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UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W., SUITE 2900
ATLANTA, GEORGIA 30323-0199

JUN 20 1994

MEMORANDUM FOR: Bruno Uryc, Enforcement and Investigation Coordination Staff

THROUGH: Albert F. Gibson, Director, Division of Reactor Safety AFG 6/20/94

FROM: Charles A. Casto, Section Chief, Test Programs Section, Division of Reactor Safety

SUBJECT: ALLEGATION NO. RII-94-A-0089 VOGTLE NUCLEAR PLANT UNITS 1 AND 2 DOCKET NUMBERS 50-424,50-425

BACKGROUND

The NRC performed an inspection on May 9 to May 20, 1994, to address issues related to this allegation. The details of the inspection are contained in NRC Inspection Report 50-424,425/94-12. The allegation stated that the emergency diesel generator (DG) failures of March 20, 1990 on DG 1A and May 23, 1990, on DG 1B were the result of causes other than those specified by the licensee in their communication with the NRC. The reported failure causes were documented in NUREG 1410 and included Calcon instrument malfunctions as the primary cause with air leaks as a contributing factor.

The following six issues were listed in the allegation report to support the alleger's conclusion that the actual failure causes, including water in the pneumatic lines, were not accounted for in the licensee's failure analysis or communication with the NRC.

1. Water in the Pneumatic Lines
2. Large and Numerous Air Leaks in Air Lines
3. Rolled Tubing
4. Change in Orifice Sizing
5. Pneumatic Logic Board Failures
6. P3 Pressure Switch Reset Repeatability

Evaluation of these items by the May 9-20, 1994, NRC inspection included an extensive review of work documentation related to the 1990 failures and all DG failures since 1990. Equipment histories for the DGs and related equipment were reviewed. The DG pneumatic control and protection system was evaluated to determine the potential impact of water contamination on the system function. Craft and engineering personnel were questioned to determine if there had been indication of water in the system at any time. Observation of DG operations and system moisture checks were conducted. Each of the items was addressed to determine if the issue was valid and if the issue presently represented a challenge to the reliability of the DGs. These allegation items are addressed individually in the following discussion.

ENCLOSURE 2

DISCUSSION

1.0 Water in the Pneumatic Lines

This allegation statement was not substantiated.

The allegation stated that the pneumatic control logic went into action (on March 20, 1990) supplying 60 psi air through a small orifice to pressurize the trip lines that are normally depressurized. Simultaneously, control air was supplied through another small orifice to a small air tank that serves as a 60-second delay. A race began between pressurizing the trip lines and pressurizing the delay tank. If the pressure in the trip lines reached a minimum value (P3 setpoint approximately 45 psi) before the time delay tank reached its minimum pressure setpoint, all was well. The components are sized so that this will normally happen. The allegation stated that water in the pneumatic lines impacted this process, via flow blockage in system orifices, and caused trips during start up of the DGs.

1.1 Operation of the Pneumatic Control and Protection System

The DG pneumatic control and protection system does not function in the manner described in the allegation. The effects of moisture on the DG pneumatic control logic cannot be adequately evaluated without first understanding the function of the shutdown board logic. The critical components for the process are logic elements in the shutdown logic board which were not addressed in the allegation description. The following discussion briefly describes the process that occurs during a normal DG start and demonstrates that orifice flow blockage by water was not a credible failure mechanism for the 1990 DG failures.

The portion of the pneumatic control system that is most likely to be affected by moisture in the control lines during diesel generator engine starts is shown in simplified form in Figures 1 through 4. The Shutdown board components are shown as they are depicted on sheet 1 of Transamerica Delaval drawing 09-500-76021, "Engine Control Schematic." The Shutdown board logic is comprised of 23 pneumatic logic elements. The abbreviated schematics depict only the essential components that affect the timing of the DG start and possible subsequent trips caused by a failure to maintain pressure on the P3 switch. As will be shown in this discussion, the most credible DG failure causes are instrumentation calibration drift, or continuous instrumentation venting. The presence of water in the control logic may cause other events to occur, but will not cause the series of trips that occurred at Vogtle in March 1990 and May 1990.

There are three distinct groups of trip sensors that can shut down the diesel generator. These sensor groups are pressurized from their respective output ports on the shutdown board. The Group I shutdown (SD) sensors are pressurized through Port 2 and consist of the High Temperature Engine Bearing trip sensors and the High Temperature Engine Lube Oil trip sensor. The Group II SD sensors are pressurized through

Port 11 and consist of the High Pressure Crankcase trip sensor, the Low Pressure Turbo Oil trip sensor, the Low Pressure Jacket Water trip sensor, the High Temperature Jacket Water trip sensor, and the High Vibration trip sensors. The Group II lockout (LO) sensors are pressurized through Port 12 and consist of the three Low Pressure Lube Oil trip sensors. The jacket water temperature trip sensors were moved from Group II LO to Group II SD and were reduced from 3 sensors to 1 sensor after the loss of vital power event at Vogtle on March 20, 1990. For the purposes of this discussion, it will be assumed that the system is still configured as it was in March and May of 1990. That is, assume that there are three jacket water temperature sensors in the Group II LO set of trips, which are pressurized by port 12 on the shutdown board.

