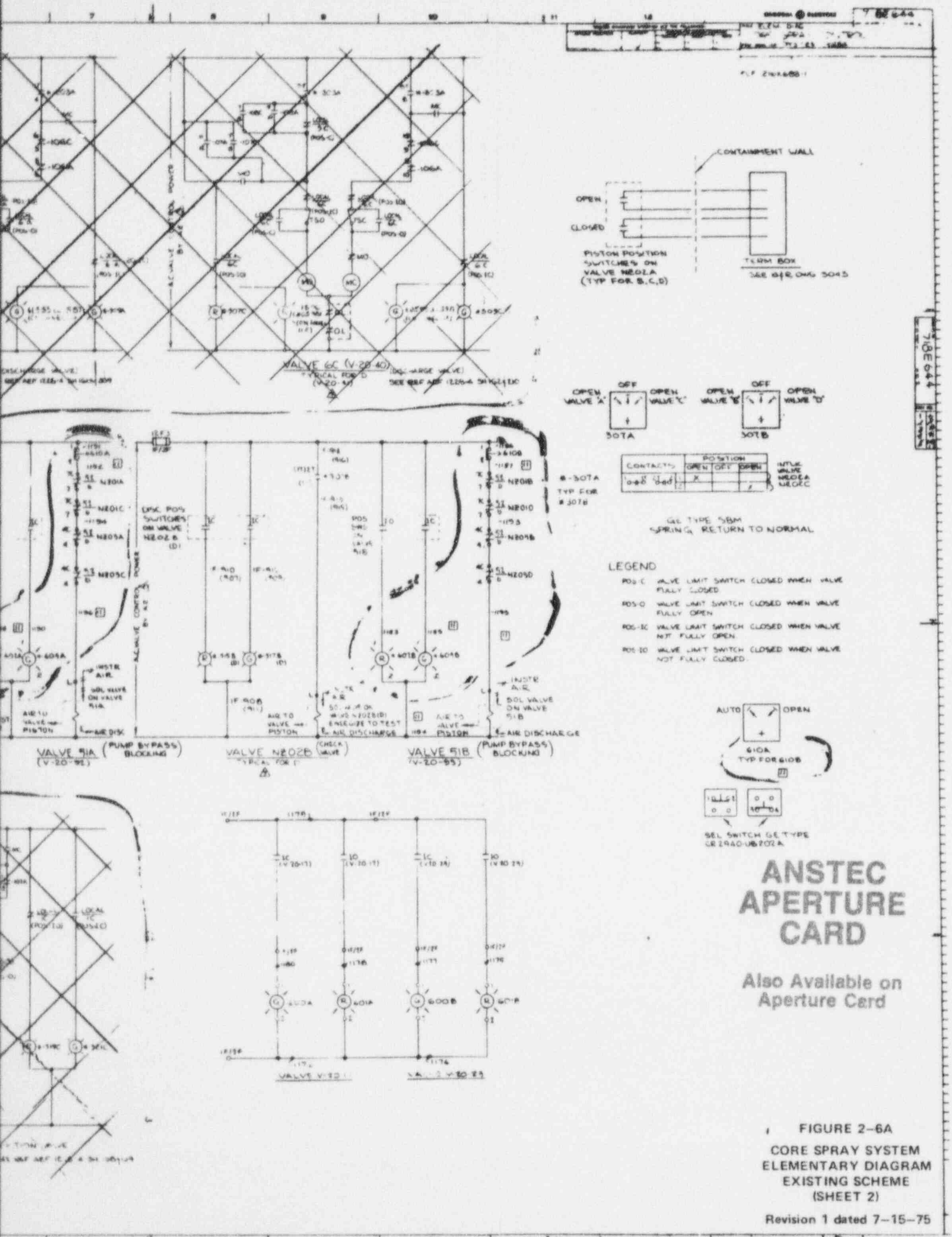


FIGURE 2-6A

CORE SPRAY SYSTEM
ELEMENTARY DIAGRAM
EXISTING SCHEME
(SHEET 2)

