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May 25, 1988

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Subject: Catawba Nuclear Station, Unit 1
Docket No. 50-413
Special Report

Gentlemen:

Pursuant to Technical Specification 3/4.8.1.1.3, please find attached a Special Report concerning the Diesel Generator (D/G) 1A 7th, 8th and 9th valid failures in the last 100 Unit 1 valid tests which took place on April 19, 1988, April 25, 1988 and May 5, 1988. This report has been expanded to include supplemental information required by Regulatory Guide 1.108 as it was indicated in my May 19, 1988 letter regarding the 7th valid failure in the last 100 D/G 1A valid tests.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

JGT/27/sbn

Attachment

xc: Dr. J. Nelson Grace, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, N.W., Suite 2900
Atlanta, Georgia 30323

Mr. P. K. Van Doorn
NRC Resident Inspector
Catawba Nuclear Station

IE22
1/1

MAY 25, 1988

DUKE POWER COMPANY
CATAWBA NUCLEAR STATION, UNIT 1

SPECIAL REPORT REGARDING
DIESEL GENERATOR 1A VALID FAILURES ON
APRIL 19, 1988, APRIL 25, 1988 AND MAY 5, 1988
DUE TO PRESSURE SENSOR DESIGN FLAWS

[IIR C88-54-1]
[IIR C88-55-1]
[IIR C88-60-1]

IE22 1/1

ATTACHMENT 1
DUKE POWER COMPANY
CATAWBA NUCLEAR STATION

DIESEL GENERATOR 1A VALID FAILURES DUE
TO PRESSURE SENSOR DESIGN FLAWS

INTRODUCTION:

While performing the operability verification test on Diesel Generator (D/G) 1A (Start Attempt #662) on April 19, 1988, at 0815 hours, the D/G tripped after approximately 60 seconds. D/G 1A was declared inoperable and Work Request (W/R) 27635 OPS was written to investigate/repair the cause of the trip. D/G 1A was started two more times with IAE personnel present but no failure occurred. Additional troubleshooting did not reveal the cause of the trip, therefore, all sensors that could have contributed to the trip and the pneumatic logic board were replaced. Start attempt #662 was declared a valid failure. This was the 5th valid failure in the last 20 valid starts on D/G 1A and the 6th in the last 100 valid starts. The surveillance interval was at least once per 7 days following the valid failure, which is in accordance with Technical Specifications Surveillance 4.8.1.1.2. This is the seventh valid failure in the last 100 valid starts on Unit 1 D/Gs.

On April 25, 1988, at 1035 hours, during its operability test, once again Diesel Generator (D/G) 1A tripped after approximately 60 seconds. D/G 1A was declared inoperable and Work Request (W/R) 27606 OPS was initiated to investigate the cause of the failure. D/G 1A was started several more times for IAE's troubleshooting purposes and again shutdown after approximately 60 seconds. It was discovered that the P3 pressure sensor in Diesel Engine Control Panel 1A (1DECPA) was not resetting causing it to vent continuously and subsequently shutdown the engine. Start attempt number 676 was declared a valid failure. This was the eighth valid failure in the last 100 valid starts on Unit 1 D/Gs. A new P3 sensor was inspected, calibrated, and installed and D/G 1A was declared operable after its operability test on April 27, 1988.

On May 5, 1988, at 1105 hours, D/G 1A was started for its operability test. Again, the engine shutdown after approximately 60 seconds. During the time period between this failure and when D/G 1A was declared operable on April 27, 1988, the engine was successfully run on two occasions. IAE's troubleshooting revealed that the P3 pressure sensor was again not resetting and venting continuously on an engine start. Start attempt number 691 was declared a valid failure. This was the ninth valid failure in the last 100 valid starts on Unit 1 D/Gs. A representative from Calcon Incorporated, the sensor's manufacturer, arrived on site to assist with our problems. It was determined that manufacturing and design flaws in the sensor prevented it from resetting. A new P3 sensor, inspected by the manufacturer's representative, was installed and D/G 1A was declared operable following its operability test on May 8, 1988.

Per Technical Specification (T.S.) 4.8.1.1.3 and Regulatory Guide 1.108, a special evaluation of the Diesel Generators reliability is required when the number of valid failures is seven or greater in the last 100 valid starts on a per unit basis. Attachment 2 addresses this requirement. This report combines the seventh, eighth, and ninth valid failures due to the root cause being the same.

Unit 1 was in Mode 1, Power Operations, at 100% power at the time of all three valid failures. D/G 1A was unavailable for approximately 58 hours following the 7th valid failure, 51 hours following the 8th valid failure, and 69 hours following the 9th valid failure.

EVALUATION:

Background

Each unit at Catawba Nuclear Station has two independent diesel generators manufactured by IMO Delaval, Incorporated. These D/Gs are used to provide an emergency standby source of power to the equipment required to safely shutdown the reactor in the event of a loss of normal power. The D/Gs also supply power to the safeguards equipment as required during a major accident coincident with a loss of normal power (blackout).

Each D/G is controlled by a separate 60 psi pneumatic control system that will trip the engine when the setpoints of various parameters are reached. This process is achieved by the venting of sensors causing the pneumatic shutdown logic board to initiate a shutdown signal. Trips are divided into Group I and Group II trips. Group II trips are locked out for a period of 60-90 seconds from engine start to allow time for certain engine parameters to reach their normal operating state. On an emergency start, all trips are blocked except lo lo lube oil, overspeed, and generator differential. Lo Lo lube oil trip is a Group II trip. It is blocked, even on an emergency start, for 60-90 seconds, then it is activated. This blocking is obtained by use of the P3 pressure sensor which is in line with the lo-lo lube oil sensors. (See Enclosure 1.) On an engine start, P3 is pressurized and blocked via port 9 of the logic board. This allows time for the lo lo lube oil sensors to block and its tubing line to pressurize. This pressure should hold P3 pressurized when port 9 pressure is lost after the 60-90 second lockout period is terminated. If process pressure to P3 is not obtained or is lost, P3 will vent and the engine will trip when the lockout period is over.

All the sensors on the engine and P3 in the control panel are manufactured by California Controls Company, Inc. (Calcon). A total of seven of these sensors are of one particular model #: Calcon B4400 (Delaval part # F-573-156). These sensors are used in the following locations: 3 lo lo lube oil trips, lo lube oil trip, 2 turbo lube oil trips, and P3 pressure sensor.

Description of Event

On April 19, 1988, at 0815 hours, D/G 1A was started (start attempt #662) to perform an operability test. The engine ran approximately 60 seconds and tripped with all Group II trip annunciators displayed. D/G 1A was declared inoperable and W/R 27635 OPS was written to investigate and repair the cause for the trip. IAE personnel had Operations start the engine again, but this time, no trip occurred. Several more starts were performed but no trips occurred. IAE removed the following Group II

instruments: Lo lube oil trip sensor, left and right front turbo oil trip sensors, Hi crankcase pressure trip sensor, and the pneumatic logic board. Each of these were checked on the bench and no abnormalities were seen. Nevertheless, each of these were replaced due to concerns that an intermittent problem could possibly exist with one of them. In addition, calibration was verified on the Hi Temperature Jacket water sensor and the three Lo-Lo Lube Oil sensors, which had been replaced on April 12, 1988. No problems were found that could have caused the trip.