During normal plant operations, the sensors in the Group I SD group and the Group II SD group are continuously pressurized by the 60 psig control system air supply through dedicated 0.006-inch diameter orifices. The orifice size is such that a downstream sensor will depressurize the shutdown board at a rate that exceeds the pressurization rate through the orifice. Check valves isolate the respective sensors from reverse airflow during Shutdown board component venting processes. Consequently, the only part of the Group I SD and Group II SD lines requiring pressurization during a DG start are the tubing runs inside the control cabinet.

Figures 1 through 4 show the sequence of events that occur on the shutdown board when a normal DG start sequence is initiated. Figure 5 provides a key for the pneumatic logic element symbols that are depicted in the figures.

During normal plant operations the shutdown board logic elements are pressurized as shown in Figure 1. The Group I SD sensors are continuously pressurized through Port 2 on the shutdown board. The Group II SD and Group II LO sensor lines upstream of the isolation check valves are pressurized through Port 11 and Port 12 on the Shutdown board, respectively.

The air supply at port 9 of the shutdown board maintains 60 psig air pressure at AND-9 port B, AND-14 port B, and at port 2 of the shutdown board.

The Group II SD and Group II LO lines are not pressurized until a DG start demand. The P3 switch is in the vent position since neither port 11 nor port 12 are pressurized. Consequently, without either an automatic actuation or a manual override, the DG fuel lines and air supply will remain isolated and the DG will not start.

Figure 2 shows the response of the essential Shutdown board logic elements when a normal DG start is initiated, and prior to the accumulator (ACC) pressure reaching 40 psig. The DG start demand causes the Shutdown Activate solenoids (not shown in these figures) to momentarily align the control system air to port 10 on the shutdown board. Pressure is transmitted through to port A on the AND-9 module. This momentary pressure pulse is held at port A.

When the pressure at AND-9 port A reaches approximately 40 psig, the AND-9 state becomes TRUE, and AND-9 transmits pressure to port B of Timer/NOT-11 and to the A/C port of the 0.006 inch parallel orifice check valve (POC-15). Timer/NOT-11 transmits pressure to the A/C port of orifice 8, and to port 12 of the shutdown board. Port 12 supplies pressure to the Group II lockout logic, which consists of the Group II LO sensors (lube oil pressure sensors and, formerly, the jacket water temperature sensors). Notice that port 12 is not pressurized by air that has been throttled by an orifice, as was stated by the alleger. In fact, all three orifices on the shutdown board are bypassed by the Group II LO logic.

Control air bleeds through orifice 8 and OR-7 to port 11 (Group II SDs). When the Group II SDs have reset, flow from port 11 is blocked on the engine and the pressure builds up to 60 psig.

Figure 3 shows the system response when the pressure in the accumulator exceeds 40 psig but is less than 60 psig. Control air bleeds through POC-15 to the A port of AND-14 and Timer/NOT-11, and to the accumulator (ACC) at port 3 on the shutdown board. Pressure slowly increases to 45 psig in approximately 60 seconds. AND-14 then becomes TRUE, thereby connecting the B port of OR-7 to the Group I SD line. This line then supplies pressure to port 11 (Group II SD sensors) in addition to port 2 (Group I SD sensors).

Note that the Group II SD sensors are pressurized through port A on OR-7 prior to the accumulator reaching 45 psig. Additionally, the AND-14 gate turns true before the Timer/NOT 11 module begins timing down for the port 12 depressurization. Consequently, the pressure at port B on the P3 OR gate should be greater than the trip setpoint before the accumulator pressure reaches 45 psig.

When the accumulator pressure reaches 45 psig, Timer/NOT-11 trips. When the timer element times out, the pressure vents at port 12, and through orifice 8, the A port of OR-7. The Group II LO sensors do not trip because there is a check valve in each air supply line that prevents depressurization of the sensors when port 12 vents. The control logic is then in the state shown in Figure 4, and the DG is in operation.

If the Group II LO sensor lines do not pressurize prior to port 12 venting, a trip signal is initiated and port B of the P3 OR gate depressurizes, causing a Group II lockout.

As shown in Figures 1 through 4, If water is in the air lines when the DG start sequence is initiated, the most likely flow path is the path of least resistance, which is from port 9 through AND-9 into port B of Timer/NOT-11 and out to the Group II LO sensors. Each Group II LO sensor has a 0.020 inch check valve orifice to prevent instrument depressurization when port 12 vents back through port C of Timer/NOT-11. There are six Group II LO check valves mounted in parallel.

In the May 23, 1990, diesel generator trips, the low pressure jacket water trip and the low pressure turbo oil trip annunciated in the first three trips. These sensors are Group II SD sensors, and are continuously vented until the engine conditions stabilize. Significant venting through these sensors could prevent pressurization of P3. The symptoms from the May 23, 1990, trips indicate that these sensors were not pressurizing. A 10 CFR Part 21 notice on the Calcon Model B4400 sensor indicates that the response of these sensors is not unusual.

1.2 Potential Sources of Water in the Pneumatic System

Water condensation in the air lines and air receiver tank would have to be conveyed from the 250 psig air supply lines through the 5 micron filter and pressure regulator in the control cabinet into the logic boards. The 250 psig air supply lines for the control cabinet connect to the top of the 4-inch air start supply headers just upstream of the air start header valves.

