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Cooper Energy Services

CORRESPONDENCE RELATING TO PNEUMATIC CONTROL COMPONENT TESTING

COPY

June 5, 1990

Georgia Power Company
40 Inverness Center Parkway
P.O. Box 1295
Birmingham, AL 35201

Attention: Mr. Kenneth Burr

Subject: Vogtle Electric Generating Plant
Enterprise Diesel Generators S/N 76021/22
Pneumatic Control Component Testing

Reference: Georgia Power Purchase Order No. 6003110
Cooper Job No. S88859

Gentlemen:

This letter documents our findings of pneumatic control component testing conducted at the San Leandro, CA facility of Cooper Industries, May 30-31, 1990. This testing was commissioned by Georgia Power Company as part of the on-going investigation into the cause of events at Vogtle, 3/20/90, and the control system related issues which have been raised since that time. The components addressed by this report consist of (4) California Controls' Pressure Sensors, Enterprise Part Number *F-573-156*, and (1) Enterprise Pneumatic Logic Board, Enterprise Part Number *1A-7055*.

Testing was conducted under the guidelines of Enterprise Procedure No. S88859-700 REV. 1, dated 5/11/90 *(copy attached)*. The following details our findings on an item-by-item basis:

Pressure Switch P/N *F-573-156*
Georgia Power VEGP I.D. No. 1PSL4903

This pressure switch was installed in the engine control panel and is designated P3 on the control schematics. Its purpose is to detect a decrease in air pressure to engine mounted shutdown sensors and affect a fast venting of the logic to overcome line volume and pressure drops. Georgia Power records indicate that this device was originally calibrated on 3/16/90. The device was installed in the control panel of engine S/N 76022, VEGP Unit 1B. The pressure switch became suspect of malfunctioning on 3/25/90 during the course of troubleshooting the controls to determine the cause of unannunciated engine shutdowns. The device was replaced on 3/26/90, though this had no affect on the control system problems. The pressure sensor was tested by Georgia Power's I&C personnel three times with satisfactory results before being placed in storage on 3/26/90. The purpose of

testing this device in San Leandro was for confirmation of the previous findings.

The pressure sensor is a California Controls' model *B4400B*, a two way, normally open, pilot actuated valve. The nameplate indicates a September 1988 manufacturing date. Two regulated air supplies fed the device. One, connected to the sensor port, was varied to cause the pressure switch to trip and reset, the pressure was indicated on a Danton 0 to 160 psig gauge, Enterprise M&TE No. *C-7611*, calibrated 5/10/90, due 8/10/90. The second regulated supply was maintained at 60 psig and went through a .028" parallel orifice/check valve oriented so as to restrict flow to the supply port of the pressure sensor, air pressure was indicated on an Aschcroft 0 to 160 psig gauge, Enterprise M&TE No. *B-2902*, calibrated 5/08/90, due 8/08/90. The sensor port pressure was adjusted between 0 and 60 psig for each valve cycle; the results were:

Test No.	*Trip Point*	*Reset Point*
1	44.5 psif (falling)	49.5 psir (rising)
2	45 psif	49.5 psir
3	44.5 psif	49.5 psir
4	44.5 psif	49.5 psir

This data is consistent with calibration records from 3/26/90 and indicates satisfactory performance of the pressure sensor. The specified pressures for this application are 45 psif to trip and a reset dead bank of 1 to 8 psi.

An interesting observation made during this test came about when the .028" orifice/check was inadvertently installed backwards causing an unrestricted 60 psi air source to be fed to the supply port. This resulted in the same trip point but it increased the pressure switch's reset dead band from 5 psi to 26 psi. The relevance of this observation is to point out the importance of using the .028" orifice to the supply port when performing calibration (the .028" orifice duplicates the restricted air supply coming from the logic board).

Pressure Switch P/N *F-573-156*
Georgia Power VEGP I.D. No. 1PS4749C

This pressure switch was installed on engine S/N 76021, VEGP Unit 1A, for the purpose of low lube oil pressure protection. It is designated as **Trip Low Press. Lube Oil No. 3**, Line E-10C on the control schematics. It is one of three pressure switches monitoring lube oil pressure; the control system logic requires that two of the three must vent to affect an engine shutdown. These sensors are active in both the normal and emergency engine operational modes.

Georgia Power records indicate that this device was originally calibrated on 10/21/88. It was removed under MWO *19001433*, on 3/30/90, for testing following reports of a lube oil pressure sensor malfunction alarm during operation on 3/20/90. Georgia Power's I&C personnel found this switch to be satisfactory, but it was placed in storage and replaced by a new sensor from stores.