Revision 1 dated 7-15-75

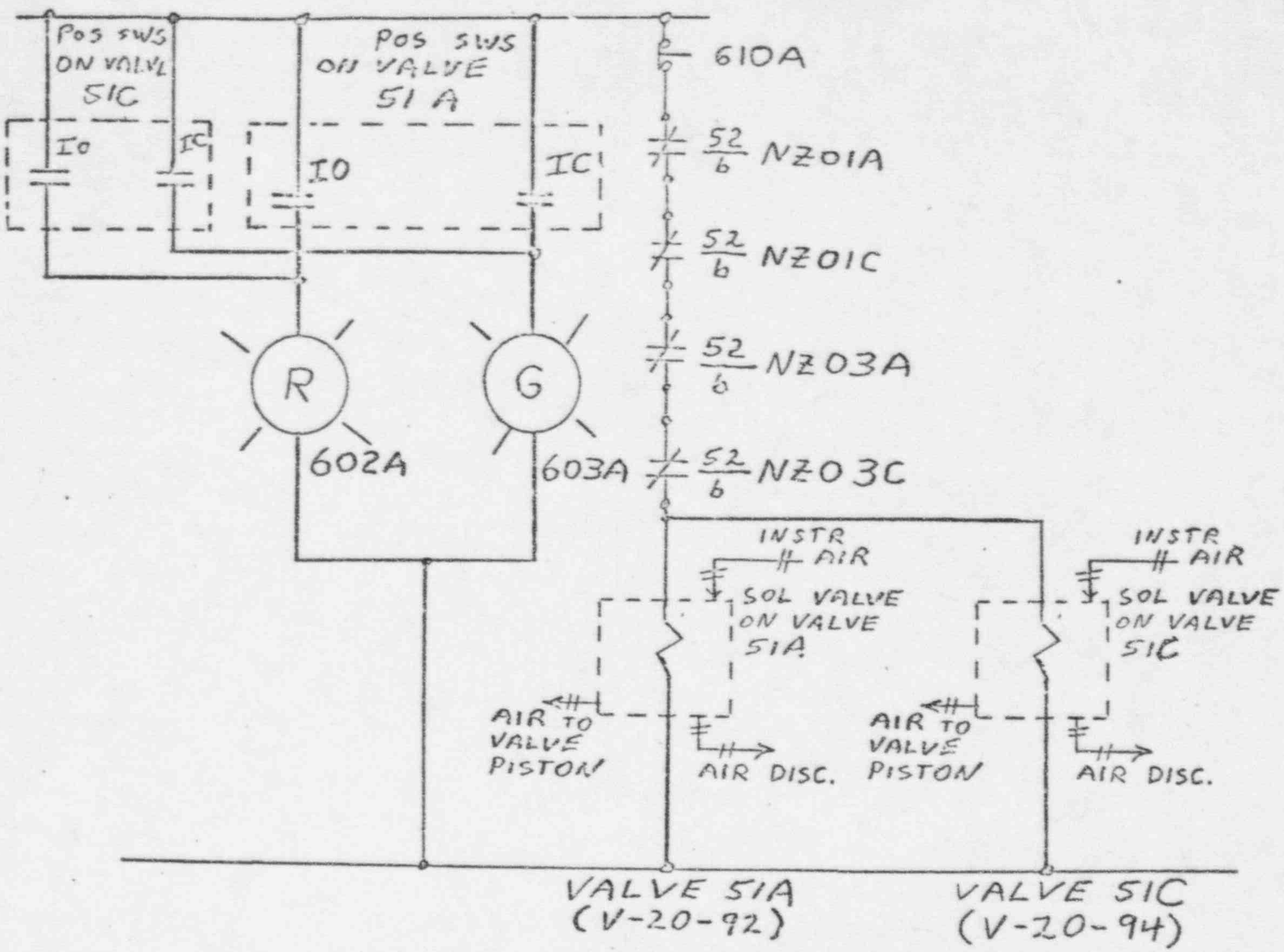


FIGURE 2–7

MODIFICATION FOR MINIFLOW VALVES

Revision 1 dated 7–15–75

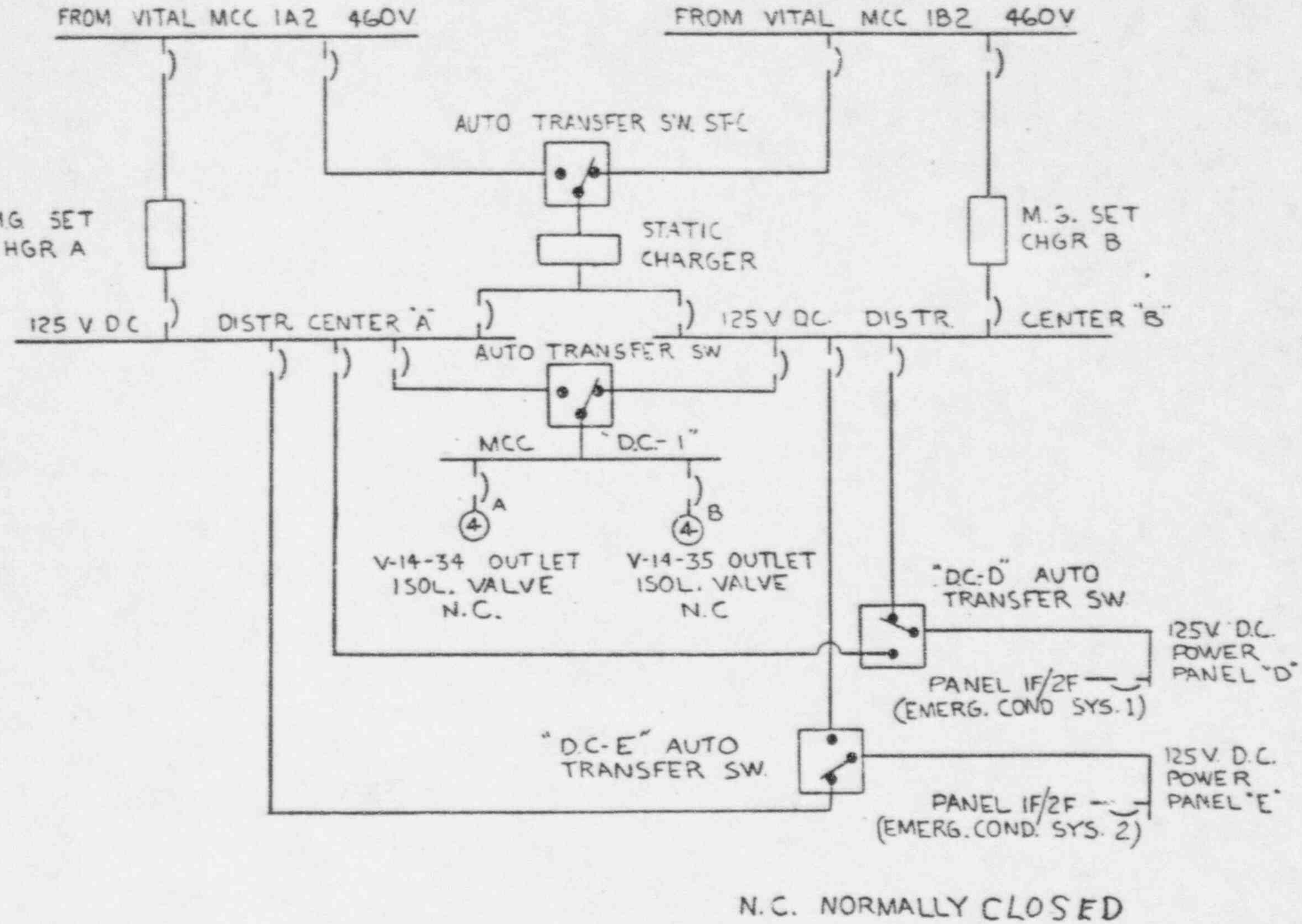


FIGURE 2–8

OYSTER CREEK
NUCLEAR GENERATING STATION
D. C. ONE LINE DIAGRAM

Revision 1 dated 7–15–75

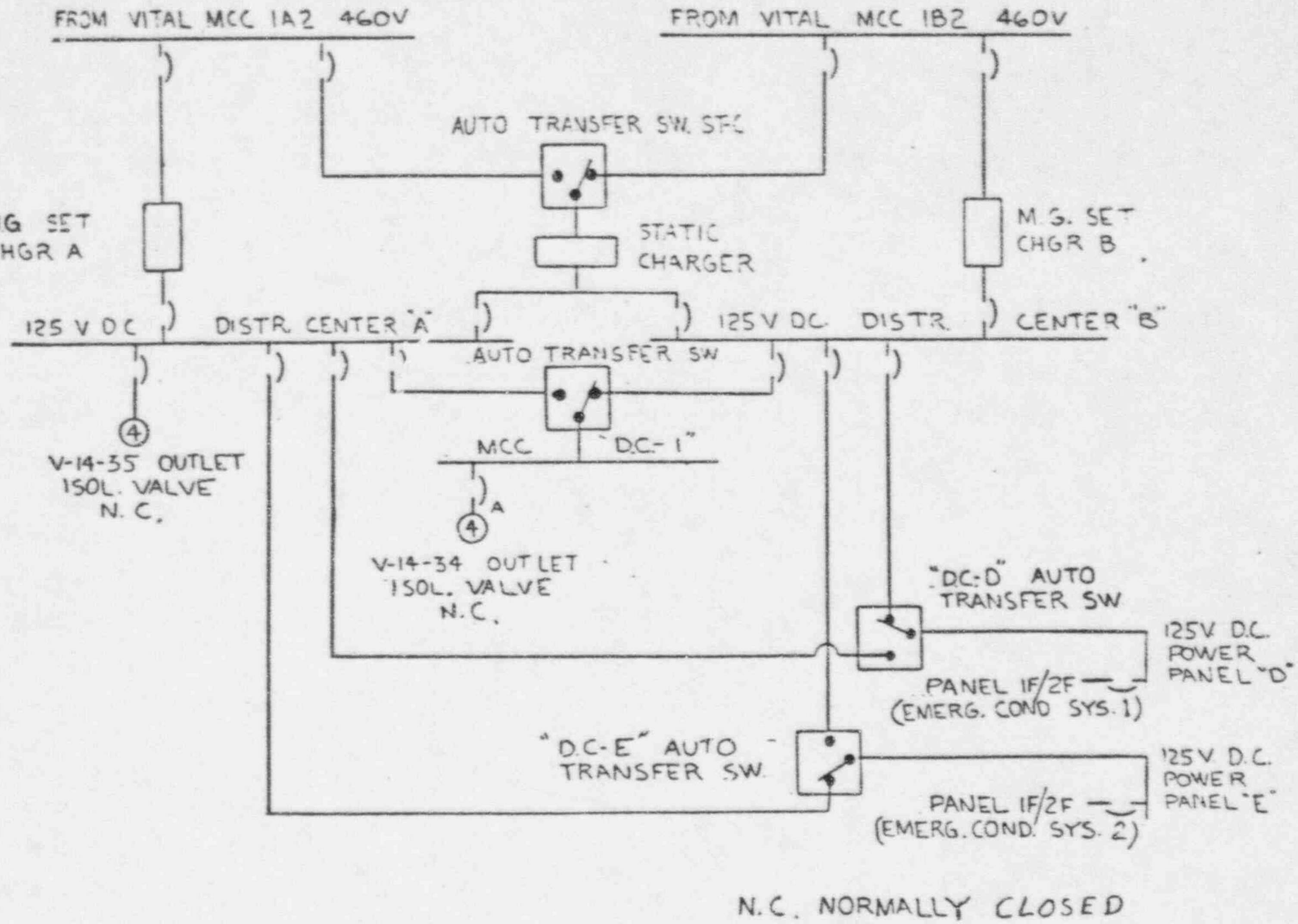


FIGURE 2–9

OYSTER CREEK
NUCLEAR GENERATING STATION
REVISED
D.C. ONE LINE DIAGRAM

Revision 1 dated 7–15–75

3. CHARACTERISTICS OF THE MODIFIED SYSTEM

The system design modification greatly enhances the ECCS availability and performance during the design basis condition (i.e., postulated LOCA). Features which shall be incorporated into the ECCS based on the designed modification are subsequently presented. The design modification addresses the ECCS core spray system (CSS) and the automatic depressurization system (ADS).

3.1 Core Spray System

The features to be incorporated into the CSS are as follows:

- A CSS actuation logic channel shall initiate operation of its assigned fluid system via the preferred spray and/or booster pumps and their associated power source and via the alternate (backup) spray and/or booster pumps which are powered by a separate and independent power source from the preferred pumps. An actuation channel shall start the alternate spray and/or booster pumps when the respective preferred pumps of that loop do not start.

- A CSS actuation logic channel shall open its redundant and independent valves in its assigned fluid sytem with similarly redundant and independent power source configuration.

- The tripping of a single input parameter (i.e., low-low level or high drywell pressure) shall initiate the CSS start sequence in the actuation channels for both spray systems I and II, which will result in commanding both 2500 KW diesel generators to start.

- The spray/booster pump and suction/isolation valve motor control center (MCC) assignments have been selectively rearranged, thereby enabling both spray systems I and II to operate at rated conditions based on either of two independent and redundant power sources.

- The power source breakers for the test recirculation bypass valves (i.e., V20-27 and V20-26) and the discharge (test) valves (i.e., V20-12 and V20-18) shall be locked out (off) during non-test operational periods. Valve position indication shall be maintained independent of breaker status.

- Keylock test switches to enable testing of the CSS actuation channels shall be installed. The test switch permits testing of an individual actuation channel independent of the interchannel inhibit interlocks. When testing an actuation channel, the interchannel inhibit is annunciated in the control room.

These design features enable the CSS to achieve operational advantages not afforded by the currently installed system.

A summary of operational enhancements is presented below. Table 4 of Appendix A can be compared with Table 6 of the existing ECCS single failure analysis to demonstrate the favorable impact of the modification with regard to the single failure vulnerability of the ECCS systems. This is accomplished as follows.

- The modified actuation channel logic and the reassignment of motor power sources enable the system to provide rated coolant flow conditions in both core spray fluid systems I and II under all combinations of a postulated LOCA coincident with a single active mechanical or electrical failure or a single passive electrical failure. Of particular emphasis is the ability of the CSS to provide rated coolant flow to the reactor vessel when the postulated LOCA occurs at one CSS pipe-reactor vessel interface and either 4160 VAC bus 1D or 1C has failed. (See Attachment I, Items 211, 212, 553, and Attachment II, Items 211A, 212A, 553A and Figures 2-2, 2-9.)

- The reassignment of CSS component power sources has corrected the system vulnerability to single failure of undervoltage relays 27X-1C, 27X1-1C, 27X-1D, and 27X1-1D. No single vital bus undervoltage relay failure can prevent spray system I or II from operating. (See Attachment I, Items 517, 518 and Attachment II, Items 517A, 518A and Figures 2-2, 2-4.)

- The modified CSS actuation logic initiates total system response (diesels 1 and 2 start and systems I and II pressurization) upon the receipt of a high drywell pressure signal or a low-low reactor water level signal to a single actuation channel. (See Attachment II, Items 509A, 514A and Figure 2-4.)

- The locking out of the "test" valves power source breakers assures that no single hot short shall cause the "test" valve to go to a state which prevents or perturbs the spray systems I and II from operating at rated conditions. Valve position indications, independent of valve operator power, will be provided in the control room. (See Attachment I, Items 804, 816.)

- The drywell pressure switches RV46B and RV46C shall be reassigned to CSS actuation channels C and B, respectively. (See Attachment II, Item 576A and Figure 2-4.)

- The installation of an additional booster pump minimum recirculation valve (V-20-94 for System I and V-20-95 for System II) in parallel with the existing valves. (See Attachment I, Item 806 and Attachment II, Item 806A and Figure 2-7.)

3.2 Automatic Depressurization System (ADS)

In addition to upgrading the CSS, the design modification shall concurrently enhance ADS performance. These modifications shall be as follows:

- CSS relay 16K115C will enable ADS relay 16K214B.

- CSS relay 16K115B will enable ADS relay 16K215A.

These modifications shall eliminate the following single failure:

- The failure of vital DC panel D or E shall not prevent the ADS from initiating reactor depressurization. (See Attachment I, Item 310.)

3.3 Emergency Condensers

As identified in the Failure Mode and Effects Analysis (Table 2 of Attachment I, Items 211 and 212) a loss of power to motor control center DC-1 can prevent both emergency condenser isolation valves (V-14-34 and V-14-35) from operating. This will prevent both emergency condenser systems from initiating. Figure 2-8 shows the present configuration.

- The modification will enable at least one system of the emergency condensers to operate in the event of a loss of power to motor control center DC-1. The modification consists of disconnecting the motor operator of emergency condenser isolation valve V-14-35 from MCC-DC1 and connecting it to a separate motor starter whose power source will be the 125 VDC distribution center A as shown on Figure 2-9. Table 5 of Attachment II is the Failure Mode and Effects Analysis for this modification.

4. SAFETY EVALUATION

4.1 Core Spray Modification Interfaces With Existing Systems

Presented herein is a discussion of the modifications and their respective interface and impact on existing systems.

4.1.1 4160 VAC Emergency Switchgear, Bus 1C and Bus 1D

The 4160 VAC emergency switchgear bus 1C and bus 1D are supplied by diesel generators 1 and 2, respectively, or the offsite power source. The design modifications presented herein do not alter this configuration.

The principle CSS related load assignments for the bus 1C and bus 1D are substation bus 1A2 and bus 1B2, respectively, and two 500 hp core spray pumps on each bus (1C and 1D). Currently, core spray pumps NZ01C and NZ01A are assigned to bus 1C, while pumps NZ01B and NZ01D are assigned to bus 1D. Based on the CSS modification, two of the core spray pumps shall be reassigned relative to bus 1C and 1D. The revised spray pump assignments are as follows:

- o Bus 1C: Core spray pumps NZ01A and NZ01D
- o Bus ID: Core spray pumps NZ01B and NZ01C

The net effect of this modification is to enable both core spray systems I and II to establish rated spray pump operation as a function of two independent and redundant AC power supplies. There is no change in the number of 500 hp core spray pumps assigned to a 4160 AC emergency switchgear bus (i.e., 1C or 1D).