The next day, D/G 1A was started again. IAE monitored test gauges installed in the pneumatic lines to aid in troubleshooting should a trip occur again. The D/G did not trip, but the trip lines did not pressurize fully until just seconds before Group II swap-over occurred. The D/G was started several more times and all pressures looked normal. D/G 1A was secured and IAE continued to troubleshoot. All instrument tubing lines that could have caused a trip were pressurized and verified not to leak. During this process, it was discovered that the .004 orifice check valve, Item #31 on Enclosure 1, was leaking past its seat. The .004 orifice check valve was removed along with the P3 pressure sensor. It was IAE's feeling that the .004 orifice check valve leaking was not significant enough to cause the D/G failure that had occurred. The orifice check valve was replaced and P3 was checked to verify proper calibration. The P3 tested good and an inspection revealed no problems with it. Nonetheless, it was replaced. D/G 1A was run three times and no problems were seen.

D/G 1A was allowed to sit idle for a period of 24 hours to try and establish a correlation between time and the failures. The previous valid failure on D/G 1A on April 12, 1988 could also not be repeated after the engine had been started in a short time period following the trip. D/G 1A was started and all pressures increased and stabilized as they should. The engine was run twice more and everything looked normal. The operability test was then run and D/G 1A was declared operable.

Temporary Station Modification (TSM) W/R 9238 IAE, which allowed installation of pressure gauges on the Group II pneumatic trip lines, was installed in 1DECPA on April 22, 1988. This modification would allow IAE to monitor these pressures during the operability tests. This was a useful tool to help pinpoint any problem areas that could possibly trip the D/G but were not reproducible on the next run. D/G 1A was started on April 23, 1988 and all indications were normal.

On April 25, 1988, at 1035 hours, D/G 1A was started (start attempt number 676) to perform an operability test. The engine ran approximately 60 seconds and tripped with all the Group II trip annunciators displayed. D/G 1A was declared inoperable and W/R 27606 OPS was initiated for IAE to investigate the reason for the trip. IAE technicians monitoring the gauges installed per TSM 9238 IAE on the trip lines noticed that none of these lines built pressure during the start attempt. Operations started the engine several more times for IAE's troubleshooting purposes. Each time the engine tripped after approximately 60 seconds. It was discovered that the P3 pressure sensor was venting continuously during the engine run which was causing D/G 1A to trip. P3 was removed and checked on the bench. It was determined

that its setpoint had drifted from its calibrated value of 40 psi to greater than 60 psi. This P3 had just been replaced on April 20, 1988 per Work Request 27635 OPS. D/G 1A had run on 2 different occasions (April 21, 1988 and April 23, 1988) with no problems since this P3 was replaced on April 20.

The failed P3 was disassembled and inspected. Slight manufacturing defects such as inadequate deburring were the only things observed internal to the sensor that could have been attributed to the failure. The sensor was reassembled and recalibrated to 40 psi decreasing. The sensor was repeatable at this setpoint when cycled several times.

A new sensor was removed from stock, inspected thoroughly, calibrated for 40 psid, checked for repeatability, and installed in 1DECPA for use as the P3 pressure sensor. D/G 1A was allowed to sit idle for a day to ensure that time was not a factor in the trip. On April 27, 1988, D/G 1A successfully passed the operability test and was declared operable.

Work Requests 9249 IAE, 9250 IAE, and 9251 IAE were written on April 28, to inspect the group II sensors on D/Gs 1B, 2A, 2B, respectively for manufacturing flaws and corrosion caused by moisture in the Instrument Air (VG) System. The sensors were cleaned/repaired/replaced as necessary. Lo Lo lube oil sensor C on D/G 2B was found to have the same failure mode as the P3 that failed on D/G 1A. It would vent continuously when 60 psi process pressure was applied. It was replaced and returned to service. Because of this being a 2 out of 3 trip, this failure did not show up in the D/G 2B runs. Meanwhile, D/G 1A was run successfully on April 29 and May 3, 1988, and no problems were encountered.

On May 5, 1988, at 1105 hours, D/G 1A was started (start attempt #691) for its operability test. After approximately 60 seconds, once again, the engine tripped with all Group II trip annunciators displayed. D/G 1A was declared inoperable and W/R 27726 OPS was initiated for IAE to investigate the cause of the failure. It was discovered that the P3 that had been just changed out on April 25, 1988, had failed. It would not reset with 60 psi control air pressure applied on it, indicating the same failure as the previous P3. The P3 pressure sensor was removed from 1DECPA and brought to the IAE shop for troubleshooting. It was initially thought that the setpoint had drifted greater than 20 psi above the required setpoint of 40 psi. The sensor was adjusted to 40 psid and verified to reset at approximately 48 psi increasing, giving a deadband of 8 psi. The sensor was allowed to sit for about 45 minutes. When checked again, on an increase in pressure, it would not reset up to 60 psi. More troubleshooting was performed and it was discovered that if more pressure was applied, the sensor would eventually reset and still retain its setpoint of 40 psi. The longer the sensor sat, the higher the deadband would be.

An IMO Delaval and Calcon representative arrived on site at IAE's request on May 7th, 1988, with 12 new Calcon Model B4400 pressure sensors that had been closely inspected. They observed first hand the problems that were being encountered. It was determined that a batch of sensors received on April 15, 1988, were of poor quality. The three that had failed (2 P3s and 1 Lo Lo Lube Oil) were of this lot. The Calcon rep pointed out that friction binding between the large spring and spring

housing internal to the sensor (see Enclosure 3) could lead to the high reset values that were seen. Work Requests 9277 IAE, 9278 IAE, and 9279 IAE were written to replace sensors from the suspect batch on D/Gs 2A, 2B, and 1B respectively. In addition, W/Rs 9282 IAE, 9283 IAE, and 9281 IAE were written to verify that the reset pressures for the P3 on D/Gs 2A, 2B, and 1B respectively, were not abnormally high. The P3 in 1DECPA was replaced with one delivered by the vendors per W/R 27726 OPS. The other sensors of this type on D/G 1A were not from the suspect batch, and therefore were not replaced.

Also during this same time period, to ensure complete reliability of D/G 1A, the decision was made to replace the VG supplied control air system, which had been plagued with a moisture problem over the years, with a nitrogen supplied system. This modification was performed per Nuclear Station Modification (NSM) #CN-11151. This modification was completed and tested on May 8, 1988. Operations completed their operability test the same day and D/G 1A was declared operable.

