APPENDIX A

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

NRC Inspection Report: 50-313/89-35 50-368/89-35 Operating License: DPR-51 NPF-6

Docket: 50-313; 50-368

Licensee: Arkansas Power & Light Company (AP&L)
P.O. Box 551
Little Rock, Arkansas 72203

Facility: Arkansas Nuclear One (ANO), Units 1 and 2

Inspection At: Russellville, Arkansas

Inspection Conducted: September 18-22, 1989

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Inspection Summary

Inspection Conducted September 18-22, 1989,(Report 50-313/89-35; 50-368/89-35)

Areas Inspected: Reactive, unannounced inspection to obtain an indepth understanding of the extent, safety significance, and licensee's corrective actions pertaining to the control wiring configuration discrepancies identified by an NRC Diagnostic Evaluation Team during the inspection conducted between August 18 and September 15, 1989.

Results: Three apparent violations of NRC regulations were identified. The first violation (identified in paragraph 2) involved noncompliance with Unit 1 Technical Specification 3.3.1.(c). Since initial startup of Unit 1 in 1974, the unit was operated with two of the three service water pumps not fully operable. The controls for Pumps P4A and P4C contained an unidentified set of contacts (that were supposed to have been removed during startup testing) which could have prevented the pumps from restarting during certain accident conditions. As such, this issue was considered by the NRC as safety significant. The second violation (identified in paragraph 3) involved the failure to maintain fiberglass sleeving for separation in accordance with the installation drawings.

The third violation (identified in paragraph 3) involved failure to take timely and appropriate corrective action subsequent to the licensee's discovery of wiring errors in 4160 and 6900 VAC switchgear panels during Unit 1 and Unit 2 outages in 1988. Although the small number of potential operational problems were formally documented and corrected, the large number of minor discrepancies and labeling errors were apparently not appropriately documented and acted upon by plant management until August/September 1989 when more such problems were found in the Unit 1 control room by the NRC Diagnostic Team.

The team considered corrective actions taken as a result of this latest discovery to be appropriate, however, it was not established as of the issuance of this report as to when the licensee intended to have all safety-related panels in compliance with the design documentation (wiring diagrams and schematics).

Upon observing a number of lifted leads in control room panels which were not clearly identified as "spares," the team reviewed the licensee's programs to assure the proper termination of lifted leads. Weaknesses were found as described in paragraph 4.a of this report. The licensee promptly implemented interim measures to reduce the possibility of lifted lead problems and committed to revisit the program in the near future. This action appeared adequate.

The team noted that the licensee had plant modification programs with excellent controls over system design configuration and that compliance with the programs would probably prevent future losses of configuration control.

DETAILS

1. Persons Contacted

*N. S. Carns, Director, Nuclear Operations
*L. W. Humphrey, General Manager, Nuclear Quality
*R. A. French, Plant Manager, Unit 2
*A. J. Wrape, III, Manager, EE/I&C Design
*B. M. Durst, Project Engineering Superintendent
*G. A. Parks, Quality Control Supervisor
*J. J. Fisicaro, Manager, Licensing
*J. H. Mueller, Manager, Central Support
*D. C. Mims, Plant Engineering Superintendent
*R. D. Lane, Manager, Engineering
*J. D. Jacks, Nuclear Safety & Licensing Specialist
*B. E. Williams, Plant Engineering Supervisor
*D. N. McKenney, Plant Engineer
*C. W. Taylor, Nuclear Safety & Licensing Specialist
K. L. Coates, Maintenance Manager, Unit 1
L. A. Taylor, Licensing Specialist
R. A. Sessoms, Manager, Central Support
G. T. Jones, Engineering General Manager
J. G. Waxenfelter, Maintenance Manager, Unit 2
D. D. Gregory, Planning and Scheduling Supervisor

*Present at exit interview.

In addition to the above personnel, the NRC inspectors held discussions with various operations, engineering, technical support, maintenance, and administrative members of the licensee staff.

2. Service Water Pump Control Circuit Deficiencies

On September 12, 1989, while performing a sampling inspection of as-built wiring connections in Unit 1 Control Room Panel C18, the NRC Diagnostic Evaluation Team identified discrepancies between the as-built wiring configuration of the control circuits for Service Water Pump P4A (Breaker A302) and the applicable wiring diagram. Panel C18 is a Division 1 Engineered Safety Feature (ESF) cabinet. The specific types of deficiencies were as follows:

- Wires were found terminated at locations where no connections were shown to exist on the internal connection diagram.
- Wires shown on the internal connection diagram were found to be missing.
- Labeling of termination points differed from that shown on the internal connection diagram; electrical connections were found at

locations different than specified on the internal connection diagram.

° Electrical jumpers were found to be installed but were not shown on the internal connection diagram.

Upon discovery of the wiring discrepancies, the licensee physically traced the affected circuits to determine the actual installed circuit configuration. The installed configuration was then compared to the electrical schematic diagram drawing showing the control circuits for Breaker A302. All differences were identified, and the effect of the differences on circuit operation was analyzed. The schematic diagrams were considered by the licensee to be the top level documents that accurately reflected the plant design and installation. The licensee's review identified an extra set of relay contacts wired into the control circuit for Breaker A302. The relay would have been energized on an ESF signal (high containment pressure or low reactor coolant system pressure). The contacts were not shown on the electrical schematic diagram and should not have been wired into the circuit. The licensee initiated Condition Report CR-1-89-481, describing the extra contacts. The condition report operability assessment and the subsequent independent operability evaluation concluded that the extra contacts had no effect on operation of Service Water Pump P4A.

On September 13, 1989, a review of the control circuits for the remaining service water pump motor feeder breakers revealed that an identical wiring error existed in the control circuit for Service Water Pump P4C (Breaker A402). The licensee issued a second condition report (CR-1-89-484). The operability assessment for this condition report was performed by a third engineer who identified a scenario in which the extra contacts would have prevented the circuit from performing its intended safety function. Under plant conditions where: (1) an ESF signal would be generated (resulting in a reactor trip and turbine-generator trip); (2) offsite power remained available; and (3) if a fast transfer (approximately 6 cycles or 1/10 of a second) of plant safety-related loads from the unit auxiliary transformer to the startup transformer failed to occur, but a slow transfer (less than 2 seconds) did occur, the wiring error would have prevented the automatic restart of the affected service water pumps. The normally operating service water pumps would trip on undervoltage at their respective 4160 VAC buses if a fast transfer did not take place. Pump restart would be prevented because the extra contact in the breaker control circuits would have sealed in the circuit breaker anti-pump circuit, which was designed to lock out the breaker in the tripped position.

