BROWNS FERRY NUCLEAR PLANT

UNITS 1 AND 2

EMERGENCY CORE COOLING SYSTEMS
LOW PRESSURE COOLANT INJECTION
MODIFICATIONS FOR PERFORMANCE IMPROVEMENT

May 1977

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1.0 INTRODUCTION

Browns Ferry Emergency Core Cooling System (ECCS) design and performance for Units 1 and 2 have been the subject of a recent review. This review led to a change in the system, which provided a significant reduction in the peak cladding temperature following a postulated recirculation line break. This reduction in peak cladding temperature has been accomplished by elimination of the Low Pressure Coolant Injection (LPCI) System recirculation loop selection and keeping the Residual Heat Removal (RHR) cross-tie valve closed. A report on this previous modification was submitted to the Nuclear Regulatory Commission in a letter from J. E. Gilleland to Benard C. Rusche dated February 12, 1976. Portions of that previous report are presented here to give a coherent description and safety analysis.

The proposed additional modification changes the power supply to the recirculation pump discharge valves, LPCI injection valves, and LPCI minimum flow valves. The change adds sufficient independent power supplies to eliminate the need for the existing swing-bus feature.

Major areas of discussion in this report include the proposed independent power supplies and a detailed safety analysis of the modification.

2.0 BACKGROUND

With the advent of the Interim Acceptance Criteria, it became advisable to consider the simultaneous occurrence of spraying and flooding to meet the stringent new temperature limit of 2300°F. The thermal-hydraulic models were refined to permit an accurate calculation of coolant remaining in the vessel following the blowdown, and of spray coolant reaching the lower plenum after the boiloff which takes place as it passes through the active fuel region. These refinements permitted an accurate calculation of the flooding rate due to spray operation, and even with the new requirement of an active component failure anywhere in the ECCS, no jet pump BWR failed to meet the Interim Acceptance Criteria. ECCS modifications which might have been suggested by the new evaluation models were therefore unnecessary.

The final ECCS acceptance criteria adopted by the AEC are more conservative than the interim acceptance criteria. These new criteria reduce operating flexibility and could result in power level restrictions. To offset the effect of the new criteria, a modification has been added to Units 1 and 2 which takes advantage of the credit given for the flooding effect achieved through the availability of additional LPCI pumps under certain single-failure conditions. TVA commited to modify the power supply to the recirculation pump discharge valves, LPCI injection valves, and LPCI minimum flow valves to eliminate the need for the existing swing-bus feature before return to power operation following the second refueling outage of the respective units.

3.0 DISCUSSION

3.1 Accident Description

The Design Basis Accident (DBA), Loss-of-Coolant Accident (LOCA), is one of several hypothesized events used to evaluate the ability of the plant to operate without undue hazard to the health and safety of the public.

The overall initial assumptions remain as described in Section 14.6.3.1 of the FSAR:

> The reactor is operating at the most severe condition at the time of the LOCA, which maximizes the parameter of interest: primary containment response, fission product release, or core standby cooling system requirements.
>
> A complete loss of normal AC power occurs simultaneously with the LOCA. This additional condition results in the longest delay time for the core standby cooling systems to become operational.
>
> The LOCA assumes that a recirculation loop pipeline is instantly severed. This results in the most rapid coolant loss and depressurization with coolant discharged from both ends of the break.

3.2 Modification

Modification of the system requires the following hardware and wiring changes on Units 1 and 2:

> The auto-transfer feature of valve motive power is eliminated on RHR injection, recirculation pump discharge, and RHR pump minimum flow bypass valves. Motive power to these selected valves is provided by hydraulic-pneumatic operators. Redundant power supplies to these actuators are provided for positioning the valves to the required LOCA configuration.

3.2.1 Suction Line Break

Figure 2 illustrates operation of the modified system for a break in the recirculation pump suction line. The break location producing the highest peak cladding temperature is, as before, at the nozzle on the pressure vessel. The other side of the postulated "double-ended" break is fed through the recirculation loop by the jet pump nozzles, whose small area limits flow to a low value and makes frictional losses negligible in the calculation.

The discharge valves of the recirculation loops will begin closing upon receipt of a permissive signal. The valves are capable of closing against a differential pressure of 200 psid. To assure the recirculation system discharge valve is not required to close with a differential pressure greater than 200 psid, valve closures are delayed until reactor vessel pressure

has decreased to less than 225 psig. By the time the recirculation discharge valve has stroked sufficiently that it could present a flow-limiting restriction, the vessel pressure will have decayed below 200 psig.

Valve closure is therefore effected in about 62 seconds, of which 29 seconds represents the reactor vessel pressure permissive and 33 seconds the maximum valve closure time. The effect is isolation of the break from the LPCI system injection point.

Approximately 46 seconds after the break, the LPCI startup sequence is complete and flow commences in both loops. Flow into the broken loop will not reach its expected value for an additional 16 seconds, when the recirculation discharge valve has fully closed. The LPCI pumps go nearly to full runout flow, as limited by the additional resistance in the pump discharge line, because each pair of pumps is delivering flow to its own bank of jet pump nozzles rather than to one bank as would be the case of loop selection logic. Additional resistance has been added to the LPCI pump discharge lines. This replaces the resistance lost when only one or two pumps are discharging into a system designed for three pump flow. The added resistance prevents insufficient Net Positive Suction Head (NPSH) in these modes of operation.

In analyzing the single failures for a suction line break, both AC and DC power failures are considered (see Figures 4 and 5). For AC power considerations the most significant single failure for the modified system is a Diesel Generator failure. This failure results in two LPCI pumps operating in one loop, one LPCI

pump operating in the alternate loop, and two CS pumps operating in one CS system.

The most significant DC power single failure would be loss of a battery. For a suction line break this failure results in two LPCI pumps operating in one loop, one LPCI pump operating in the alternate loop, and two CS pumps operating in one CS system. Table 1 shows the various pump combinations for postulated single failures.

The unique power arrangement at Browns Ferry Units 1 and 2 requires examination of an opposite unit spurious accident signal. For this event one RHR pump in each loop of each reactor and one core spray system (two pumps) plus all required valves are available. (Figure 6)

The limiting single failure is that failure which results in the longest reflood time and consequently the highest peak cladding temperature (PCT). Sensitivity studies have been performed which demonstrate that a typical limiting failure in the modified system is the failure of the LPCI injection valve in the unbroken loop. This failure results in four core spray pumps, two in each CS loop, and two LPCI pumps in one loop providing ECCS flow to the core. This combination gives a longer reflooding time than one core spray system (two pumps) and one LPCI pump in each loop which is available following an opposite unit spurious accident signal. This is due in part to the effects of counter current flow limiting (CCFL) on the amount of the core spray flow available for reflooding. The assumed occurrence of CCFL results

in there being only a slight improvement with four CS pumps when compared to two CS pumps. Additionally, the two LPCI pumps feeding into one loop deliver significantly less than twice the flow delivered by a single pump feeding each loop due to the system orificing effects. Thus the availability of one LPCI pump in each loop for the alternate unit spurious accident signal provides better reflood characteristics than two LPCI pumps into one loop even when supplemented by two additional CS pumps.

3.2.2 Discharge Line Break

Figure 7 illustrates the operation of the modified system with a break in the recirculation pump discharge line.

When the LPCI startup sequence is complete, the LPCI flow in the broken loop is lost through the break. With the modification, the worst-case single failures are failure during opening of the LPCI injection valve opposite the break and failure during opening of the LPCI minimum flow bypass valve serving the RHR pumps intended for injection into the unbroken loop. Table 1 and Figures 8-11 show the pump combination which results from the postulated single failures.

The suction line break remains the design basis accident for the modified system, but with a lower calculated peak cladding temperature.

A typical limiting single failure for the discharge line break is the LPCI injection valve failure. This failure results in four core spray pumps available for core reflooding. This condition results in a longer reflood time than the opposite unit spurious accident signal in which two core spray and one LPCI pumps are available for reflooding. As previously discussed one LPCI pump provides faster reflooding and, consequently lower PCT than two additional CS pumps.

Representative relative peak cladding temperature for the two events described above is shown in Table 2.

The present Browns Ferry Units 1 and 2 system utilizes two power supplies for the electrical distribution system providing power to the LPCI valves. Figure 12 shows the arrangement of the buses and the valves fed from these buses. Figure 13 shows the modified system which eliminates the auto-transfer feature for the electrical distribution system. Electrical interlocks will be maintained to prevent manual paralleling of the two AC sources. The AC power only supplies power for the non-essential hydraulic pumps on the valve operators. Figures 16 through 27 show the valve operator redundant DC power supplies to provide the motive power to produce the stored pneumatic energy.

3.3 Model Application

The core heatup calculations are performed using the approved Appendix K emergency core cooling evaluation models.

3.4 Safety Analysis

The proposed modification has been analyzed and evaluated to assure the changes do not introduce adverse effects to the overall plant. The areas evaluated are discussed in the balance of this section.

3.4.1 Equipment Capability to Perform as Analyzed

The major components of the proposed modification are unchanged, except for the valve operators and the power supplies for selected valves. Each major element is considered below:

3.4.1.1 Emergency Diesel-Generators

The proposed modification does not change any of the operating requirements of the diesel generators.

3.4.1.2 LPCI Pumps

The operating modes of the LPCI pumps were changed by the previous modification such that two pumps discharge to each injection header thereby changing the discharge flow characteristics from that previously established. Prior to reactor startup after the previous modification, flow tests were conducted to establish the pump discharge path characteristics from which pump flow curves were developed. This information was used to determine the additional resistance to be added on the

discharge side of each pump to ensure satisfaction of pump Net Positive Suction Head (NPSH) requirements.

3.4.1.3 Control Circuitry

All standards for engineered safeguards control equipment are maintained. Additional relays and wiring have been added to assure single-failure capability.

3.4.1.4 Recirculation Loop Equalizer Valve and LPCI System Cross-Tie Valve

Inadvertent opening of these valves could negate the LPCI system injection when needed, therefore one equalizer valve and the cross-tie valve were closed and motive power removed by the previous modification. An annunciator was added to indicate the LPCI cross-tie valve and/or equalizer valve are not fully closed.

3.4.1.5 Recirculation Pump Discharge Valves

Closure of the recirculation pump discharge valves is of importance to the proper application of the proposed modification. Hydraulic-pneumatic operators will be added to these valves. Four aspects of valve compatibility have been investigated:

3.4.1.5.1 Environment

As reported in Section 5.2 of the Browns Ferry FSAR, the recirculation system valves are designed to operate under the environmental conditions associated with the DBA-LOCA. The added hydraulic-pneumatic operators are designed to operate under the same conditions.

3.4.1.5.2 Break Effects

A study of the drywell geometry was performed prior to the previous modification to determine the effects of jet impingement resulting from a postulated recirculation line break. For the suction line break, re-routing of cable has been provided, to prevent discharge valve operator malfunction. Valve closure at the time of a discharge line break is not considered in the ECCS analysis. Also, closure of the discharge valve does not change the LPCI system input capability during a discharge line break (See Figure 7).

For the break effects study, breaks were assumed at all terminals, branch lines, and at other locations based upon stress. Breaks were assumed at all locations where pressure plus dead load plus thermal plus earthquake stresses exceed $0.8(1.2S_h+S_A)$. Additionally, in piping runs where no stresses occur in excess of $0.8(1.2S_h+S_A)$, a minimum of two intermediate breaks were postulated based upon the highest total stresses combined as above.

3.4.1.5.3 Valve Differential Pressure

Recirculation valve closure requires both a LOCA initiation signal and a decrease in reactor pressure to the permissive setting. With valve closure initiation delayed until reactor pressure has decayed to less than 225 psig (approximately 29 seconds) the differential pressure across the closed valve will always be less than the maximum 200 psid. The sensor and permissive circuitry are designed to satisfy all requirements for engineered safeguards control systems.

3.4.1.6 Minimum Flow Bypass Valve

Minimum flow bypass valves will be provided with hydraulic-pneumatic operators with redundant DC power supplies and flow switches to assure maximum pump protection under postulated accident conditions. This modification eliminates the need for the auto-transfer of power to these valves. AC power will only supply the nonessential hydraulic pump to the operators of these valves.

3.4.1.7 Batteries

DC power from qualified station batteries will be the primary and redundant power sources to the hydraulic-pneumatic operator. Each source is selected such that no single battery failure inhibits redundant power sources or results in a configuration of ECCS pump availability that is less than adequate for core cooling.

3.4.1.8 Hydraulic Operators

See Figure 28. Alarms will be provided in the main control room for non-standard accumulator parameters. Accumulator pressure indication will also be provided for operator verification and interpretation.

3.4.1.8.1 Seismic Qualification

The operability of the hydraulic-pneumatic valve operators and all the appurtenances vital to their operation during and after a SSE is verified in accordance with IEEE 382 and 384 as applicable to the plant. If the installation of the hydraulic-pneumatic valve operators produce increased loading condition, the LPCI system and recirculation water system shall be requalified to the standards and codes which were applied to the original unmodified system.

3.4.2 Equipment Interfaces

The effects of the proposed change on the various operating modes of the equipment have been evaluated and found to be acceptable, as described below:

3.4.2.1 Emergency Diesel-Generators

The proposed modification introduces no new or different interfaces for this equipment.

3.4.2.2 Motor Control Centers and Control Panels

Motor control centers will be modified on those valves necessary for automatic operation for LPCI injection (LPCI injection, recirculation pump discharge, and RHR pump minimum flow bypass valves) in order to accomodate the addition of hydraulic-pneumatic operators. A control panel will be added for backup control to the hydraulic-pneumatic operators. All standards for engineering safeguards control will be maintained.

3.4.2.2.1 Valve Power

Existing Limitorque valve operators will be replaced by hydraulic-pneumatic operators on valves necessary for automatic operation for LPCI injection. This modification allows elimination of the valve motive power auto-transfer feature for redundant power supplies. Physically and electrically separate, redundant DC power supplies are provided to the new operator to assure proper valve movement to the required position during a LOCA. Valve motion times are maintained in order for previous analyses to remain applicable.

3.4.2.2.2 Valve Motor Control

To ensure that a malfunction in the individual valve controller does not couple back to the other valve control circuits, the redundant A and B circuits were provided separate relays and contacts in the logic panels on a previous modification. This separated, redundant arrangement has been applied to the LPCI and

recirculation system valves needed for operation as described. System interfacing and protection as related to the valve motor control centers are unchanged except as noted in 3.4.2.2.

3.4.2.2.3 DC Control Power

As shown in Figure 14 and Browns Ferry FSAR Figure 8.6-3, 250 VDC from the station batteries provides control power to LPCI logic panels. After the proposed modification the same equipment receives power from this source as in the original design. These station batteries are also the power source for hydraulic-pneumatic operators. Failure of any one station battery does not cause interactions that exceed the limiting case for core cooling capabilities. See also 3.4.1.7.

3.4.2.3 LPCI Logic Panels

To provide the necessary redundancy required on the previous modification, changes were made to the LPCI logic panels. To preclude valve-to-valve interface, redundant and separate relays and contacts were provided for each LPCI and recirculation system. Each of the added redundant relays was provided full separation from all others by enclosure in a metal box. The wiring from redundant contacts between the two logic panels was provided separation by enclosure in flex conduit and termination in metal junction boxes. This logic scheme will be maintained in the new modification. The only changes to be made to the LPCI logic panels on this modification will be to add redundant flow information to the minimum flow bypass valves. Since redundant

flow switches will be added to each LPCI system, and each circuit can be kept separate to the new operators, no new interfacing will be necessary in the logic panels.

3.4.2.4 Hydraulic/Pneumatic Operators

Physical and electrical separations are maintained on the operators to assure redundant features.

3.4.3 Functional Interface

The RHR system, as discussed in this report, performs as a short-term post-LOCA core cooling function. The system also provides a long-term containment cooling function which is described in Sections 4.8.6.2 and 14.6.3.3.2 of the FSAR. The effects of the proposed change to the core cooling function on the containment cooling function were evaluated and found to be acceptable after modification as described below.

In analyzing single failures which might influence long-term suppression pool cooling, both AC and DC control and emergency power failures as well as component failures in the RHR and RHRSW (cooling water) systems were considered. The worst case single failure (Reactor MOV Board loss) with the modified system still leaves two RHR heat exchangers, two RHR pumps, and two RHR Service Water pumps and associated valving available for suppression pool cooling. The suppression pool temperature versus time response for this combination of equipment is shown by curve C in FSAR Figure 14.6-12.

3.4.4 Satisfaction of Appropriate Standards

The proposed modification directly affects as Engineered Safeguards System and has been designed to Class I system standards. The standards and guides which were applicable to the original design have been reviewed to assure the modified system design, equipment, and installation meet or exceed the qualifications of the unmodified system.

3.4.5 Quality Assurance and Control

Quality assurance and control will be applied to this modification as detailed in Appendix D of the Browns Ferry FSAR. Appendix D incorporates the requirement of 10CFR50, Appendix B.

4.0 SUMMARY AND CONCLUSIONS

The proposed modification involves some physical changes to the plant to permit elimination of the swing-bus concept and adoption of the total system availability of the new design.

The analytical methods used reflect the most recent determinations of NRC staff and reactor suppliers for modeling the performance of Emergency Core Cooling Systems.

The application of the proposed modification adds to the overall capability of the plant to continue operation in a manner that ensures the health and safety of the public while providing benefit in the production of electrical energy.

5.0 REFERENCES

1. Interim Policy Statement, USAEC, dated June 19, 1971; Subject: AEC Adopted Interim Acceptance Criteria for Performance of ECCS for Light-Water Power Reactors.