The 250 psig air supply for the control cabinets and the DG air start headers is drawn from an air receiver tank, which is approximately 12-15 feet high by 6 feet in diameter. The 4-inch air supply line connects to the air start receiver approximately 8-feet above the bottom of the tank. The 4-inch air supply line is approximately 50 feet long and has at least one vertical section before reaching the DG air start headers.

The 3/8-inch air supply tubing for the control cabinet tees off the top of the air supply line and runs next to the DG intake manifold for the length of the DG before proceeding to the control cabinet. The air in the 3/8-inch tubing enters the control cabinet below the floor level, is filtered with a 5-micron filter, and then is reduced in pressure from 250 psig to 60 psig. The reduced pressure air is then carried to the control logic mother board, which is approximately 6 feet above the floor.

During normal plant operations, the only demands for control air are from the supplementary instrument line connections in the control logic cabinet. The corresponding air flow through the 4-inch air supply header is such that the air/liquid interfacial drag will not be sufficient to convey the water out of the air receiver tank, through the 4-inch air supply header, and into the 3/8-inch air supply line that runs just below the intake manifold of the DG.

An air-vapor mixture with a dew point higher than the ambient temperature of the DG room could occur in the 3/8-inch 250 psig tubing outside the control cabinet. The 250 psig air supply tubing next to the DG is at the highest point in the tubing run. Consequently, if vapor did condense and collect inside the tubing, a subsequent DG start demand for air could sweep the moisture along the tubing into the control cabinet. The effect of this moisture on the operability of the DG shutdown board components is discussed in paragraph 1.3 of this report.

The dew point of the 250-psig supply air will significantly decrease when the pressure is reduced to 60 psig by the control cabinet pressure regulator. A psychometric chart that shows dew point temperature as a function of pressure demonstrates that dew point values decrease with a decrease in pressure. For example, assuming a worst case dew point of 85°F (29°C) at 250 psig, the equivalent dew point at 60 psig is approximately 50°F (10°C). The control cabinets are heated with resistance-type heaters and shield the control components from outside air drafts. All system orifices are located in the control cabinet. The minimum design temperature for the control cabinets is the same as for the DG, 50°F (10°C). Consequently, even with the highest dew point conditions that have been measured to date, the dew point of the air in the control cabinets was only equal to the control cabinet ambient temperature. <u>The inspectors concluded that condensation of the 60 psig air supply in the control cabinets does not occur.</u>

During the inspection of May 9-20, 1994, the NRC staff witnessed the blowdown of a Vogtle air receiver that had 63°F dewpoint air with overnight ambient conditions of 48°F. These conditions were similar to those described in the allegation for the 1990 DG failures. Assuming the wall thickness of the air receiver is approximately 2 inches, the temperature time constant is 15-20 minutes. Consequently, the temperature on the inside surface of the tank should have reached steady state conditions in less than two hours. The air was blown into a large metal tin at slow, medium, and fast rates. No moisture was detected.

The inspectors interviewed three instrumentation technicians, ([redacted]), a plant equipment operator ([redacted]), and two engineers ([redacted]). These licensee personnel did not recall evidence of water in the air lines at any time. These personnel had been involved with DG maintenance in 1990 and in 1994. The maintenance documentation from 1990 to the present, including maintenance work orders (MWOs) specifically related to the troubleshooting activity of the 1990 DG failures, did not identify evidence of water in the pneumatic control system.

As a further check of the alleger's theory, the staff correlated out-of-tolerance high dew point data, for Unit 1 DGs, with corresponding minimum ambient temperature data and then reviewed the DG operating logs for the days when the dew point temperature exceeded the ambient temperature. If condensation in the long tubing runs does cause DG trips, then the DG operating logs should have records of similar trip events for other dates when the conditions were similar to the conditions that existed on March 20, 1990 and May 23, 1990. The staff found two dates when the Unit 1A DG started and did not trip but the dew point exceeded the minimum ambient temperature by 20°F-40°F. There were four dates when a DG 1B air receiver dew point exceeded the ambient temperature by 5°F to 30°F. The allegation theory concerning water in the air supply lines is not supported by the data from the DG operating logs, the dew point histories, and the ambient temperature histories.

1.3 Potential Impact of Water on DG Operation

There is a 5-micron air filter in the 250-psig air lines immediately before the 60-psig pressure regulator in the control cabinet. The purpose of the filter is to remove particulate from the air before it is admitted into the pneumatic control modules. If water was present in the 250-psig air supply line, the 5-micron filter in the control cabinet would atomize the water droplets into a fine mist. Assuming the water droplets are approximately 5 microns in diameter, the smallest orifice in the control system at 0.006 inch (152 microns) is approximately 30 times larger than the atomized water droplets. Consequently, even if all of the air flowed through the 0.006-in orifice, the probability of choked flow is insignificant. Additionally, as shown in Figures 1 through 4, the majority of the control air bypasses the 0.006-inch orifice and pressurizes the A port in the P3 upstream OR gate. Consequently, the effect of moisture on the pressurization of the P3 switch OR gate ports is insignificant.