On May 9, 1988, at approximately 1430 hours, a call was received from the IMO Delaval Rep. He stated that the Calcon Rep, after leaving Catawba, made more discoveries about the suspect model of sensors. It was requested that the IMO Delaval and Calcon Rep visit the site once more with some newly modified sensors and assist IAE with replacing all sensors of this type on each engine. The IMO Delaval Rep stated that the engines were not inoperable with the sensors that were currently installed, however, the additional measure of replacing the sensors was needed. The Calcon and IMO Delaval Rep. arrived on site on May 11, 1988, with more new sensors. They explained in detail the discoveries about the sensors that had been determined to be the main reason they had failed. Because of a tolerance stack-up in the manufacture of the sensor, the pressure sensing diaphragm can be held solid against the pressure head, thus creating a smaller surface area (see Enclosure 3). This smaller surface area would require a much higher pressure to reset the sensor. Calcon had remanufactured the pressure head on the new sensors brought with them to add an additional 1 1/8" diameter circular bore .030" deep, to provide a positive gap between the head and the diaphragm. The new sensors will be stamped P/N B4400B to distinguish them from the questionable sensors. All Calcon B4400 sensors were replaced on D/Gs 1A, 1B, 2A, and 2B per W/Rs 9295 IAE, 9296 IAE, 9297 IAE, and 9298 IAE with Calcon B4400B sensors.

CONCLUSION

Based on the discoveries made by Calcon, it is concluded that the 7th, 8th, and 9th valid failures within the last 100 valid starts on Unit 1 D/Gs are attributed to the same root cause: inadequate design and manufacture of the Calcon Model B4400 pressure sensor. Upon returning to his plant on May 9, 1988, the Calcon Rep discovered that by stacking up the tolerances allowed in the manufacture of the sensor, it was possible to have negative .022" or no gap between the diaphragm (P/N 283) and the pressure head (P/N 4370). (See Enclosure 3.) If all parts were in the middle of these tolerances, there would be a .010" gap. And, if the parts were at the other extreme of the tolerances, then a .030" gap would be present. The effect of the negative gap would cause the diaphragm to fuse to the

pressure head from spring pressure on the pressure plate (p/n 4380). This in turn reduced the normal pressure area of approximately 1 1/8" diameter down to 3/8" diameter, thus requiring more pressure to overcome the spring pressure and reset the sensor. On newly calibrated sensors, this is not seen because the diaphragm has not had time to stretch and seat itself against the pressure head. This explains the time factor involved in the failure of these sensors. The failed sensors, including the P3 removed after the 7th valid failure, were measured and verified to have a negative difference between the diaphragm and pressure head, indicating the diaphragm was actually being compressed. This was also evident from inspecting the diaphragm and noting the compression ring on the diaphragm. Calcon's modification to this type of sensor ensured that a positive gap will always be present between the diaphragm and the pressure head. With all of these type sensors being replaced, no further failures of this type should exist. Further verification of the effectiveness of this modification was demonstrated by calibrating 2 of the failed sensors and checking reset pressure. After a period of time, reset pressure was seen to raise significantly. The modification of taking .030" from the inside of the pressure head was then performed on these 2 sensors. They were again recalibrated and allowed to sit overnight. The next day they were checked and reset pressure had not changed.

This design flaw had a significant effect on D/G operation. All of these sensors are set on a decreasing pressure to trip the engine. However, the reset pressure is critical also. If the sensor is not reset on an engine start, then it will vent continuously and not allow pressure to build up in any of the pneumatic lines. This explains why all annunciators for Group II trips were received during these 2 failures. The reason the defect was so pronounced with a sensor used in the P3 application was because the setpoint of 40 psid is higher than the other sensor applications: lo lo lube oil, 30 psid; lo turbo oil, 15 psid; lo lube oil, 35 psid. This means that a higher spring pressure must be overcome to reset the sensor. Also, lube oil pressure, which the other sensors are seeing, actually increases higher than 60 psi which the maximum P3 would ever sense.

Per Calcon, this design flaw has existed since 1980, as none of the parts involved have had changes affecting these tolerances. From inspections performed by the Calcon Rep on site it was noted that approximately 40% of the sensors checked actually had a negative clearance between the diaphragm and the pressure head. It so happened that the ones with this discrepancy were used in the P3 application on D/G 1A during the 7th and 8th, and 9th valid failures.

A problem with air quality in the VG system has been a major concern over the past months, in particular on D/G 1A. Several older sensors that had been removed following the D/G 1A failures were seen to have a degree of corrosion in their internals. This corrosion was initially thought to be a major contributing factor in the failures on D/G 1A due to it possibly causing sensors to stick in the vented position. Maintenance history showed that the VG system for D/G 1A had been exposed to more moisture carryover problems from the system's aftercoolers over the past several years than the other D/Gs. Therefore, following the 9th valid failure, it was decided to replace the VG supplied pneumatic control system with a nitrogen supplied system to further ensure the reliability of D/G 1A.

The nitrogen system will supply a clean and dry source of control medium. The aftercoolers on all 4 D/G's VG System dryers are now being blown down twice a shift to remove moisture buildup. Also, Performance is monitoring-the moisture content in all 4 D/G's VG Systems on a more frequent basis. Other measures to improve long term reliability are detailed in the special report, Attachment 2.

SAFETY ANALYSIS:

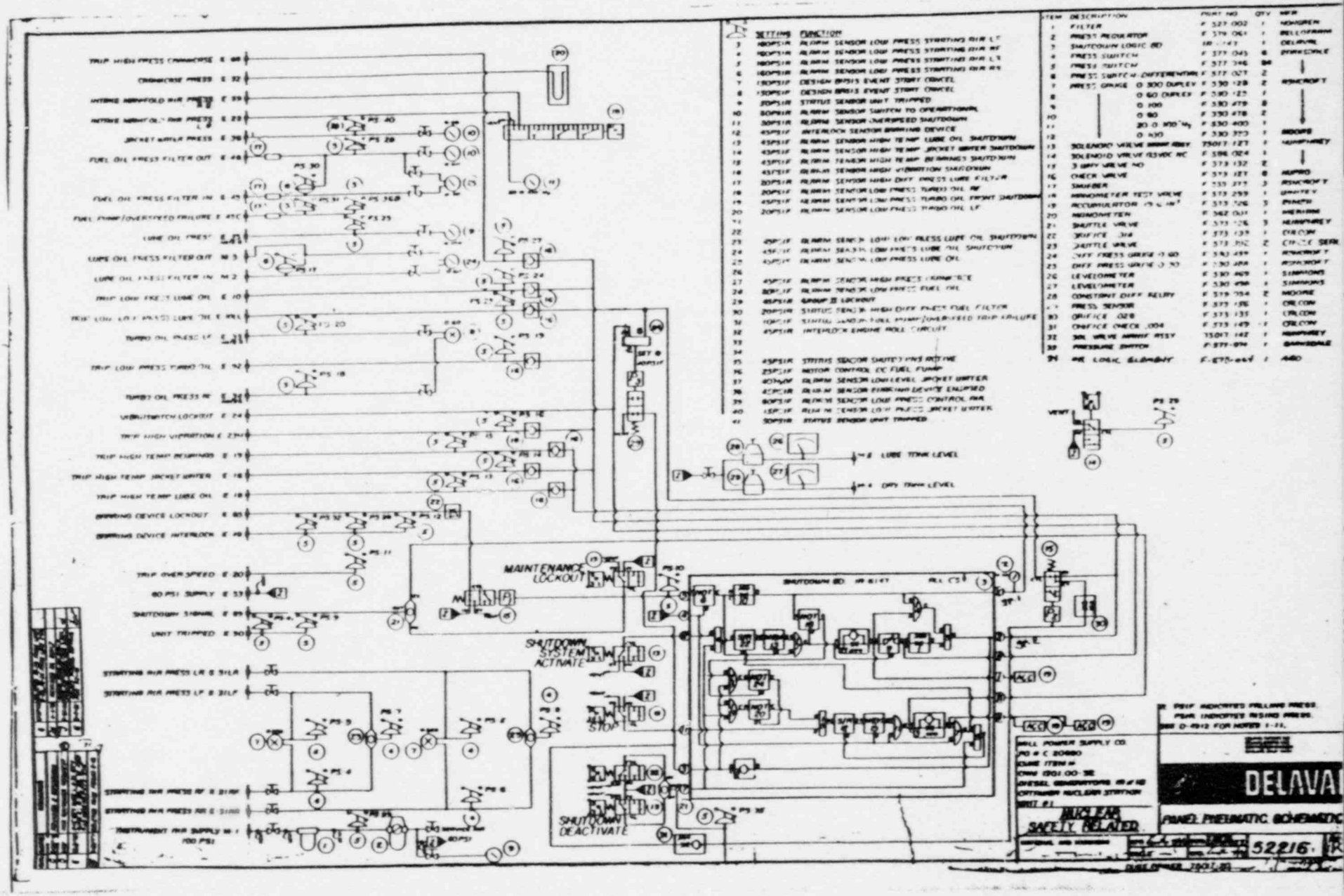
Technical Specifications requires that when either an offsite AC electrical power source or D/G is inoperable, the availability of the remaining power sources must be demonstrated. This was done each time D/G 1A was inoperable per Tech Spec guidelines. D/G 1B was operable and available during the period in which D/G 1A was inoperable.