2. NEDE-20973, Supplement 1.

3. Letter from J. E. Gilleland (TVA) to Benard C. Rusche (NRC) dated February 12, 1976.

TABLE 1

ECCS PUMP CONFIGURATION

Suction Side Break	Pumps Available**
No Failures	4 Core Spray, 2 LPCI in each Loop
Opposite Unit Spurious Accident Signal	2 Core Spray, 1 LPCI in each Loop
LPCI Injection Valve Failure*	4 Core Spray, 2 LPCI in one Loop
LPCI Minimum Valve Failure*	4 Core Spray, 2 LPCI in one Loop
Recirculation Discharge Valve Failure-Break Side*	4 Core Spray, 2 LPCI in one Loop
Diesel Failure	2 Core Spray, 2 LPCI in one Loop, 1 LPCI in other Loop
Battery Failure	2 Core Spray, 2 LPCI in one Loop, 1 LPCI in other Loop

Discharge Side Break	Pumps Available**
No Failures	4 Core Spray, 2 LPCI in one Loop
LPCI Injection Valve Failure*	4 Core Spray
LPCI Minimum Flow Valve Failure*	4 Core Spray
Diesel Failure	2 Core Spray, 1 LPCI
Battery Failure	2 Core Spray, 1 LPCI
Opposite Unit Spurious Accident Signal	2 Core Spray, 1 LPCI

*Limiting Single Failure
**In Unbroken Loop

TABLE 2

LOCAL PEAK CLADDING TEMPERATURES AND REFLOOD TIMES FOLLOWING A LOCA AND WORST SINGLE FAILURE.

	Peak Cladding Temperature (°F)	Flooding Time (seconds)
Suction Line Break	2200	108
Discharge Line Break	2022	126

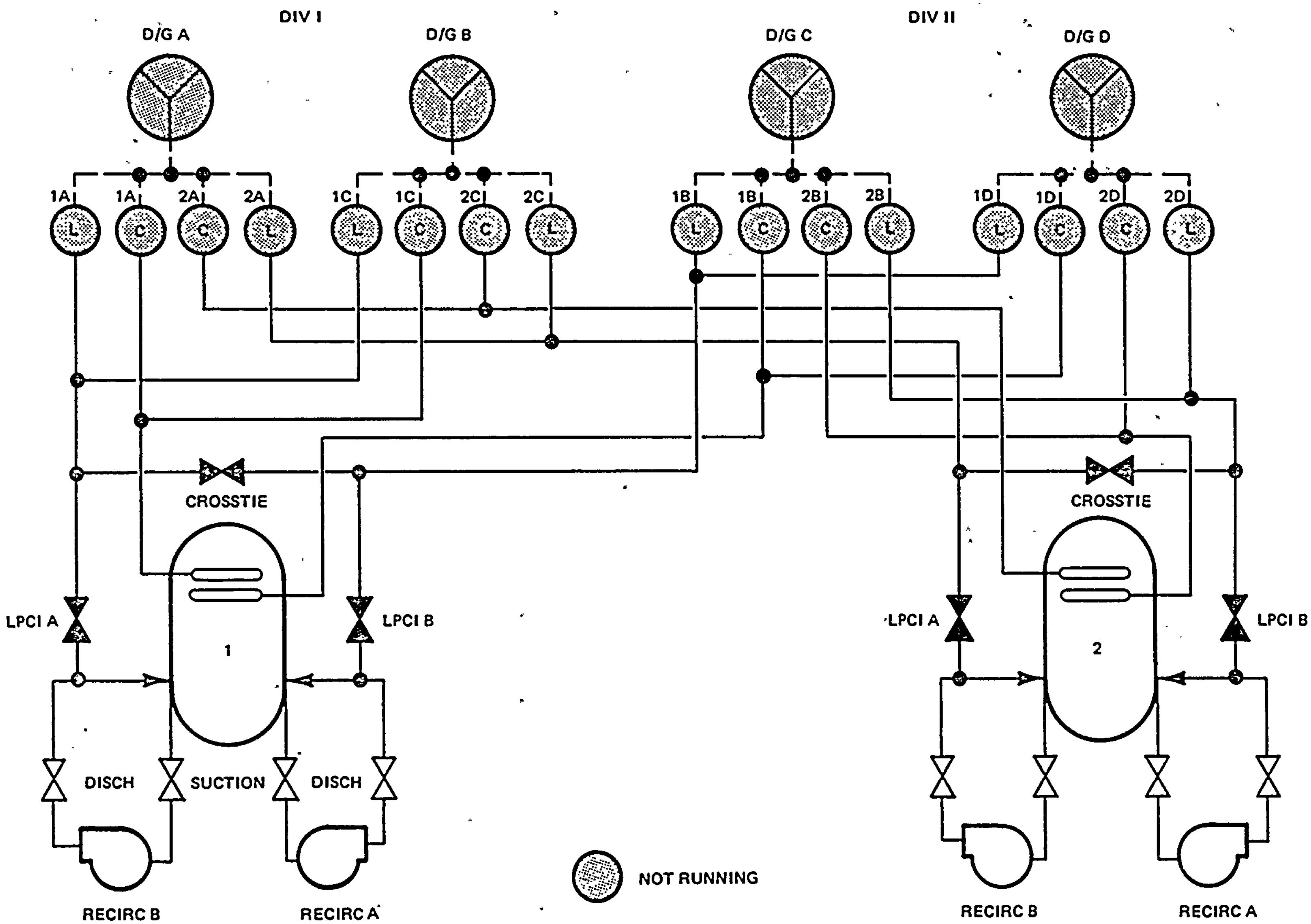


Figure 1 *System Normal Operation*

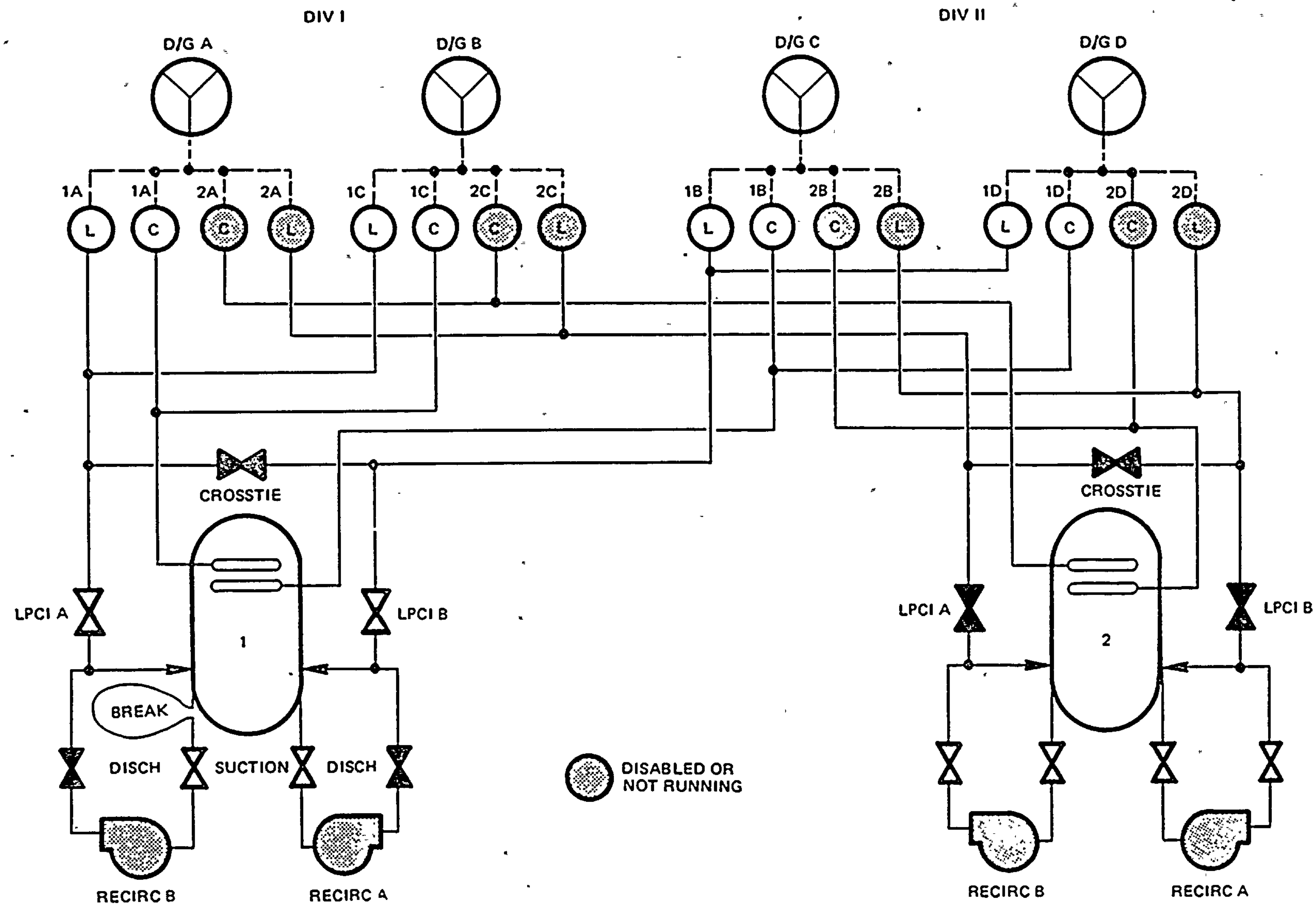


Figure 2 *System Mode of Operation During Unit 1 LOCA (Suction Line Break).— No Failures*

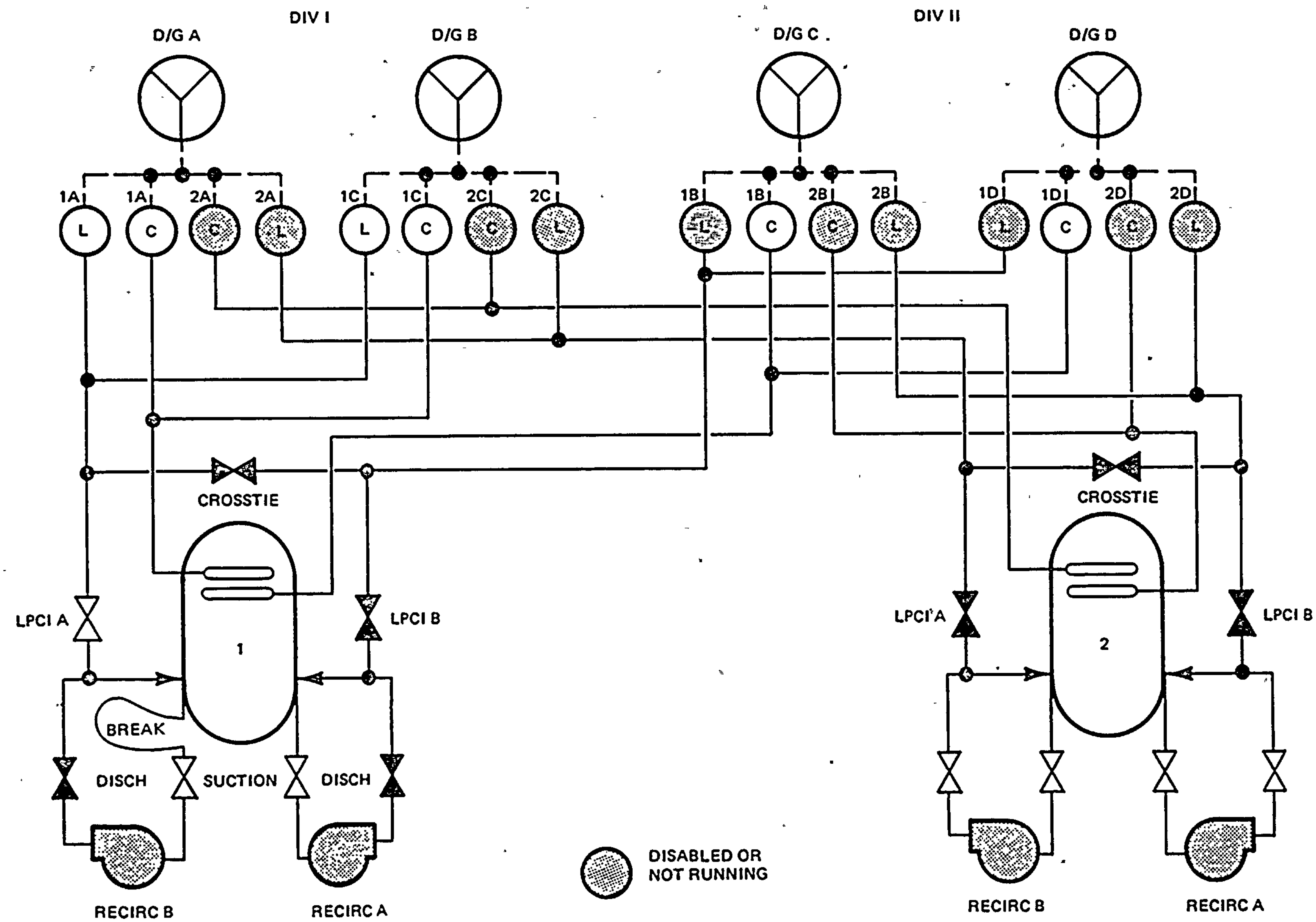


Figure 3 *System Mode of Operation During Unit 1 LOCA (Suction Line Break) — LPCI Injection Valve Failure*

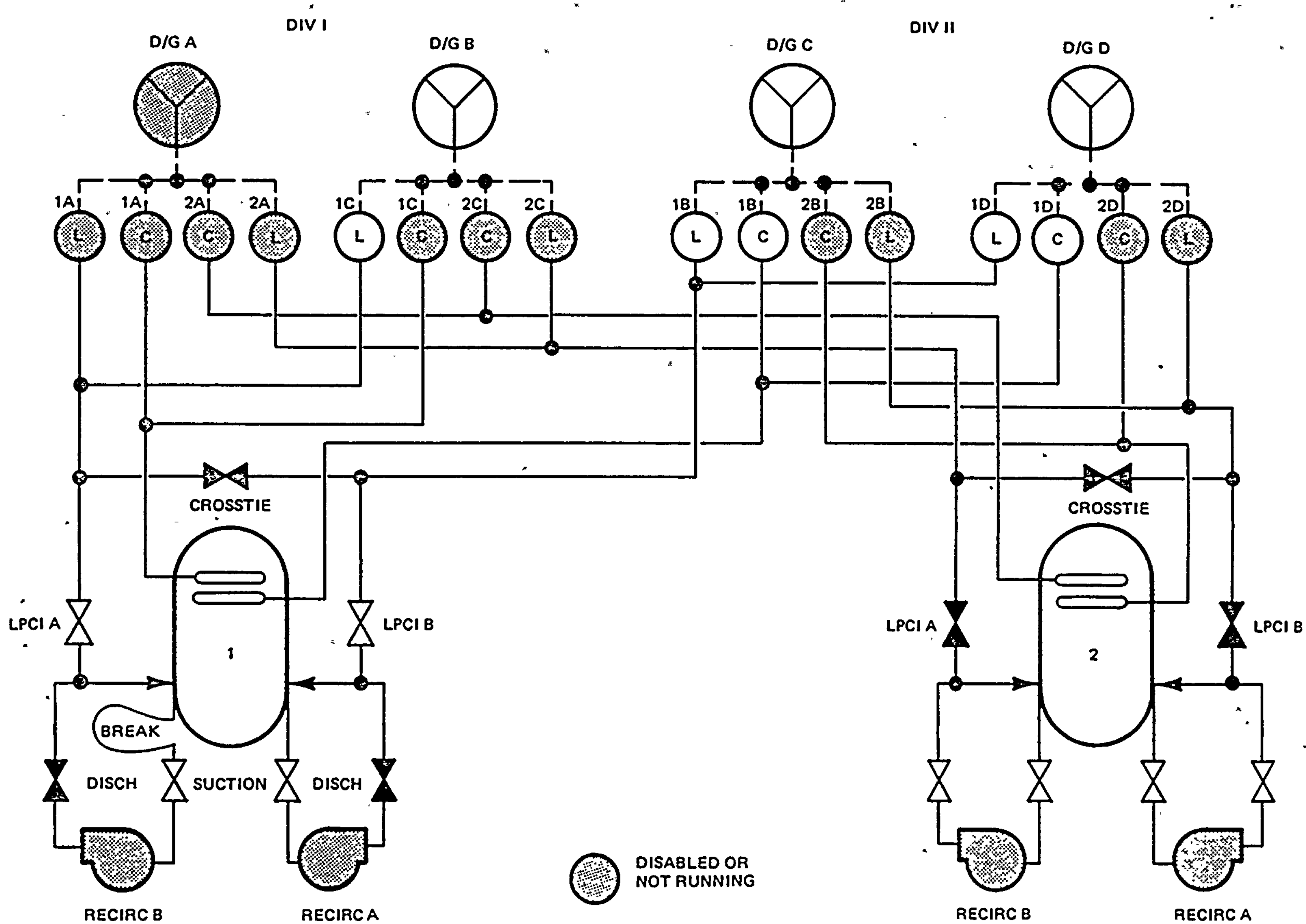


Figure 4 System Mode of Operation During Unit 1 LOCA (Suction Line Break) – Diesel Failure