The control logic component design is such that the presence of moisture in the air supply will not cause DG trips during the startup phase of operation. If there were enough water to cause Timer/NOT-11 port A to sense a false pressure signal, there would be a similar response at port A of the AND-14 module, which would result in pressurization of the B port of the P3 OR module. Water in the pneumatic line would result in either the DG tripping before 60 seconds, or the DG not tripping at all. The timing of the DG trips in March 1990 and May 1990 indicate that this did not occur.

Water inside the control modules could cause corrosion of the metal parts inside the logic modules and inside the DG instrumentation. This could affect the sensitivity of the instruments, and thereby affect the startup of the DG. However, review of MWOs and deficiency cards (DCs) for the two units did not reveal any cases of corrosion caused by unknown sources of water. One MWO, 19104783, did state that the vendor introduced water into a sensor during a pneumatic leak test with a bubbler. The NRC staff concludes that the presence of water in the control system air lines has not been confirmed by evidence of corrosion.

1.4 Control of Dew Points in Air Supply System

The licensee checks the dew point of each air receiver tank every 28 days using Surveillance Checklist 00166 (SCL00166), Rev 6, "Diesel Generator Air Start Dryer Maintenance." This SCL provides instructions for cleaning the air dryer condensing unit and measuring the dew point temperature at the air receiver. When a dew point is not within the acceptance criteria (32°F to 50°F), the SCL directs the instrument technician to notify the system engineer, initiate a corrective action

MWO if required, and notify operations to request the air dryer and compressor be tagged out. The instrument technician is instructed not to tag out the air receiver outlet valve unless moisture is detected in the control air system. The procedure for performing a moisture check in the control air system is to open for a few seconds the test connection valve in the lower part of the control cabinet every 12 hours until the air receiver dew point is acceptable.

The results of the SCL-00166 surveillances were recorded in the corresponding MWOs. The inspectors reviewed the MWOs and DCs from 1990 to the present to assess the licensee's commitment to maintain dew point conditions within the allowable band of temperatures (32°F to 50°F). The inspectors noted numerous examples of out-of-tolerance dew points, however, there was no evidence of actual water formation in the lines. The licensee's actions to feed and bleed the air receivers to reduce dew point were appropriate. The inspectors identified one example where moisture checks following an out-of-tolerance dew point readings in January 1994, were not performed as required by SCL-00166. A violation was issued for this condition.

<u>The inspectors concluded that there was no evidence to demonstrate the existence of water in the pneumatic control and protection system lines in 1990. There was no indication that system air moisture content presently represented a challenge to DG reliability.</u>

2.0 Large And Numerous Air Leaks In Air Lines

<u>This allegation statement was substantiated.</u>

The allegation does not correctly state the NUREG 1410 categorization of system air leakage. NUREG 1410, page J-14, last sentence, states, "Except for the temperature sensors, no significant leaks were identified during the leak testing." This statement demonstrated that the licensee communicated the scope and magnitude of system air leakage the NRC.

The inspectors review of Maintenance Work Orders (MWOs) from 1990 to the present indicated that there was frequent leakage related corrective maintenance performed. Pneumatic trip sensor leaks (premature venting) was the greatest leakage cause followed by component leakage and fitting leakage. During 1990. no specific leakage acceptance criteria was used during leakage tests, only visual soap bubble checks. During 1990, no procedure was used for installation of Swagelock compression fittings.

The licensee has implemented corrective actions which indicated an increased sensitivity to leakage problems and has achieved a significant reduction in leakage related MWOs. The refueling outage functional testing on the DG pneumatic system now incorporates detailed leakage measurement and specific leakage acceptance criteria. A procedure was developed to ensure proper installation of Swagelock compression fittings.

The inspectors witnessed DG testing of DG 2A on May 13, 1994 and DG 1B on May 18, 1994. During this testing, the inspectors checked for leaks at sensors, tubing fittings, and inside the engine control panels. No leakage was noted. The inspectors review confirmed that the DG pneumatic control system experienced frequent air leakage during 1990 and potentially contributed to DG failures in 1990. Licensee corrective actions have adequately addressed this issue and no present concern exists with air leakage.

3.0 Rolled Tubing And System Configuration

This allegation statement was not substantiated.

The inspectors reviewed MWOs from 1990 to the present and did not identify any cases of incorrectly connected tubing. A tagging concern was identified related to the high temperature jacket water pneumatic tubing connections and their respective test valves.

Two examples were noted where a sensor was left disconnected following functional testing. One example occurred in 1990 and was identified and corrected by the licensee. The inspectors identified disconnected tubing at the low pressure jacket water sensor on DG 1A. A violation was issued for this condition.

The inspectors performed a walkdown of a portion of the pneumatic control system for DG 1A and DG 1B. All tubing connections were in accordance with system drawings. Tubes and connections in the control panel and bulkhead fittings were labeled. Additionally, MWOs for functional testing included independent verification of tubing connections by the Quality Control personnel. The inspectors concluded that no problem presently exists with rolled tubing.

4.0 Change in Orifice Sizing

This allegation statement was not substantiated.

This allegation stated that design changes were made to replace smaller orifices with larger ones that would pass more air, and be less prone to blockage and accommodate more leakage.