Based on the revised philosophy of operation, both CSS I and II must supply rated core spray when one of the vital AC power sources (i.e., bus 1C or bus 1D) is unavailable. The load on the associated diesel generator is increased by 800 hp. The load increase is due to the operation of the preferred spray (500 hp) and booster (300 hp) pumps associated with one core spray fluid system and in addition, the alternate spray and booster pumps associated with the other core spray fluid system. Under normal operating conditions, that is both bus 1C (diesel generator 1) and bus 1D (diesel generator 2) operational, each vital bus (i.e., bus 1C or 1D) shall provide power to the preferred spray (500 hp) and booster (300 hp) pumps associated with a single core spray system. The load schedule for an emergency switchgear bus such as bus 1C (diesel generator 1) for normal operation and for operation assuming a bus (bus 1C or bus 1D) is unavailable is presented on Page 4-3. The load schedule reflects both the nameplate rating of each load and the load required to achieve rated condition.

Each diesel generator has a nominal rating of 2500 KW. The estimated loads, when based on the nameplate ratings of the motors, exceed 2500 KW. However, the actual load of these motors when operating at rated conditions reduce the total bus load to 2500 KW. Each of the existing diesel generators is fully capable of carrying the 2500 KW load.

Tests have been successfully performed on the diesel generators at the plant to ascertain the capability of a diesel to start a 1000 HP condensate pump while carrying a load of 850 HP. Since these tests imposed more severe transient loads on the diesel generator than anything outlined in the foregoing starting sequence it can be conservatively assumed that starting transients with the CSS modification are acceptable.

Normal Operation[1] (Bus 1C and Bus 1D Available)

	Nameplate Rating	Rated Condition
Emergency Lighting (immediately)	70	70
Instruments, Controls, Misc. Small Motors, and System Losses (immediately)	250	250
Closed Cooling Water Pumps (immediately)	200	176
Standby Gas Treatment (immediately)	70	70
Core Spray Pump (immediately on command)	500	462
Core Spray Booster (5 seconds after CSP)	300	285
Control Rod Drive Feed Pumps (After booster discharge pressure attained)	250	252
Service Water (2 minutes delay)	250	252
Containment Spray (45 seconds delay)	300	237
Emergency Service Water Pump (5 minutes after containment spray)	400	405
Normal Operation Total Category I Load	2590 HP	2457 HP

Additional CSS[2] Loads (Bus 1C or Bus 1D Unavailable)

	Nameplate Rating	Rated Condition
Additional Core Spray Pump (5 seconds after first booster)	500	462
Additional Booster Pump (5 seconds after additional CSP)	300	285
Total Category I Load which must start automatically	3390 HP	3204 HP
Equivalent KW	2528 KW	2390 KW
Assume 95% efficiency for large motors, total load	2646 KW	2500 KW

(1) Load sequence identical to existing load profile.
(2) Additional loads imposed based on the proposed CSS modification.

4.1.2 460 VAC Substations 1A2 and 1B2

The independent and redundant bus 1A2 and bus 1B2 are powered from bus 1C and bus 1D, respectively. The design modification does not alter this power service network.

Currently, CSS booster pumps NZ03A and assigned to bus 1A2 and CSS booster pumps NZ02B and NZ02D are assigned to bus 1B2. Under the proposed modification the pump-bus assignments are as follows:

- o Bus 1A2: CSS booster pumps NZ03A and NZ03D
- o Bus 1B2: CSS booster pump NZ03B and NZ03C.

The net effect of the modification is no load change on bus 1A2 or bus 1B2, but enhanced capability for CSS I and II through the use of independent and redundant AC power sources.

4.1.3 460 VAC Vital MCC 1A2 and MCC 1B2

The vital MCC busses 1A2 and 1B2 are energized, respectively, from substation buses 1A2 and 1B2. The design modification does not alter this network.

Currently, vital MCC 1A2 provides power to both CSS System I isolation valves (i.e., V20-15 and V20-40) and alternate power to the MCC 1AB2 bus via the automatic transfer switch. Vital MCC bus 1B2 has no CSS associated load other than providing power to MCC 1AB2 via the automatic transfer switch (ATS).

Subsequent to the modification, the load pattern shall be as follows:

- o Vital MCC 1A2 - System I isolation valve V20-15 and ATS.

- o Vital MCC 1B2 - System I isolation valve V20-40 and ATS.

The net result of this change shall be a balanced CSS load on the respective busses. In addition, CSS I shall be enhanced via an independent and redundant isolation valve power source configuration.

4.1.4 460 VAC MCC 1AB2 and MCC 1A21B

Currently, MCC 1AB2 provides power to the CSS II isolation valves V20-21 and V20-41. MCC 1A21B provides power to System I recirculation valve V20-27. Subsequent to the modification, MCC 1AB2 shall power CSS I V20-41 only and MCC 1A21B shall power CSS I V20-27 and CSS II V20-21.

The result of this modification is to assure an independent and redundant CSS II isolation valve-power source configuration.

4.1.5 460 VAC MCC 1A21A and MCC 1B21A

As presented on Figure 2-1, the currently configured MCC 1A21A provides power for CSS I suction valves V20-32 and V20-3 and CSS I discharge (test) valve V20-12. MCC 1B21A powers CSS II suction valves V20-4 and V20-33, CSS II recirculation valve V20-26, and CSS II discharge (test) valve V20-18.

To provide an independent and redundant valve-power source configuration, the suction valves V20-32 (CSS I) and V20-33 (CSS II) shall be reassigned as shown on Figure 2-2. The current recirculation and discharge (test) valve-power source arrangement meets the independent and redundant power source requirements.

4.1.6 Automatic Depressurization System (ADS)

As discussed in Section 3.2, the design modification concurrently enhances ADS performance.

4.1.7 Other Interfaces

During the evolution of final design, all other interfaces that may exist will be identified and evaluated.

4.2 ECCS Analysis Considerations

The core spray line break loss-of-coolant accident, when coupled with a single failure of the diesel generator or a diesel generator bus fault which provides power to the unbroken core spray loop, has been analyzed and found to require operator action in order to mitigate the effects of the accident. The modification to the ECCS system described in this submittal provides the system with the capability to automatically respond to the above failure assumptions and to satisfactorily mitigate the effects of the accident in compliance with 10 CFR 50.46 without operator action.

The response of the modified system to the core spray line break and diesel generator failure or diesel bus fault in the unbroken loop is such that the system will be capable of automatically delivering rated core spray under the conditions of high drywell pressure or low-low water level and permissive system pressure. The effect on the peak cladding temperature in this case can be seen from Figures 20 and 24 of our April 28, 1975 analysis. The core spray isolation valves will automatically open when system pressure reaches 285 psig. This occurs when the water level is slightly below the top of the active fuel. From that point on, the water level behavior can be considered to behave analogously with the feedwater line break presented in Figure 25 for comparison purposes. On this basis, the water level will begin to turn around in approximately 300 seconds. This can be compared to the results presented in Figure 24 which shows that the peak cladding temperature will be less than 1800°F, far less than the 2200°F criterion.

Consideration has also been given to the modified system effectiveness in mitigating the effects of the remaining spectrum of analyzed breaks. The capability of the system in this regard has not been degraded and has been enhanced by providing for both core spray systems to operate when one diesel generator is inoperative. In previous analyses, when a diesel generator failure was assumed, only one core spray system was available. With the modified system, two core spray fluid systems will be available.

4.3 Single Failure Analysis

A single failure analysis for the modification has been performed and is included as Appendix A. No additional single failures have been created by this modification. Of those single failures which have been identified in the analysis performed to comply with Condition 2.D.2 of Amendment 8 to the Oyster Creek Provisional Operating License, several have been corrected and are identified in the Appendix. The resulting single failure analysis reflects the ECCS system as modified.

5. SCHEDULE

The implementation of this modification can reasonably be conducted over a ninety day schedule, subject to the availability of material and the extent and duration of the Commission review requirements. A significant portion of this period is required for verification, review and Q. A. procedures which apply to the nuclear grade safety system design, procurement, construction and testing. Work is proceeding while awaiting NRC approval and assuming no major disagreements, the ninety day period can be assumed to have started. The availability of materials to the proper specifications does not appear to be a problem, however all the hardware has not been defined and therefore reservations on a ninety day commitment must be expressed with regard to the availability of special hardware (and its required documentation) which may be beyond our control.

With regard to the schedule, the tasks that must be accomplished are listed below with a schedule shown in Figure 5-1 for a ninety day pre-shutdown implementation. The tasks are:

1. NRC approval received.

2. Plant Operations Review Committee and General Office Review Board review of modification.

3. Verify existing wiring diagrams; although no discrepancies are expected, it is prudent to conduct a verification and establish pre-modification documentation of terminal connections and cable routing.

4. Conduct detailed design; the new cable and conduit runs, instrument and control re-wiring and new relay installation must be detailed.

5. Verification and Q. A. procedures applied to the detailed design.

6. Write procurement specifications and purchase orders.

7. Review and Q. A. procedures applied to procurement specifications and purchase orders.

8. Delivery, receipt and inspection of materials.

9. Work package preparation; for this type of modification, each wire to be changed must be pre-documented and inspection checkoff lists developed. Working from drawings alone is not an adequate procedure.