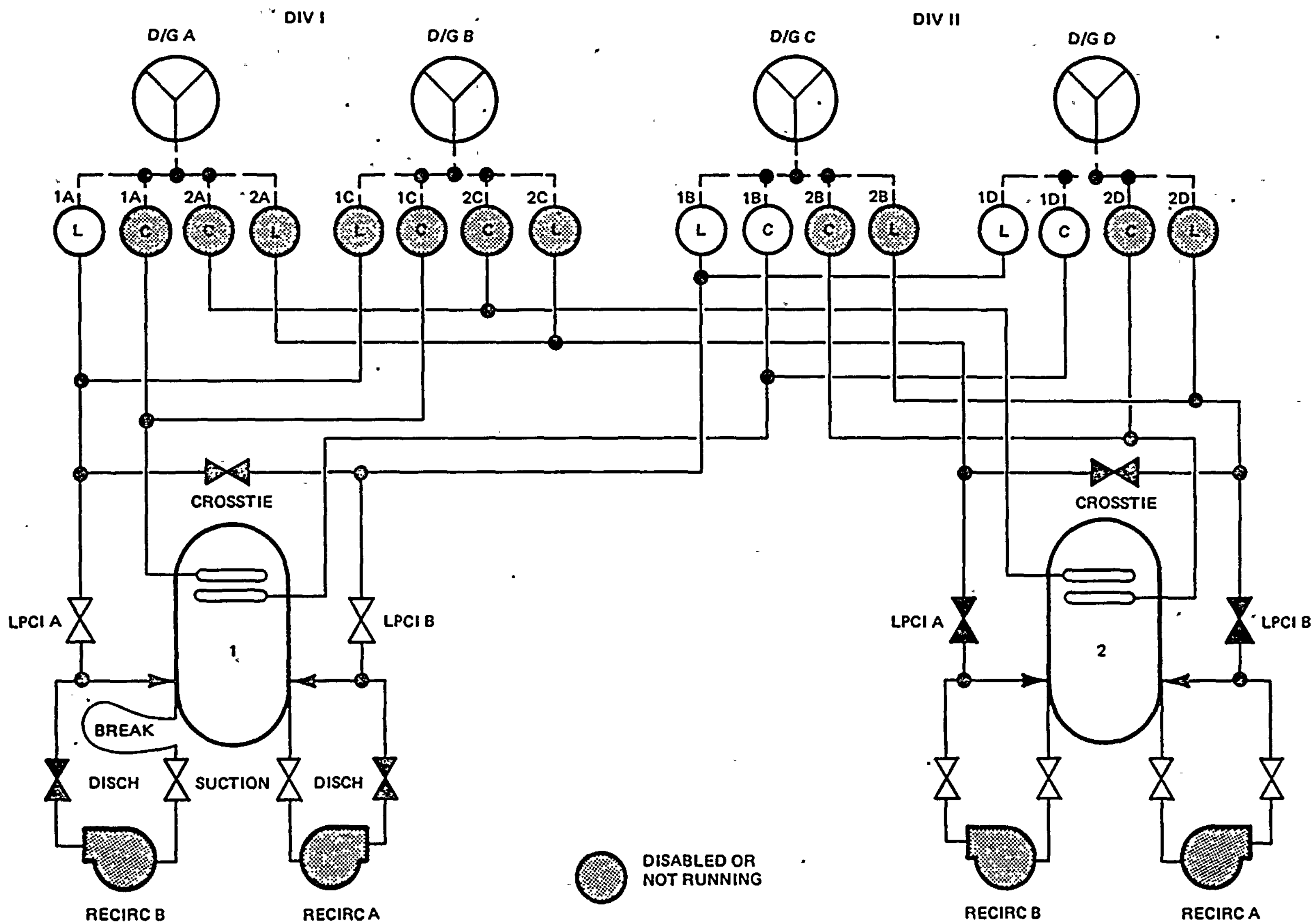


Figure 5 System Mode of Operation During Unit 1 LOCA (Suction Line Break) — Battery Failure

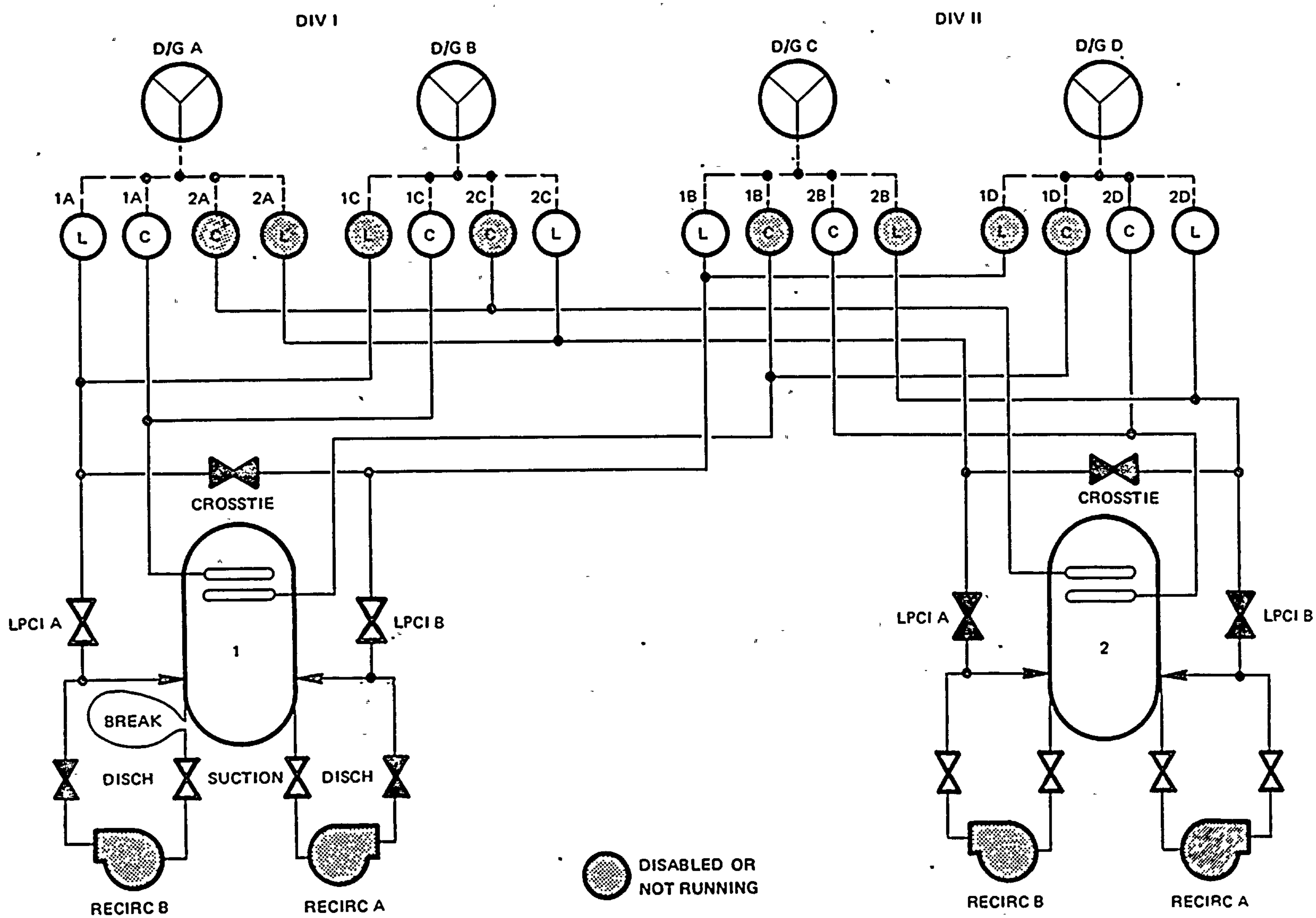


Figure 6 *System Mode of Operation During Unit 1 LOCA (Suction Line Break) – Opposite Unit Spurious Accident Signal*

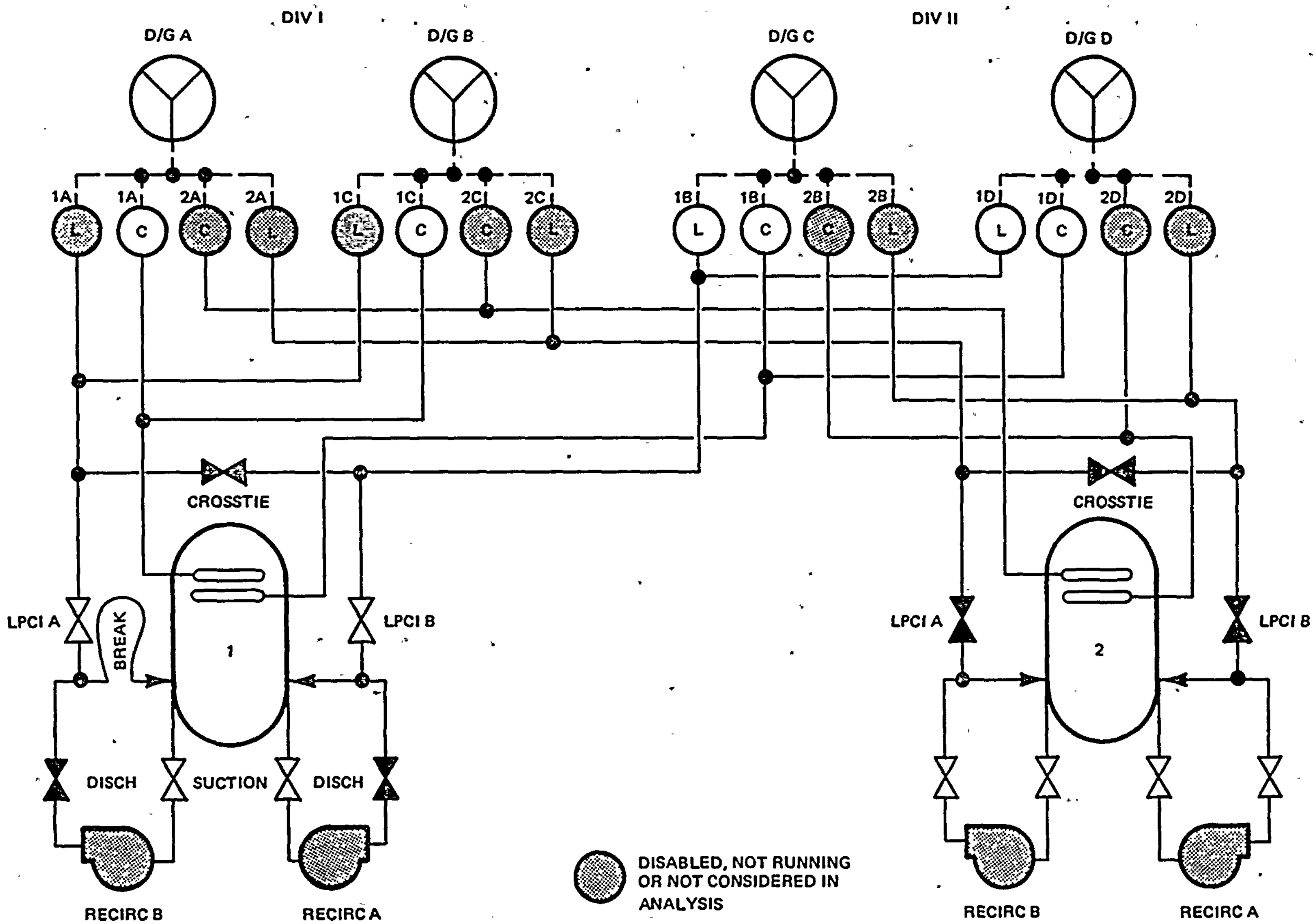


Figure 7 System Mode of Operation During Unit 1 LOCA (Discharge Line Break) — No Failures

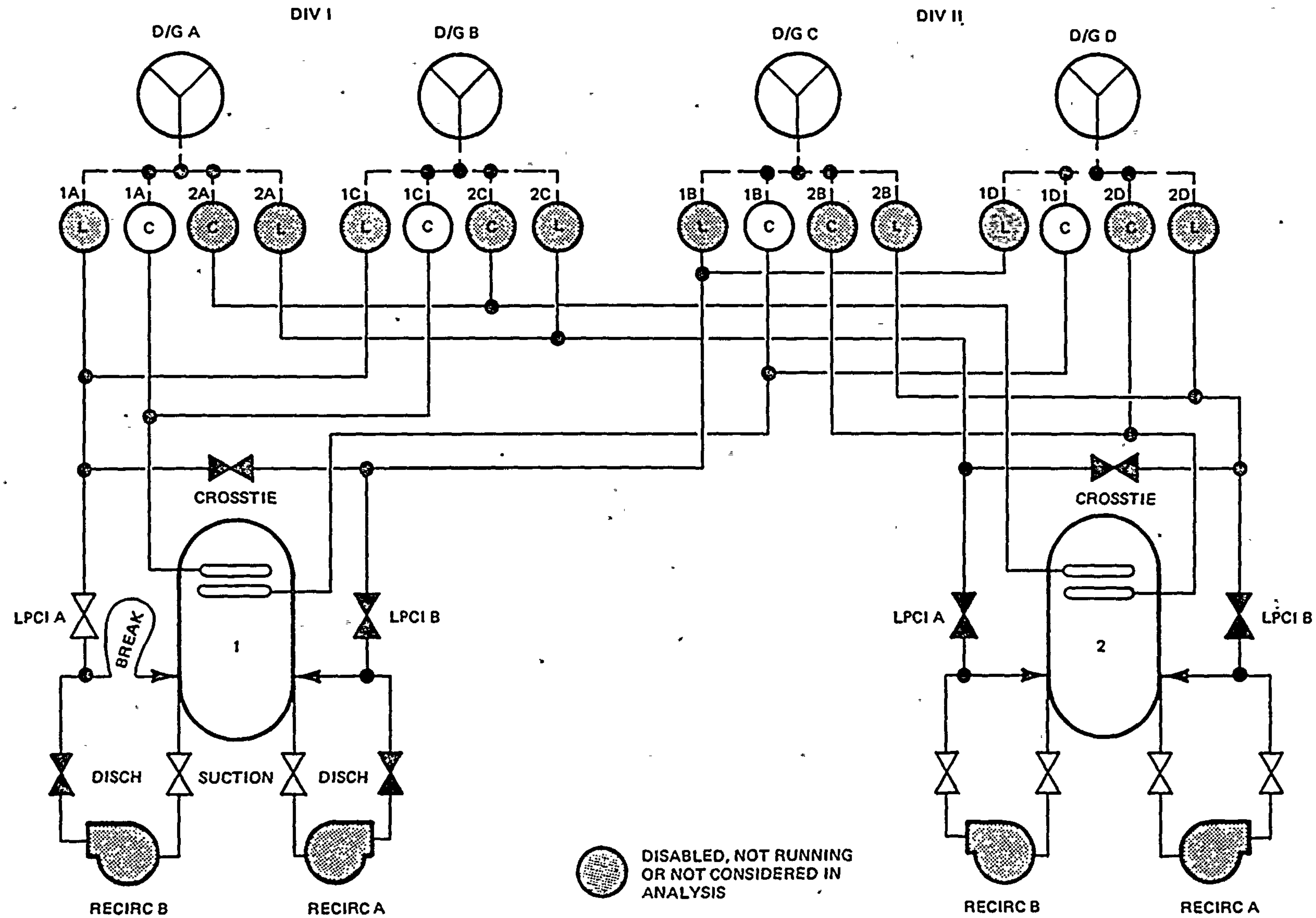


Figure 8 *System Mode of Operation During Unit 1 LOCA (Discharge Line Break) — LPCI Injection Valve Failure*

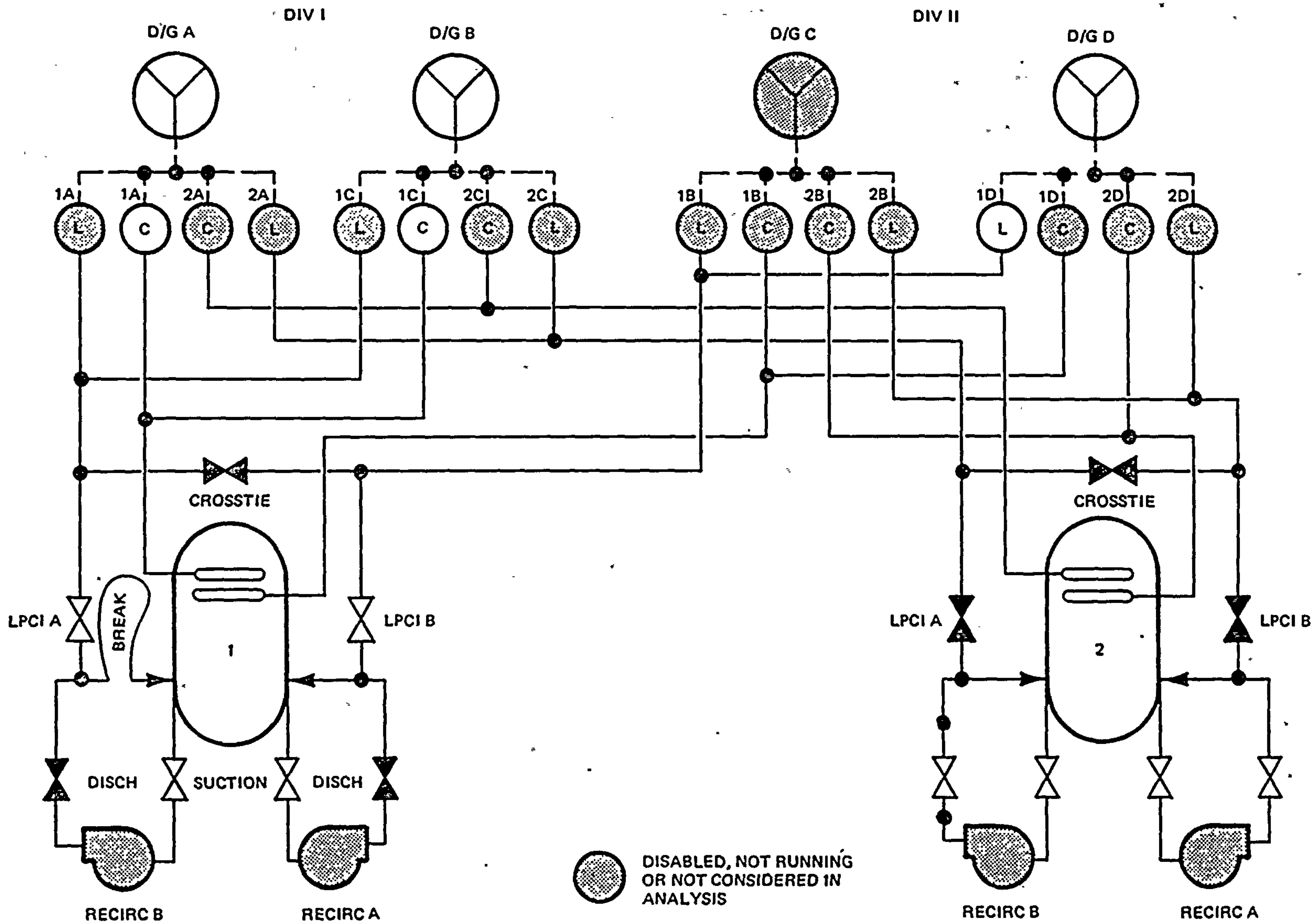


Figure 9 *System Mode of Operation During Unit 1 LOCA (Discharge Line Break) — Diesel Failure*