Power distribution to the service water pump motors and operation of the circuit breakers, including the anti-pump circuitry, are discussed in detail in Appendix B.

Upon discovery that the extra contacts in the breaker control circuits would prevent pump restart during the accident scenario described above, the licensee declared Pumps P4A and P4C inoperable. The third service water pump (P4B) remained operable; its breaker control circuits did not contain the extra contacts. The ANO-1 Technical Specifications (TS) contained a limiting condition for operation (LCO) that required the reactor to be in the hot shutdown condition within 36 hours if two out of the three service water pumps were not operable to provide redundant and independent flow paths. On September 15, 1989, the licensee removed the extra contacts and exited the LCO.

The licensee determined that the extra contacts had existed in the breaker control circuits since plant construction in 1974. Although Service Water Pump P4B was unaffected by the wiring error, only Pumps P4A and P4C were operating in the normal system lineup. P4B was a standby "swing pump" that could be powered from either electrical division and was used to replace Pumps P4A and P4C when they were taken out of service. If pumps P4A and P4C were in service when an ESF signal and slow transfer to offsite power occurred, neither pump would restart. The standby pump (P4B) would have to be manually started to reestablish service water flow. Under these conditions, a single failure of P4B would result in the loss of all service water. Restart of Pumps P4A and P4C could only be accomplished through nonroutine operator actions at the breaker cubicles in their respective switchgear rooms since the anti-pump circuit bypassed both the remote and local control switches.

The licensee attempted to reconstruct the series of revisions made to the schematic diagrams and wiring diagrams applicable to service water pump controls to determine the root cause of this problem. The results were complex and, in some instances, speculative. It was the team's understanding that the unwanted contacts were originally intended to start the service water pumps automatically upon receipt of an ESF signal. Through the evolutionary process of preoperational testing and schematic diagram revisions, the contacts were supposed to have been disconnected because the licensee considered that they were not needed to start already running pumps. The schematic was revised to show the contacts removed, but because the wiring diagram did not accurately reflect the as-built (i.e., the contacts for P4A and P4C appeared disconnected), the electrician was probably misled to believe the contacts were already removed from the control circuits for Service Water Pumps P4A and P4C, when in fact they were still installed.

Since initial plant operation in 1974, Service Water Pumps P4A and P4C appeared to have been incapable of performing their intended safety function given an ESF signal occurring in conjunction with a slow transfer of safety-related loads to the startup transformer. Although this scenario has not occurred at ANO-1, successful completion of slow transfers following failures to fast transfer have been experienced. The wiring problems were not detected during periodic routine surveillance testing because the test conditions did not include simulation of an ESF signal in conjunction with a slow transfer. Consequently, two of the three service water pumps were not fully operable as required by ANO-1 TS 3.3.1.(c) since initial startup. This is an apparent violation of

NRC regulations and will be the subject of discussion at the enforcement conference referred to in the letter transmitting this inspection report.

NRC Information Notice 88-75, Supplement 1, "Disabling Diesel Generator Output Circuit Breakers by Anti-Pump Circuitry," (dated April 17, 1989) discussed design problems where circuit breakers for safety-related equipment have been locked out in the tripped condition by unwanted actuation of anti-pump circuitry and the importance of carefully analyzing all differences between plant conditions during testing and conditions that could exist when the equipment under test is required to perform its safety function in order to verify the acceptability of the test. The analysis is necessary whenever complete system integrated testing cannot be performed under actual conditions.

On September 16, 1989, a second error affecting Unit 1 service water system wiring was identified in ESF Cabinet C-18. An unterminated wire was found that resulted in inoperability of a "Service Water Pump Trip" annunciator in the control room. The loose wire disabled inputs to the annunciator from Service Water Pump P4A, and also from Service Water Pump P4B, when it was aligned to receive power from 4160 VAC Bus A3. The length of time that the annunciator was inoperable was unknown. The control room annunciators were not designed as safety-related equipment. The safety significance of the inoperable annunciator was that the operators would not have been immediately informed of changes in pump status that, in the absence of operator actions, could have led to the overheating of safety-related equipment cooled by the service water system. However, other information was available in the control room providing indication of a service water pump trip (e.g., service water loop pressure indication, SPDS diagnostic screen for the service water system, equipment temperature alarms, and pump run lights).

A review of the schematic and wiring diagrams for the affected annunciator revealed a discrepancy between the diagrams. One diagram identified the unterminated wire as a spare; the other diagram showed the wire to be terminated. The licensee initiated a "temporary modification" which quickly reterminated the wire to restore the alarm functions.

3. Review of Wiring Errors and Corrective Actions

Following the discovery of wiring errors, which reduced the ability of Service Water Pumps P4A and P4C to perform their safety function during certain accident scenarios, the licensee developed an inspection plan to determine the extent of wiring problems at ANO-1 and ANO-2. The inspection plan consisted of three phases. Each phase involved comparison of as-built installed wiring to the corresponding schematic and wiring diagrams to identify errors in either the as-built plant wiring or the diagrams. The safety significance of the errors would then be evaluated. Final long-term corrective actions were to be determined based on the findings from each of the three phases.

Phase I of the inspection plan consisted of a review of the control circuits for all 4160 VAC circuit breakers similar in design to the service water pump breakers that were affected by the wiring error. In addition to the service water pumps for both ANO-1 and ANO-2, the licensee reviewed the breaker control circuits for the following automatically actuated safety-related equipment:

° Reactor Building Spray Pumps (Unit 1) and Containment Spray Pumps (Unit 2),

° Primary Makeup Pumps (Unit 1) and High Pressure Injection Pumps (Unit 2),

° Decay Heat Removal Pumps (Unit 1) and Low Pressure Injection Pumps (Unit 2),

° Motor Driven Emergency Feedwater Pump (Unit 1).