10. Verification of work package.

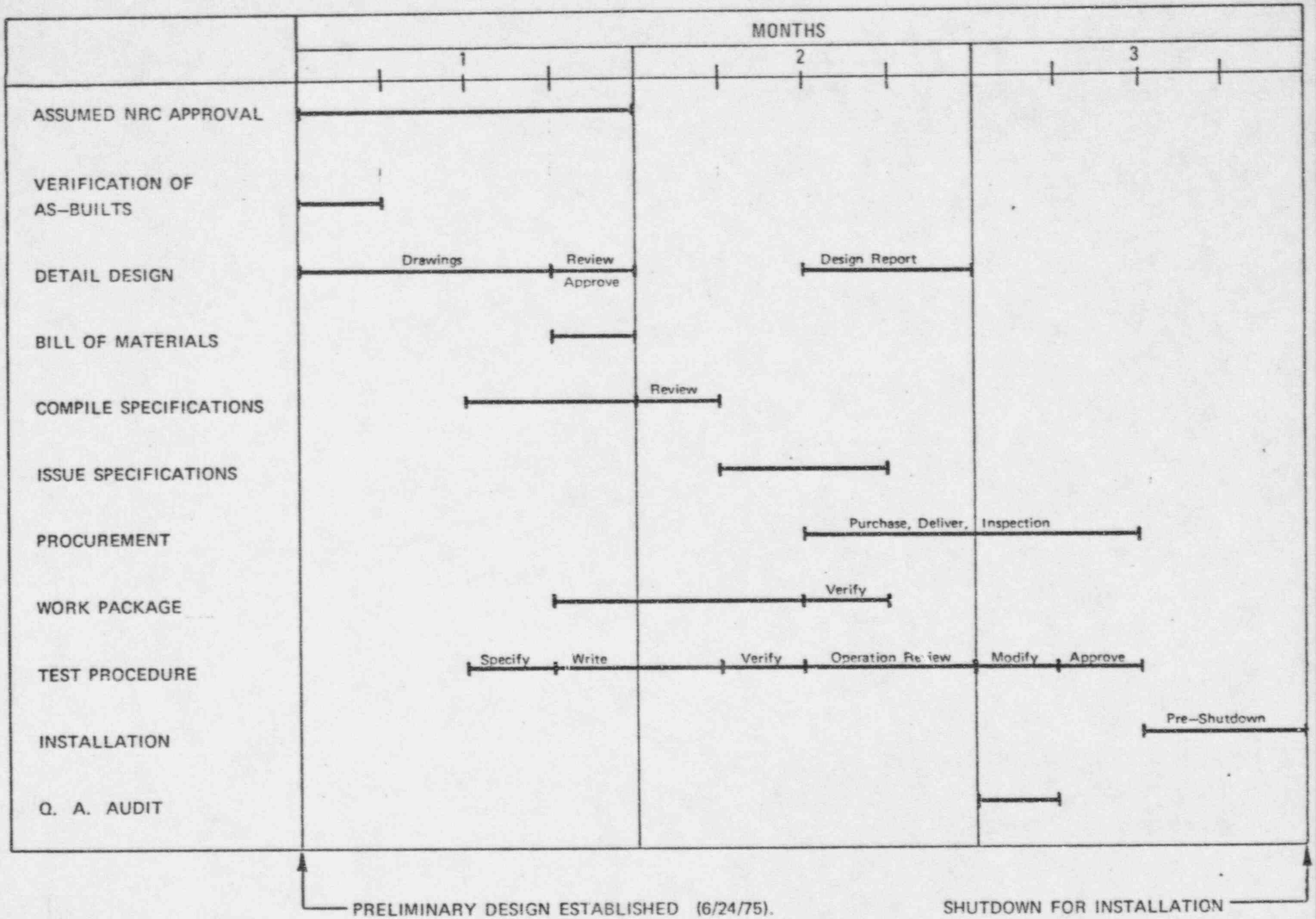
11. Preparation of specific component, subsystem and system test procedures; new components will have to be tested, interfaces verified and an integrated sytem test performed.

12. Test procedure review and approval; whenever a new or modified detailed test is to be performed on a safety system such as is the case here, review and approval by the Plant Operations Review Committee is required.

13. Installation and installation inspection.

14. Testing.

FIGURE 5–1
OYSTER CREEK CORE SPRAY MODIFICATION
90 DAY SCHEDULE



With respect to the emergency condenser single failures, items 211A and 212A on Table 5 (sheet 3), the modification described in section 3 will be implemented during the next scheduled refueling outage. It should be noted that the effect of the loss of both emergency condensers on ECCS performance has been evaluated in our letter dated July 3, 1975, which considered the following ECCS system combinations for the 0.35 ft^2 limiting break and the 4.69 ft^2 design basis break:

2 Core Spray + 0 Emergency Condensers + ADS

The results of the ECCS performance considerations under these conditions have been accounted for by appropriately conservative MAPLHGR reductions. Thus, Oyster Creek operation is in complete accord with this single failure assumption and modification during the next scheduled refueling outage is appropriate.

APPENDIX A

TABLE 1

CORE SPRAY SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
500	K101A	Auto Start	FD	1	Prevents Channel A from starting all System I pumps, opening System I valves 6A, 6C, 5A, 1A, and 1C, and closing valve 13A. Prevents start of diesel #1 from Channel A	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Channel C is available to start System I. Valves 5A, 1A, and 1C are normally open. Valve 13A is normally closed.
			FE	2	Starts CS Pump (01A or 01C). Closes CS valve 13A. Opens CS Valves 1A, 1C. Starts Diesel #1.	Annunciator	Has no effect on System I ability to respond to legitimate actuation signal.	Bypass lines are provided so that pumps can be operated without damage.
501	K102A	Auto Start	FD	1	Prevents Channel A from starting System I booster pumps. System I initiation is not sealed in by Channel A	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Channel C is available to start System I
			FE	2	Energizes K101A. Starts CS pump (01A or 01C). Closes CS valve 13A. Opens CS valves 1A, 1C. Starts booster pump (03A or 03C).	Annunciator	Has no effect on System I ability to respond to legitimate actuation signal.	Bypass lines are provided so that pumps can be operated without damage.
502	K103A	Start Pump 01A	FD	1	Channel A cannot start CS pump 01A.	Periodic Test	Degrades logic redundancy to start CS pump 01A from 1/2 to 1/1 but does not affect System I operation.	Channel A can start pumps 01A and 03A. Channel C can start all pumps.
			FE	2	Starts CS pump 01A.	Annunciator	Has no effect on System I ability to respond to legitimate actuation signal.	
503A	K104A	Seq. Start Pump 01C	FD	1	Prevents start of backup CS pump 01C and Booster Pump 03C by Channel A.	Periodic Test	Degrades logic redundancy to start CS pump 01C and booster pump 03C from 1/2 to 1/1 but does not affect System I operation.	Channel A can start pumps 01A and 03A. Channel C can start all pumps.
			FE	2	Permits CS pump 01C and booster pump 03C to start. CS pump 01A and booster pump 03A prohibited from starting because of trip signal from K105A and K113A. Therefore, backup pumps are not available in System I.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	
504	K105A	Start Pump 01C	FD	1	Prevents start of backup CS pump 01C and trip of pump 01A.	Periodic Test	Degrades logic redundancy to start CS pump 01C from 1/2 to 1/1 but does not affect System I operation.	Channel A can start CS pump 01A. Channel C can start either CS pump 01A or 01C.

CORE SPRAY SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
			FE	2	Starts backup CS pump 01C and trips or prohibits start of CS pump 01A.	CRI for pump	Degrades System I redundancy from 1/2 to 1/1.	
505	K106A	Readies Valves	FD	1	None	Periodic Test	Does not affect automatic CS operation of valves and therefore does not affect System I operation.	
			FE	2	Prevents manual closing of valves 5A, 6A and 6C (Valves 6A and 6C are normally closed).	Periodic Test	Does not affect automatic CS operation of valves and therefore does not affect System I operation.	Degrades manual valve control ckt. (closing direction) redundancy.
506	K107A	Readies Valves	FD	1	Prevents Channel A from opening CS discharge valves 6A, 6C (and opening 5A, if required).	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Channel C is available to open System I valves. Manual operation of valves 6A, 6C and 5A is available.
			FE	2	Opens CS discharge valves 6A, 6C (and 5A, if closed). Provides automatic interruption of closing ckt. for valves 1A, 1C.	CRI for valves Event Recorder	Does not affect System I operation. System I depends on two parallel check valves to isolate low pressure from reactor pressure.	Isolation valves NZ02A and NZ02C will isolate CS System I from reactor pressure.
507	K108A or RE17A	Reactor Pressure or Reactor Pressure Sensor	FD FH (open)	1 3	Prevents Channel A from opening CS discharge valves 6A, 6C (and opening 5A, if required).	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Channel C is available to open System I valves.
	K108A or RE17A		FE FL (closed)	2 4	Permits CS discharge valves 6A, 6C (and 5A, if closed) to be opened when Channel A starts CS pump regardless of reactor pressure. Also permits CS valves 6A, 6C or 5A to be opened manually regardless of reactor pressure.	Annunciator	Does not affect System I operation. System I depends on two parallel check valves to isolate low pressure piping from reactor pressure.	Isolation valves NZ02A and NZ02C will isolate CS System I from reactor pressure until pressure is reduced to point where NZ02A/NZ02C (powered check valves) open.

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
508	K109A or RV29A	System I Discharge Pressure or System I Discharge Pressure Sensor	FD	1	Prevents Channel A from starting System I booster pumps.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Channel C is available to start System I booster pumps.
			FL (open)	3				
	K109A or RV29A		FE	2	Starts System I booster pump simultaneously with CS pump 01A.	Annunciator	Booster pump 03A may cavitate until CS pump 01A is up to speed. Short term cavitation will not affect System I operation. Degrades System I redundancy from 1/2 to 1/1.	Backup booster pump 03C is available if 03A cannot develop pressure. CS pump 01A is available for actuation by either Channel A or C.
			FH (Closed)		Prevents CS pump 01C from being operated by either Channel A or Channel C.			
509A	K110A or RE02A	Reactor Vessel Low Level or Reactor Low Level Sensor	FD	1	Prevents Channel A and Channel B from starting on Low Low Level signal from Channel A sensor.	Periodic Test	Degrades Channel A diversity. Does not affect System I operation for either Low Low Level or High Drywell Pressure.	Channel A is available to start System I and System II on High Drywell Pressure. Channel C is available to start System I and System II on Low Low Level and/or High Drywell Pressure.
			FH (open)	3				
	K110A or RE02A		FE	2	Energizes K101A, K102A starts CS pump (01A or 01C) closes CS valve 13A (if not closed) opens CS valves 1A, 1C, starts booster pump (03A or 03C). Auto starts System II (Channel B).	Annunciator	Has no effect on System I or System II ability to respond to legitimate actuation signal.	Relay provides interlocks to Emergency Condenser and Containment Spray (16K6A).
			FL (Closed)	4				
510	K111A	Start Pump 03A	FD	1	Channel A cannot start booster pump 03A.	Periodic Test	Degrades logic redundancy to start booster pump 03A from 1/2 to 1/1 but does not affect System I operation.	Channel A can start booster pump 03C. Channel C can start either booster pump 03A or 03C.
			FE	2	Starts booster pump 03A.	Annunciator	Has no effect on System I ability to respond to legitimate actuation signal.	-

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
511	K112A	Seq. Start Pump 03C	FD	1	Prevents start of backup booster pump 03C by Channel A.	Periodic Test	Degrades logic redundancy to start booster pump 03C from 1/2 to 1/1 but does not affect System I operation.	Channel A can start booster pump 03A. Channel C can start either booster pump 03A or 03C.
			FE	2	Permits booster pump 03C to start. Booster pump 03A would not start because of trip signal from K113A. Therefore a backup booster pump is not available.	CRI	Degrades System I redundancy from 1/2 to 1/1.	
512	K113A	Start Pump 03C	FD	1	Prevents start of backup booster pump 03C by Channel A.	Periodic Test	Degrades logic redundancy to start booster pump 03C from 1/2 to 1/1 but does not affect System I operation.	Channel A can start booster pump 03A. Channel C can start either booster pump 03A or 03C.
			FE	2	Starts backup booster pump 03C and trips or prohibits start of booster pump 03A.	CRI for Pump	Degrades System I redundancy from 1/2 to 1/1.	
513	K114A or RV40A	Booster Pump Discharge Pressure, or Booster Pump Discharge Pressure Sensor	FD	1	None	Periodic Test	Degrades logic redundancy which sequences booster pumps from 1/2 to 1/1 but does not affect System I operation.	Channel C relay K114C will perform required pump sequencing.
			FL (open)	3				
	K114A or RV40A		FE	2	Prevents booster pump 03C from being operated by either Channel A or Channel C.	Annunciator	Degrades System I redundancy from 1/2 to 1/1.	Booster pump 03A is available for actuation by either Channel A or Channel C.
			FH (Closed)	4				Relay provides interlocks to ADS (16K201A, 202A, 2026A, 207A).