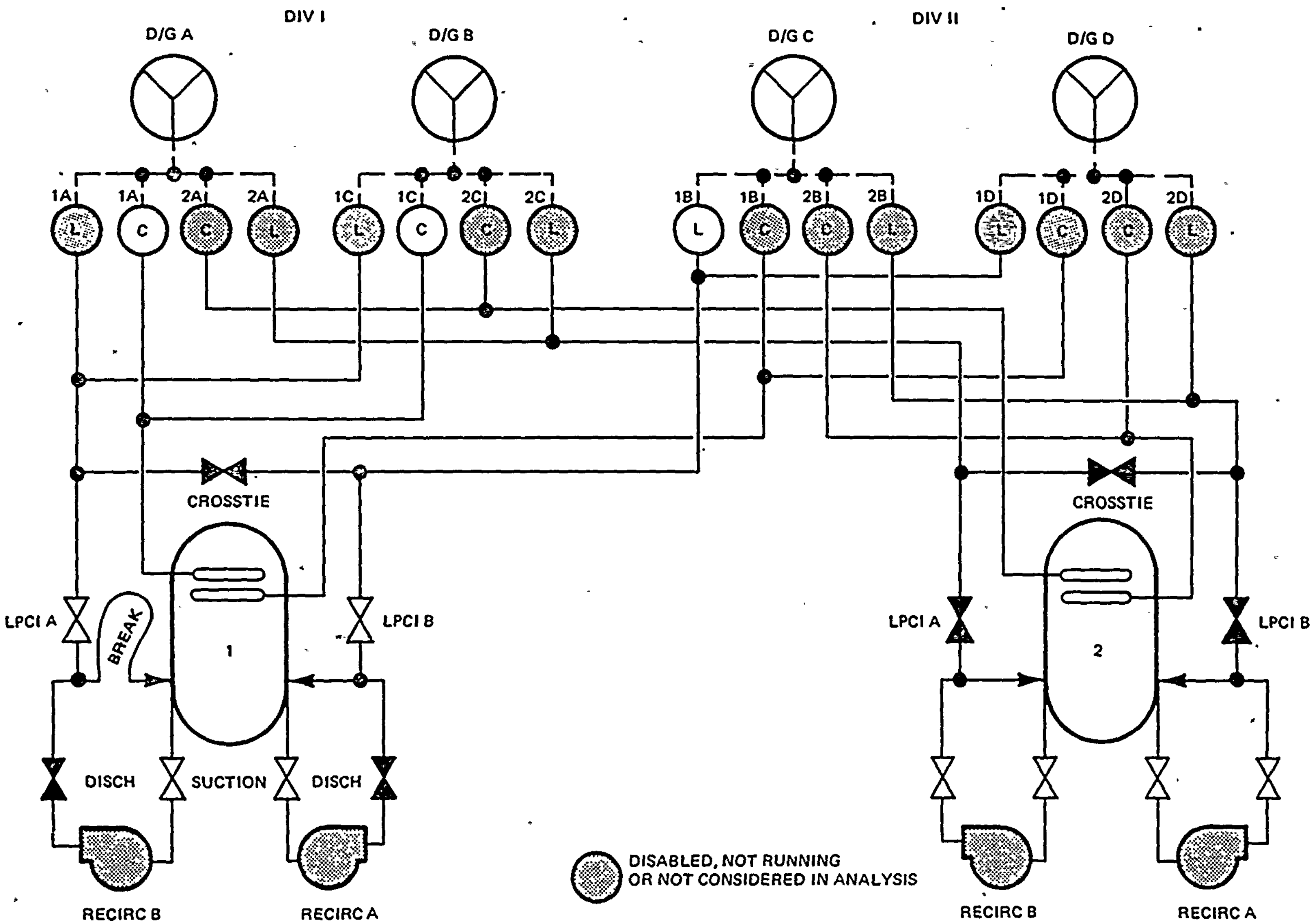


Figure 10 System Mode of Operation During Unit 1 LOCA (Discharge Line Break) – Battery Failure

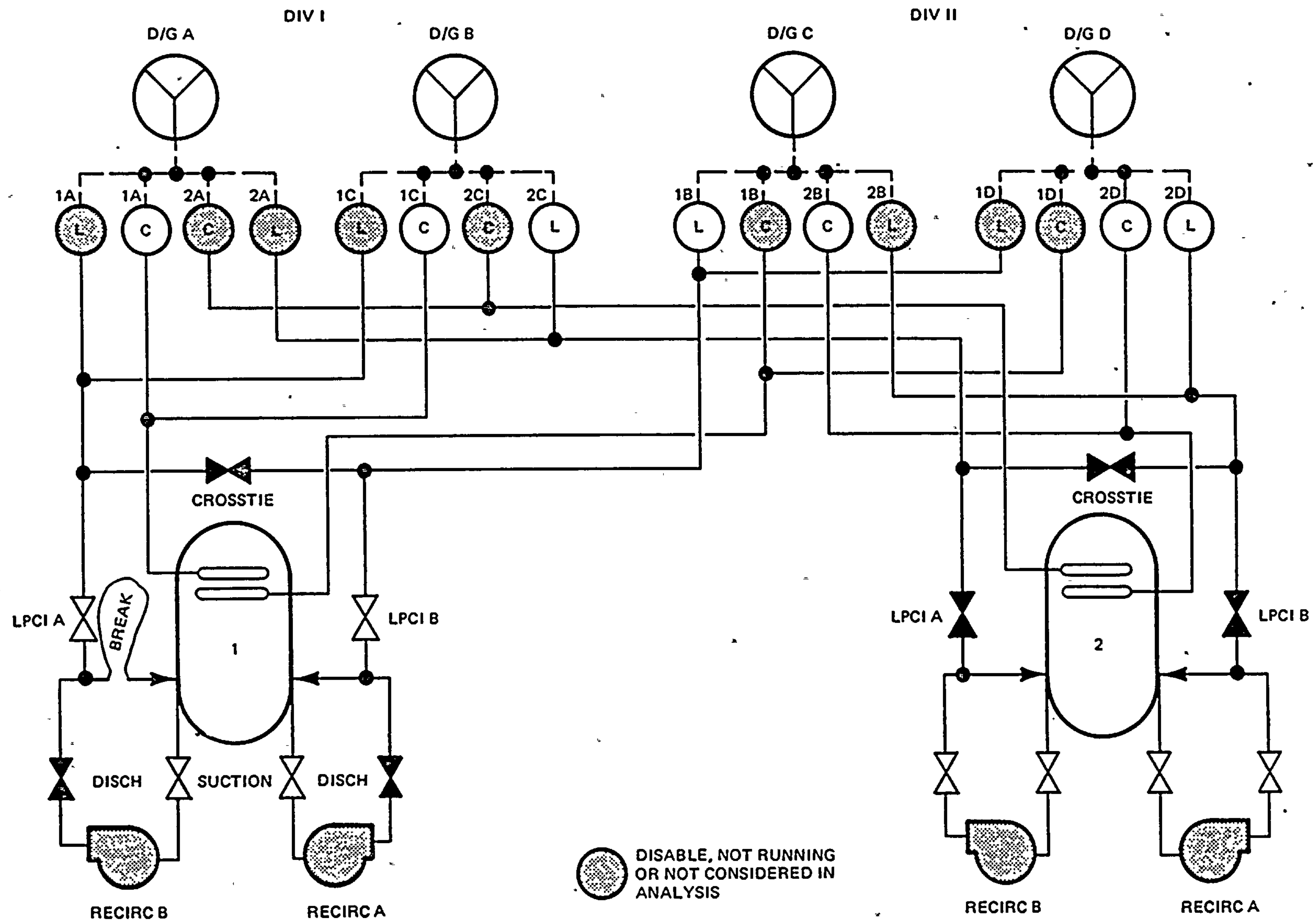


Figure 11 *System Mode of Operation During Unit 1 LOCA (Discharge Line Break) – Opposite Unit Spurious Accident Signal*

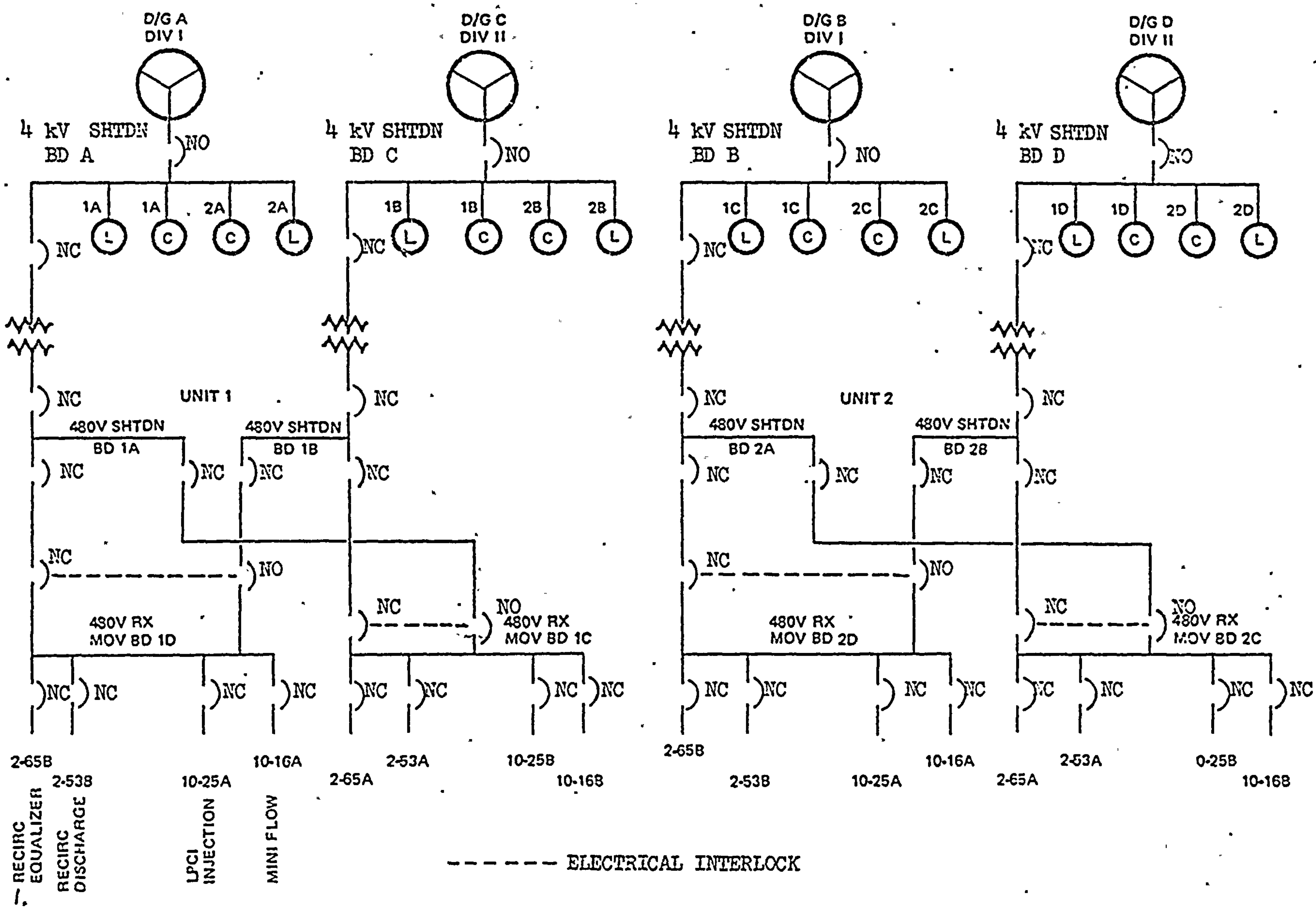


Figure 12 Existing System Valve Bus Arrangement

1. Valve closed and motive power removed.

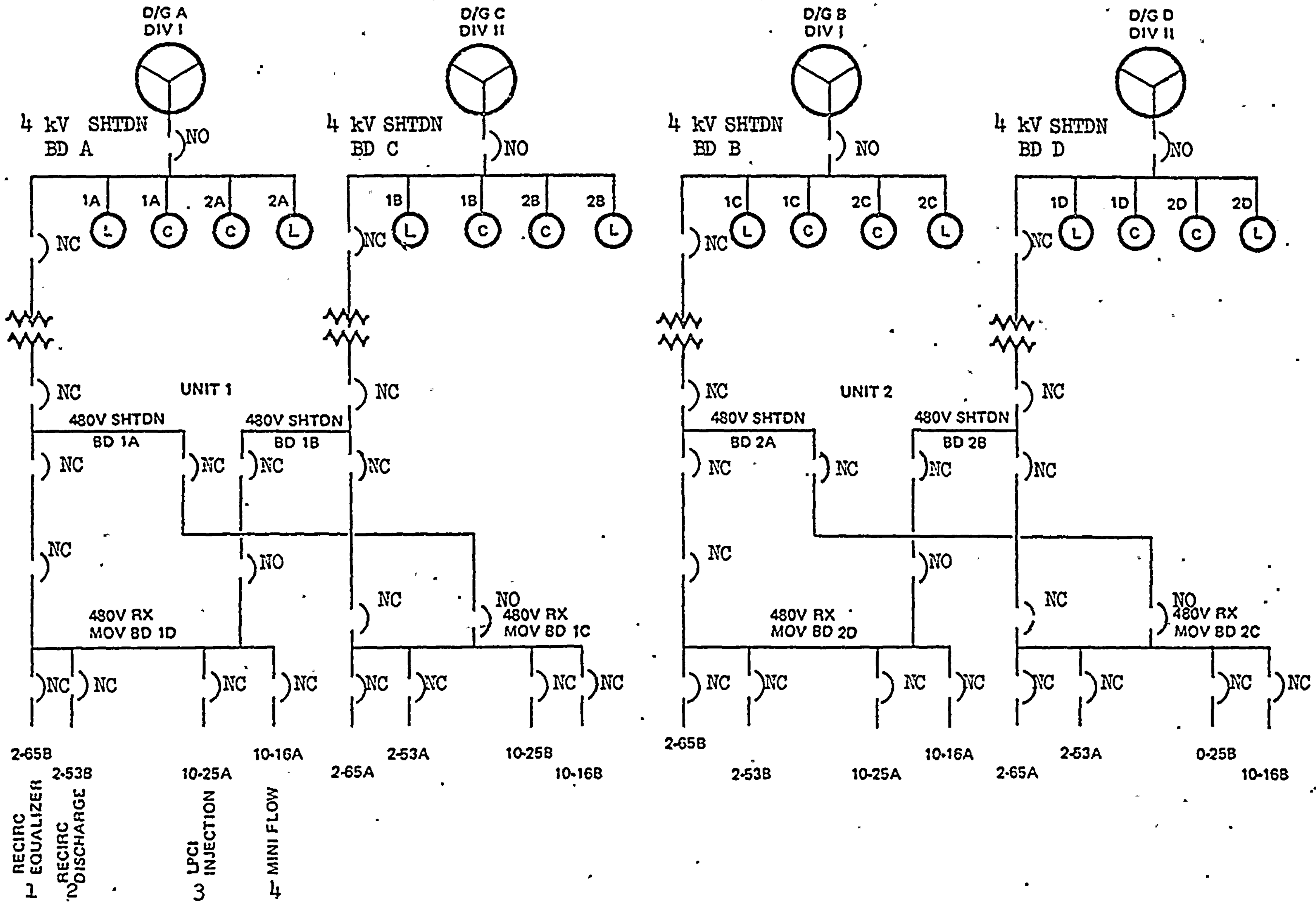


Figure 13 Modified System Valve Bus Arrangement

1. Valve closed and motive power removed.
2. Power for hydraulic pump - not required for valve closure.
3. Power for hydraulic pump - not required for valve opening.
4. Power for hydraulic pump - not required for one cycle of valve operation.