The Phase I review involved comparison of the as-built control circuits to the electrical schematic diagrams and the internal and external connection diagrams. The schematic diagrams showed the electrical interconnections between the individual components used to make up the control circuit for a given breaker. During plant construction for Unit 1, the schematic diagrams were more carefully controlled, revised, and maintained than the connection (wiring) diagrams. The schematic diagrams were considered the most accurate electrical drawings at ANO. The schematic diagram for a given circuit was referred to as a "scheme." For example, the control circuit for Breaker A302 is referred to as Scheme A302. The interface connections between wiring internal to the divisional ESF cabinets (located in the control room) and the external field wiring for a given scheme was typically contained on a single terminal strip mounted inside the ESF cabinet. On Unit 1, the terminal strip was numbered the same as the scheme (i.e., the wiring for Scheme A302 is found on Terminal Strip A302). The internal wiring (i.e., wiring inside the cabinet that was connected to individual components mounted within the cabinet such as relays, switches, annunciators, etc.) was terminated via crimped ring lug to screw connections to one side of the strip. The external wiring (i.e., wiring that left the cabinet going to other locations such as other control room cabinets, the breaker cubicles in the switchgear room, etc.) was similarly terminated to the other side of the strip. The internal wiring was shown on "internal connection diagrams," also referred to as "vendor prints," because the diagrams were originally supplied by the cabinet vendor that wired the cabinet prior to its shipment onsite. The vendor for the Unit 1 ESF cabinets was Magnetics, Inc. The vendor prints were not well controlled during plant construction. The vendor prints were not always revised accurately or in a timely manner; the licensee relied almost exclusively on the schematic diagrams as the source of information for all activities involving plant circuit configurations. The external wiring was shown on "external connection diagrams," which were originally prepared by the plant architect engineer and constructor, Bechtel Corporation. The external connection diagrams were considered to be more accurate than the vendor prints but not as accurate as the schematic diagrams.

For each scheme reviewed in Phase I, the internal wiring was traced from the terminal strip to the individual components. The internal wiring was all red in Cabinet C18 (Division 1) and all green in Cabinet C16 (Division 2). Internal wires were labeled at each end (i.e., at both the terminal strip and the device). The labels designated the terminal strip and termination point to which the wire was connected. The internal wires were individually reviewed to determine if the labeling at each end was correct and if the wires were terminated at the proper locations. The wires were pull-checked by hand where possible to ensure that corresponding labels at each end were affixed to the same wire. In a few cases, wires were not pull-checked because their routing was difficult to follow and the licensee was concerned that physically moving the wires could affect plant operation. The Phase I review was conducted with both units at power.

All discrepancies between the actual (as-built) wiring and the vendor prints or schematic diagrams were documented. Similarly, the external wiring was reviewed, and all discrepancies between the actual wiring and the external connection diagrams or schematic diagrams were also documented. The external wiring left the cabinet via multi-conductor cables. Each conductor in a given cable was color coded. The external wiring was inspected to determine if the individual wires were terminated at the proper locations, and properly color coded, and that the labeling was correct.

The sampling inspection of cabinet wiring for the schemes in Phase I were performed by two teams. Each team included an instrumentation and control (I&C) technician and a system electrical engineer. The teams were accompanied by Quality Control (QC) personnel who independently monitored the walkdown activities. Technical support for evaluation of identified discrepancies was provided by plant licensing and engineering groups. The licensee indicated that over 20 people were involved in the Phase I review. During the circuit tracing process, the wiring diagrams were colored according to as-found conditions. The diagrams were marked with yellow highlighter as the wiring was reviewed. Red was used to indicate wires that were found installed but not shown on the diagrams; green was used to indicate wires shown on the diagrams that were found to have been deleted or not installed. Blue was used to indicate terminations that were electrically correct, but the as-found termination point differed from the termination point designated by the wiring diagram. All drawings were signed as verified by the engineers performing the inspections.

A total of 84 discrepancies were found between as-built wiring and the corresponding electrical diagrams during the Phase I review (47 at Unit 1 and 37 at Unit 2). Discrepancies were found on schematic diagrams, internal connection diagrams, and external connection diagrams. All discrepancies were documented and subsequently reviewed to determine the impact on the operability of the circuit. No operational or functional problems were identified as a result of the 84 discrepancies. The majority of the discrepancies were found during review of the vendor prints (73 total; 37 at Unit 1 and 36 at Unit 2). A total of four errors were found on the external connection diagrams (three at Unit 1), and seven errors were found on the schematic diagrams (all seven at Unit 1). Six of the seven schematic diagram errors involved conductors for a given cable not being listed in the proper sequence on the diagrams. The convention used at ANO listed the conductors in order based on their color coding. No unanticipated circuit operations or "sneak circuits" were discovered.

The licensee appeared satisfied that the Phase I results verified that the schematic diagrams were accurate. Approximately 40 percent of the errors identified during the vendor print inspections were wire labeling errors (i.e., the destination notation shown on the label physically attached to the wire was incorrect) or terminal strip termination point labeling errors. The licensee's recommended corrective action was to retag the mislabeled wires and termination strips to show the correct cable destinations and termination points. Approximately 60 percent of the errors identified during the vendor print walkdowns were drawing errors. The licensee's recommended corrective action was to revise the vendor prints as necessary to accurately reflect the as-built wiring installation. Typical drawing errors included items such as the following:

- Jumpers correctly installed but not shown on the vendor prints,

- Spare relay contacts incorrectly shown to be wired into the circuit, and

- Different relay contacts shown on the drawings than are used in the actual circuit.

The licensee provided the results of the completed Phase I review to the team. The team reviewed the Phase I results and conducted separate plant walkdowns of the as-built wiring for several schemes included in the licensee's Phase I review. The team found that drawings used by the licensee during their walkdowns accurately reflected the results. The team did not find any discrepancies that were not already documented by the licensee during the Phase I review. Based on the above, the team concluded that the licensee's Phase I inspections were as thorough and carefully performed as could be expected while the plant was at power. The team also concluded that the licensee's Phase I review was reasonable to provide an adequate level of assurance that breaker control circuit wiring problems, such as affected service water pump operability at ANO-1, would not exist in breaker control circuits of similar design used to automatically actuate safety-related equipment at ANO-1 and ANO-2.