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
514A	K115A or RV46A	High Drywell Pressure, or High Drywell Pressure Sensor	FD FL (open)	1	Prevents Channel A and Channel B from starting on High Drywell Pressure signal from Channel A sensor.	Periodic Test	Degrades Channel A Diversity. Does not affect System I operation for either Low Low Level or HIgh Drywell Pressure.	Channel A is available to start System I and System II on Low Low Level. Channel C is available to start System I and System II on High Drywell Pressure or Low Low level.
	K115A or RV46A		FE FH (Closed)	2 4	Energized K101A, K102A, starts CS pump (01A or 01C), closes CS valve 13A (if not closed), opens CS valves 1A, 1C, starts booster pump (03A or 03C). Auto starts System II (Channel B).	Annunciator & Event Recorder	Has no effect on System I or System II ability to respond to legitimate actuation signal.	Relay provides interlock to ADS (16K214A).
515	K116A	Control System Power Failure	FD	1	None	Annunciator	None.	
			FE	2	None.	Periodic Test	None.	
517A	27X-1C	Under-volt-relay	FD	1	Prevents operation of preferred pumps of System I and backup pumps of System II.	Annunciator	Degrades System I and II from 1/2 to 1/1.	
			FE	2	Does not clear buss so that loads may be sequenced after Diesel 1 starts.	Periodic Test	Possible overload of Diesel 1 degrades System I and II from 1/2 to 1/1.	
518A	27X1-1C	CS Pump Trip	FD	1	Trips CS pumps 01A and 01D	Annunciator	Degrades System I and II from 1/2 to 1/1.	
			FE	2	Does not protect CS pumps (01A, 01C) against undervoltage conditions.	Periodic Test	Does not prevent actuation of System I or II. System I will operate if voltage is adequate.	System I and II available.
519A	302A	Reset	Contact 1 fails open	5	Prevents "seal in" of K102A.	Periodic Test	Has no effect on System I operation.	Channel C will provide required "seal in" for System I.
			Contact 1 fails closed	6	Prevents reset of Channel A following either test or operation.	Annunciator	Has no effect on System I operation.	

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
520 (See also 303)	303A	Manual Operation of valves 6A and 6C	Contacts 1 and/or 5 fail open	5	Prevents manual opening of valve 6A and/or 6C.	Periodic Test	Has no effect on System I operation.	
			Contacts 1 and/or 5 fail closed	6	Prevents proper manual control of valve 6A and/or 6C during System I test.	Periodic Test	Has no effect on System I operation.	May open valve 6A and/or 6C but IV (check) NZ02A and NZ02C protect System I piping from reactor pressure.
			Contacts 4 and/or 8 fail open	5	Prevents manual closure of valve 6A and/or 6C.	Periodic Test	Has no effect on System I operation.	
			Contacts 4 and/or 8 fail closed	6	Prevents proper manual operation of valve 6A and/or 6C during System I test.	Periodic Test	Has no effect on System I performing ECCS function.	Valves 6A and 6C are normally closed. This failure will not prevent opening of valve 6A or 6C since MO contactors have priority and K106A and K106C contacts will open.
			Contact 2 fails open	5	Prevents proper manual operation of valve 5A during System I test.	Periodic Test	Has no effect on System I operation.	Valve 5A is normally open.
			Contact 2 fails closed	6	Prevents proper manual operation of valve 5A during System I test.	Periodic Test	Has no effect on System I operation.	

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
521 (See also 883)	Motor Operator 6A (6C)	Valve 6A(6C) Actuator	MC coil is energized	Hot Short	Prevents Valve 6A (6C) from being opened by either Channel A or C.	Periodic Test LI	Degrades System I redundancy from 1/2 to 1/1.	Overload device will function to protect actuator motor.
			MO coil is energized	Hot Short	Valve 6A (6C) will open. Overload device will function to protect actuator motor.	CRI for valves LI	Does not affect System I operation.	Isolation valves NZ02A & NZ02C will isolate CS system from reactor pressure.
522	305A	Manual Operation of Valves 1A, 1C.	Contacts 1 and/or 3 fail open	5	Prevents manual closure of valve 1A and/or 1C.	Periodic Test	Has no effect on System I operation.	Valves 1A and 1C are normally open.
			Contacts 1 and/or 3 fail closed	6	Closes valve 1A (1C).	CRI for valve	Has no effect on System I operation.	Valve 1A will open when System I is actuated since MO contactor has priority and K107A and K107C contacts will open.
			Contacts 2 and/or 4 fail open	5	Prevents manual opening of valve 1A (1C).	Periodic Test	Has no effect on System I operation.	
			Contacts 2 and/or 4 fail closed	6	Prevents manual closure of valve 1A (1C).	Periodic Test	Has no effect on System I operation.	Valves 1A and 1C are normally open.
523	Motor Operator 1A (1C Channel C)	Valve 1A Actuator	MC coil is energized	Hot Short	Closes valve 1A (1C). Overload device will function to protect actuator motor.	CRI for valve	Degrades System I redundancy from 1/2 to 1/1.	Valve 1C (1A) remains open.
			MO coil is energized	Hot Short	Prevents valve 1A (1C) from being closed manually. Overload device will function to protect actuator motor.	Periodic Test LI	Does not affect System I operation.	

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
524A (See also 804)	306A	Manual Operation of Motor Operator Valve 5A After Racking in Motor Operator	Contact 1 fails	5	Prevents manual closure of valve 5A.	Periodic Test	Has no effect on System I operation.	Valve 5A is normally open.
			Contact 1 fails closed	6	Closes valve 5A.	CRI for valve	Has no effect on System I operation.	Valve 5A will open when System I is actuated since MO contactor has priority and K106A and/or K106C contacts will open.
			Contact 2 fails open	5	Prevents manual opening of valve 5A with both 6A and 6C closed.	Periodic Test	Has no effect on System I operation.	
			Contact 2 fails closed	6	Prevents manual closure of valve 5A with both 6A and 6C closed.	Periodic Test	Has no effect on System I operation.	
525A (See also 804)	Motor Operator 5A	Motor Operator Valve 5A Actuator	MC coil is energized	Hot Short	Closes valve 5A. Overload device will function to protect actuator motor.	CRI for Valve. LI	Motor Operator Racked out (open position) during normal operation. No affect on system.	System II available during testing of System I.
			MO coil is energized	Hot Short	Prevents valve 5A from being closed. Overload device will function to protect actuator motor.	LI Periodic Test	Does not affect System I operation.	
526A	Test Discharge Valve Switch (Local Test Station)	Motor Operator open Valve 13A After Racking in Motor Operator	Contact fails open	5	Prevents manual opening of valve 13A.	Periodic Test	Has no effect on System I operation.	Valve 13A is normally closed.
			Contact fails closed	6	Opens valve 13A.	CRI for Valve.	Has no effect on System I operation.	Valve 13A will close when System I is actuated since MC contactor has priority and K101A and K101C contacts will open.
527A	Test Discharge Valve Switch (Local Test Station)	Close Valve 13A After Racking in Motor Operator	Contact fails open	5	Prevents manual closure of valve 13A.	Periodic Test	Has no effect on System I operation.	

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
			Contact fails closed	6	Prevents proper operation of valve during System I test.	Periodic Test	Has no effect on System I operation.	
528A	Motor Operator Valve 13A	Valve 13A Actuator	MC coil is energized	Hot Short	Closes valve 13A. Overload device will function to protect actuator motor.	Periodic Test LI	Does not affect System I operation.	
			MO coil is energized	Hot Short	Opens valve 13A. Overload device will function to protect actuator motor.	CRI for valve. LI	Motor Operator racked out in closed position. No affect to system.	System II available during testing of System I.
529	307A	Manual Operation of Valve NZ02A and NZ02C	Contacts 1 and/or 2 fail open	5	Prevents manual opening of Valve NZ02A and/or NZ02C.	Periodic Test	Does not affect System I operation.	Valves NZ02A and NZ02C are power operated check valves. Valves can only be powered open.
			Contacts 1 and/or 2 fails closed	6	Opens Valve NZ02A and/or NZ02C.	CRI for valve	Does not affect System I operation.	Isolation valves 6A and 6C isolates CS System I from reactor pressure.
530	308A (305C) (310A) (310C)	Manual Operation of CS System I Pump 01A (01C, 03A, 03C).	Contact 1 or 2 fails open	5	Prevents manual tripping of CS System I pump 01A (01C, 03A, 03C).	Periodic Test	Does not affect System I operation. If required, pump can be stopped by turning off power to the pump.	
			Contact 1 and 2 fails closed	6	Trips or prevents start of CS System I pump 01A (or 01C, or 03A, or 03C).	CRI for pump	Degrades System I redundancy from 1/2 to 1/1.	Second CS or booster pump available to perform function.
			Contact 3 or 4 fails open	5	Prevents manual start of CS System I pump 01A (01C, 03A, 03C).	Periodic Test	Does not affect System I operation.	
			Contacts 3 and 4 fails closed.	6	Starts CS System I pump 01A (or 01C, or 03A, or 03C).	CRI for pump	Has no effect on System I ability to respond to legitimate actuation signal	

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
542	CB 62-65 Panel D	Channel A Control Power	Open		Removes 125 VDC from Channel A logic circuit.	Annunciator	Degrades System I redundancy from 1/2 to 1/1.	Channel C is available to start System I.
543	CB 62-128 Panel E	Channel C Control Power	Open		Removes 125 VDC from Channel C logic circuit.	Annunciator	Degrades System I redundancy from 1/2 to 1/1.	Channel A is available to start System I.
544	CB 12-344	Valve Actuator 6A Power	Open		Removes 460 VAC from valve actuator 6A so that valve fails in closed position.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Valve 6C is available for operation.
545	CB 12-385	Valve Actuator 6C Power	Open		Removes 460 VAC from valve actuator 6C so that valve failes in closed position.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Valve 6A is available for operation.
546A (See also 816)	CB 12-416 (MCC1A21A) -381 (MCC1B21A) -411 (MCC1A21A) -413 (MCC1A21B)	Valve Actuator Power for 1A 1C 5A 13A	Open		Removes 460 VAC from valve actuator so that each valve failes in "as is" position.	Periodic Test	Has no effect on System I operation.	Each valve is normally in position required for System I operation.
547	CB 14-16 Emer.Swgr. 1C	CS Pump 01A Power	Open		Prevents CS pump 01A from operating.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Pump 01C is available.
548A	CB Emer. 14-38 Swgr. 1D	CS Pump 01C Power	Open		Prevents Cs pump 01C from operating.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Pump 01A is available.