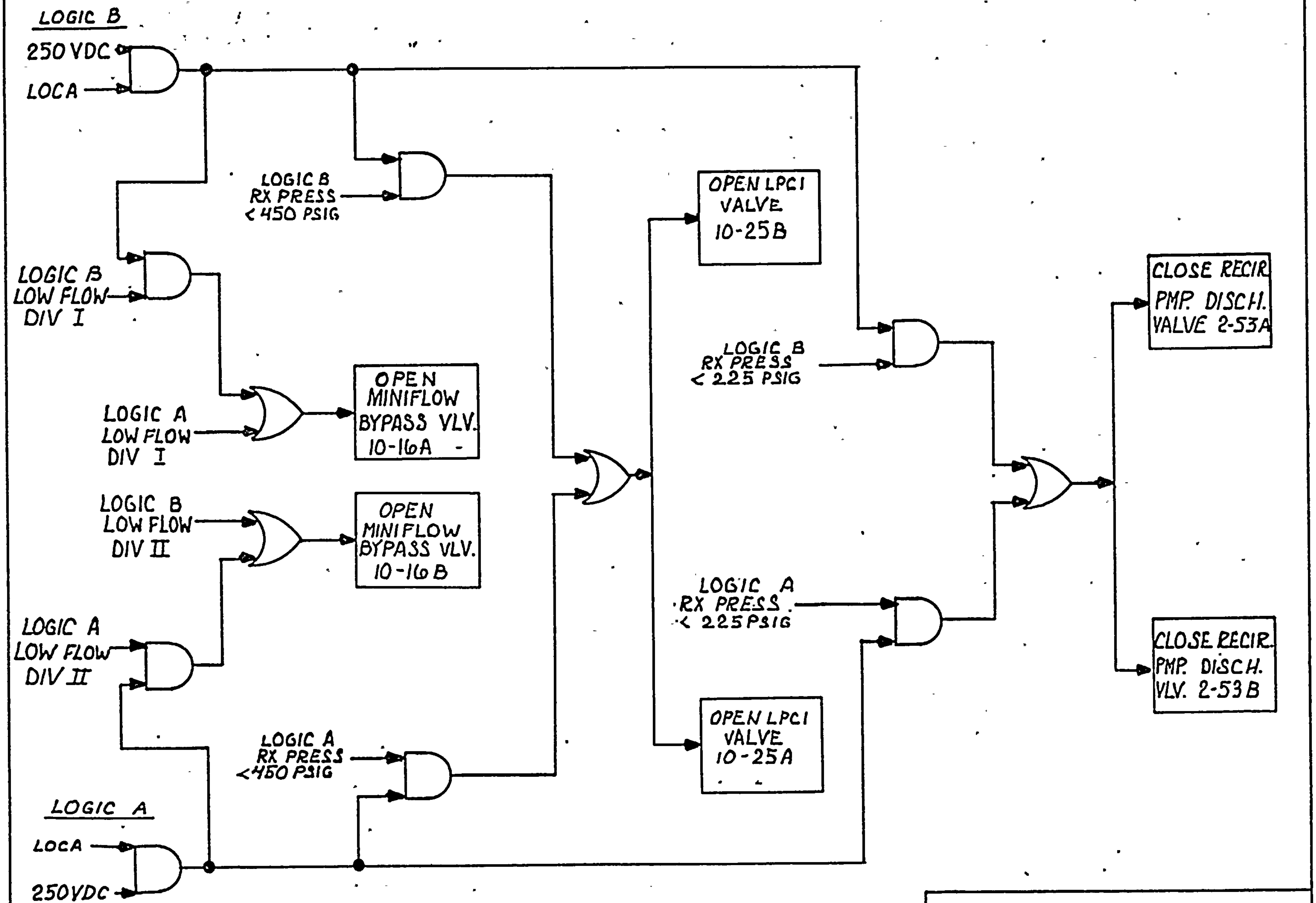
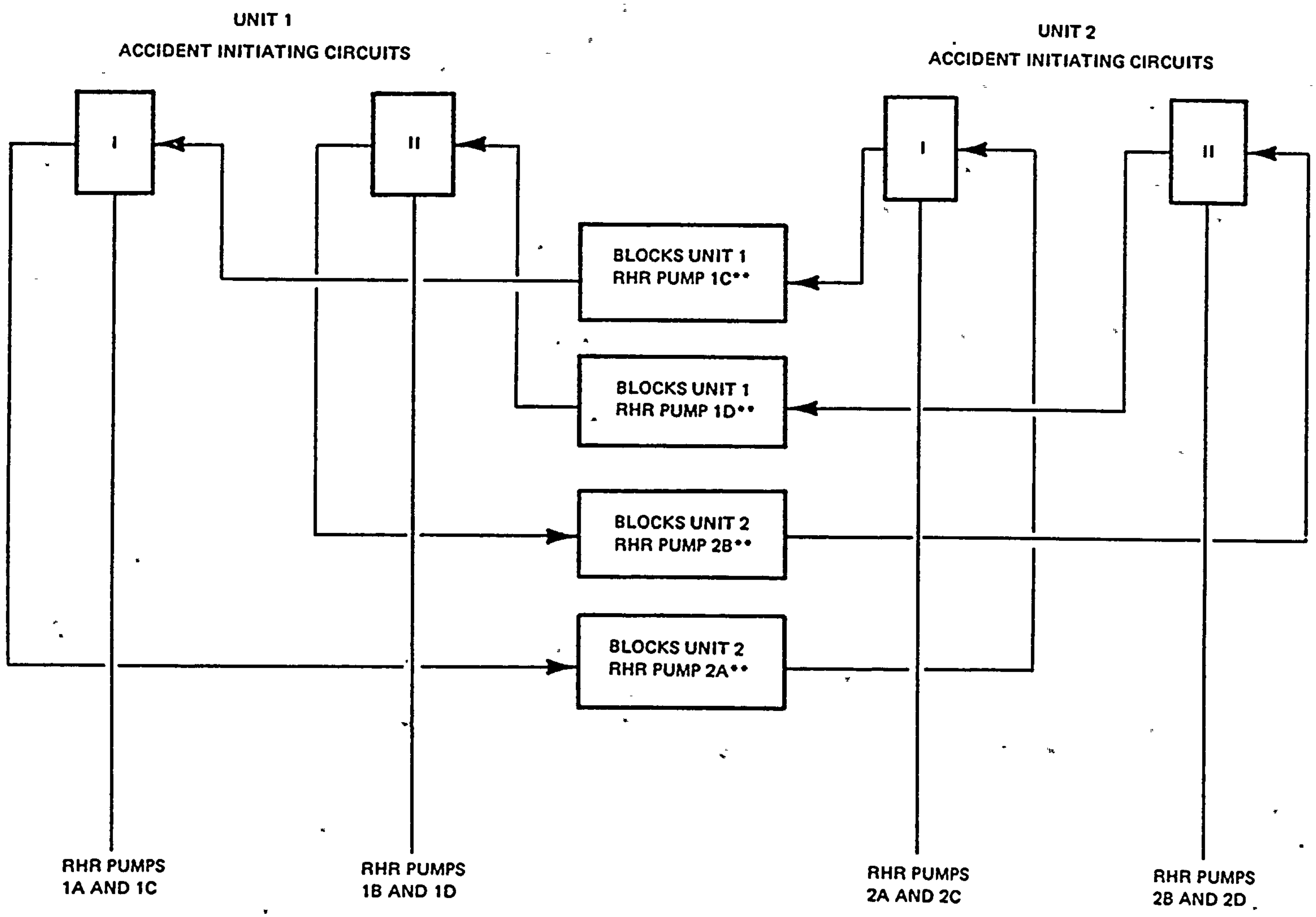


FIGURE 14

SYST. VALVE CONTROL
POWER ARRANGEMENT



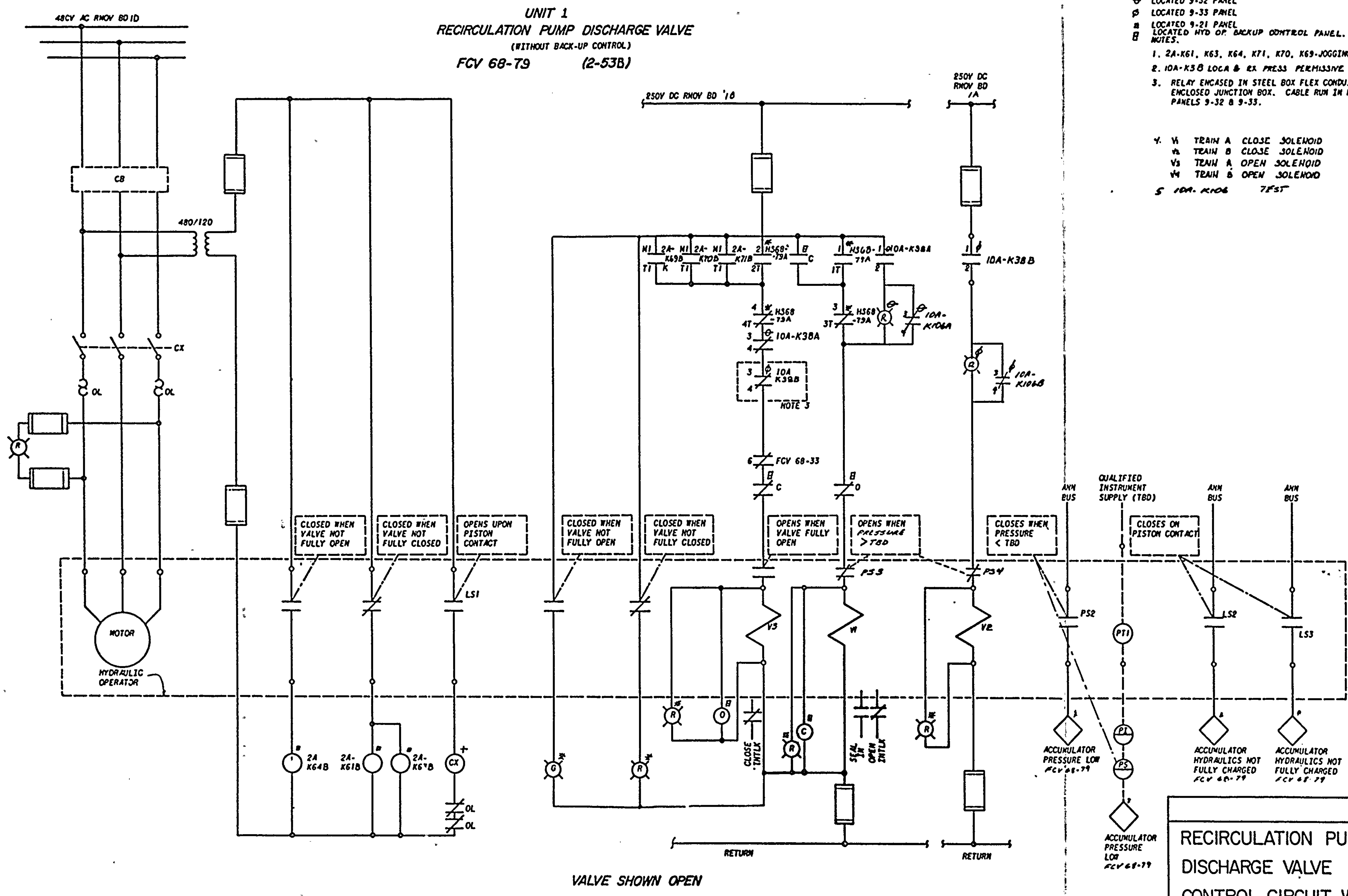
* FOR CORE SPRAY PUMP PRIORITIES, SEE BROWNS FERRY NUCLEAR PLANT FSAR, FIGURE 8.5A-4

** STOPS IF RUNNING

Figure 15 Modified *System RHR Pump Divisional Priorities* *

SYMBOLS:
- L LOCATED LOCAL PANEL
- # LOCATED MAIN CONTROL ROOM PANEL
- Θ LOCATED 9-32 PANEL
- Ø LOCATED 9-33 PANEL
- ■ LOCATED 9-21 PANEL
- ⊟ LOCATED HYD OP. BACKUP CONTROL PANEL.

NOTES.
1. 2A-K61, K63, K64, K71, K70, K69-JOGGING CIRCUIT
2. 10A-K38 LOCA & RX PRESS PERMISSIVE
3. RELAY ENCASED IN STEEL BOX FLEX CONDUIT FROM CONTACTS TO ENCLOSED JUNCTION BOX. CABLE RUN IN FLEX CONDUIT BETWEEN PANELS 9-32 & 9-33.
4. V1 TRAIN A CLOSE SOLENOID
   V2 TRAIN B CLOSE SOLENOID
   V3 TRAIN A OPEN SOLENOID
   V4 TRAIN B OPEN SOLENOID
5. 10A-K106 TEST



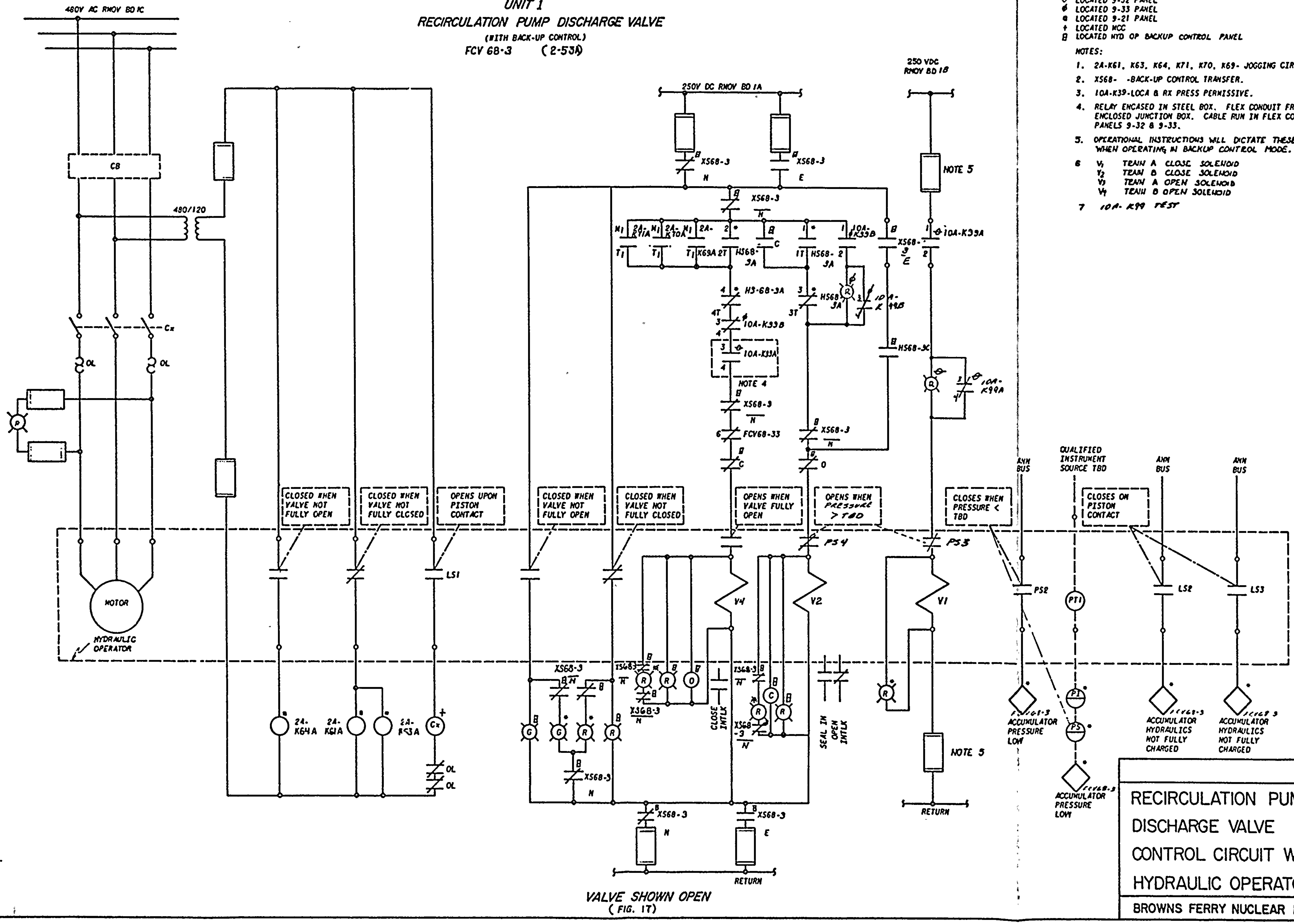
VALVE SHOWN OPEN

(FIG. 16)

RECIRCULATION PUMP DISCHARGE VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR

BROWNS FERRY NUCLEAR PLANT UNIT 1

UNIT 1
RECIRCULATION PUMP DISCHARGE VALVE
(WITH BACK-UP CONTROL)
FCV 68-3 (2-53A)



VALVE SHOWN OPEN
(FIG. 17)