Phase II of the licensee's inspection plan consisted of an expanded scope of inspections of control circuits for safety-related equipment to identify wiring errors and drawing discrepancies. The same methodology used in the Phase I review was applied to the Phase II review. The licensee performed comparisons of the as-built wiring configuration using the associated wiring diagrams; the diagrams were marked and all errors were documented for subsequent engineering evaluation, including comparison reviews against the schematic diagrams. The circuits traced in the Phase II review were associated with 86 individual schemes between Units 1 and 2. All circuits were located inside cabinets in the control rooms. The schemes included circuitry used to actuate motor operated valves, solenoid operated valves, fans, coolers, and auxiliary relays. Circuits reviewed were associated with a number of different systems, including the following:

° Core Flood Tanks,

° Emergency Feedwater System,

° Emergency Power Distribution,

° Primary Makeup and Safety Injection Systems,

° Reactor Coolant Pump Seals,

° Steam Generator Blowdown and Sampling,

° Decay Heat Removal System,

° Control Rod Drive Cooling, and

° Service Water System.

The results of the Phase II review were very similar to the results of Phase I. Numerous discrepancies were identified between the actual circuit installation and the corresponding diagrams. None of the discrepancies resulted in operability problems for safety-related equipment. All installed wiring reviewed during Phase II was verified to be electrically correct; no new failure modes or "sneak circuits" were identified. However, a total of 131 discrepancies were identified (78 at Unit 1 and 53 at Unit 2). Again, discrepancies were found on the schematic diagrams, external connection diagrams, and internal connection diagrams (vendor prints). Similar to Phase I, most of the Phase II discrepancies were associated with vendor prints (102 out of 131; 56 at Unit 1 and 46 at Unit 2), and consisted primarily of destination marking errors on the drawings. As was the case in Phase I, a number of labeling errors were found on installed wires and terminal blocks during Phase II. Labeling errors accounted for 35 out of 131 (or approximately 27 percent) of the discrepancies.

There were 17 errors identified during Phase II on schematic drawings (14 at Unit 1). The schematic drawings contained "cable block diagrams" that showed the cables routed between different locations containing components used in the circuit and listed the conductors (including spares) associated with the cables. The majority of the schematic drawing discrepancies were associated with these cable block diagrams. The cable block diagrams were a secondary function of the schematics and, as such, the errors were considered minor. Several errors were found in the circuit arrangement portion of the schematic diagrams (e.g., misnumbered handswitch contacts). The licensee also considered these errors to be minor and concluded that the Phase II results restored confidence in the accuracy of the schematic diagrams.

The licensee's recommended corrective actions for Phase II were to correct the labeling problems and to revise the drawings as necessary to eliminate the discrepancies between the drawings and the installed wiring. The team performed a review of Phase II, similar to Phase I, with similar results. It appeared that the licensee's comparisons were thorough and precise.

Phase III of the licensee's inspection plan consisted of additional inspections of wiring inside control room cabinets, and in local panels throughout the plant for Unit 1 only. Unit 2 was excluded because, within a few days, Unit 2 was to be shut down for the seventh refueling outage, after which more complete inspections could be conducted. The review methodology used in Phase III was the same as that used during the Phase I and Phase II reviews. The Phase III review had not been completed prior to completion of the team's activities onsite and, thus, the results of the Phase III review were not available.

The team performed an independent walkdown comparison of as-built wiring to the corresponding wiring diagrams for selected circuits, both inside control room cabinets and at local panels that had not been reviewed by the licensee. The control room circuits reviewed included circuits inside the reactor protection system cabinets for Unit 1. No discrepancies were identified between reactor protection system circuits and the associated diagrams. However, discrepancies were identified during the review of wiring internal to local panels and at the 480 VAC switchgear. The discrepancies were similar to those identified by the licensee during the Phase I and Phase II reviews. For example, in electrical equipment room Chiller VCH4A Control Panel C198, the following discrepancies were identified:

- Color coding of installed conductors did not match that shown on the wiring diagram,

- The actual labeling of terminal strip termination points differed from that shown on the wiring diagram,

- Three conductors were terminated to one termination point; there should have been a maximum of two,

- Installed jumpers were not shown on the wiring diagram, and

° Two wires were connected to points where only one wire was shown on the drawing.

It appeared that several of the discrepancies in C198 were associated with the multiplication of termination points that resulted from "daisy chained" power supply returns for a number of control relays mounted inside the panel. It did not appear that these discrepancies had any effect on circuit operation; however, a complete circuit evaluation using the schematic diagrams was not performed.

The team randomly selected electrical drawings of components which the licensee had inspected. The following Unit 2 (Control Room Panel 2C17) components were checked by the licensee and verified by the inspectors.

° HPI Pump "A"	Drawing M-2201-285-28
° LPI Pump "A"	Drawing M-2202-285-17
° Containment Spray Dump (2P35A)	Drawing M-2201-285-19
° Service Water Pump (2P4B)	Drawing M-2201-285-24
° Service Water Pump (2P4A)	Drawing M-2201-285-20

The results of the verification of the licensee inspection by the team indicated that the discrepancies were correctly identified. The team did not identify any different types of discrepancies than those already identified by the licensee.

In conjunction with the Unit 2 components mentioned above, the NRC inspector also verified the wiring scheme for the Unit 1 (Control Room Panel C16) components listed below:

° Reactor Building Spray Pump (P35A)

° Primary Makeup Pump (P36A)

° Primary Makeup Pump (P36B)

° Decay Heat Removal Pump (P34A)

The results of this inspection did not identify any additional significant wiring problems. Discrepancies such as labeling errors, drawing errors, and terminal board mislabeling were evident. The discrepancies identified were minor and did not appear to have any adverse effect on the operability of the components inspected.

Also, during the inspection of Control Room Panels C16 and C18, the team noted housekeeping was poor. The following concerns were identified by the team and discussed with the licensee:

- Terminal strip covers were found laying in the bottom of the cabinets even though Bechtel Drawing E-2054, Sheet 1 of 4, stated terminal strips should have covers.