This pressure sensor is a California Controls' model *B4400*. It is the same as the **P3** valve described earlier except that it does not incorporate the **"B"** modification (to be described later in this report). The nameplate did not indicate a manufacturing date, however, the valve was still covered by factory engine paint which dates it as pre-August '81; engine S/N 76021 shipped from Oakland 8/31/81. A 1/4" Swagelok 90° ell was still attached to the sensor port. Upon removal we noted that this was a special orificed fitting of the type used on the fuel return side of the Bendix fuel injection pump. This fitting does not affect the findings of this report, nor is it suspected to have relevance to the events of 3/20/90, but it is a misapplication of a special fitting which maintenance and I&C personnel should be made aware of.

This pressure sensor was tested by the same method as described for the **P3** valve though a different pressure gauge was used to indicate sensor port pressure. A Delaval -20 to 0 to 100 In. Hg. Test Gauge, Enterprise M&TE No. *B-4246*, calibrated 5/08/90, due 8/08/90 was installed on the sensor port. The gauge substitution was made to improve resolution, the 0 to 100 psi gauges specified by the procedure were not available at the time of this testing. The sensor port pressure was adjusted between 0 and 100 In. Hg. for each valve cycle. The results were:

Test No.	*Trip Point*	*Reset Point*
1 (34.8 psir)	61.5 In. Hg. (30.1 psif)	71 In. Hg.
2 (34.7 psir)	62 In. Hg. (30.4 psif)	70.75 In. Hg.
3 (34.7 psir)	62 In. Hg. (30.4 psif)	70.75 In. Hg.
4 (34.7 psir)	62.25 In. Hg. (30.5 psif)	70.75 In. Hg.

This data is consistent with Vogtle's calibration records from 3/30/90 and indicates satisfactory performance of the pressure sensor. The specified pressures for this application are 30 psif to trip and a reset dead band of 1 to 8 psi.

Pressure Switch P/N *F-573-156*
Georgia Power VEGP I.D. No. 1PS4749B

This pressure switch was installed on engine S/N 76021 as the No. 2 Low Press. Lube Oil Trip on pneumatic line E-10B. It too was removed on 3/30/90 for the same reasons as described for the No. 3 device and when tested, was found to be satisfactory. This pressure switch was also covered by factory engine paint, with no manufacturing date. It is assumed to be of the same vintage as the "C" device. The results were:

Test No.	*Trip Point*	*Reset Point*
1	60.5 In. Hg. (29.7 psif)	74.5 In. Hg. (36.5 psir)
2	62 In. Hg. (30.4 psif)	74.5 In. Hg. (36.5 psir)
3	62 In. Hg. (30.4 psif)	75 In. Hg. (36.8 psir)
4	62 In.Hg. (30.4 psif)	75 In. Hg. (36.8 psir)

This data again indicates satisfactory performance of the pressure sensor.

Pressure Switch P/N *F-573-156*
Georgia Power VEGP I.D. No. 1PS4749A

This pressure switch was installed on engine S/N 76021 as the No. 1 Low Press. Lube Oil Trip on pneumatic line E-10A. This switch was removed at the same time as the other two, however, when this one was checked by Vogtle I&C, they found that it would not reset. A failure of the device to reset would explain the sensor malfunction alarm reported on 3/20/90.

This switch was again covered by factory engine paint though this one was stamped with assembly code No. *8103* to signify manufacture in March of 1981. Georgia Power's records indicate initial VEGP calibration on 10/21/88.

We tested this device in San Leandro by the same methods and apparatus as the others. Our findings confirmed VEGP's in that the device remained at a full vent and would not reset with a sensor pressure of up to 100 In. Hg. (49 psig), representing approximately normal lubricating oil pressure. We proceeded to disassemble the pressure switch to determine the cause of malfunction. When the pressure head was removed we found that the diaphragm was stretched and fully set solid against the head. The affect of this is a substantial reduction in the area in which sensor pressure can act to counter the spring forces transmitted through the pressure plate. The reduction in area requires a proportional increase in pressure to achieve the same force necessary to reset the pressure switch.

This condition was identified as a potential problem by our 10CFR21 report No. 145, addendum 1, dated May 12, 1988 *(copy attached)*. The cause of this problem was found to be the result of a manufacturing tolerance stack-up which allowed the pressure plate to push the diaphragm up squarely against the head. Over time, the diaphragm would stretch to conform to the head and reduce the sensor port area. To remedy the problem Calcon has developed the ***B4400B*** model which incorporates a counterbore in the head to ensure clearance between the diaphragm and head; existing model ***B4400*** pressure sensors can be reworked to the ***B4400B*** configuration.
The pressure switch was completely disassembled for examination to verify that the diaphragm problem was the only cause of malfunction. One small piece of metallic debris and some dirt was found within the spring chamber where it would not impact the switch's function. Evidence of moisture tracks and a rusty spring were also observed but again they are not considered as relevant to the reset problem. The remainder of components were found to be in good condition.