SYMBOLS

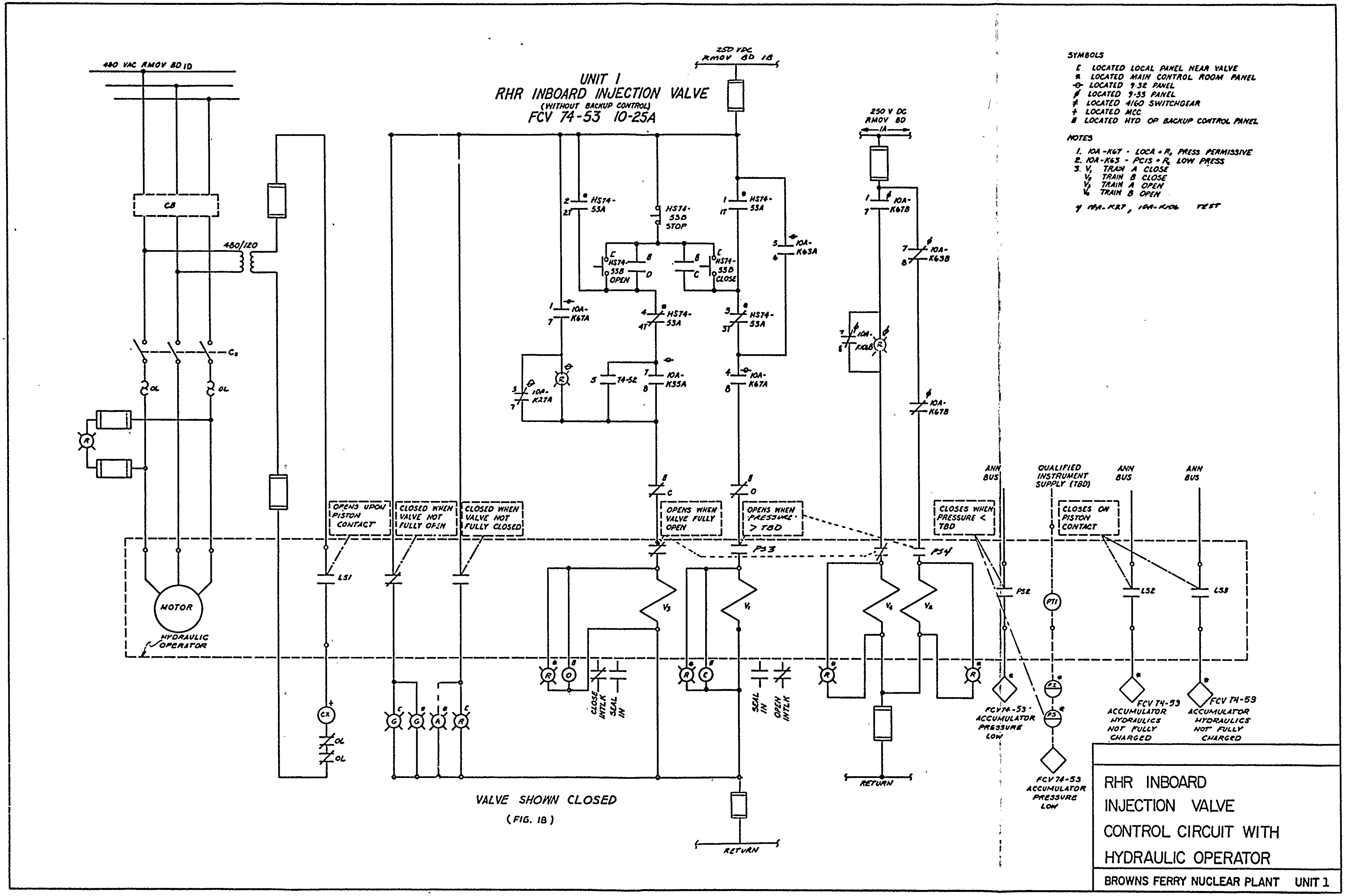
- [LOCATED LOCAL PANEL
- * LOCATED MAIN CONTROL ROOM PANEL
- ⊖ LOCATED 9-32 PANEL
- ∅ LOCATED 9-33 PANEL
- ● LOCATED 9-21 PANEL
- † LOCATED MCC
- B LOCATED HYD OP BACKUP CONTROL PANEL

NOTES:

1. 2A-K61, K63, K64, K71, K70, K69- JOGGING CIRCUIT.
2. XS68- -BACK-UP CONTROL TRANSFER.
3. 10A-K39-LOCA & RX PRESS PERMISSIVE.
4. RELAY ENCASED IN STEEL BOX. FLEX CONDUIT FROM CONTACTS TO ENCLOSED JUNCTION BOX. CABLE RUN IN FLEX CONDUIT BETWEEN PANELS 9-32 & 9-33.
5. OPERATIONAL INSTRUCTIONS WILL DICTATE THESE FUSES BE REMOVED WHEN OPERATING IN BACKUP CONTROL MODE.
6. V_1 TRAIN A CLOSE SOLENOID
   V_2 TRAIN B CLOSE SOLENOID
   V_3 TRAIN A OPEN SOLENOID
   V_4 TRAIN B OPEN SOLENOID
7. 10A-K99 TEST

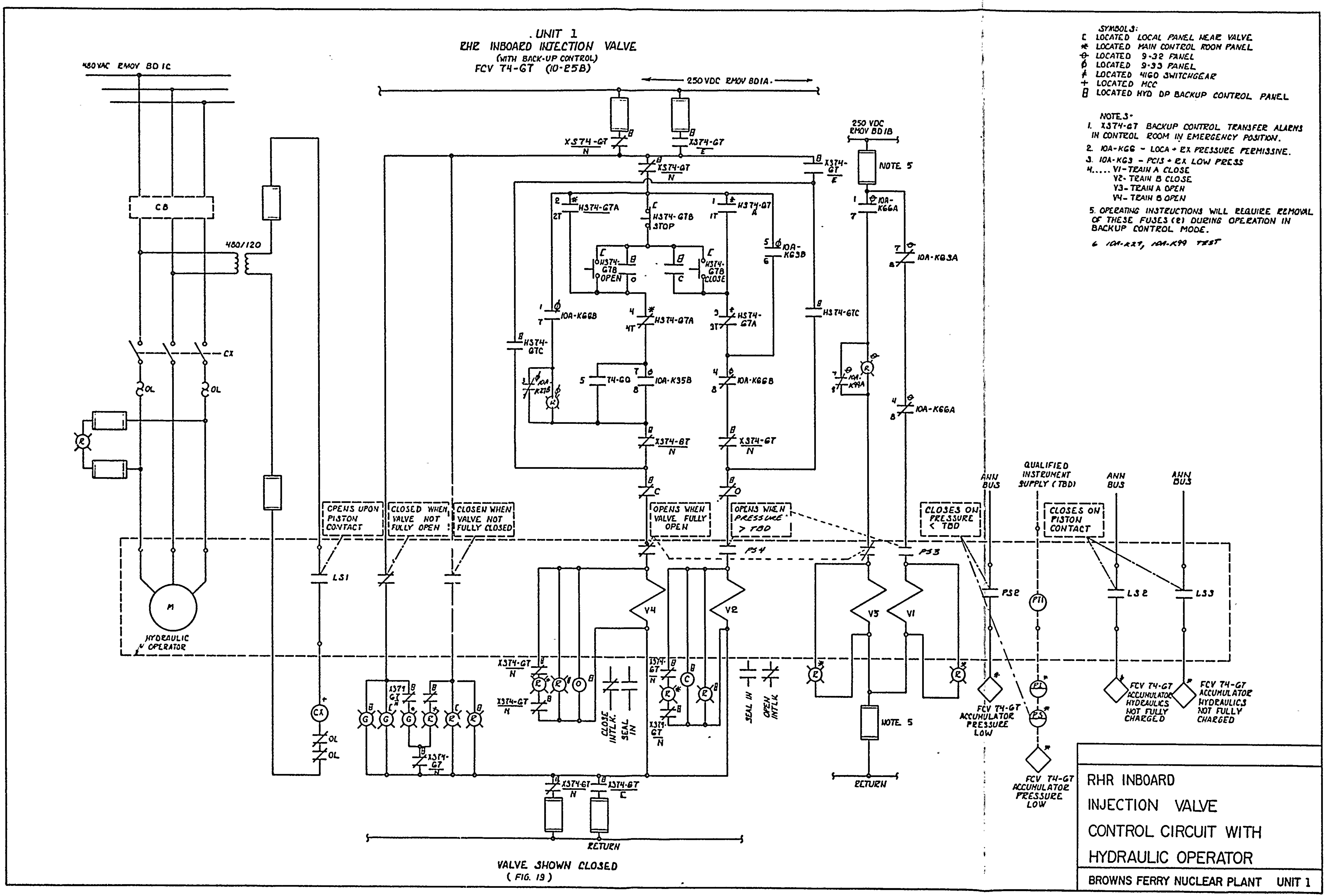
RECIRCULATION PUMP DISCHARGE VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR

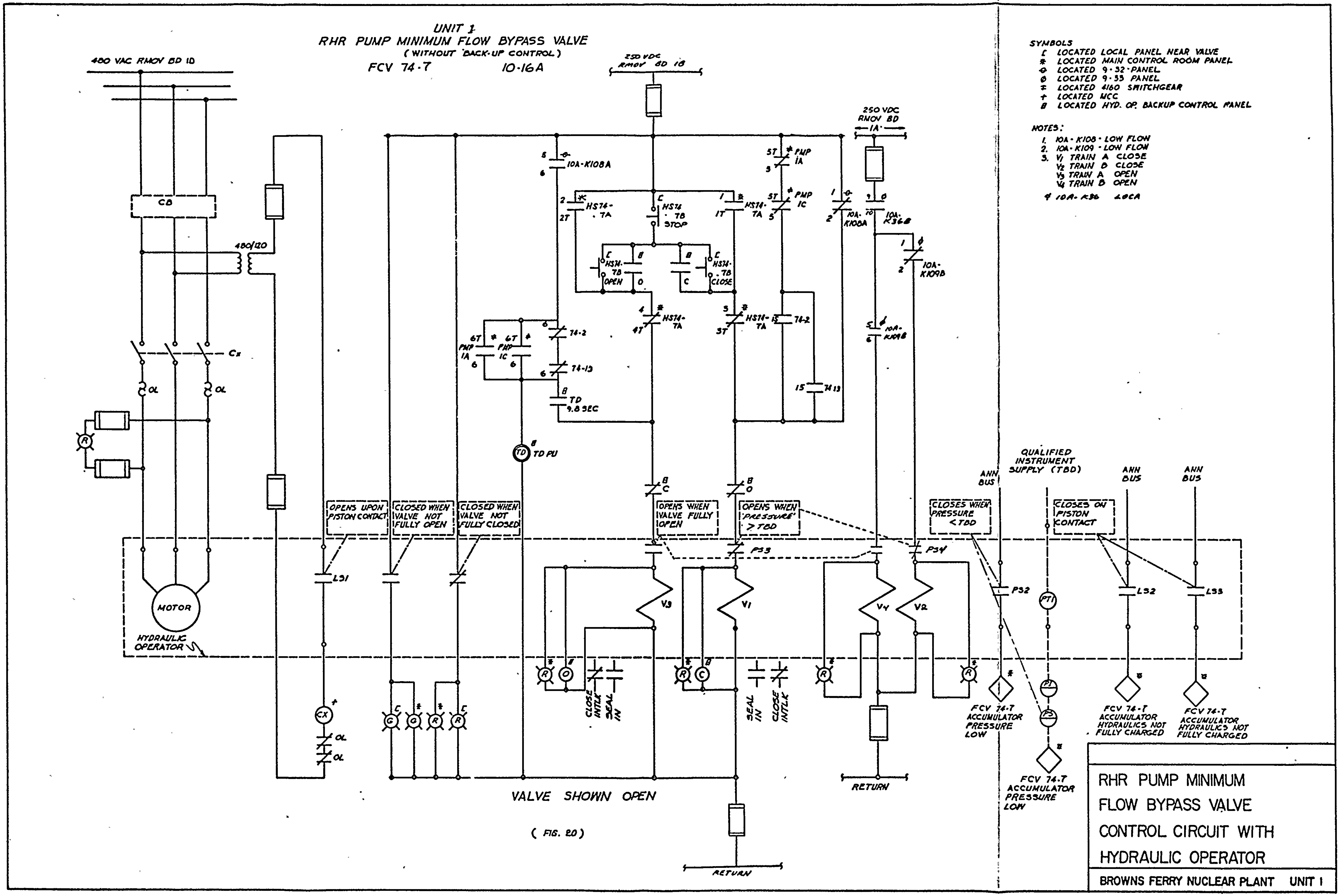
BROWNS FERRY NUCLEAR PLANT UNIT 1



RHR INBOARD INJECTION VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR

BROWNS FERRY NUCLEAR PLANT UNIT 1


UNIT 1
RHR INBOARD INJECTION VALVE
(WITH BACK-UP CONTROL)
FCV 74-67 (10-25B)
480VAC RMOV BD 1C
250 VDC RMOV BD 1A
250 VDC RMOV BD 1B
CB
480/120
CX
OL
HYDRAULIC OPERATOR
M
LS1
OPENS UPON PISTON CONTACT
CLOSED WHEN VALVE NOT FULLY OPEN
CLOSED WHEN VALVE NOT FULLY CLOSED
OPENS WHEN VALVE FULLY OPEN
OPENS WHEN PRESSURE > TBD
CLOSES ON PRESSURE < TBD
CLOSES ON PISTON CONTACT
QUALIFIED INSTRUMENT SUPPLY (TBD)
ANN BUS
PS4
PS3
PS2
LS2
LS3
V4
V2
V3
V1
NOTE 5
CLOSE INTLK.
SEAL IN
OPEN INTLK
RETURN
FCV 74-67 ACCUMULATOR PRESSURE LOW
FCV 74-67 ACCUMULATOR HYDRAULICS NOT FULLY CHARGED
VALVE SHOWN CLOSED
(FIG. 19)
SYMBOLS:
L LOCATED LOCAL PANEL NEAR VALVE
* LOCATED MAIN CONTROL ROOM PANEL
LOCATED 9-32 PANEL
LOCATED 9-33 PANEL
LOCATED 4160 SWITCHGEAR
+ LOCATED MCC
B LOCATED HYD OP BACKUP CONTROL PANEL
NOTES:
1. XS74-67 BACKUP CONTROL TRANSFER ALARMS IN CONTROL ROOM IN EMERGENCY POSITION.
2. 10A-K66 - LOCA + RX PRESSURE PERMISSIVE.
3. 10A-K63 - PCIS + RX LOW PRESS
4. V1- TRAIN A CLOSE
V2- TRAIN B CLOSE
V3- TRAIN A OPEN
V4- TRAIN B OPEN
5. OPERATING INSTRUCTIONS WILL REQUIRE REMOVAL OF THESE FUSES (2) DURING OPERATION IN BACKUP CONTROL MODE.
6 10A-K27, 10A-K99 TEST
RHR INBOARD INJECTION VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR
BROWNS FERRY NUCLEAR PLANT UNIT 1

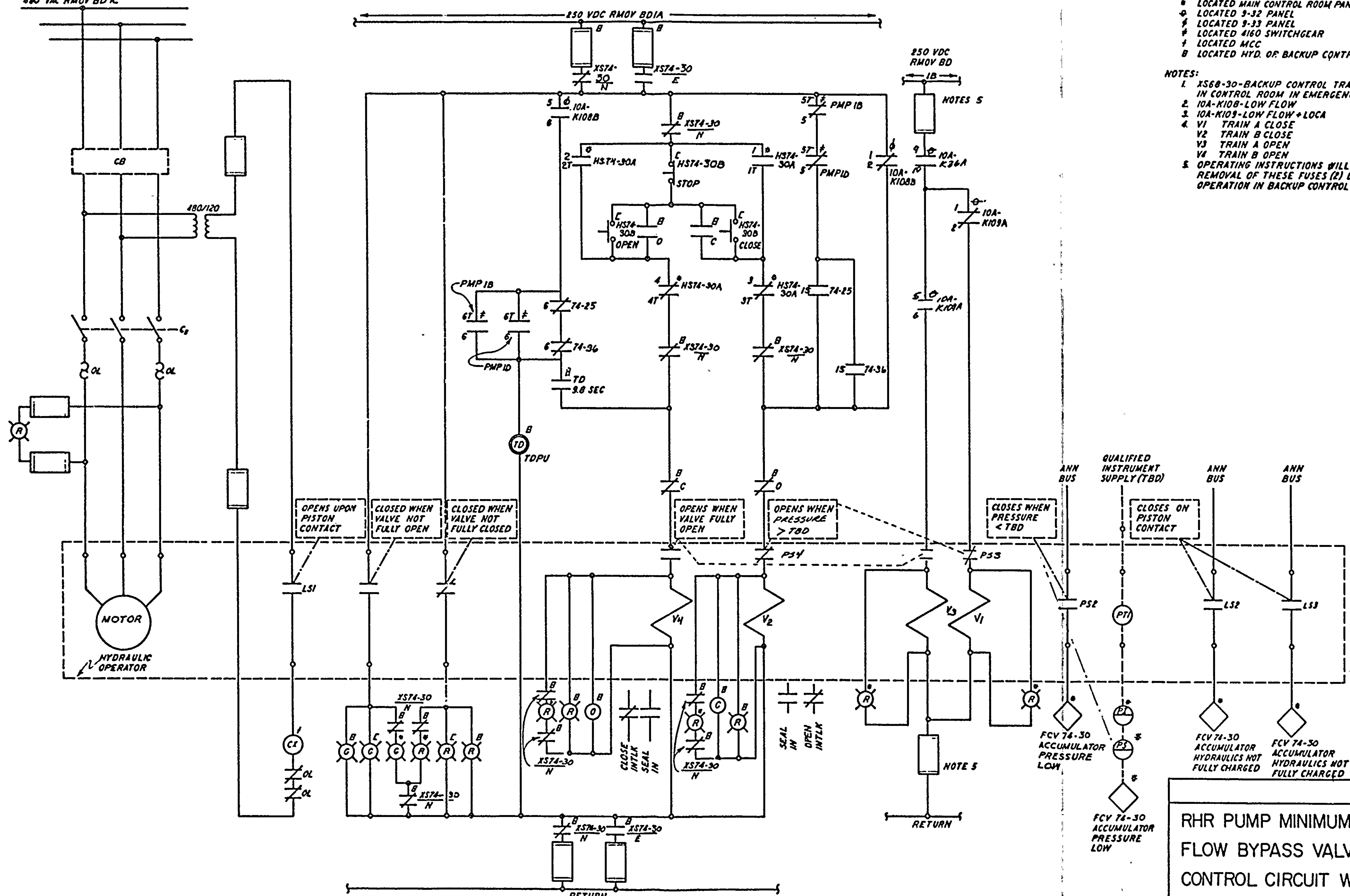

UNIT 1
RHR PUMP MINIMUN FLOW BYPASS VALVE
(WITHOUT BACK-UP CONTROL)
FCV 74-7
10-16A
480 VAC RMOV BD 1D
250 VDC RMOV BD 1B
250 VDC RMOV BD 1A
CB
480/120
Cx
OL
MOTOR
HYDRAULIC OPERATOR
10A-K108A
HS74-7A
HS74-7B STOP
HS74-7B OPEN
HS74-7B CLOSE
PMP 1A
PMP 1C
74-2
74-13
TD 9.8 SEC
TD PU
10A-K36B
10A-K109B
OPENS UPON PISTON CONTACT
CLOSED WHEN VALVE NOT FULLY OPEN
CLOSED WHEN VALVE NOT FULLY CLOSED
OPENS WHEN VALVE FULLY OPEN
OPENS WHEN 'PRESSURE' > TBD
CLOSES WHEN PRESSURE < TBD
CLOSES ON PISTON CONTACT
LS1
LS2
LS3
PS2
PS3
PS4
V1
V2
V3
V4
CLOSE INTLK
SEAL IN
ANN BUS
QUALIFIED INSTRUMENT SUPPLY (TBD)
FCV 74-7 ACCUMULATOR PRESSURE LOW
FCV 74-7 ACCUMULATOR HYDRAULICS NOT FULLY CHARGED
RETURN
VALVE SHOWN OPEN
SYMBOLS
L LOCATED LOCAL PANEL NEAR VALVE
* LOCATED MAIN CONTROL ROOM PANEL
LOCATED 9-32 PANEL
LOCATED 9-33 PANEL
LOCATED 4160 SWITCHGEAR
+ LOCATED MCC
B LOCATED HYD. OP. BACKUP CONTROL PANEL
NOTES:
1. 10A-K108 - LOW FLOW
2. 10A-K109 - LOW FLOW
3. V1 TRAIN A CLOSE
V2 TRAIN B CLOSE
V3 TRAIN A OPEN
V4 TRAIN B OPEN
4 10A-K36 LOCA
RHR PUMP MINIMUM FLOW BYPASS VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR
BROWNS FERRY NUCLEAR PLANT UNIT 1
(FIG. 20)

UNIT I

RHR PUMP MINIMUM FLOW BYPASS VALVE
(WITH BACK-UP CONTROL)
FCV 74-30   10-16B

SYMBOLS:
- C LOCATED LOCAL PANEL NEAR VALVE
- • LOCATED MAIN CONTROL ROOM PANEL
- ◊ LOCATED 9-32 PANEL
- ∮ LOCATED 9-33 PANEL
- ‡ LOCATED 4160 SWITCHGEAR
- † LOCATED MCC
- B LOCATED HYD. OP. BACKUP CONTROL PANEL

NOTES:
1. XS68-30-BACKUP CONTROL TRANSFER ALARMS IN CONTROL ROOM IN EMERGENCY POSITION
2. 10A-K108-LOW FLOW
3. 10A-K109-LOW FLOW + LOCA
4. V1 TRAIN A CLOSE
   V2 TRAIN B CLOSE
   V3 TRAIN A OPEN
   V4 TRAIN B OPEN
5. OPERATING INSTRUCTIONS WILL REQUIRE REMOVAL OF THESE FUSES (2) DURING OPERATION IN BACKUP CONTROL MODE.