The following modifications were related to changes in orifice components in the pneumatic control system. Minor Design Deviations (MDDs) 89-V1M194 installed 0.014 inch orifices in the lube oil pressure sensing lines where no orifice was previously installed. This was to assure establishing low lube oil protection for an emergency start following a normal shutdown and was completed in March 1990. In October 1990, MDDs 90-V2M193 and 90-V1M194 decreased the orifice size in the shutdown logic board from 0.028 to 0.020 inches. DCPs 91-V1N0113 and 91-V2N0114 installed 0.006 inch diameter orifices in the jacket water temperature sensor air supply lines similar to other non-emergency trip sensors. The inspectors' configuration walkdowns discussed in paragraph 2.7 of NRC inspection report 50-424,425/94-12, verified installed orifices were consistent with as-built drawings for the sample reviewed. The inspectors concluded that changes to the pneumatic control system appropriately implemented the design control process and contributed to increased DG reliability. No orifices were replaced with larger orifices.

5.0 Pneumatic Logic Board Failures

This allegation statement was not substantiated

The inspectors identified 3 examples where DG pneumatic logic boards were replaced. Additionally, two examples were identified in which logic elements within a logic board were replaced. The boards were replaced during DG control system troubleshooting as potential failure causes. Later inspection and testing by the vendor indicated that the boards had not failed. The element failures were not indicative of a failure trend.

The inspectors reviewed MWOs which documented the results of the DG functional testing performed each refueling outage. The results of the testing did not indicate a trend of failures of pneumatic logic boards.

The inspectors witnessed DG 2A testing on May 13, 1994, and DG 1B testing on May 18, 1994. The tests were successful, no problems were noted with the pneumatic logic. The inspectors concluded that no problem presently exists with pneumatic logic boards.

6.0 P3 Pressure Switch Reset Repeatability

This allegation statement was not substantiated.

The allegation stated that the "Barksdale" trip line pressure switches were known to have reset repeatability problems and that the setpoint was adjusted after the March 20, 1990, site area emergency.

The inspectors reviewed the MWOs and DCs initiated from 1990 to the present related to the P3 Calcon shutdown pressure switch (note: these are not Barksdale switches). There have been three incidents in which the P3 pressure switch was thought to have failed (MWOs 19001537 and 19001542, and DCP 90-V1N0164). The failure addressed by MWO 19001542 was reported on March 25, 1990, and required replacement of the P3 switch. The pressure switch failure addressed by MWO 19001537 occurred when the P3 switch failed to reset after tripping. The switch was replaced. MWO 19001511 dated March 28, 1990, tested the EDG 1A P3 switches at various air pressures and with different orifices sizes on the test stand. The test conclusion was that repeatability throughout the variations was consistent. The following MWOs during 1990 included P3 switch replacements and calibrations: 19000068, 19002711, and 19000016. These MWOs did not identify problems with setpoint repeatability.

DCR 90-V1N0164 was initiated to lower the set point on P3 pressure switches. This DCR was cancelled and the set points were not changed. The basis for cancellation stated that the P3 set/reset set point values were not the cause of EDG 1A failures being investigated. P3 switch operation was impacted by normally charged lines being bled down during maintenance. These lines had not been sufficiently recharged prior to attempted EDG starts.

The inspectors concluded that P3 switch malfunctions have not impacted EDG reliability. The Maintenance history indicated few failures and the calibration documents did not identify occurrences of setpoint repeatability problems.

This allegation is closed.

Charles A. Casto

Attachment:
Simplified Logic Diagram

cc: R. Moore, DRS
G. MacDonald, DRS
M. Waterman, NRR
M. Shymlock, DRS
P. Skinner, DRP
D. Seymour, DRP