The health and safety of the public were not affected by these incidents.

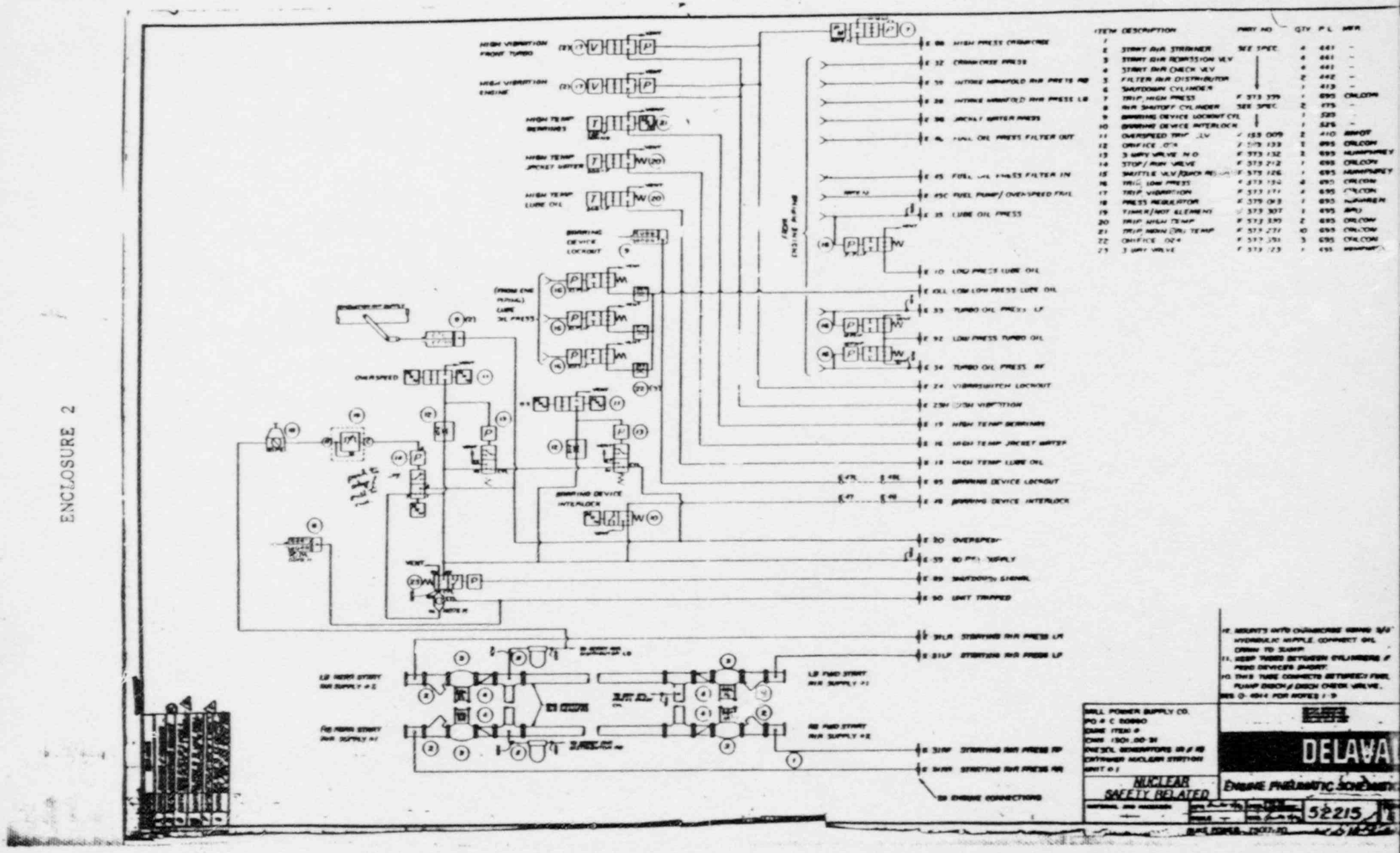
ENCLOSURES

1. Panel Pneumatic Schematic
2. Engine Pneumatic Schematic
3. Calcon Pressure Sensor Model #B4400

ENCLOSURE 1


MAINTENANCE LOCKOUT
SHUTDOWN SYSTEM ACTIVATE
SHUTDOWN DEACTIVATE
DELAVAL
NUCLEAR SAFETY RELATED
52216

ENCLOSURE 2



ITEM	DESCRIPTION	PART NO	QTY	P.L.	MFR
1					
2	START AIR STRAINER	SEE SPEC	4	441	–
3	START AIR ADMISSION VLV		4	441	–
4	START AIR CHECK VLV		4	441	–
5	FILTER AIR DISTRIBUTOR		2	442	–
6	SHUTDOWN CYLINDER		1	413	–
7	TRIP, HIGH PRESS	F 573 339	1	695	ORLCON
8	AIR SHUTOFF CYLINDER	SEE SPEC	2	475	–
9	BARRING DEVICE LOCKOUT CYL		1	525	–
10	BARRING DEVICE INTERLOCK		1	526	–
11	OVERSPEED TRIP ,LV	F 153 009	2	410	WOOT
12	ORIFICE ,07"	F 573 133	1	695	ORLCON
13	3 WAY VALVE N.O.	F 573 132	3	695	HUMPHREY
14	STOP/ RUN VALVE	F 573 212	1	695	ORLCON
15	SHUTTLE VLV/CHECK RE	F 573 126	1	695	HUMPHREY
16	TRIP, LOW PRESS	F 573 134	4	695	ORLCON
17	TRIP, VIBRATION	F 573 171	4	695	ORLCON
18	PRESS REGULATOR	F 579 043	1	695	NORGREN
19	TIMER/HOT ELEMENT	F 573 307	1	695	BMD
20	TRIP, HIGH TEMP	F 573 339	2	695	ORLCON
21	TRIP, HIGH OIL TEMP	F 573 271	10	695	ORLCON
22	ORIFICE ,024	F 573 351	3	695	ORLCON
23	3 WAY VALVE	F 573 123	1	695	HUMPHREY