VALVE SHOWN OPEN

(FIG 21)

RHR PUMP MINIMUM FLOW BYPASS VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR

BROWNS FERRY NUCLEAR PLANT UNIT I

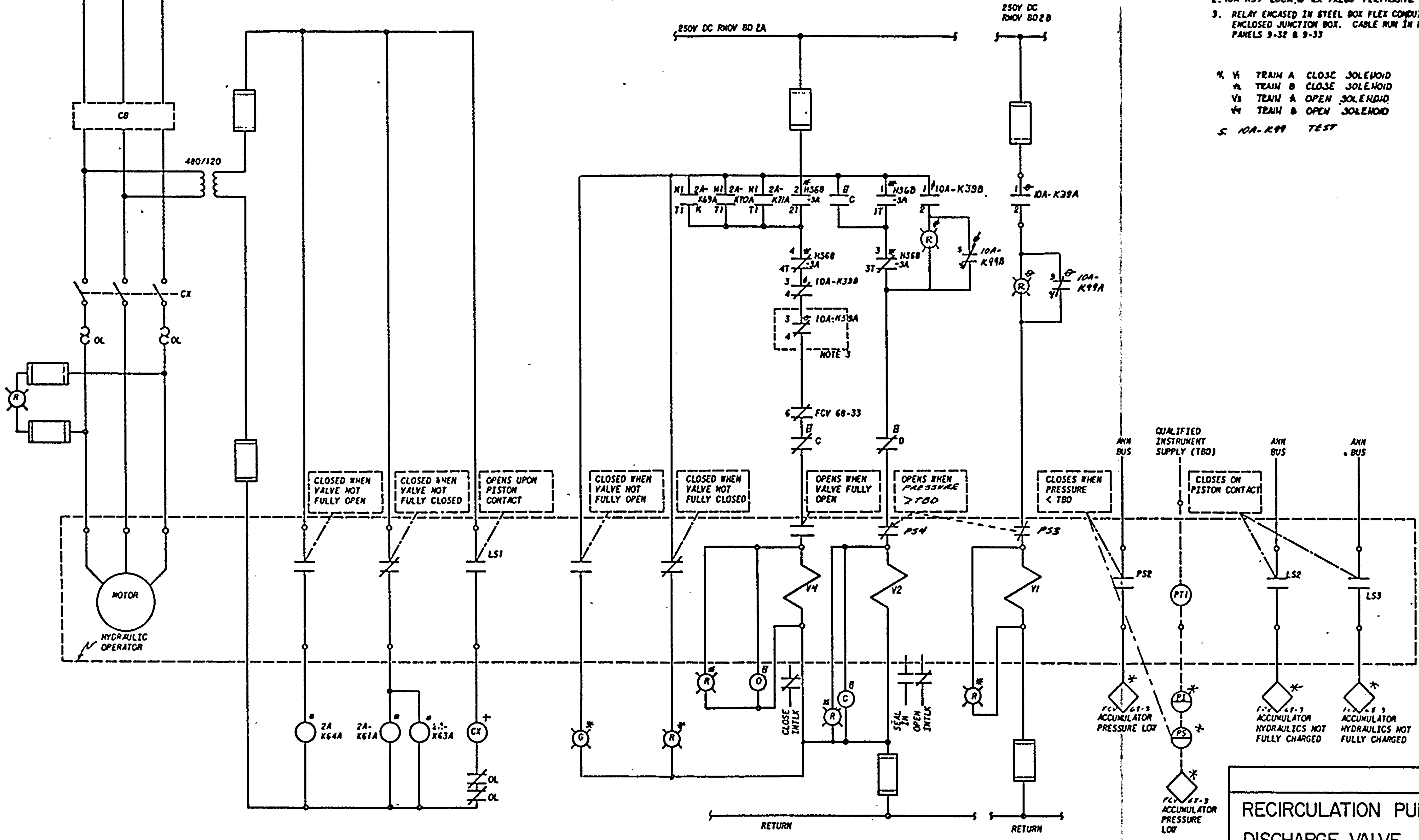
UNIT 2
RECIRCULATION PUMP DISCHARGE VALVE
(WITHOUT BACK-UP CONTROL)
FCV 68-3 (2-53A)

SYMBOLS:
- LOCATED LOCAL PANEL
- LOCATED MAIN CONTROL ROOM PANEL
- LOCATED 9-32 PANEL
- LOCATED 9-33 PANEL
- LOCATED 9-21 PANEL
- LOCATED HYD. OP BACKUP CONTROL PANEL.

NOTES:
1. 2A-K61, K63, K64, K71, K70, K69-JOGGING CIRCUIT.
2. 10A-K39 LOCAL & EX PRESS PERMISSIVE
3. RELAY ENCASED IN STEEL BOX FLEX CONDUIT FROM CONTACTS TO ENCLOSED JUNCTION BOX. CABLE RUN IN FLEX CONDUIT BETWEEN PANELS 9-32 & 9-33

V1 TRAIN A CLOSE SOLENOID
V2 TRAIN B CLOSE SOLENOID
V3 TRAIN A OPEN SOLENOID
V4 TRAIN B OPEN SOLENOID

5. 10A-K99 TEST

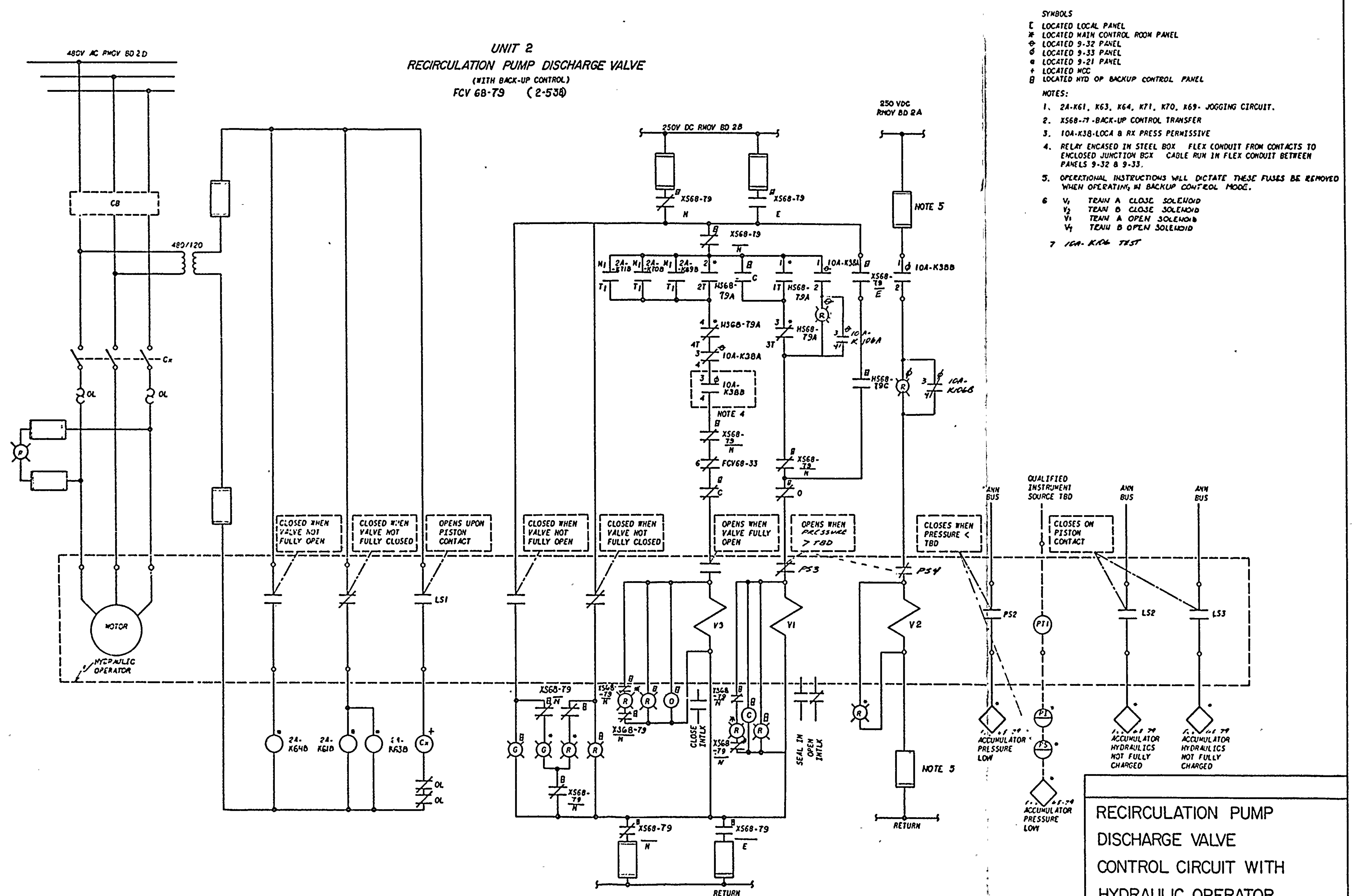


VALVE SHOWN OPEN

(FIG. 22)

RECIRCULATION PUMP DISCHARGE VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR

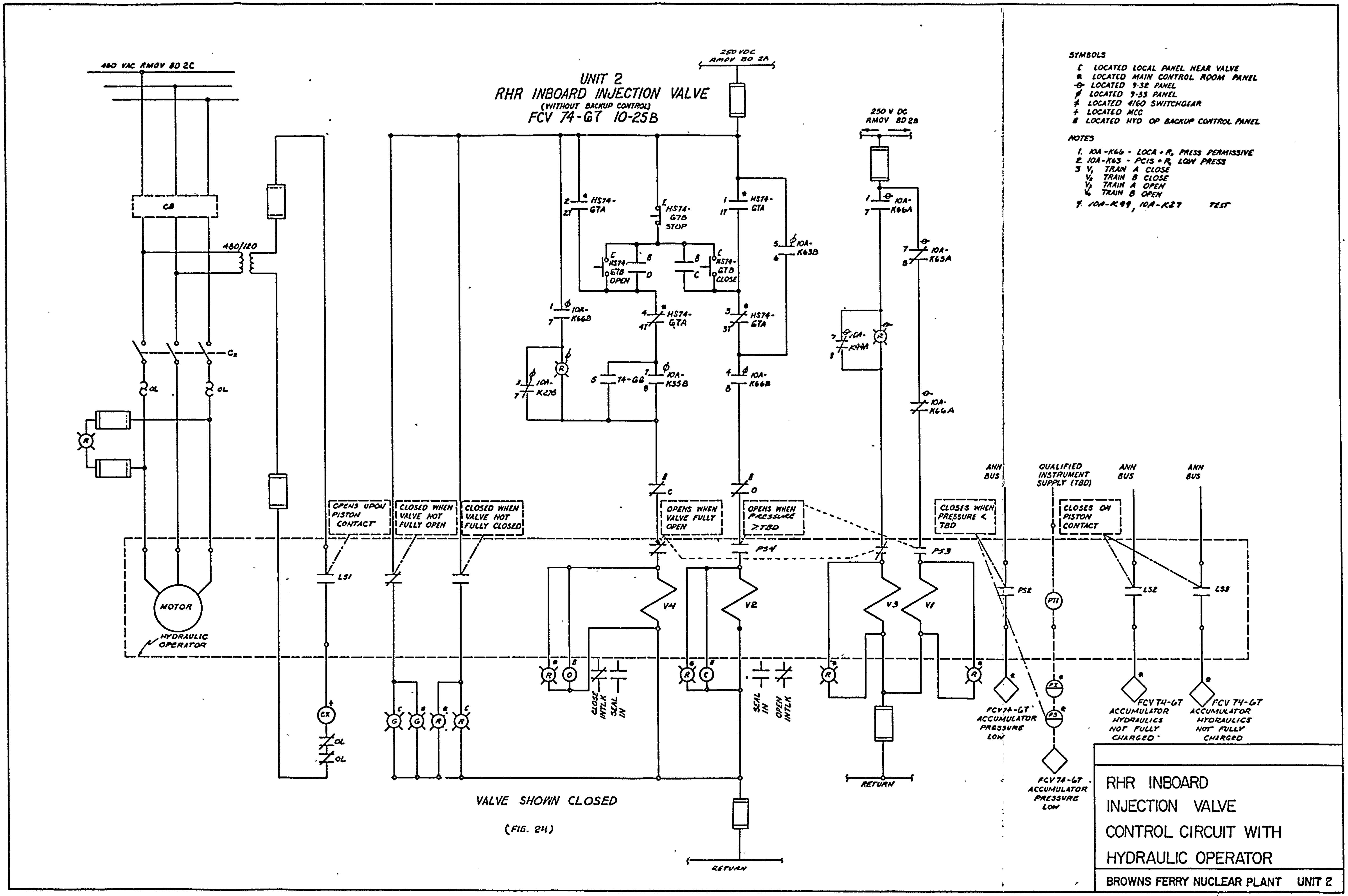
BROWNS FERRY NUCLEAR PLANT UNIT 2



VALVE SHOWN OPEN
(FIG. 23)

RECIRCULATION PUMP DISCHARGE VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR

BROWNS FERRY NUCLEAR PLANT UNIT 2

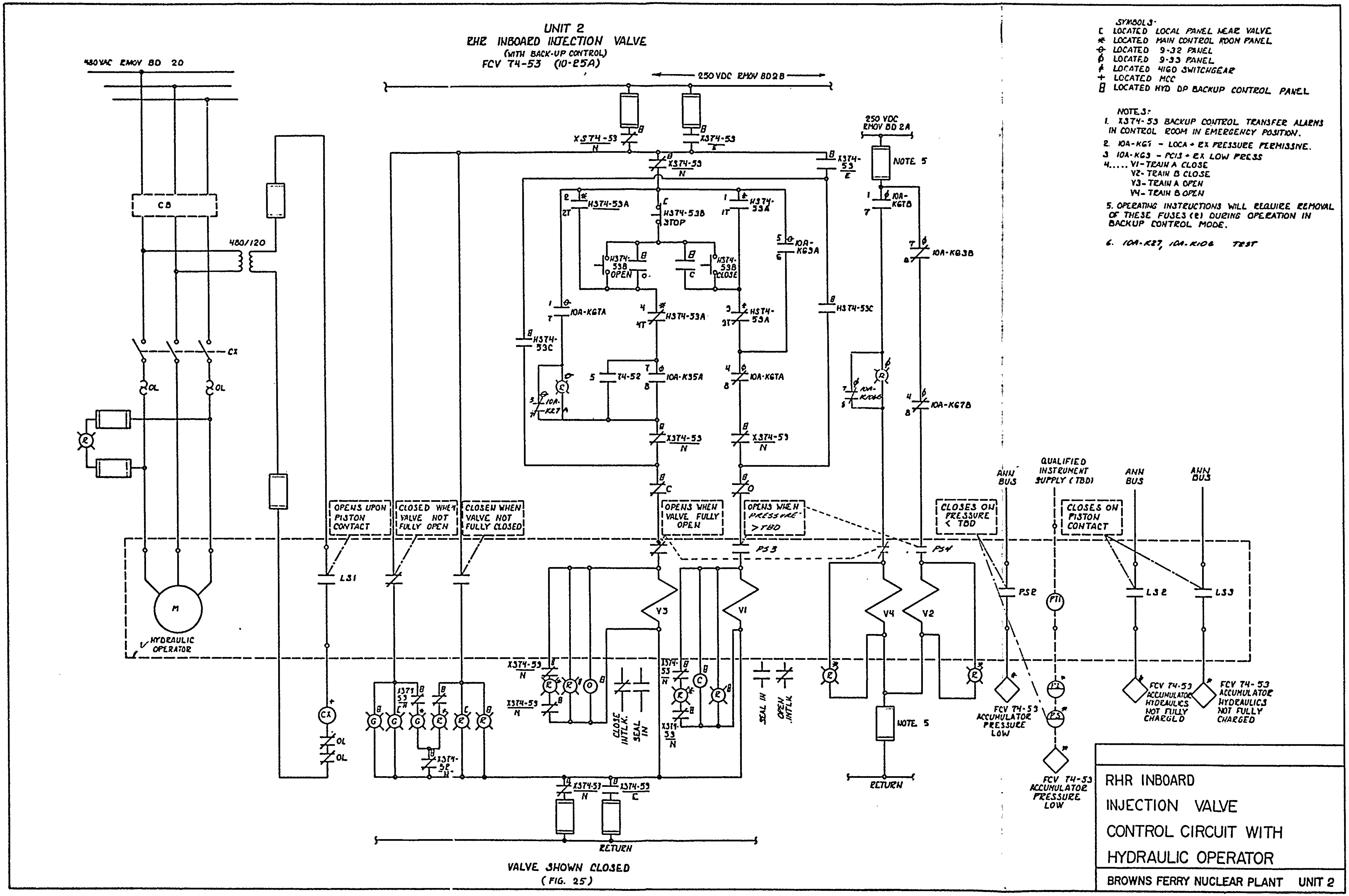


VALVE SHOWN CLOSED

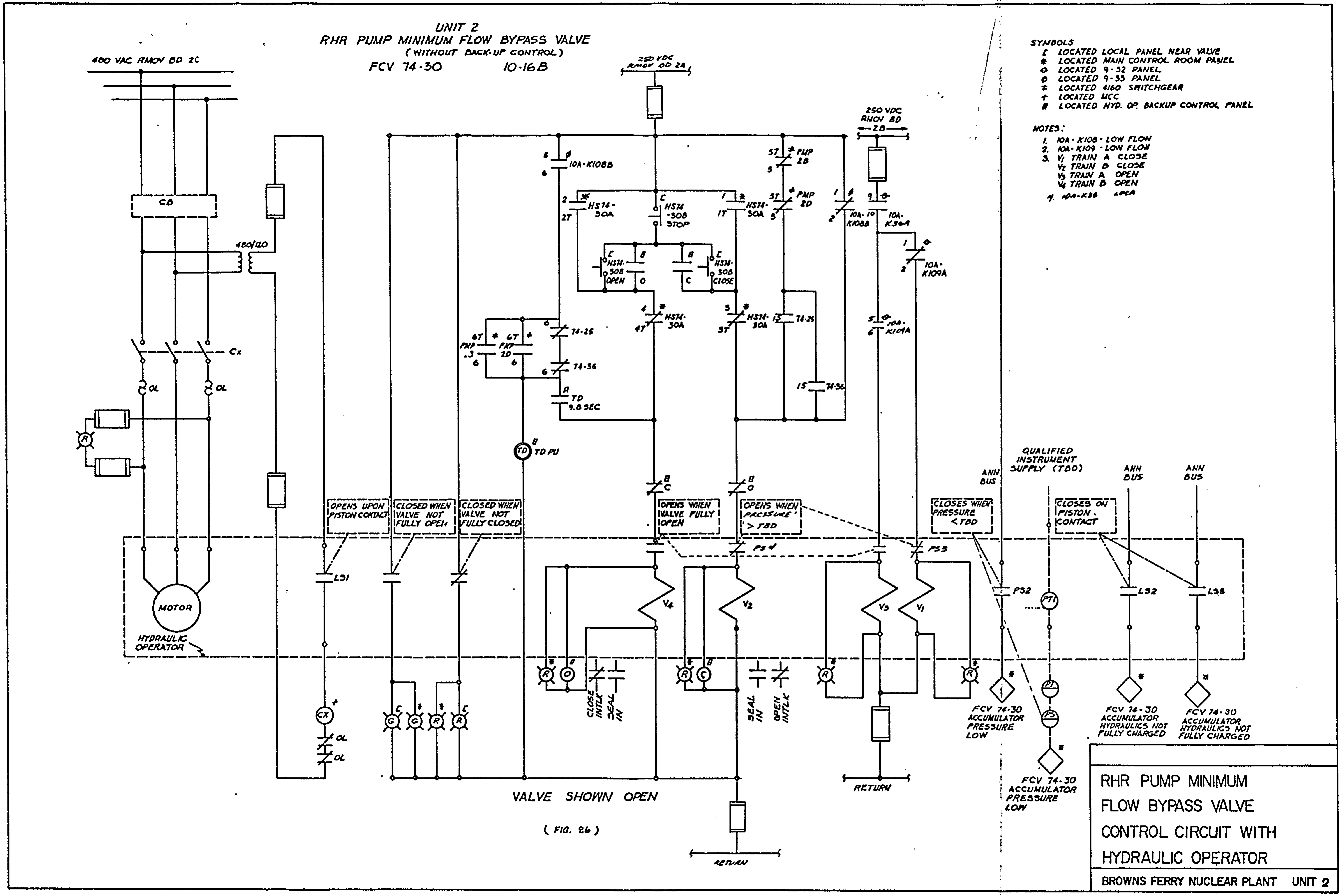
(FIG. 24)

RHR INBOARD INJECTION VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR

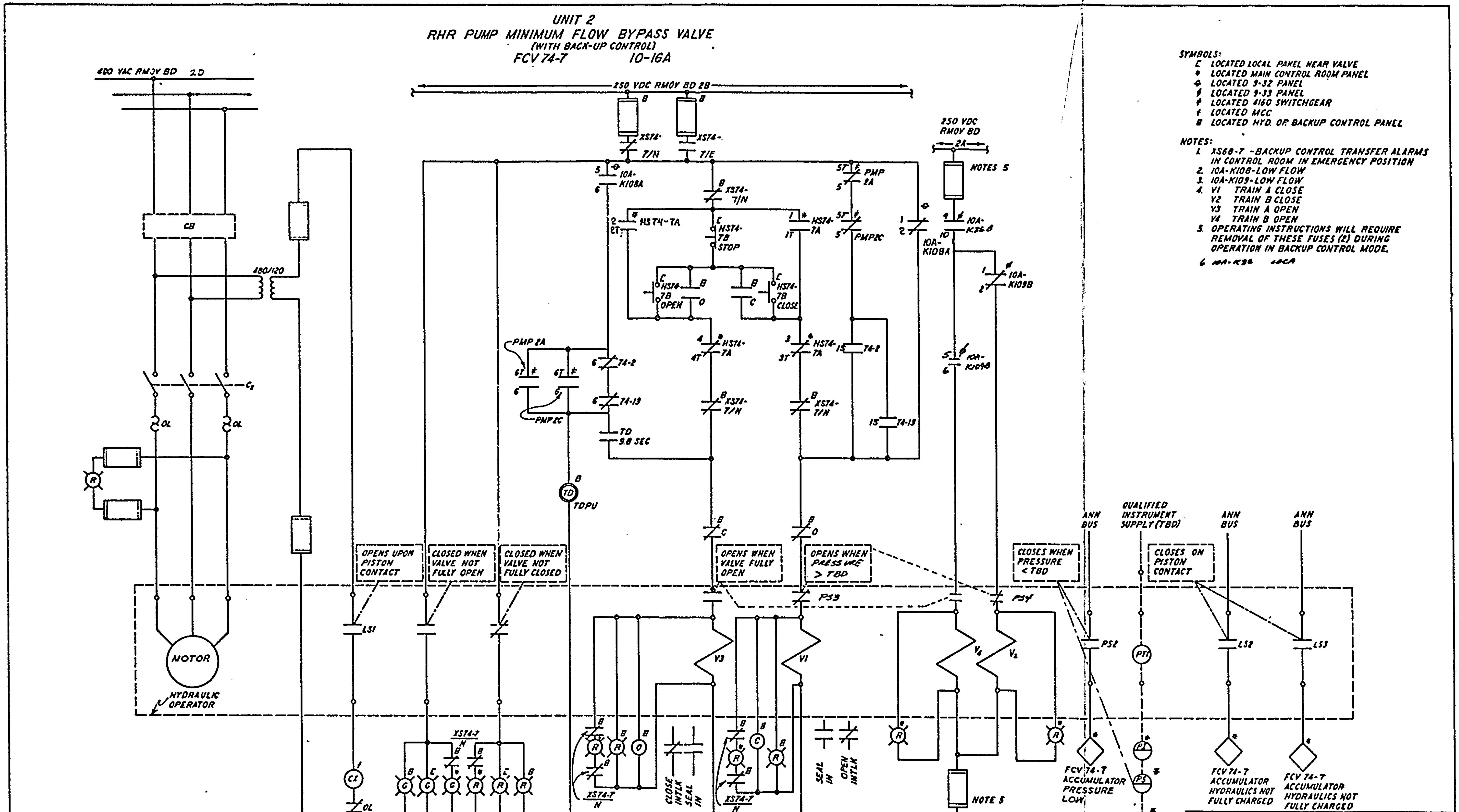
BROWNS FERRY NUCLEAR PLANT UNIT 2



UNIT 2
RHR INBOARD INJECTION VALVE
(WITH BACK-UP CONTROL)
FCV 74-53 (10-25A)
480 VAC RMOV 8D 2D
250 VDC RMOV 8D2B
250 VDC RMOV 8D 2A
CB
480/120
CX
OL
HYDRAULIC OPERATOR
LS1
OPENS UPON PISTON CONTACT
CLOSED WHEN VALVE NOT FULLY OPEN
CLOSED WHEN VALVE NOT FULLY CLOSED
OPENS WHEN VALVE FULLY OPEN
OPENS WHEN PRESSURE > TBD
CLOSES ON PRESSURE < TBD
CLOSES ON PISTON CONTACT
QUALIFIED INSTRUMENT SUPPLY (TBD)
ANN BUS
PS3
PS4
PS2
LS2
LS3
V1
V2
V3
V4
NOTE 5
RETURN
SEAL IN
OPEN INTLK.
CLOSE INTLK.
FCV 74-53 ACCUMULATOR PRESSURE LOW
FCV 74-53 ACCUMULATOR HYDRAULICS NOT FULLY CHARGED
VALVE SHOWN CLOSED
(FIG. 25)
SYMBOLS:
C LOCATED LOCAL PANEL NEAR VALVE
* LOCATED MAIN CONTROL ROOM PANEL
⊖ LOCATED 9-32 PANEL
ϕ LOCATED 9-33 PANEL
‡ LOCATED 4160 SWITCHGEAR
+ LOCATED MCC
B LOCATED HYD OP BACKUP CONTROL PANEL
NOTES:
1. XS74-53 BACKUP CONTROL TRANSFER ALARMS IN CONTROL ROOM IN EMERGENCY POSITION.
2. 10A-K67 - LOCA + RX PRESSURE PERMISSIVE.
3. 10A-K63 - PCIS + RX LOW PRESS
4.... V1-TRAIN A CLOSE
V2-TRAIN B CLOSE
V3-TRAIN A OPEN
V4-TRAIN B OPEN
5. OPERATING INSTRUCTIONS WILL REQUIRE REMOVAL OF THESE FUSES (2) DURING OPERATION IN BACKUP CONTROL MODE.
6. 10A-K27, 10A-K106 TEST
RHR INBOARD INJECTION VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR
BROWNS FERRY NUCLEAR PLANT UNIT 2


UNIT 2
RHR PUMP MINIMUN FLOW BYPASS VALVE
(WITHOUT BACK-UP CONTROL)
FCV 74-30
10-16B
480 VAC RMOV BD 2C
250 VDC RMOV BD 2A
250 VDC RMOV BD 2B
CB
480/120
Cx
OL
MOTOR
HYDRAULIC OPERATOR
10A-K108B
HS74-30A
HS74-30B STOP
HS74-30B OPEN
HS74-30B CLOSE
PMP 2B
PMP 2D
74-25
74-36
TD 9.8 SEC
TD PU
10A-K36A
10A-K109A
OPENS UPON PISTON CONTACT
CLOSED WHEN VALVE NOT FULLY OPEN
CLOSED WHEN VALVE NOT FULLY CLOSED
OPENS WHEN VALVE FULLY OPEN
OPENS WHEN PRESSURE > TBD
CLOSES WHEN PRESSURE < TBD
CLOSES ON PISTON CONTACT
LS1
PS4
PS3
PS2
LS2
LS3
PT
V1
V2
V3
V4
ANN BUS
QUALIFIED INSTRUMENT SUPPLY (TBD)
CLOSE INTLK
SEAL IN
OPEN INTLK
RETURN
FCV 74-30 ACCUMULATOR PRESSURE LOW
FCV 74-30 ACCUMULATOR HYDRAULICS NOT FULLY CHARGED
VALVE SHOWN OPEN
SYMBOLS
C LOCATED LOCAL PANEL NEAR VALVE
* LOCATED MAIN CONTROL ROOM PANEL
LOCATED 9-32 PANEL
LOCATED 9-33 PANEL
LOCATED 4160 SWITCHGEAR
+ LOCATED MCC
# LOCATED HYD. OP. BACKUP CONTROL PANEL
NOTES:
1. 10A-K108 - LOW FLOW
2. 10A-K109 - LOW FLOW
3. V1 TRAIN A CLOSE
V2 TRAIN B CLOSE
V3 TRAIN A OPEN
V4 TRAIN B OPEN
4. 10A-K36 ADCA
RHR PUMP MINIMUM FLOW BYPASS VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR
BROWNS FERRY NUCLEAR PLANT UNIT 2

(FIG. 26)



RHR PUMP MINIMUM FLOW BYPASS VALVE CONTROL CIRCUIT WITH HYDRAULIC OPERATOR

BROWNS FERRY NUCLEAR PLANT UNIT 2

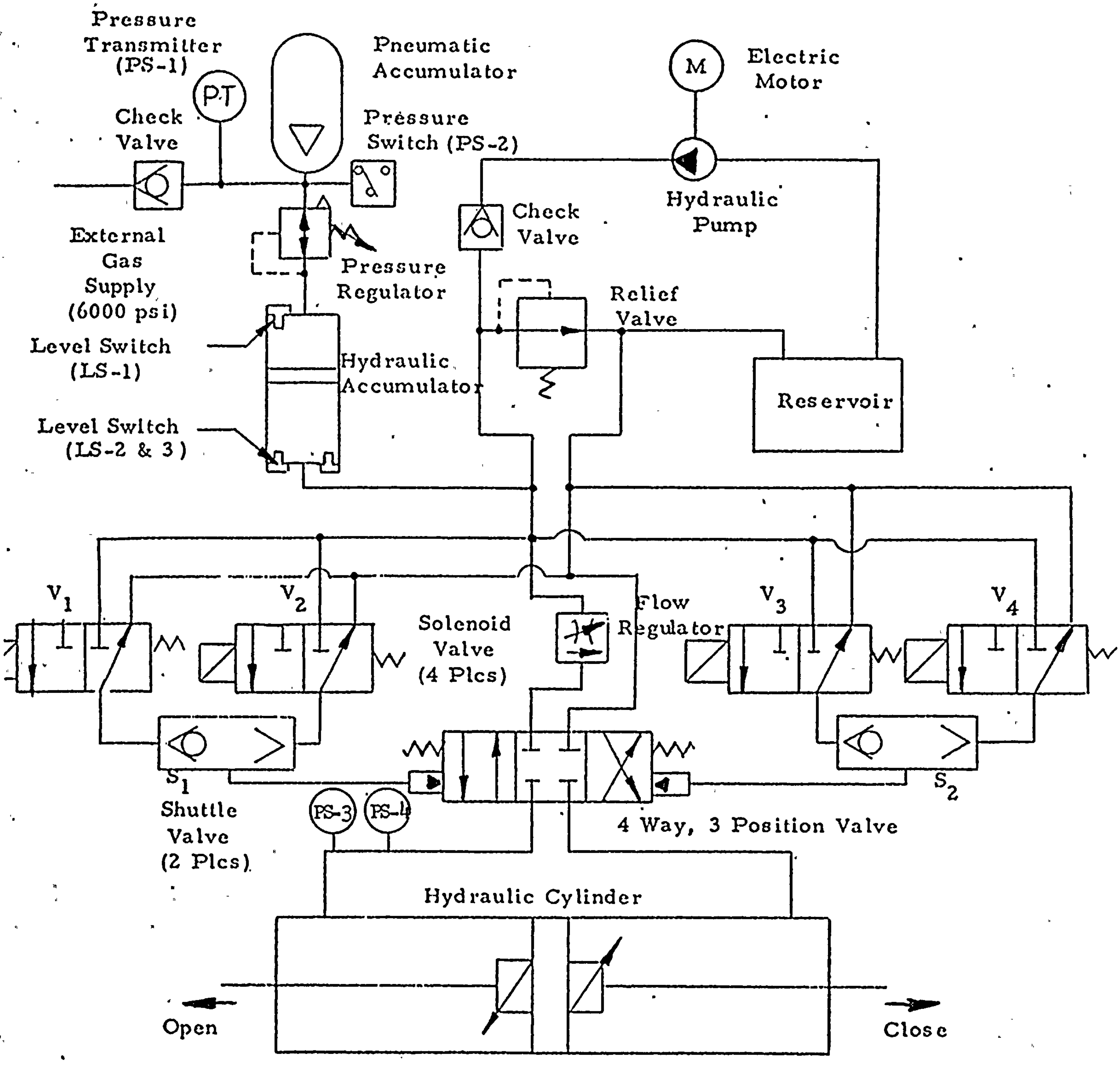


Figure 28 Typical Schematic For Hydraulic - Pneumatic Operator