RII:DRS

AGibson
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Attachment

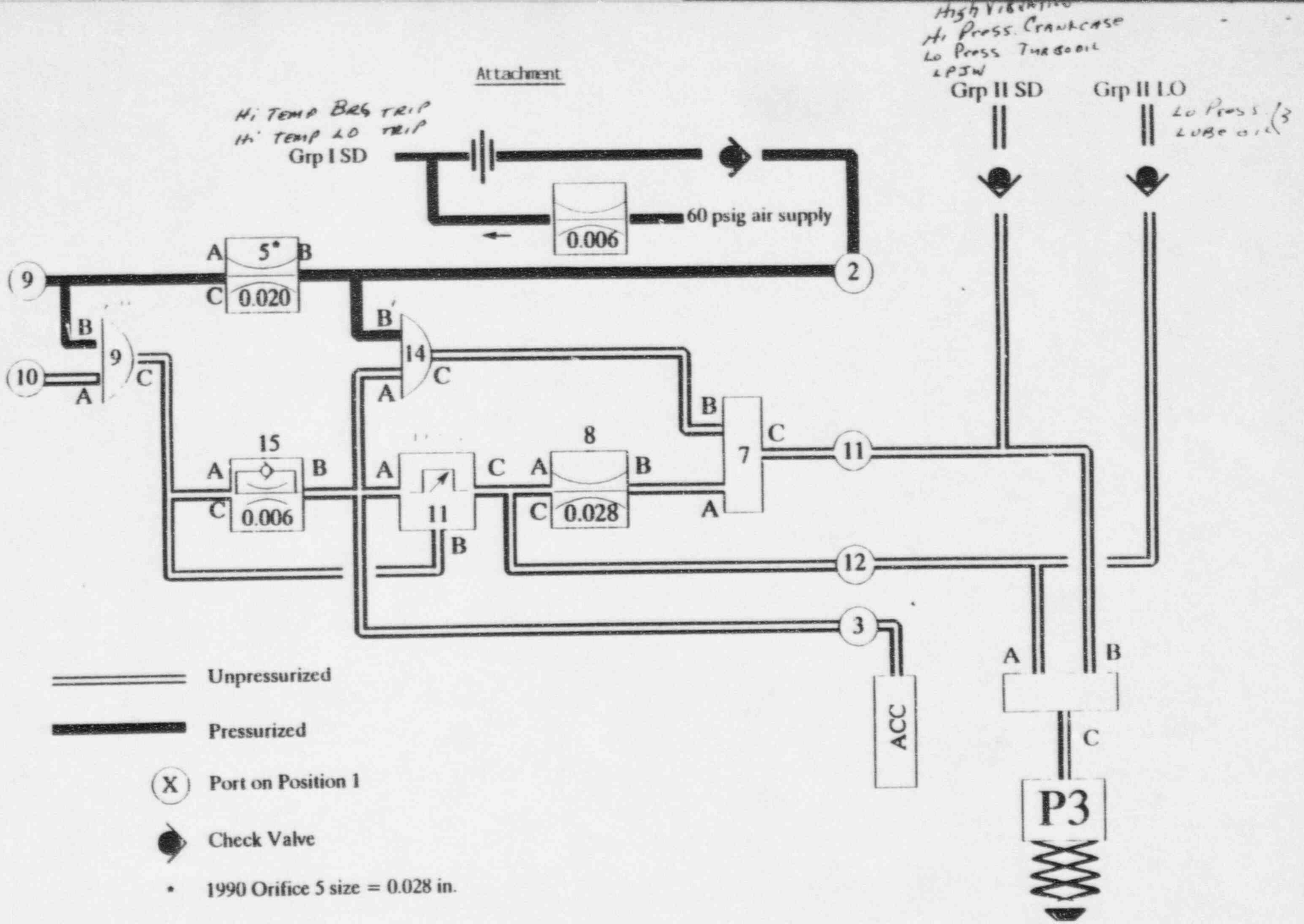


Figure 1. Simplified diagram of Shutdown board logic functions prior to DG start signal.