To further verify that the diaphragm was the sole cause of malfunction we switched the diaphragm and pressure head assembly with the one installed on the P3 valve which incorporates the ***B4400B*** modification. The valve was tested without disturbing the adjusting screw's original position and the following results were obtained:

Test No.	*Trip Point*	*Reset Point*
1	29 psif	33 psir
2	29 psif	32.5 psir
3	29 psif	32.5 psir
4	29 psif	32.5 psir

The pressure switch was then reassembled with its original diaphragm and pressure head without disturbing the set of the diaphragm against the head. The Danton 0 to 160 psig pressure gauge, No. *C-7611*, was connected to the sensor port and the pressure was increased to determine where the switch

would reset. The diaphragm broke free and the switch reset at 118 psir. With the diaphragm free the device was tested for its trip point with the following results:

Test No.	*Trip Point*	*Reset Point*
1	28.5 psif	33.5 psir
2	28.5 psif	33 psir
3	28.5 psif	33 psir
4	28.5 psif	33 psir

These results clearly indicate that the diaphragm's set against the pressure head was the sole cause of sensor malfunction.

Shutdown Logic Board P/N 1A-7055

A shutdown logic board malfunction occurred on 3/26/90 during functional testing of the engine control panel for 76022, VEGP Unit 1B. In a simulated operational condition, one of the engine shutdown sensors was very slowly vented by loosening the tubing connection to that sensor at the control panel bulkhead. If the venting was performed slowly enough the logic board would *"lock up"* and fail to produce output to the shutdown cylinder. It should be noted that actual venting of the on engine shutdown devices would consistently produce the proper shutdown response. Due to schedule constraints at the time of functional testing, the logic board was replaced with an assembly from stores which remedied the problem.

The logic board was connected to the factory simulator and tested in accordance with the procedure on drawing *61-560-7055 REV. D.* All of the test steps produced satisfactory results. The test fixture was then modified in an attempt to simulate site conditions by installing a check valve, Enterprise P/N *F-573-127*, and a Whitey two way shutoff valve at port 11 of the logic board, the group II shutdown circuit. The check valve was the same as that used to isolate engine mounted shutdowns at Vogtle; its orientation for this testing allowed flow from port 11 of the logic board to the Whitey valve and subsequently to vent to atmosphere. The check valve was used to simulate the pressure drop in the control panel and the Whitey valve provided a means to slowly vent the logic circuitry. Group I pressure was monitored by a Danton 0 to 160 psi gauge, Enterprise No. *C-7611*, calibrated 5/10/90, due 8/10/90. Group II pressure was monitored on an Aschcroft 0 to 160 psi gauge, Enterprise No. *B-2717*, calibrated 5/08/90, due 8/08/90. The following tests were conducted *(a copy of the logic board schematic and functional description is attached for reference):*

A) Charge the logic board at 60 psig control air pressure; simulate a running state and slowly bleed Group II pressure to produce a trip: Shutdown pressure at port 7 occurred with Group I at 16 psif and Group II at 8.5 psif.

B) Fully open the Whitey valve on port 11 to measure system pressure drops: Group I pressure was 12 psig and Group II was 1-1/4 psig.

C) Increase control air pressure to 65 psig and repeat **Step A**: Shutdown pressure at port 7 occurred with Group I at 18 psif and Group II at 9.5 psif.

D) Open the Whitey valve fully with control air at 65 psig and measure system pressure drops: Group I was 13.5 psig and Group II was 1.5 psig.

E) Return control air pressure to 60 psig and replace not element 13 with a new element; repeat **Step A**: Shutdown pressure at port 7 occurred with Group I at 16 psif and Group II at 9 psif.

F) The logic board was removed and all of the elements necessary to activate for shutdown were disassembled and visually examined. This consisted of looking at element Nos. 5, 7, 13, 14, 16, 17, 18, 20, 22, 23 and 24. No abnormalities were observed and the board was reassembled.

G) The board was retested after assembly in accordance with the procedure on drawing *61-560-7055* and again performed with satisfactory results. **Steps A&B** were repeated to determine if reassembly affected the pressure drops but the results matched the initial test.

CONCLUSIONS AND RECOMMENDATIONS

The logic board could not be caused to fail on the factory simulator, and the observed function and pressures are normal for this component. The actions which caused malfunction at Vogtle were not truly representative of actual engine operation and a problem may never have occurred with that board in service. It is recommended that the board be rebuilt with new elastomer materials and returned to stock.

The low pressure lube oil trip malfunctioned due to manufacturing tolerances which allowed the diaphragm to seat against the pressure head thereby reducing forces generated on the sensing side of the diaphragm. The problem has been addressed by 10CFR21 notification and can be corrected by rework or replacement. It is recommended that all of the model ***B4400*** pressure

switches at Vogtle be reworked to ensure against the reoccurrence of this problem.

Report By:

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RJ:djl