- The fiberglass sleeving installed over several non-Class IE cables was torn and ragged. Bechtel Drawing E-2059 stated that fiberglass sleeving may be used in lieu of metal raceways or steel barrier plates where the distance between non-Class IE and Class IE wiring is less than 6 inches. In some cases, the fiberglass sleeving was torn to the extent that its purpose (to provide protection for redundant systems) was not being fulfilled. The failure to maintain the fiberglass sleeving in accordance with Drawing E-2059 is an apparent violation of Criterion V of Appendix B to 10 CFR Part 50.

- Tape, dust, trash, and lead flagging material (found attached to an Agastat Relay) were found inside the cabinets.

- Spare cable ends were not capped or taped.

- Terminal wires to Annunciator Panel C-07 were determinated with the lugs still on the terminals, thus making it difficult for anyone inspecting the cabinet to determine whether or not the determinated wires were supposed to be in that condition.

The team randomly selected various electrical panels not inspected by the licensee to verify whether similar as-built conditions existed. This sampling included Motor Control Centers (MCCs), chiller and unit cooler control panels, protection cabinets, and emergency diesel generator panels.

The results of this inspection indicated that:

- Housekeeping was better than that found in the control room panels.

- Spare cables were taped or capped. It was obvious that they were spares.

- As-built conditions of the cabinets were generally reflected in the drawings being used. There were minor exceptions similar to those found during the licensee's Phase I and Phase II inspections but to a lesser degree.

Prior to the licensee's implementation of Phase III inspections, the team questioned the licensee's focus on control room cabinets rather than including cabinets outside the control room. In response, the licensee indicated that while Phase III would be looking at such panels, detailed walkdowns of the 6900 and 4160 VAC switchgear were performed during the last outage for Units 1 and 2. Unit 1 was inspected in the September 1988 timeframe, and Unit 2 was inspected in the March 1988 timeframe. The team reviewed the results of those inspections and found that on Unit 1 60 cubicles were inspected involving approximately 95 drawings. The same nature of discrepancies (roughly 200) were found and were documented on the drawings as described above. Also, nine condition reports were issued for problems such as deficient crimps, incorrect wiring, jumpers missing, and improper terminations. These deficiencies were corrected prior to startup following the outage. On September 19, 1988, one wiring error was discovered in Unit 1 that could have prevented automatic start of High Pressure Injection Swing Pump P36B on an ESF actuation signal. The walkdown revealed that a wire in the as-built configuration was terminated on a different terminal than specified on the drawings. Subsequent investigation determined that an interlock between a pump power supply breaker and the associated motor operated disconnect in the proper feeder line was miswired and could have defeated the automatic start function of the pump. This was reported in LER 1-88-013.

In Unit 2, one wiring problem was identified and corrected before startup following the outage. Fifty-eight cubicles were inspected involving about 105 drawings, with roughly 250 discrepancies identified on the marked up drawings.

The team noted that the licensee did not formally document the many minor discrepancies found on both units such that proper management attention would be focused on the timeliness and extent of corrective actions. Consequently, the team was led to believe that roughly 450 documented discrepancies in the electrical plant were stored in an engineering file cabinet and were receiving little or no attention until resources became available to correct the drawings. There was no apparent priority. The results of the Phase I and II inspection illustrated that the problem was widespread and should have been promptly expanded and corrected in 1988. 10 CFR 50, Appendix B, Criterion XVI, requires, in part, that measures be established to ensure that such conditions adverse to quality be promptly identified and corrected. Failure of the licensee to meet this requirement after identifying the high number of minor deficiencies in the 4160 and 6900 VAC switchgear cabinets is an apparent violation of NRC regulations.

Although the safety significance of each of the minor discrepancies in the panels may have been minimal, the large number appeared to increase the potential for errors that could affect safety system operability during activities that rely on the accuracy of electrical diagrams (e.g., troubleshooting and repair or circuit modifications). For example, on October 26, 1988, I&C technicians were working on a trend recorder in Unit 1 Control Room Panel C14. In order to deenergize the recorder, the technicians traced the power supply lead wires back to a fuse panel mounted in Control Room Panel C14 that contained two fuses. One fuse was labeled as a spare, and the other fuse was unlabeled. Upon removing the unlabeled fuse (thought to be in the recorder circuit since the other fuse was labeled as a spare), power was lost to the controllers for both decay heat removal cooler outlet valves, causing the valves to close, resulting in loss of the decay heat removal function. Subsequently, the fuse labeled spare was pulled which deenergized the trend recorder. As corrective action for the event, the fuses were properly labeled, and an internal memo was issued to craft personnel at ANO that described the event and stressed that when improper labeling is found during a job, work should be stopped and the appropriate supervisor informed.

4. Wiring Configuration Control Programs

a. Lifted Lead and Jumper Control

The team conducted a review to establish confidence that adequate controls were in place to ensure that lifted leads would be reconnected to the proper terminals. The licensee could not produce any specific procedural requirements implementing such controls, except that Maintenance Administrative Procedure 1025.003, Revision 30, "Conduct of Maintenance," did address the subject, though inadequately. Attachment 1, "Maintenance Reference Guides," had Guideline 3.9 under "Electrical Systems Guide" which stated that "Lifted leads should be marked to aid in re-termination. Independent verification of re-termination should be done. (Rotation of motors should be maintained correct)." There were no guidelines in the I&C Guide which addressed lifted leads. This was an area that appeared most vulnerable to lifted lead problems.