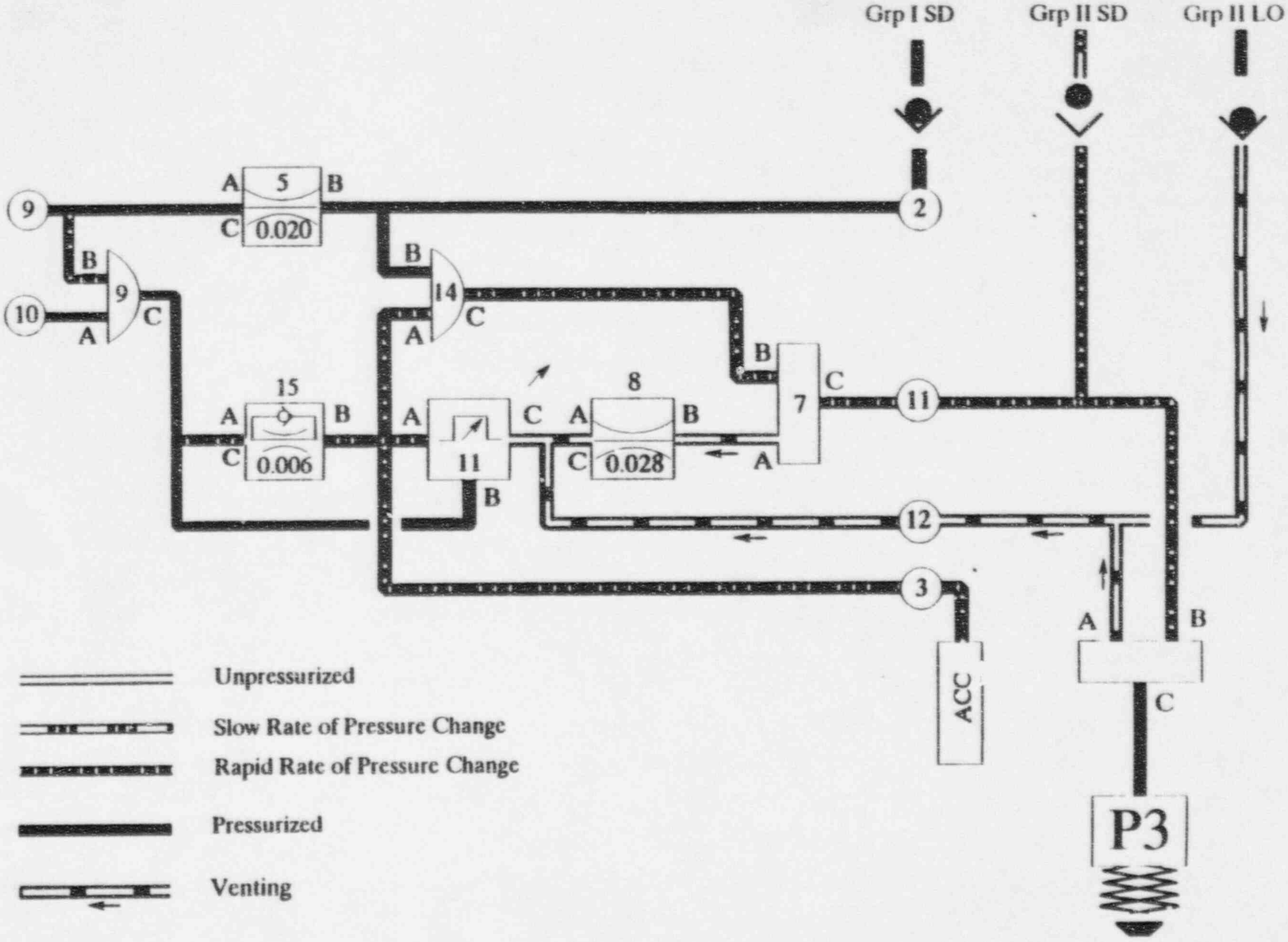


Figure 3. State of essential modules between 40 psig and 60 psig Accumulator pressure.

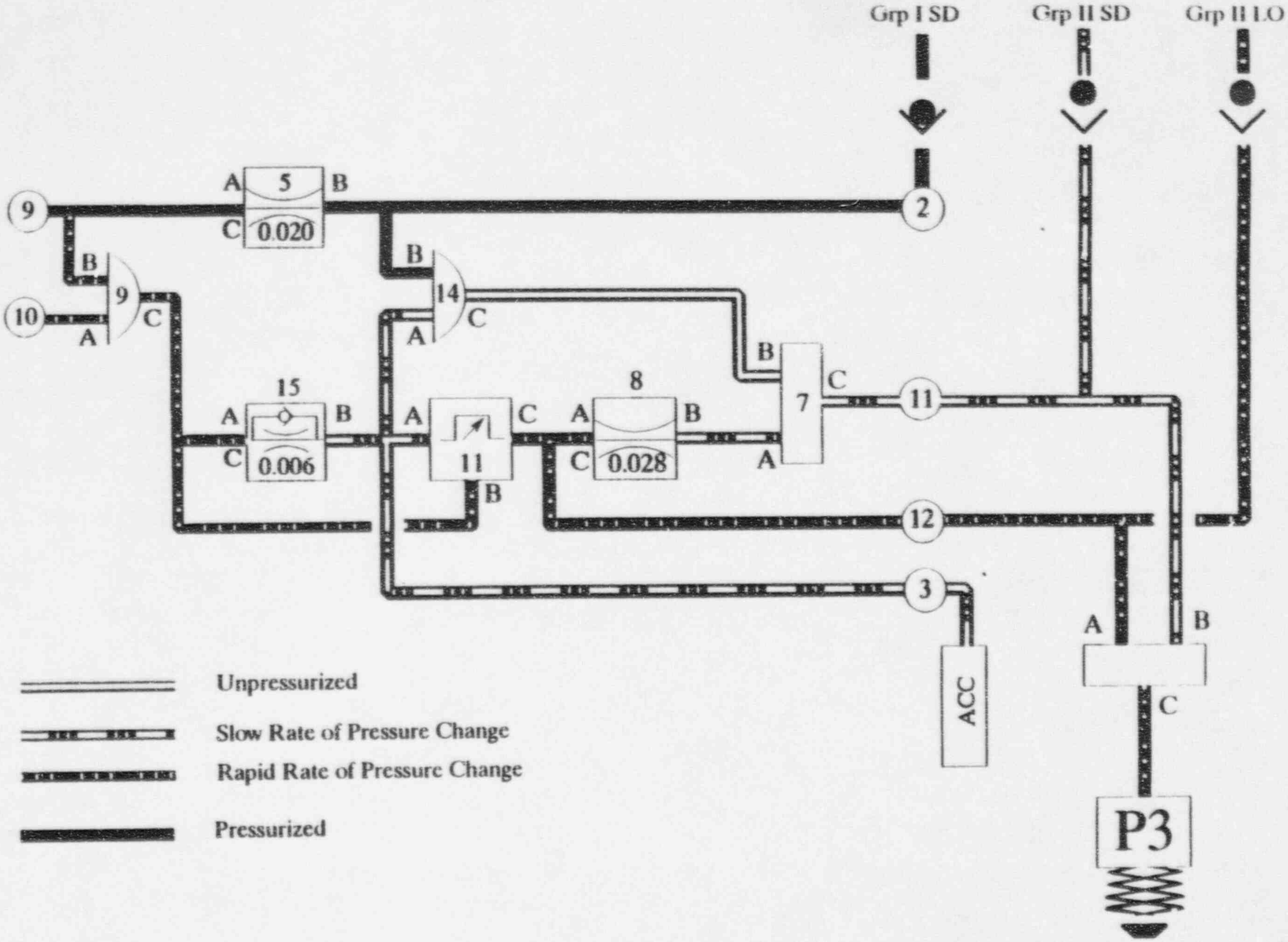


Figure 2. State of essential modules prior to 40 psig Accumulator pressure.