MILL POWER SUPPLY CO.	
PO # C 80880	
ENGINE ITEM #	
ENGINE MODEL 16-251-00-31	
ENGINE, GENERATOR SET #	
CATERPILLAR NUCLEAR STATION	
UNIT # 2	
NUCLEAR SAFETY RELATED	

DELAVA

ENGINE PNEUMATIC SCHEMATIC

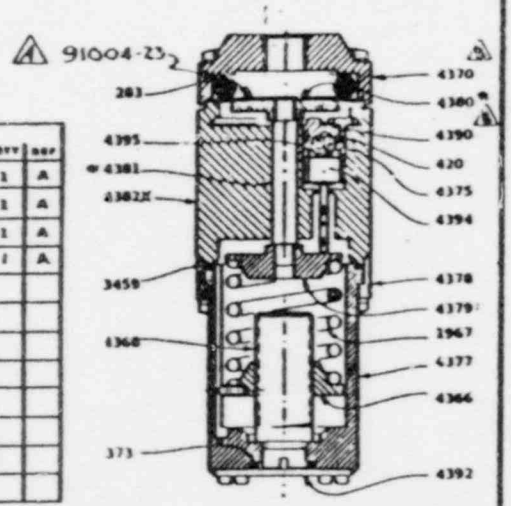
52215

ENCLOSURE 3

PROPRIETARY RIGHTS
NOT TO BE COPIED OR USED WITHOUT PERMISSION

NOTES:

1. A – PART AVAILABLE FOR FIELD REPAIR.
2. LUBRICATE MOVING PARTS WITH G.E. VERSILUBE® SILICONE GREASE
3. *LOCTITE 4381/4380

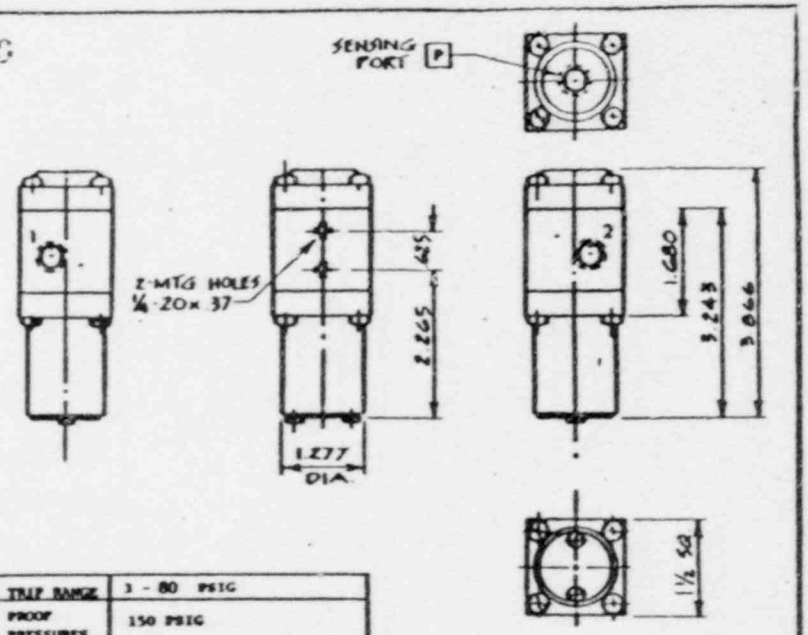


SENSING HEAD 4347			
NO	DESCR	QTY	REF
283	DIAPHRAGM	1	A
4370	HEAD	1	A
4380	PRESSURE PLATE	1	A
91004-23	O-RING	1	A

VALVE SECTION 4338			
NO	DESCR	QTY	REF
420	O-RING	1	A
3681	VENT SEAL (NOT SHOWN)	1	A
4275	LABEL (NOT SHOWN)	1	
4375	VALVE GUIDE	1	A
4381	SHAFT	1	A
4382X	BODY	1	
4390	RETAINER CLIP	1	A
4394	VALVE POPPET ASSEMBLY	1	A
4395	SPRING	1	A

SPRING ADJUST GROUP 4337			
NO	DESCR	QTY	REF
373	O-RING	1	A
1967	SPRING	1	A
3459	O-RING	1	A
4366	ADJUSTER SEAT ASSEMBLY	1	A
4368	ADJUSTER SCREW	1	A
4377	SPRING HOUSING	1	A
4378	HOUSING SLEEVE	1	A
4379	SPRING SEAT	1	A
4392	NAMEPLATE	1	

B4400 | PRESSURE SENSOR SUB-ASSEMBLIES | CHG NO. A B 1



TRIP RANGE	3 - 80 PSIG
PROOF PRESSURES	150 PSIG
FACTORY SETTING	AS REQUIRED
DEAD BAND	1 PSI DEPENDENT ON SUPPLY & SETTING
CONNECTIONS	ALL 1/8-27 NPT
SERVICE TEMP	0° TO 200°F
VALVE	PNEUMATIC, 100 PSI MAX
WETTED MATERIALS	6061 ALUMINUM BUNA-N
BODY MATERIALS	6061 ALUMINUM, STAINLESS STEEL, BUNA-N
SENSING ELEMENT	BUNA-N DIAPHRAGM

			FR010 6-76	PRESSURE SENSOR	FALCON
B	REVISED				
A	RELEASED				
					B4400B

Attachment 2
D/G 1A Special Report

General

The following information is provided in response to the requirements of USNRC Regulatory Guide 1.108 revision 1, section C.3.b. This regulatory guide section requires that additional narrative material be supplied if the number of failures in the last 100 valid tests is seven or more. On April 19, 1988 a valid failure occurred on Catawba engine 1A. This was the seventh valid failure in the last one hundred valid tests for the two Catawba Unit 1 emergency diesel generator sets. An eighth valid failure, which occurred on April 25, 1988 and a ninth, on May 5, 1988 will also be included in this report.

Reliability Improvement Measures

The following are descriptions and basis for corrective measures, taken or planned, to increase the reliability of the generator units.

a. The sensors and circuits that can trip the engine during an emergency run will be changed from pneumatic operation to electrical. These are the engine overspeed trip and the low low lube oil pressure trip. The third (generator fault circuit) is already electrically actuated.

   A majority (7 of 9) of the valid failures have involved problems in the pneumatic control system. Converting the emergency trips to QA class 1E components will isolate engine availability during an emergency from pneumatic system problems that have been seen in the past. This modification is to be completed by the end of the next refueling outage on each unit.

b. Non-emergency engine protection trip sensors will be replaced with electric or electronic sensors that can provide information to an engine monitoring computer.