The team discussed Guideline 3.9 with maintenance personnel and learned that in most detailed procedures, where a lead is to be pulled, there was a signoff and verification on re-termination, but that was only required on the initiative of the procedure writers or reviewers because there was no procedural requirement that independent verification of retermination be done. The team also noted that some licensee personnel considered a motor rotation test sufficient verification that the motor leads were properly connected. The team expressed concern to the licensee that while postmaintenance testing is essential to prove the success of the maintenance activity, failure to independently verify proper retermination could lead to equipment damage and/or personnel injury. The team also pointed out the increased importance of independent verification in view of so many labeling errors in the electrical panels. The licensee committed to reconsider lifted lead controls and, as an interim, committed to add instructions to Procedure 1025.003 that would require validation of the applicable wiring drawing before leads would be lifted, when specific lead lifting instructions were not provided. The licensee also reported, during a conference call on October 2, 1989, that the "shoulds" in Guideline 3.9 were changed to "shall." The NRC staff will follow up during a future inspection to verify that acceptable lifted lead controls have been placed in effect (Inspector Followup Item 313/8935-01; 368/8935-01).

b. Plant Modifications

The team reviewed the licensee's plant modification process to determine if proper controls were in place to assure that plant configuration and documentation will not be degraded as a result of temporary or permanent plant changes. The team reviewed the following documents:

- NP-20, Revision 3, "ANO Plant Modifications Manual"
- 1000.103, Revision 4, "Plant Modification Process"
- 6030.003, Revision 2, "Installation Verification and AS-Built Requirements"

The team also reviewed many of the lower tier implementing 6000-series procedures. The team noted that the licensee had developed and implemented a well-defined, carefully controlled, plant modifications program. In April 1984, the licensee formed a task force to develop a comprehensive list of deficiencies and concerns with the program in place at the time and then to provide alternatives for eliminating these problems. As a result, an 18-step process was developed and implemented, and was in effect during this inspection. The 18 steps carried a given plant change from the identification of the need to the critique and completion report. Excellent controls were in place to ensure that drawing and procedure updates were made at the appropriate time in the process. After reviewing the controlling documents and discussing the plant modification process with cognizant licensee personnel, the team concluded that the process should not cause any problems in plant configuration documentation and controls.

No violations or deviations were identified.

5. Corrective Actions and Conclusions

On the basis of information provided by the licensee, and independent inspections and reviews conducted by the team, the team concluded that ANO, Units 1 and 2, both had a significant number of minor discrepancies between the as-built electrical panels in and out of the control room and the design documents (wiring drawings). Since the electrical schematics appeared to reflect the as-built condition, the team considered it unlikely that additional errors affecting the operability of safety-related equipment will be found.

As discussed above, the team was concerned that the licensee was aware of the large number of discrepancies in the 4160 and 6900 VAC switchgear panels, but failed to take timely action to correct the specifics and to look at other panels for similar problems. The concern was partly based on the increased probability of errors that could be caused by working in panels with labeling and wiring errors. One such error was discussed above when decay heat removal was lost due to pulling improperly labeled fuses. The concern was also based on the possibility that, had the licensee inspected the control room and other panels sooner, the service water pump "sneak circuit" may have been found by the licensee long before the NRC Diagnostic Team evaluation in August and September 1989.

The team noted that the housekeeping problems identified in the control room cabinets in Unit 1 were not typical of other cabinets in Units 1 or 2.

The licensee's Phase I and II inspections appeared adequate to provide confidence that the control rooms for both units were not likely to have additional operational problems. During a conference call conducted on October 2, 1989, the licensee reported that the Phase III inspection had been completed. Phase III was similar to Phase I and II but was limited to Unit 1 only. This inspection included more circuits in the control room and some MCC panels outside the control room. The results were similar to those found by the team when they inspected panels outside the control room.

Having just commenced the seventh refueling outage on Unit 2 (2R7), the licensee committed to conduct detailed walkdowns on the Unit 2 480 VAC MCCs outside the control room and Control Room Panels 2C16, 2C17, 2C18, and 2C33. These, in addition to the 4160 and 6900 VAC switchgear panels previously inspected, were considered by the licensee to be the areas of greatest exposure for safety problems. The licensee further committed to have all spare leads (not terminated) identifiable by a standard and consistent method, such as cutting off the lug and covering the end with a heat shrink insulator.

The licensee did not commit to a schedule for walkdown and correction of drawing and hardware deficiencies for all safety-related panels at the time of this inspection. This will be the subject of further discussion with licensee management during the scheduled enforcement conference.

6. <u>Exit Interview</u>

The inspection scope and findings were summarized on September 22, 1989, with those persons indicated in paragraph 1 above. The licensee did not identify, as proprietary, any of the material provided to, or reviewed by, the team during this inspection.

APPENDIX B

Service Water Pump Configuration and Pump Breaker Anti-Pump Circuit Operation

The service water system at ANO-1, contains three 100 percent capacity pumps that can provide service water flow to ESF equipment, including control room and switchgear room cooling units, the emergency feedwater pumps, and the emergency diesel generators. Only one pump is needed to satisfy shutdown cooling requirements under accident conditions. Power distribution to the service water pumps is shown in Figure 1. Power to the pump motors is provided from independent and redundant Class 1E safety-related 4160 VAC buses A3 and A4. These buses can receive power from the main generator via the unit auxiliary transformer, from offsite via either of two startup transformers, or from the emergency diesel generators. Power to Service Water Pump P4A is supplied from Bus A3 and power to Service Water Pump P4C is supplied from Bus A4. Service Water Pump P4B is a "swing pump" that is powered from 4160 VAC Bus A6, which in turn can receive power from either Bus A3 or A4. Bus A6 is normally aligned to receive power from Bus A3 (A4) when Service Water Pump P4A (P4C) is taken out of service.

During normal plant operation, two of the three service water pumps are continuously running; power to the pumps is provided from the main generator via the unit auxiliary transformer. If the main generator trips, as would occur on an ESF signal, power to 4160 VAC Buses A3 and A4 is designed to automatically fast transfer (approximately 1/10 of a second) from the unit auxiliary transformer to one of the two startup transformers. The startup transformer selected depends on the positioning of "preferred standby" selector switches in the control room. Both startup transformers are powered from the offsite power system. If a fast transfer does not occur, a slow transfer should occur within the next 2 seconds, assuming the standby source is available (i.e., secondary voltage is normal, breaker control power is available, etc.). If the fast transfer is successful, the service water pumps will continue to operate. If the fast transfer is unsuccessful, the service water pumps will trip because the voltage at the 4160 VAC buses will decay to below the pump breaker undervoltage trip setpoint before the slow transfer takes place. Therefore, on a slow transfer, it is necessary to restart the pumps. The control circuit for service water pump Breakers A302, A303, A402, and A403 are designed to automatically restart the pumps following a slow transfer. If a slow transfer does not occur within 2 seconds, feeder Breakers A309 and A409 will open to isolate Bus A3 and A4 from the startup transformers. Emergency Diesel Generators No. 1 and No. 2 will automatically start, attain rated speed and voltage, and tie onto Buses A3 and A4 (via closure of diesel generator output Breakers A308 and A408) within 15 seconds after sensing loss of bus voltage. The service water pumps should sequence onto the diesel generators in approximately an additional 15 seconds.