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
549	CB Unit Substation 1A2	Booster Pump 03A Power	Open		Prevents booster pump 03A from operating	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Pump 03C is available.
550A	CB Unit Substation 1B2	Booster Pump 03C Power	Open		Prevents booster pump 03C from operating.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Pump 03A is available.
551A	4160V Emer. Swgr 1C	CS Pump Power	Open		Prevents CS pumps 01A and 01D from operating.	Annunciator	Degrades System I and II from 1/2 to 1/1.	
552A	460V Unit Substation 1A2	Booster Pump Power	Open		Prevents Booster pumps 03A and 03D from operating.	Annunciator	Degrades System I and II from 1/2 to 1/1.	
553A	460 MCC 1A2	Valve 6A Power	Open		Prevents valve 6A from opening.	Annunciator	Degrade System I from 1/2 to 1/1.	System II available.
554	460 MCC 1A2	Valve 6C Power	Open		Prevents valve 6C from opening.	Annunciator	Degrade System I from 1/2 to 1/1.	System II available.
555	302AT	Keylock Channel Interlock Switch	Open	5	Prevents synchronization of channel A and B. Prevents actuation of channel B by channel A.	Annunciator	Does not prevent auto state of either channel.	System I and II available.
			Closed	6	Prevents testing of channel B without actuating both systems.	Periodic	System I and II available.	
556	ID-A	UV aux Trip	FD		Prevents backup pumps from operating	Annunciator	Degrades System I from 1/2 to 1/1.	
			FE		Allows timing sequence to start for backup pump immediately after actuation signal.	Periodic	No effect on system operation.	

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
562	K101C	Auto Start	FD	1	Prevents Channel C from starting all System I pumps, opening System I valves 6A, 6C, 5A, 1A, 1C and closing valve 13A. Prevents start of diesel #1 from Channel C.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Channel A is available to start System I. Valves 5A, 1A and 1C are normally open. Valve 13A is normally closed.
			FE	2	Starts CS pump (01A or 01C). Closes CS valve 13A. Opens CS valves 1A, 1C. Starts Diesel #1.	Annunciator	Has no effect on System I ability to respond to legitimate actuation signal.	Bypass lines are provided so that pumps can be operated without damage.
563	K102C	Auto Start	FD	1	Prevents Channel C from starting System I booster pumps. System I initiation is not sealed in by Channel C.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1	Channel A is available to start System I.
			FE	2	Energizes K101C. Starts CS pump (01A or 01C). Closes CS valve 13A. Opens CS valves 1A, 1C. Starts booster pump (03A or 03C).	Annunciator	Has no effect on System I ability to respond to legitimate actuation signal.	Bypass lines are provided so that pumps can be operated without damage.
564	K103C	Start Pump 01A	FD	1	Channel C cannot start CS pump 01A.	Periodic Test	Degrades logic redundancy to start CS pump 01A from 1/2 to 1/1 but does not affect System I operation.	Channel C is available to start CS pump 01C. Channel A is available to start either CS pump 01A or 01C.
			FE	2	Starts CS pump 01A.	Annunciator	Has no effect on System I ability to respond to legitimate actuation signal.	
565A	K104C	Seq. Start Pump 01C	FD	1	Prevents start of backup CS pump 01C and Booster Pump 03C by Channel C.	Periodic Test	Degrades logic redundancy to start CS pump 01C and Booster Pump 03C from 1/2 to 1/1 but does not affect System I operation.	Channel C can start pumps 01A and 03A. Channel A can start all CS pumps.
			FE	2	Permits CS pump 01C to start. CS pump 01A and Booster Pump 03A prohibited from starting because of trip signal from K105C and K113C. Therefore, backup pumps are not available in System I.	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	

CORE SPRAY SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
566	K105C	Start Pump 01C	FD	1	Prevents start of backup CS pump 01C and trip of pump 01A.	Periodic Test	Degrades logic redundancy to start CS pump 01C from 1/2 to 1/1 but does not affect System I operation.	Channel C can start CS pump 01A. Channel A can start either CS pump 01A or 01C.
			FE	2	Starts backup CS pump 01C and trips or prohibits start of CS pump 01A.	CRI for pump.	Degrades System I redundancy from1/2 to 1/1.	
567	K106C	Readies Valves	FD	1	None	Periodic Test	Does not affect automatic CS operation of valves and therefore does not affect System I operation.	Degrades manual valve control ckt (closing direction redundancy.
			FE	2	Prevents manual closing of valves 5A, 6A and 6C (valves 6A and 6C are normally closed).	Periodic Test	Does not affect automatic CS operation of valves and therefore does not affect System I operation.	
568	K107C	Readies Valves	FD	1	Prevents Channel C from opening CS discharge valves 6A, 6C (and opening 5A, if required).	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Channel A is available to open System I valves. Manual Operation of valves 6A, 6C and 5A is available
			FE	2	Opens CS discharge valves 6A, 6C (and 5A, if closed). Provides automatic interruption of closing ckt for valves 1A, 1C.	CRI for valves Event Recorder	Does not affect System I Operation. System I depends on two parallel check valves to isolate low pressure piping from reactor pressure.	Isolation valves NZ02A and NZ02C will isolate CS System I from reactor pressure.
569	K108C or RE17B	Reactor Pressure or Reactor Pressure Sensor	FD FH (open)	1 3	Prevents Channel C from opening CS discharge valves 6A, 6C (and opening 5A, if required).	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Channel A is available to open System I valves.
	K108C or RE17B		FE FL (closed)	2 4	Permits CS discharge valves 6A, 6C (and 5A, if closed) to be opened when Channel C starts CS pump regardless of reactor pressure. Also permits CS valves 6A, 6C or 5A to be opened manually regardless of reactor pressure.	Annunciator	Does not affect System I operation. System I depends on two parallel check valves to isolate low pressure piping from reactor pressure.	Isolation valves NZ02A and NZ-2C will isolate CS System I from reactor pressure until pressure is reduced to point where NZ02A/NZ02C (powered check valves) open.

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
570	K109C	System I Discharge Pressure	FD	1	Prevents Channel C from starting System I booster pumps	Periodic Test	Degrades System I redundancy from 1/2 to 1/1.	Channel A is available to start System I booster pumps.
	or RV29C	or System I Discharge Pressure Sensor	FL (open)	3				
	K109C		FE	2	System I starts booster pump simultaneously with CS pump 01A.	Annunciator	Booster pump 03A may cavitate until CS pump 01A is up to speed. Short term cavitation will not affect System I Operation. Degrades System I redundancy from 1/2 to 1/1.	Backup booster pump 03C is available if 03A cannot develop pressure. CS pump 01A is available for actuation by either Channel A or C.
	or RV29C		FH (closed)	4	Prevents CS pump 01C from being operated by either Channel A or Channel C.			
571A	K110C	Reactor Vessel Low Level	FD	1	Prevents Channel C and D from starting on Low-Low-Level signal from Channel C sensor.	Periodic Test	Degrades Channel C diversity. Does not affect System I operation for Low-low-Level or High Drywell Pressure.	Channel C is available to start System I and II on High Drywell pressure. Channel A is available to start System I and II on Low-Low-Level and/or High Drywell Pressure
	or RE02C	or Reactor Low Level Sensor	FH (open)	3				
	K110C or RE02C		FE	2	Energizes K101C, K102C. Starts CS pump (01A, or 01C), closes CS valve 13A (if not closed), opens CS valves 1A, 1C, starts booster pump (03A or 03C). Starts Auto System II (Channel D).	Annunciator	Has no effect on System I ability to respond to legitimate actuation signal.	Relay provides interlocks to Emergency Condenser and Containment Spray.
			FL (closed)	4				

CORE SPRAY SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
572	K111C	Start Pump 03A	FD	1	Channel C cannot start Booster pump 03A.	Periodic Test	Degrades logic redundancy to start Booster pump 03A from 1/2 to 1/1 but does not affect System I operation.	Channel C can start Booster pump 03C. Channel A can start either Booster pump 03A or 03C.
			FE	2	Starts Booster pump 03A.	Annunciator	Has no effect on System I ability to respond to legitimate actuation signal.	
573	K112C	Seq. Start Pump 03C	FD	1	Prevents start of backup Booster pump 03C by Channel C.	Periodic Test	Degrades logic redundancy to start Booster pump 03C from 1/2 to 1/1 but does not affect System I operation.	Channel C can start Booster pump 03A Channel A can start either Booster pump 03A or 03C.
			FE	2	Permits Booster pump C3C to start. Booster pump 03A would not start because of trip signal from K113C. Therefore a backup Booster pump is not available.	CRI	Degrades System I redundancy from 1/2 to 1/1.	
574	K113C	Start Pump 03C	FD	1	Prevents start of backup booster pump 03C by Channel C.	Periodic Test	Degrades logic redundancy to start booster pump 03C from 1/2 to 1/1 but does not affect System I operation.	Channel C can start booster pump 03A. Channel A can start either Booster pump 03A or 03C.
			FE	2	Starts backup Booster pump 03C and trips or prohibits start of booster pump 03A.	CRI for pump	Degrades System I redundancy from 1/2 to 1/1.	
575	K114C or RV40C	Booster Pump Discharge Pressure or Booster Pump Dis-Charge Pressure Sensor	FD FL (open)	1 3	None	Periodic Test	Degrades logic redundancy which sequences booster pumps from 1/2 to 1/1 but does not affect System I operation.	Channel A relay K114A will perform required pump sequencing.

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
575 (cont'd)	K114C or RV40C		FE FH (closed)	2 4	Prevents booster pump 03C from being operated by either Channel A or Channel C.	Annunciator	Degrades System I redundancy from 1/2 to 1/1.	Booster pump 03A is available for actuation by either Channel A or C. Relay provides interlocks to ADS (16K201A 202A 206A 207A).
576A	K115C or RV46B	High Drywell Pressure High Drywell Pressure Sensor	FD FL (open)	1 3	Prevents Channel C and D from starting on High Drywell Pressure signal from Channel C sensor.	Periodic Test	Degrades Channel C diversity Does not affect System I operation for either low-low-level or High Drywell Pressure.	Channel C is available to start System I and II on low-low-level. Channel A is available to start System I on either low-low-level or high drywell pressure.
	K115C or RV46B		FE FH (closed)	2	Energizes K101C, K102C, starts CS pump (01A or 01C) closes CS valve 13A (if not closed) opens CS valve 1A, 1C starts ooster pump (03A or 03C). Auto Starts System II (Channel D).	Annunciator & Event Recorder	Has no effect on System I or II ability to respond to legitimate actuation signal.	Relay provides interlock to ADS (16K214A).
577	K116C	Control System Power Failure	FD	1	None	Annunciator	None	
			FE	2	None	Periodic Test	None	
578A	302C	Reset	Contact 1 fails open	5	Prevents "seal in" of K102C.	Periodic Test	Has no effect on System I operation.	Channel A will provide required "seal in" for System I.
			Contact 1 fails closed	6	Prevents reset of Channel C following either test or operation.	Annunciator	Has no effect on System I operation.	