   A number of past failures can be grouped because of their association with intermittent problems. This system will trend data from engine sensors and alert responsible parties if abnormalities are noted. Data will also be collected for troubleshooting intermittent problems which can cause multiple failures before being corrected.

c. The control panel on the desiccant air dryer will be replaced with a panel designed in house.

   The desiccant dryer control panel has demonstrated low reliability and has been out of service frequently because of long replacement lead times and poor vendor support. The Duke designed panel will allow us the control replacement lead times and make improvements by having control over drawings and material lists. This system is expected to be installed during the next refueling outages.

d. Manually operated starting air aftercooler condensate dump valves will be replaced with automatic dump valves.

A number of the components removed from the pneumatic control system have been found to have corrosion on the internal parts. This suggests that the air supply is too moist.

Operators drain the condensate from the aftercooler on their rounds twice a shift. During the summer or if the starting air system is used more frequently, the condensate can flood the starting air piping. If the water reaches the desiccant towers and wets the desiccant, it is rendered ineffective. More frequent operator action does not take into account fluctuations in system demand and changes in relative humidity. Automatic dump valves should improve starting air system reliability by improving air quality.

e. Fuel coalescers will be added to the fuel system between the fuel storage tanks and the day tanks.

Engine 1A has suffered 3 valid failures due to clogged fuel strainers. Other engines show significant amounts of foreign material (grit, sand, metal shavings, paper, man made fibers) in the bottom of the day tanks. While the day tanks are cleaned each refueling outage, a more continuous means of preventing this sediment from reaching the strainers will assure greater engine reliability.

f. Procedural changes will be made to enhance engine reliability.

1. Preventative maintenance on the starting air system desiccant drying towers, which includes desiccant change out, will be performed semi-annually rather than annually to enhance air quality.

2. Operators tours of the diesel rooms will include a check to see that the generator control cabinet fans are operating to prevent overheating of the diodes and rectifiers inside.

3. Starting air (VG) system dew point will be monitored monthly rather than quarterly to provide better information on VG system reliability. This will continue until automatic monitoring is established.

4. Surveillances on the Calcon sensors will be increased from 18 months to a 6 month frequency. Included in this will be steps to verify no corrosion exists on the sensor's internals.

Engine Reliability Assessment

Of the 100 valid tests conducted previous to and including the seventh (April 19, 1988) failure, engine 1A suffered 5 failures in 35 tests and engine 1B suffered 2 failures in 65 tests. Counting back 100 valid tests from the eighth (April 25, 1988) failure, engine 1A had 6 failures in 36 tests and engine 1B had 2 failures in 64 tests. At the ninth valid failure (May 5, 1988), engine 1A had 7 failures in 40 tests and engine 1B had 2 in 60.

Two different approaches can be used to evaluate the reliability. One approach treats each diesel as having a separate failure rate. The failure rate for each engine is calculated and the two rates are then combined to give a reliability for the system.

Using this approach engine 1A has a mean failure rate of 0.1428 or 85.72% reliability at a 50% confidence level. Engine 1B has a mean failure rate of 0.0307 or 96.93% reliability. The reliability of the system, or of at least having one of the two engines operate successfully is the product of the two failure rates subtracted from unity. This results in a mean reliability rate of 0.9956 or 99.56% reliable with a 50% confidence level.

The second method treats both engines as having an average failure rate of 7 out of a hundred tests or each is 93% reliable. The reliability using this method is between 0.99063 and 0.99742 with a 50% confidence level and a mean of 0.99510 or 99.5% reliable.

Both methods yield values that exceed the 0.99 reliability goal at a 50% confidence level established by NUREG75/087 appendix 7-A.

For the eighth valid failure, 1A had 6 failures in 36 tests with a mean reliability of 83.33%. 1B had 2 failures in 64 tests with a mean reliability of 96.87%. The combined reliability for the engine pair is 99.48% at a 50% confidence level.

For the ninth valid failure, 1A had 7 failures in 40 tests with a mean reliability of 82.53%. 1B had 2 failures in 60 tests with a mean reliability of 96.66%. The combined reliability for the engine pair is 99.42% at a 50% confidence level.

Basis for Continued Operation

The plant will continue to be operated because the reliability of electric power to the engineered safety feature equipment exceeds the goal required by regulations and stringent programs are in place to improve engine reliability beyond this goal. The engines have suffered no further failures since the correction of the manufacturing tolerences on the Calcon pressure sensors after the 5/5/88 valid failure.

Summary of Tests

The Catawba Technical Specifications currently require that the diesel engine operability test (PT/1/A/4350/02A) be performed once every 31 days if four valid failures (VF) or less have occurred in the last 100 valid attempts **AND** if one valid failure (VF) or less has occurred in the last 20 valid attempts otherwise, testing will be performed weekly. Attached is a summary of the start attempts for engines 1A and 1B.

"Valid Attempt Number" is a counting of the most recent 100 valid successes (VS) or valid failures (VF) for the Unit 1 engines combined.

"Engine Start Number(s)" are assigned to each engine start and are recorded together with other information about each run, in the control room log books. The numbers began when the engines were first declared operable at Catawba.

"Test Result" is one of four possible codes, VS, IT, IF or VF.

VS stands for valid success. For a test to be considered a valid success "VS", all of the following conditions must be met:

a: The diesel engine starts and accelerates to greater than or equal to 441 RPM (greater than or equal to 98% speed) within 11 seconds.

b: D/G voltage and frequency shall be at least 4160 plus or minus 420 volts and 60 plus or minus 1.2 Hz within 11 seconds after start signal.

c: The D/G is successfully loaded to greater than or equal to 2875 KW (50% continuous rating) and operates at this load for at least one hour.

d: D/G shutdown was not due to an abnormal condition that would have ultimately resulted in D/G damage or failure.

IT stands for an "invalid test". A test is considered an "invalid test" if any of the conditions described above for VS are not met due to an intentional shutdown prior to loading or operating for greater than one hour at 2875 KW or better that was not due to an abnormal condition that would have ultimately resulted in D/G damage or failure.

IF stands for an "invalid failure". If any of the conditions of a VS are not met **AND** the test is not an IT as described **AND** if any of the following conditions are met, the test in considered an IF.

a: Operator error.

b: Spurious operation of a trip that is bypassed in the emergency operating mode.

c: Malfunction of equipment that is not operative in the emergency operating mode or is not part of the defined D/G unit design.

d: The failure occurs during the process of trouble shooting.

e: The failure occurs during the process of a functional check out prior to returning the D/G to service following maintenance.

Note: The Functional Check Out should be performed prior to and <u>independent of</u> the Operability Test which is performed for the purpose of declaring operability. Once the Operability Test has <u>begun</u> any subsequent failure for reasons other than those listed above is considered a VALID FAILURE.

tands for "valid failure". A test is considered a valid failure if any of following conditions are true.

a: The test cannot be classified as a VS, IT, or IF as described above.

b: The test is intentionally terminated because of an abnormal condition that would have ultimately resulted in D/G damage or failure.

c: Performance of a cranking or venting procedure leads to the discovery of a condition (such as excessive water or oil in a cylinder) that would result in engine failure during operation.

e 1A had 30 VS's, 5 VF's, 110 IT's, and 4 IF's and engine 1B had 63 VS's, s, 126 IT's, and 0 IF during the 99 valid tests preceding the April 19, valid failure.