A simplified block diagram of the control circuit for Breaker A302 is shown in Figure 2. The control circuits for Breakers A303, A402, and A403 are similar. The control circuit is designed to either: (1) close the breaker by energizing the closing coil in response to an automatic or manual pump start signal, or (2) trip the breaker by energizing the trip coil in response to an automatic or manual pump trip signal. Auxiliary contacts located on the circuit breaker itself will change status as the breaker opens and closes. The auxiliary contacts are used in the control circuit to allow only the closing coil or the trip coil to be energized at a given time. The auxiliary contacts also open to deenergize the closing coil (trip coil) when the breaker closes (opens) to prevent coil burnout. Although the closing coil and trip coil cannot be energized simultaneously, under certain conditions both a close signal and a trip signal could coexist (e.g., when a fault condition occurs after the breaker has been signaled to close). The circuit breaker anti-pump circuit prevents the breaker from cycling repeatedly between the closed and tripped positions whenever both close and trip signals coexist. The anti-pump circuit is designed such that, following a breaker trip, one attempt to reclose the breaker is allowed; however, subsequent closure attempts are prevented.

Following a trip of Breaker A302 on Bus A3 undervoltage, four conditions (permissives) must be satisfied before the breaker will automatically reclose to restart Pump P4A. The permissives are numbered 1 through 4 on Figure 2 and are listed below:

1. The pump must be running when the undervoltage condition occurs (the control switch contacts are closed in the "after start" position; a pump not previously running will not automatically start).

2. The voltage at Bus A3 must have returned to above the undervoltage trip setpoint (i.e., bus voltage is acceptable for pump operation).

3. Power to Bus A3 must be supplied from upstream 4160 VAC Bus A1 via Circuit Breaker A309 within 2 seconds of the undervoltage condition or breaker closure is prevented until 15 seconds after power is restored to Bus A3 from Emergency Diesel Generator No. 1 via circuit Breaker A308. The 15-second delay is provided to ensure proper diesel generator load sequencing. The tripping of Feeder Breaker A309 on Bus A3 undervoltage is delayed for 2 seconds to allow time for a slow transfer to restore power to the bus from offsite.

4. The anti-pump circuit must be deenergized. If a close signal exists when the breaker trips, the closing coil will energize causing the breaker closing springs to discharge. The breaker will attempt to close but will open again if a trip signal still exists. Limit switch contacts on the closing springs will close to energize the anti-pump circuit when the springs discharge. The anti-pump circuit will seal in if the close signal is still present and will remain sealed in as long as a close signal exists. The anti-pump circuit locks out the breaker in the tripped position preventing subsequent closure attempts although the close signal remains. This action is intended to prevent repeated attempts to close the breaker against a fault condition. The anti-pump circuit must be reset by removing the close signal before another attempt can be made to reclose the breaker.

None of the above conditions for automatic restart of a service water pump depend on the existence of an ESF signal. However, the extra contacts from engineered safeguards Relay 152X-302 that were found wired onto the breaker close circuit effectively bypass the control switch and Bus A3 voltage permissives. The extra contacts are shown using a dashed line in Figure 2. The problem caused by the extra contacts is that on an ESF signal where a slow transfer from the unit auxiliary transformer to the startup transformer occurs, the breaker will trip on bus undervoltage, but the existing breaker close signal will not clear because the Bus A3 voltage permissive is bypassed by the contact. The slow transfer will restore power to Bus A3 within 2 seconds (therefore, Bus Feeder Breaker A309 remains closed), but not before the breaker has attempted to reclose and the anti-pump circuit has energized and sealed in. Since both the remote and local control switch contacts are bypassed by the extra contact, reset of the anti-pump circuit (hence, breaker closure to restart the pump) is not possible without nonroutine operator action (e.g., removing the circuit breaker 125 VDC control power fuses at the breaker cubicle in the switchgear room. If the extra contact were not in the circuit and a slow transfer occurred, the Bus A3 voltage permissive would clear the close signal at the same time that the breaker trips on bus undervoltage. Reclosure of the breaker does not occur until bus voltage returns to an acceptable level (seal in of the anti-pump circuit will not occur until after the breaker has successfully reclosed).