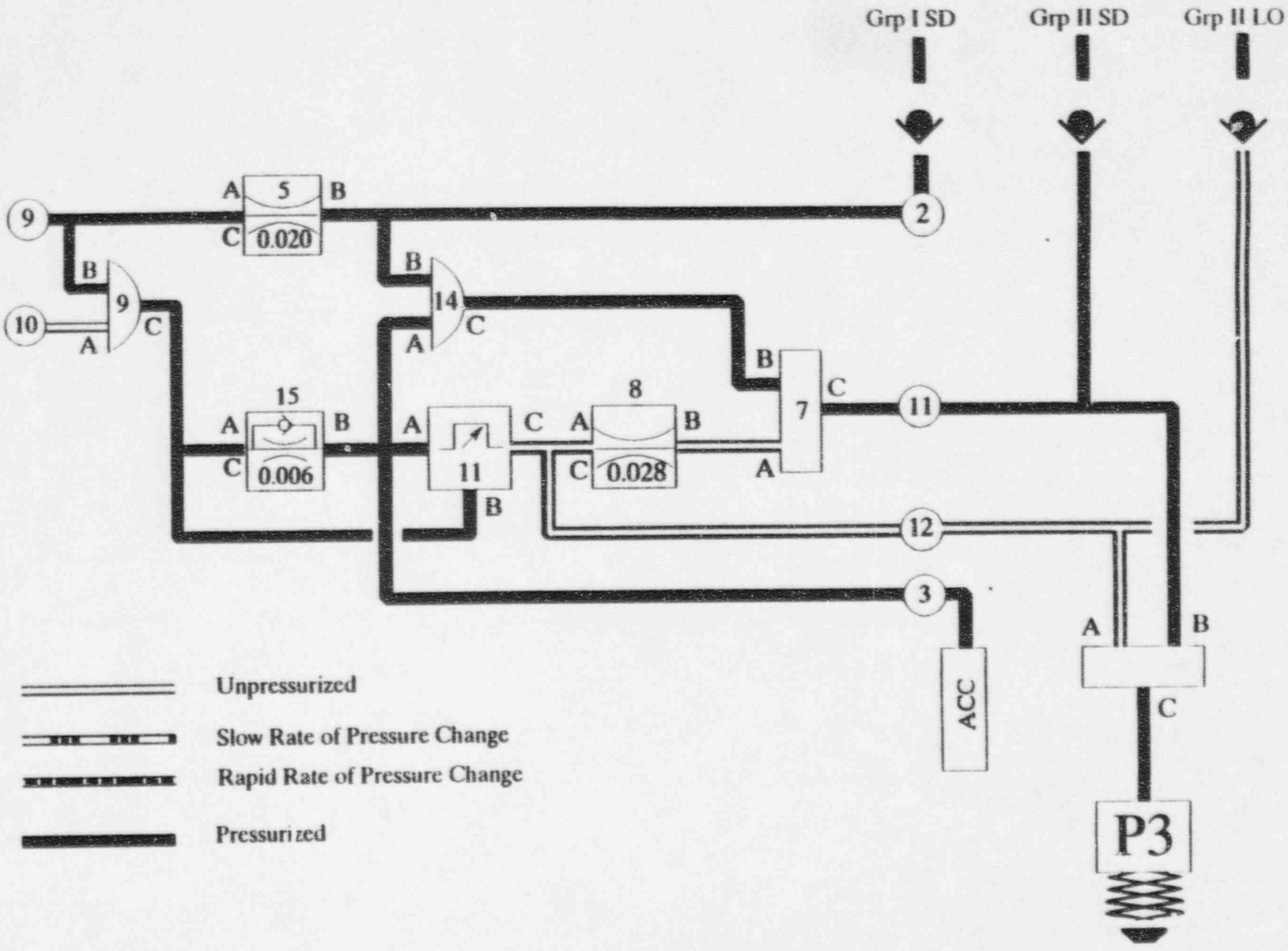
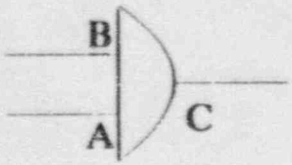


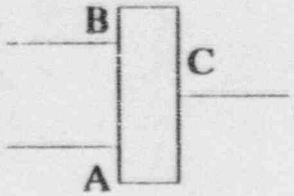
Figure 4. State of essential modules when Accumulator pressure is 60 psig.

Symbol | **Device Description**



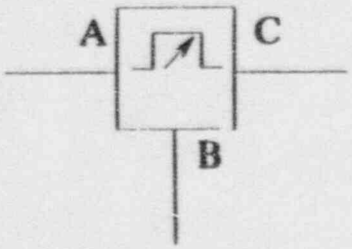
AND

Pressure flows from port B to Port C when there is pressure at A and B. If either A or B is depressurized, C will vent through internal exhaust port. With 60 psi supply at B, element turns TRUE at 40 psi rising and FALSE at 20 psi falling (typical).



OR

Pressure flows from port A to port C, or from port B to port C when there is pressure at A or B. Without pressure at A or B, pressure vents back from C to B.



TIMER/NOT

With pressure at port B only, pressure flows from port B to port C. When pressure is applied to port A, pressure flow from port B to port C is terminated after delay. Output termination time is adjustable from 0.08 to 7.5 seconds. Ports A and B are sometimes connected to a common source for a single shot pulse output.

Figure 5. Pneumatic Logic Element Symbols