Attachment 3

D/G 1A Test Data

lid tempt mber		Engine 1A Start Number	Test Result	Test Date	Engine 1B Start Number	Test Result	Test Date
07		700	VS	5/17/88			
06					796	VS	5/15/88
05		699	VS	5/14/88			
04		698	VS	5/13/88			
		697	IT	5/13/88			
03					795	VS	5/12/88
02					794	VS	5/12/88
					793	IT	5/12/88
					792	IT	5/12/88
01		696	VS	5/8/88			
		695	IT	5/8/88			
		694	IT	5/8/88			
00					791	VS	5/6/88
		693	IF	5/5/88			
9	*	692	VF	5/5/88			
					790	VS	5/4/88
		691	VS	5/3/88			
					789	VS	4/30/88
					788	IT	4/30/88
					787	IT	4/30/88
					786	IT	4/30/88
		690	VS	4/29/88			
		689	VS	4/27/88			
		688	IT	4/27/88			
		687	IT	4/27/88			
		686	IT	4/27/88			
		685	IT	4/27/88			
					785	VS	4/26/88
		684	VS	4/25/88			
		683	IT	4/25/88			
		682	IT	4/25/88			
		681	IT	4/25/88			
		680	IT	4/25/88			
		679	IF	4/25/88			
		678	IF	4/25/88			
		677	IF	4/25/88			
	*	676	VF	4/25/88			
					784	VS	4/24/88
		675	VS	4/23/88			
		674	VS	4/21/88			
		673	IT	4/21/88			
		672	IT	4/21/88			
		671	IT	4/21/88			
		670	IT	4/21/88			
		669	IT	4/21/88			
					783	VS	4/19/88
		668	IT	4/19/88			
		667	IT	4/19/88			
		666	IT	4/19/88			
		665	IT	4/19/88			
		664	IT	4/19/88			

Valid Attempt Number		Engine 1A Start Number	Test Result	Test Date	Engine 1B Start Number	Test Result	Test Date
		663	- IT	4/19/88			
86	*	662	VF	4/19/88			
85					782	VS	4/18/88
84					781	VS	4/13/88
83					780	VS	4/13/88
82		661	VS	4/12/88			
		660	IT	4/12/88			
		659	IT	4/12/88			
		658	IT	4/12/88			
		657	IT	4/12/88			
		656	IT	4/12/88			
		655	IT	4/12/88			
		654	IT	4/12/88			
		653	IF	4/12/88			
81	*	652	VF	4/12/88			
80		651	VS	4/6/88			
79					779	VS	4/6/88
78					778	VS	3/30/88
		650	IT	3/29/88			
		649	IT	3/29/88			
		648	IT	3/29/88			
77		647	VS	3/29/88			
76					777	VS	3/28/88
75		646	VS	3/23/88			
		645	IT	3/22/88			
		644	IT	3/22/88			
		643	IT	3/22/88			
		642	IT	3/22/88			
		641	IT	3/22/88			
		640	IT	3/22/88			
		639	IT	3/22/88			
		638	IT	3/22/88			
		637	IT	3/22/88			
		636	IT	3/22/88			
		635	IT	3/22/88			
		634	IT	3/22/88			
		633	IT	3/22/88			
74					776	VS	3/22/88
73		632	VS	3/22/88			
72	*	631	VF	3/22/88			
71					775	VS	3/21/88
					774	IT	3/21/88
70					773	VS	3/13/88
69		630	VS	3/8/88			
68					772	VS	3/8/88
		629	IF	3/8/88			
		628	IF	3/8/88			
67	*	627	VF	3/7/88			
(1A start 627 changed to "VF" from "IF" during NRC audit on 5/17/88)							
		626	IT	3/7/88			
		625	IT	3/7/88			

Valid Attempt Number		Engine 1A Start Number	Test Result	Test Date	Engine 1B Start Number	Test Result	Test Date
		624	- IT	3/7/88			
66	*	623	VF	3/7/88			
65					771	VS	3/6/88
64					770	VS	2/29/88
63					769	VS	2/22/88
					768	IT	2/22/88
62					767	VS	2/15/88
61					766	VS	2/10/88
60		622	VS	2/8/88			
59					765	VS	2/5/88
58					764	VS	1/31/88
57					763	VS	1/25/88
					762	IT	1/23/88
		621	IT	1/23/88			
56					761	VS	1/17/88
55		620	VS	1/13/88			
54		619	VS	1/11/88			
53					760	VS	1/9/88
52					759	VS	1/3/88
51					758	VS	12/28/87
50					757	VS	12/21/87
49		618	VS	12/15/87			
		617	IT	12/15/87			
		616	IT	12/15/87			
		615	IT	12/15/87			
		614	IT	12/15/87			
		613	IT	12/15/87			
48					756	VS	12/14/87
47					755	VS	12/11/87
46					754	VS	12/5/87
					753	IT	12/5/87
					752	IT	12/5/87
					751	IT	12/5/87
					750	IT	12/5/87
					749	IT	12/5/87
					748	IT	12/3/87
					747	IT	12/3/87
					746	IT	12/3/87
					745	IT	12/3/87
					744	IT	12/3/87
					743	IT	12/3/87
					742	IT	12/3/87
					741	IT	12/3/87
					740	IT	12/3/87
					739	IT	12/3/87
					738	IT	12/3/87
					737	IT	12/3/87
					736	IT	12/3/87
					735	IT	12/3/87
					734	IT	12/3/87
					733	IT	12/3/87

Valid Attempt Number		Engine 1A Start Number	Test Result	Test Date	Engine 1B Start Number	Test Result	Test Date
					732	IT	12/3/87
					731	IT	12/3/87
					730	IT	12/3/87
					729	IT	12/3/87
					728	IT	12/2/87
					727	IT	12/1/87
					726	IT	12/1/87
45					725	VS	12/1/87
					724	IT	12/1/87
					723	IT	12/1/87
					722	IT	12/1/87
					721	IT	12/1/87
					720	IT	12/1/87
44	*				719	VF	12/1/87
					718	IT	11/30/87
					717	IT	11/25/87
43		612	VS	11/21/87			
		611	IT	11/20/87			
		610	IT	11/20/87			
		609	IT	11/20/87			
		608	IT	11/20/87			
		607	IT	11/20/87			
		606	IT	11/20/87			
		605	IT	11/20/87			
		604	IT	11/20/87			
		603	IT	11/20/87			
		602	IT	11/20/87			
		601	IT	11/20/87			
		600	IT	11/20/87			
		599	IT	11/20/87			
		598	IT	11/20/87			
		597	IT	11/20/87			
		596	IT	11/20/87			
		595	IT	11/20/87			
		594	IT	11/20/87			
		593	IT	11/20/87			
		592	IT	11/20/87			
		591	IT	11/20/87			
		590	IT	11/20/87			
		589	IT	11/20/87			
		588	IT	11/20/87			
		587	IT	11/20/87			
		586	IT	11/20/87			
		585	IT	11/20/87			
		584	IT	11/20/87			
		583	IT	11/20/87			
		582	IT	11/20/87			
		581	IT	11/20/87			
		580	IT	11/20/87			
		579	IT	11/20/87			
		578	IT	11/20/87			