TABLE 2

CORE SPRAY SYSTEM (MECHANICAL)

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
801	V-20-17 (V-20-23) Core spray isolation valve inside containment	Isolate core spray inside containment for maint. (manual valve)	Open	Locked open	None - Normal position locked open	VPI	None	
			Closed	Manually closed for Maint.	Blocks flow through one core spray train	VPI	Loss of one of two 100% flow paths	Administrative procedures preclude improper valve position.
802	NZ02A (NZ02C) Core spray containment isolation check valves	Satisfy containment isolation inside containment (Air assisted open for test, spring assisted shut)	Open	Test air suppl.	None	VPI	Reduces low pressure portion of system to single valve isolation protection	
			Closed	Mech. failure	Blocks flow through that portion of parallel lines.	VPI	None	Flow available through parallel check valve.

CORE SPRAY SYSTEM (MECHANICAL)

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
807	P203A,C Core spray booster pumps	Develop adequate discharge pressure for effective core spray	Off	1)Loss of power 2)Logic fault 3)Mech. failure	Starts redundant pump in train.	Alternate pump start, run lights in C.R.	None. 100% redundant in each system.	
808	V-20-16 V-20-8 Spray pump discharge check valve	Prevents backflow through idle pump	Open	Mech. failure	Reduces effective flow from pump. May cause idle pump to fail.	1) Low suction pressure to booster pumps 2) Fill pump is unable to maintain shutdown pressure	Low flow in one system.	
809	P201A,C Core spray pumps	Provides core spray flow from suppression pool to booster pump suction	Off	1)Loss of power 2)Logic fault 3)Mech. failure	Starts redundant pump in system.	Run light off. Alternate pump running.	None. 100% redundant pump in system.	

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
805	V-20-50 Booster pump discharge check valve	Prevent backflow through bypass leg						
			Closed	Mech. failure	Prevents bypass of core spray discharge directly into core.	Redundant pump start	None.	Valve only important if both booster pumps fail and redundant CS system is unavailable.
806A	V-20-92 Booster pump minimum recirc. valve	Provides minimum pump flow path for core spray and booster pumps	Open	Loss of Air	None	VPI	None.	
			Closed	1) Test 2) Logic fault 3) Solenoid failure to vent air	Redundant Minimum flow valve V-20-94 provides flow path.	VPI Periodic Test	No effect on system	
824	V-20-52, 53 Booster pump discharge check valve	Prevent backflow through idle booster pump						
			Closed	Mech. failure	Blocks flow from one booster pump, redundant pump starts	Low flow indication FI-RV27A	None. Redundant pump available.	

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
803 (See also 520, 521)	V-20-15 V-20-40 Core spray outside isolation valves	Satisfy containment outside containment (motor operated) opens on CS actuation at 285 psig in reactor	Open	1) Short to motor 2) Man. override 3) Test 4) Logic failure	None.	VPI	Reduce low pressure portion of system to single valve isolation protection	
			Closed	1) Loss of Power 2) Logic failure 3) Mech. fault	Blocks flow through that portion of parallel lines.	VPI Periodic Test	None	Have 100% flow through parallel valve for ECCS function.
804A (See also 524,A 525)A	V-20-12 Test Isolation valves (motor operated)	Provide second valve barrier when testing V-20-15, etc. or NZ 02	Open	1) Normally open 2) Loss of power	None	VPI Periodic Test	None	Motor Operator racked out in open position during normal operation does not affect System II operation except during test
			Closed	1) Short to motor 2) Loss of power during testing 3) Manual override	No flow in System II.	VPI, High booster pump pressure (PI-RV42) low spray flow indicated (FI 2V27)	Blocks all flow in System II.	Redundant System I must be available during test.

VPI = Valve Position Indication.

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
810 (See also 546, 522, 523)	V-20-3, 32 Spray pump suction valves (motor operated)	Supply core spray water from suppression pool	Open	Loss of power (Norm. position)	None.	VPI Periodic Test	None.	
			Closed	1)Mech. over-ride 2)Hot short 3)Logic fault	Causes associated pump to fail due to loss of suction.	VPI	None. 100% redundant in system.	
816A (See also 546)A	V-20-27 Recircu-lation test valves (Keylock closed)	Open for routine core spray pump functional tests	Open	1)Logic failure 2)Elec. short 3)Loss of power during test	Bypasses core spray flow to suppression pool.	VPI	6" line allows high per-centage of flow to bypass core, reducing effective core spray in one system.	Valve racked out in closed position during normal operation. No effect on system.
			Closed	Normal	None	VPI Periodic Test	None.	

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
822	Fill pump core spray system	Provide water to system to keep filled and prevent water hammer on startup	Off	1) Loss of power 2) Motor failure 3) Manual over-ride	System may drain through leakage to level of suppression pool.	Low pressure indicated at various points in system.	Could cause water hammer on system startup.	Not required after system initiation.
			On	1) Logic failure 2) Manual over-ride	None.		None.	
823	V-11-119 (V-11-118) 15 psig pressure regulating valve		Open		None.		None. Check valve prevents flow out of system.	

TABLE 3

AUTO DEPRESSURIZATION SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
300	K201A	ADS Sub-channel Trip Relay	FD	1	Contact remains open. System I is inoperative. ADS trip coincidence changes from 2/2 or 2/2 to 2/2.	Periodic Test	System II remains for each valve.	
			FE	2	Contacts remain closed. ADS trip coincidence reduces from 2/2 or 2/2 to 1/1 or 2/2.	Event Recorder & Annunciator	Less stringent trip logic in System I. System II unchanged.	
	K207A K207AX	ADS Sub-channel Trip Relay	FD	1	Contact remains open. System I is inoperative. ADS trip coincidence changes from 2/2 or 2/2 to 2/2.	Periodic Test	System II remains for each valve.	
			FE	2	Contact closes. ADS trip coincidence reduces from 2/2 or 2/2 to 1/1 or 2/2.	Event Recorder & Annunciator	Less stringent trip logic in System I. System II unchanged.	
301	K202A	Time Delay Circuit Interlock Relay	FD	1	Contact remains open. System I inoperative. ADS trip coincidence changes from 2/2 or 2/2 to 2/2.	Periodic Test	System II remains for each valve.	
			FE	2	Contact closes. ADS trip coincidence changes from 2/2 or 2/2 to 1/1 or 2/2. Relay K201A energized.	Periodic Test	Less stringent trip logic. System II unchanged.	
302	K206A	Timer Lock in Relay	FD	1	Contact remains open. If initiation signals clear, ADS trip coincidence changes from 2/2 or 2/2 to 2/2	Periodic Test	System II remains for each valve.	No effect until initiation signals clear.
			FE	2	Contact closes. Two minute timer is energized. After two minutes, ADS actuation logic changes from 2/2 or 2/2 to 1/1 or 2/2 when relay K202A is energized.	Annunciation	Less stringent trip logic. System II unchanged.	

TABLE 3

AUTO DEPRESSURIZATION SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
303	K214A or K215A	High Drywell Pressure Relay	FD	1	Contact remains open. ADS trip coincidence reduces from 2/2 or 2/2 to 2/2. System I inoperative.	Periodic Test	System II remains for each valve.	
			FE	2	Contact closes. System I logic changes from 2/2 to 1/1 for high drywell pressure.	Annunciation	Less stringent trip logic in System I. System II unchanged.	
304	K216A	DC Power Supply Transfer	FD	1	Contact opens. Power to ADS logic System I and valve control circuit "A" is supplied from DC panel "E".	Annunciation	Automatic transfer of power source. Systems I & II unchanged.	Normal DC power supply is from Panel "D".
			FE	2	Contact remains closed. Power to ADS logic and/or valve control circuit is unchanged.	Periodic Test	Alternate power source (Panel "E") not available Systems I & II unchanged.	
305	K217A or K217C	Reactor Triple Low Water Level Relay	FD	1	Contact remains open. ADS trip coincidence changes from 2/2 or 2/2 to 2/2. System I inoperative.	Periodic Test	System II remains for each valve.	
			FE	2	Contact closes. System I triple low reactor vessel water level logic changes from 2/2 to 1/1.	Annunciation & Event Recorder	Less stringent trip logic in System I. System II unchanged.	
306	M232A	Timer	FD	1	Timer contact remains open. System I inoperative. ADS trip coincidence reduces from 2/2 or 2/2 to 2/2.	Periodic Test	System II remains for each valve.	
			FE	2	Timer contact closes.	Annunciation	No time delay associated with ADS actuation.	

TABLE 3

AUTO DEPRESSURIZATION SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
307	RE18A or RE18C	Reactor Triple Low Water Level Switch	FH (Open)	5	Level switch contact remains open. System I inoperative. ADS trip coincidence reduces from 2/2 or 2/2 to 2/2.	Periodic Test	System II remains for each valve.	
			FL (Closed)	6	Level switch contact closes. System I logic coincidence changes from 2/2 to 1/1 for triple low reactor vessel water level.	Annunciation & Event Recorder	Less stringent trip logic in System I. System II unchanged.	
308	S230A	Reset Switch	FO	5	Reset switch contact opens. K201 & K207 relays prevented from closing when auto depressurization signal exists. System I inoperative.	Periodic Test	System II remains unaffected for each valve.	
			FC	6	Reset switch remains closed in System I. Does not allow channel to be reset after tripping on auto depressurization signal.	Periodic Test	Unable to reset System I after trip. System II remains unaffected for each valve.	
309	S231A	Reset Switch	FO	5	Reset switch contact opens. K214A & K215A relays prevented from closing on high drywell pressure. System I inoperative.	Periodic Test	System II remains unchanged for each valve.	
			FC	6	Reset switch contact remains closed in System I. Does not allow channel to be reset after tripping on high drywell pressure.	Periodic Test	Unable to reset System I after trip. System II unchanged.	
310A	125VDC Power Panel "D"	125VDC Power Supply	FD	7	K216 relay will automatically transfer the ADS valve control circuit to the standby 125VDC source.	Annunciator	Automatic transfer of power supply.	Panel "D" is the normal supply for ADS valves A, C & E through Panel ER18A. Panel "E" is the backup supply.
					Relay coils for K115A & K115B in core spray system both fail de-energized; this prevents K214A & K215A from energizing on high drywell pressure; therefore System I fails.		System I fails. System II available.	