ANO-1 POWER DISTRIBUTION TO THE SERVICE WATER PUMPS

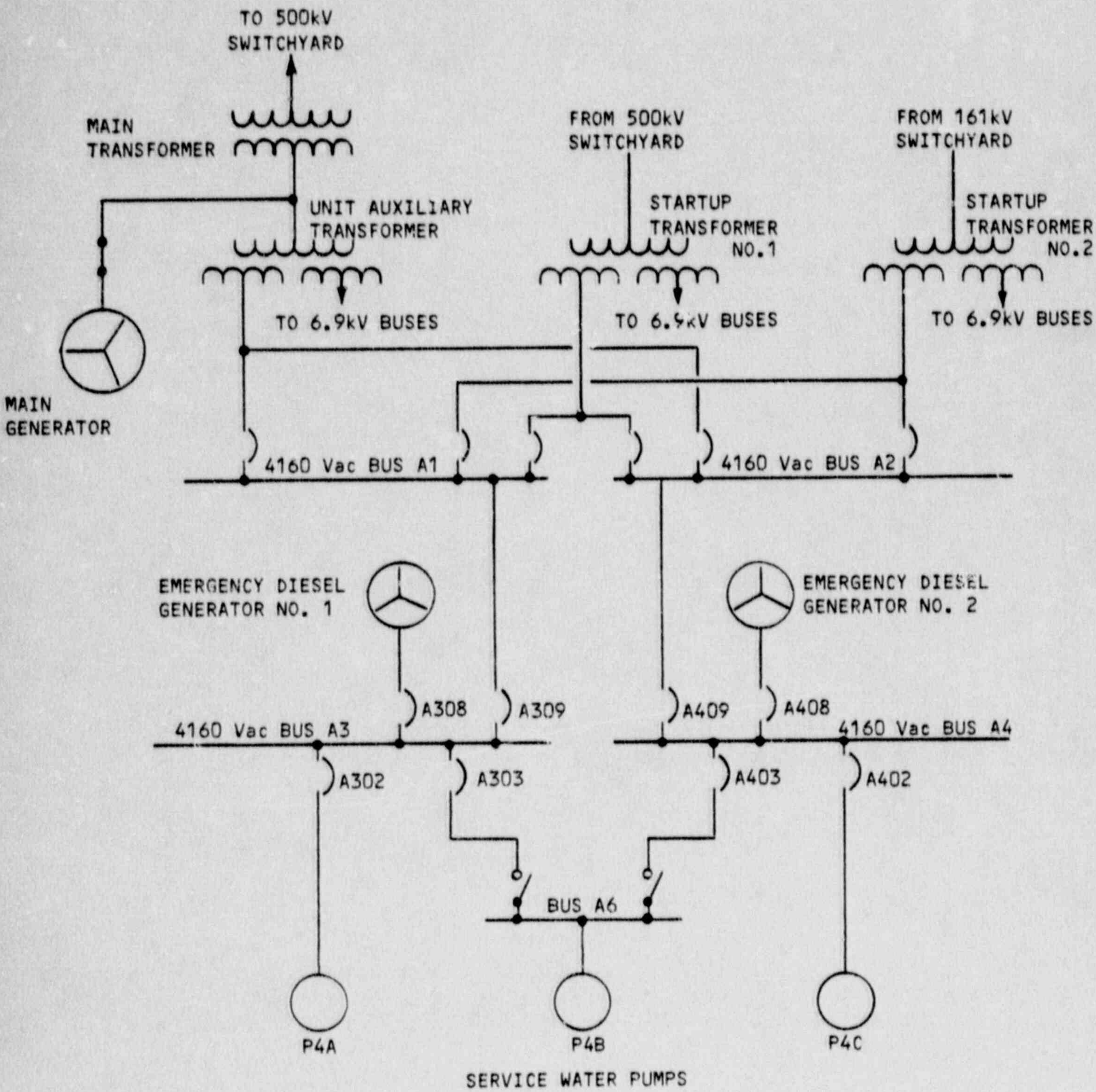

FIGURE 1

SERVICE WATER PUMP P4A BREAKER A302 CONTROL CIRCUIT
(SIMPLIFIED BLOCK DIAGRAM)

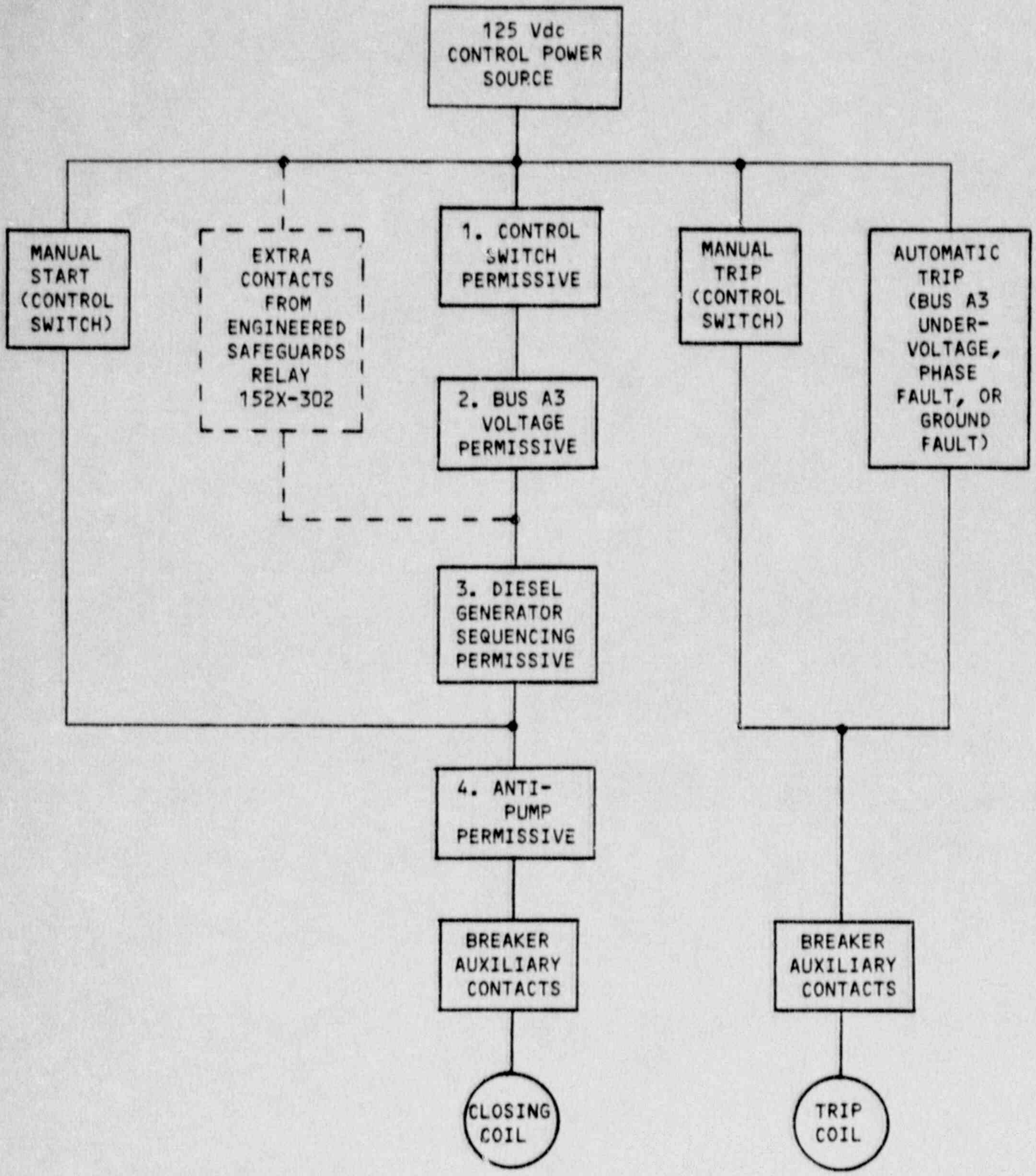

FIGURE 2