Valid Attempt Number	Engine 1A Start Number	Test Result	Test Date	Engine 1B Start Number	Test Result	Test Date
	577	IT	11/20/87			
	576	IT	11/19/87			
	575	IT	11/19/87			
	574	IT	11/19/87			
	573	IT	11/19/87			
	572	IT	11/19/87			
	571	IT	11/19/87			
	570	IT	11/19/87			
	569	IT	11/19/87			
	568	IT	11/19/87			
	567	IT	11/18/87			
	566	IT	11/18/87			
	565	IT	11/18/87			
	564	IT	11/18/87			
	563	IT	11/18/87			
	562	IT	11/18/87			
	561	IT	11/18/87			
	560	IT	11/18/87			
				716	IT	11/17/87
	559	IT	11/16/87			
	558	IT	11/15/87			
	557	IT	11/15/87			
	556	IT	11/15/87			
	555	IT	11/15/87			
42	554	VS	11/14/87			
	553	IT	11/14/87			
	552	IT	11/14/87			
	551	IT	11/14/87			
	550	IT	11/13/87			
	549	IT	11/13/87			
	548	IT	11/13/87			
	547	IT	11/13/87			
				715	IT	11/1/87
41				714	VS	10/29/87
				713	IT	10/29/87
				712	IT	10/29/87
				711	IT	10/29/87
				710	IT	10/29/87
				709	IT	10/29/87
				708	IT	10/29/87
				707	IT	10/29/87
				706	IT	10/29/87
				705	IT	10/29/87
				704	IT	10/29/87
				703	IT	10/29/87
				702	IT	10/29/87
				701	IT	10/29/87
				700	IT	10/29/87
				699	IT	10/29/87
				698	IT	10/29/87
				697	IT	10/29/87

Valid Attempt Number	Engine 1A Start Number	Test Result	Test Date	Engine 1B Start Number	Test Result	Test Date
				696	IT	10/29/87
				695	IT	10/29/87
				694	IT	10/29/87
				693	IT	10/29/87
				692	IT	10/29/87
				691	IT	10/29/87
				690	IT	10/29/87
				689	IT	10/29/87
				688	IT	10/29/87
				687	IT	10/29/87
				686	IT	10/28/87
				685	IT	10/28/87
				684	IT	10/28/87
				683	IT	10/28/87
				682	IT	10/28/87
				681	IT	10/28/87
				680	IT	10/28/87
				679	IT	10/28/87
				678	IT	10/28/87
				677	IT	10/28/87
				676	IT	10/28/87
				675	IT	10/28/87
				674	IT	10/28/87
				673	IT	10/28/87
				672	IT	10/28/87
				671	IT	10/27/87
				670	IT	10/27/87
				669	IT	10/27/87
				668	IT	10/27/87
				667	IT	10/27/87
				666	IT	10/27/87
				665	IT	10/27/87
				664	IT	10/27/87
				663	IT	10/27/87
				662	IT	10/26/87
				661	IT	10/26/87
				660	IT	10/26/87
				659	IT	10/26/87
				658	IT	10/26/87
				657	IT	10/26/87
				656	IT	10/26/87
				655	IT	10/26/87
40				654	VS	10/26/87
				653	IT	10/24/87
				652	IT	10/10/87
				651	IT	10/9/87
39				650	VS	10/9/87
38				649	VS	10/9/87
				648	IT	10/8/87
				647	IT	10/8/87
				646	IT	10/8/87

Valid Attempt Number		Engine 1A Start Number	Test Result	Test Date	Engine 1B Start Number	Test Result	Test Date
					645	IT	10/8/87
					644	IT	10/8/87
					643	IT	10/8/87
					642	IT	10/8/87
					641	IT	10/8/87
37	*				640	VF	10/7/87
36					639	VS	10/7/87
					638	IT	10/7/87
35					637	VS	10/6/87
		546	IT	10/6/87			
		545	IT	10/6/87			
					636	IT	10/6/87
		544	IT	10/5/87			
34		543	VS	10/4/87			
33		542	VS	10/1/87			
					635	IT	9/14/87
32					634	VS	9/14/87
31		541	VS	9/9/87			
30					633	VS	9/8/87
29					632	VS	8/30/87
28					631	VS	8/24/87
27					630	VS	8/17/87
26		540	VS	8/11/87			
25					629	VS	8/10/87
		539	IT	8/4/87			
24					628	VS	8/3/87
					627	IT	8/3/87
23					626	VS	7/16/87
22		538	VS	7/13/87			
21					625	VS	6/28/87
20		537	VS	6/19/87			
19					624	VS	6/9/87
18		536	VS	6/5/87			
		535	IT	6/5/87			
17		534	VS	6/3/87			
16					623	VS	6/1/87
					622	IT	6/1/87
15		533	VS	5/27/87			
14		532	VS	5/20/87			
13					621	VS	5/8/87
12		531	VS	5/7/87			
		530	IT	5/7/87			
		529	IT	5/7/87			
		528	IT	5/7/87			
11					620	VS	4/27/87
10		527	VS	4/24/87			
9					619	VS	4/22/87
8		526	VS	4/13/87			
7					618	VS	3/30/87
6					617	VS	3/30/87
5		525	VS	3/26/87			

Valid Attempt Number	Engine 1A Start Number	Test Result	Test Date	Engine 1B Start Number	Test Result	Test Date
4						
3		-		616	VS	3/23/87
2				615	VS	3/16/87
				614	VS	3/9/87
				613	IT	3/8/87
				612	IT	3/8/87
				611	IT	3/8/87
				610	IT	3/8/87
1	524	VS	3/5/87	609	IT	3/7/87
0						
				608	VS	3/4/87
				607	IT	3/4/87
				606	IT	3/2/87
				605	IT	2/23/87
(1)				604	IT	2/23/87
	523	IT	2/17/87	603	VS	2/23/87
	522	IT	2/17/87			
(2)						
	521	IT	2/13/87	602	VS	2/16/87
(3)						
(4)				601	VS	2/9/87
(5)	520	VS	1/28/87	600	VS	2/2/87
(6)						
	519	IT	1/28/87	599	VS	1/28/87
	518	IT	1/28/87			
(7)						
				598	VS	1/22/87
				597	IT	1/22/87
				596	IT	1/22/87
				595	IT	1/22/87
(8)				594	VS	1/13/87
(9)	517	VS	1/9/87			
	516	IT	1/9/87			
	515	IT	1/9/87			
(10)						
(11)	514	VS	12/30/86	593	VS	1/9/87
(12)						
(13)				592	VS	12/29/86
				591	VS	12/22/86
	513	IT	12/16/86	590	IT	12/22/86
(14)						
				589	VS	12/15/86