TABLE 3

AUTO DEPRESSURIZATION SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
311	62-69 or 62-91	125VDC Power Supply Circuit Breaker	FO	7	K216A relay will automatically transfer the ADS valve control circuit to the standby 125VDC source.		Automatic transfer of power supply. Trip Systems I & II remain unaffected.	CB 62-69 (Panel "D") & CB 62-91 (Panel "E" feed Panel ER18A. CB62-79 (Panel "D") & CB 62-102 (Panel "E") feed panel ER18B.
312	F301A or F304A	Control Circuit Fuses	FO		K216A relay remains on its normal source (Panel D) as long as it is available.	Periodic Test	Alternate power source (Panel E) is not available for System I.	
313	F302A or F303A	Control Circuit Fuses	FO		K216A relay will automatically transfer the ADS valve "A" and trip System I to alternate source.	Annunciator	Automatic transfer of power supply.	
314	NR108A or NR108B or NR108C or NR108D or NR108E	Valve & Pressure Controller & Control Station or Pressure Switches or Valve Solenoid Assembly or Manual Control Switch	Valve closed		ADS valve "A" does not open when required by auto depressurization signal.	Periodic Test	ADS valve "A" does not open when required. Remaining 4 ADS valves are operable.	
			Valve open		ADS valve "A" opens when auto depressurization is not required.	VPI Torus temperature increase	No effect on System's abilit to respond to ECC conditions	

TABLE 3

AUTO DEPRESSURIZATION SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
513	K114A	Core Spray Booster Pump Discharge Pressure Relay	FD	1	Contact remains open. System I pump discharge pressure coincidence changes from 1/2 to 1/1.	Periodic Test	More stringent trip logic in System I. System II unchanged.	Contacts supplied from core spray logic.
			FE	2	Contact closes. System I pump discharge pressure logic circuit is satisfied.	Annunciation	Less stringent trip logic. System II unchanged.	Contacts supplied from core spray logic.
575	K114C	Core Spray Booster Pump Discharge Pressure Relay	FD	1	Contact remains open. System I pump discharge pressure coincidence changes from 1/2 to 1/1.	Periodic Test	More stringent trip logic in System I. System II unchanged.	Contacts supplied from core spray logic.
			FE	2	Contact closes. System I pump discharge pressure logic circuit is satisfied.	Annunciation	Less stringent trip logic in System I. System II unchanged.	Contacts supplied from core spray logic.
514	K115A	High Drywell Pressure Relay	FD	1	Contacts remain open. System I inoperative. ADS trip coincidence changes from 2/2 or 2/2 to 2/2.	Periodic Test	System II remains for each valve.	Contacts supplied from core spray logic.
			FE	2	Contact closes. Relay K214A is energized. System I coincidence from drywell pressure trip changes from 2/2 to 1/1.	Event Recorder & Annunciator	Less stringent trip logic in System I. System II unchanged.	Contacts supplied from core spray logic.
576A	K115C	High Drywell Pressure Relay	FD	1	Contacts remain open. System II inoperative. ADS trip relay coincidence changes from 2/2 or 2/2 to 2/2.	Periodic Test	System I remains for each valve.	Contacts supplied from core spray logic. K115C changed to ADS System II.
			FE	2	Contact closes. Relay K214B is energized. System II coincidence from drywell pressure trip changes from 2/2 to 1/1.	Annunciator & Event Recorder	Less stringent trip logic in System II. System I unchanged.	

TABLE 3

AUTO DEPRESSURIZATION SYSTEM

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
676	K115B	High Drywell Pressure Relay	FD	1	Contacts remain open. System I inoperative. ADS trip relay coincidence changes from 2/2 or 2/2 to 2/2.	Periodic Test	System II remains for each valve.	Contacts supplied from core spray logic.
			FE	2	Contact closes. Relay K215A is energized. System I coincidence from drywell pressure trip changes from 2/2 to 1/1.	Annunciator & Event Recorder	Less stringent trip logic in System I. System II unchanged.	Contacts supplied from core spray logic.

TABLE 4

TABLE 4 (CORRESPONDS TO TABLE 6 OF PRE-MODIFICATION ANALYSIS)

SUMMARY RESULTS OF MODIFICATION WITH RESPECT TO PREVIOUS SINGLE FAILURES WHICH RESULTED IN LESS THAN MINIMUM ECCS AVAILABILITY

FMEA REF. NO.	FAILURE	SYMPTOMS AND LOCAL EFFECTS INCLUDING DEPENDENT FAILURES AND EFFECT ON ECCS SYSTEMS	REMARKS
542	Loss of Power to DC Panel D	See Table I, Attachment II, Item 542A	No degradation of minimum ECCS availability results*
310		See Table III, Attachment II, Item 310A	No degradation of minimum ECCS availability results*
543	Loss of power to DC Panel E	Same as for Item 542	No degradation of minimum ECCS availability results*
211 212	Loss of power to motor control center MCC-DC1	See Table 5, Attachment II, Items 211A and 212A	No degradation of minimum ECCS availability results*
804	Spurious closure of motor operated test isolation valve V-20-12	See Table 2, Attachment II, Item 804A	No degradation of minimum ECCS availability results*
816	Spurious opening of motor operated recirculation line valve V-20-26	See Table 2, Attachment II, Item 816A	No degradation of minimum ECCS availability results*
806	Failure of minimum flow valve to open V-20-92	See Table 2, Attachment II, Item 806A	No degradation of minimum ECCS availability results*
517	Undervoltage relay 27X-1C fails deenergized	See Table 1, Attachment II, Item 517A	No degradation of minimum ECCS availability results*
518	Undervoltage relay 27X1-1C fails deenergized	See Table 1, Attachment II, Item 518A	No degradation of minimum ECCS availability results*
553	Loss of MCC 1A2	See Table 1, Attachment II, Item 553A	No degradation of minimum ECCS availability results*

*See July 3, 1975 letter from I. R. Finfrock to G. Lear.

Revision 1 dated 7-15-75

TABLE 5

EMERGENCY CONDENSER

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
200	16K110A or 16K110C	Reactor Vessel Low Low Level	FE	2	Associated time delay on dropout relay deenergized (6K9 or 6K10)	Annunciator	Makes trip 1/2 vs 1/2 twice. Less stringent trip logic coincidence.	Contacts supplied from core spray logic. Affects logic for both systems.
			FD	1	Associated TDDO remains energized	Periodic test	Makes trip 1/1 + 1/2 vs 1/2 twice. More stringent trip logic.	Affects logic for both systems.
201	RE15A or RE15B	Reactor High Pressure Sensor	FC	4	Associated TDDO remains energized	Periodic test	Makes trip 1/1 + 1/2 vs 1/2 twice for high pressure initiation	Does not affect logic for initiation for ECCS function
			FO	3	Associated TDDO deenergizes	Periodic test	Makes trip 1/2 vs 1/2 twice. Less stringent trip logic.	Affects logic for both systems.
202	6K9 or 6K10	E.C. Isol. Valve System I Time Delay Trip Relay	FE	2	Associated contacts remain open	Periodic test	Makes trip 1/1 + 1/2 vs 1/2 twice. More stringent trip logic.	Affects logic for both systems.
			FD	1	Associated contacts close	Periodic test	Makes trip 1/2 vs 1/2 twice. Less stringent trip logic coincidence.	Affects logic for both systems.
203	3K5A or 3K5B	E.C. Reset System I	FE	2	Defeats lockout of 6K9 and 6K11	Periodic test	Valve would open and shut as level cycled around low low level.	Affects both System I and System II condensers
			FE	2	For automatic isolation circuitry, the valves would reopen when high flow signal cleared	Periodic test	For a break in the EC line outside containment, valves would cycle open and shut	System II not affected.
			FD	1		Periodic test	Would not be able to reset logic circuitry	Does not affect ECCS function .

TABLE 5

EMERGENCY CONDENSER

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
204	6K7B or 6K7A	System I line break time delay trip relay	FE	2	High flow sensed by associated sensors would not isolate Emergency Condenser high flow isolation logic changed from 1/4 to 1/2	Periodic test	More stringent trip logic coincidence for isolation.	Does not affect ECCS function.
			FD	1	EC System I not available.	Valve indication	All valves associated with System I would be closed	System II not affected.
205	6K5A or 6K3A	System I line ruptures aux. relay	FE	2		Periodic test	More stringent logic to close isolation valves in the event of a line break.	Does not affect ECCS function. System II not affected.
			FD	1		Annunciator	System I E.C. isolates. V-14-34 will not open automatically	System II not affected.
206	6K5B or 6K3B	System I line ruptures aux. relay	FE	2		Periodic test	More stringent logic to close isolation valves in the event of a line break.	Does not affect ECCS function. System II not affected.
			FD	1	Locks in false high flow signal	Valve position indication	System I E.C. isolates	System II not affected.
207	IB05-A1 or IB05-A2 or IB11-A1 or IB11-A2	High flow switches	FO	3	Gives false high flow signal	Periodic test	System I E.C. isolates	System II not affected.
			FC	4		Periodic test	Makes logic to close valves for line break 1/3 vs 1/4. More stringent trip logic for isolation.	Does not affect ECCS function. System II not affected.

TABLE 5

EMERGENCY CONDENSER

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
208	6K57 or 6K58	6K57 Lock-out 6K9 & 6K11	FE	2	6K57 deenergizes 6K9 and 6K11. 6K58 deenergizes 6K10 and 6K12.	Periodic test	Makes logic to open 1/2 vs 1/2 twice	Affects logic for both systems.
		6K58 Lock-out 6K10 & 6K12	FD	1	6K57 defeats lockout of 6K9 and 6K11. 6K58 defeats lockout of 6K10 and 6K12.	Periodic test	If System I initiated because of low level or high pressure, V-14-34 would cycle as pressure cycled or level cycled	System II not affected.
209	3S5	Reset switch	FO	5		Periodic test	Unable to reset system	Does not affect initiation
			FC	6	Energizes 3K5A and B defeats lockout of TDDO's for both System I and System II	Periodic test	If System I or II initiated because of low level or high pressure V-14-34 or V-14-35 would cycle as pressure or level cycled	Affects both System I and II condensers
210	Valve actuator V-14-34	Open valve	MC Coil is energized	Hot short	Valve won't open	Periodic test	System I won't initiate	System II not affected.
			MO Coil is energized	Hot short	Valve opens.	Valve posi-position indication	System I initiated.	System II not affected.
211A	MCC DC1	Power supply to V-14-34	Loss of Power		Valve V-14-34 won't open	Loss of valve position indication	System I fails to initiate.	System II not affected.
212A	Auto transfer switch to MCC DC1	Power supply to MCC-DC-1	Loss of Power		Valve V-14-34 won't open	Loss of valve position indication	System I fails to initiate.	System II not affected.

TABLE 5

EMERGENCY CONDENSER

FAILURE MODE AND EFFECTS ANALYSIS AFTER MODIFICATION

No.	Name	Function	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Effect on System	Remarks
213	6S5	Control switch for V-14-34	Open Position	5	Valve open	Valve position indication	System I initiated	System II not affected.
			Closed Position	6	Valve won't open	Periodic test	System I won't initiate	System II not affected.
214	6F1 6F2	Fuse for high flow logic circuitry and 6K9	FO		High flow logic circuitry and 6K9 deenergized.	Valve position indication	System I isolates. Makes trip for System II 1/2 vs 1/2 twice. Less stringent trip logic.	
215	6F1A 6F2A	Fuse for 6K10	FO		6K10 deenergized.	Periodic test	Makes trip 1/2 vs 1/2 twice. Degraded trip logic.	Affects logic for both systems.
310	125V DC Power Panel D	125V DC Power supply to logic	FD		Logic circuitry deenergized	Valve position indication	System I isolates. System II initiates.	