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SUBJECT: Special Rept 89-01:on 890101,Diesel Generator 1-1 failure to start.

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James D. Shiffer
Vice President
Nuclear Power Generation

March 3, 1989

PG&E Letter No. DCL-89-055

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

Re: Docket No. 50-275, OL-DPR-80
Diablo Canyon Unit 1
Special Report 89-01, Diesel Generator 1-1 Failure to Start

Gentlemen:

In accordance with the requirements of Diablo Canyon Technical Specifications (TS) 6.9.2 and 4.8.1.1.4, and the guidance of NRC Generic Letter No. 83-43 and Revision 1 to NRC Regulatory Guide (RG) 1.108, this Special Report is submitted concerning the failure of Diesel Generator (DG) 1-1 to start.

On February 1, 1989, at 1305 PST, with the unit in Mode 1 (Power Operation), DG 1-1 did not start during the performance of a surveillance test. Using the guidance of RG 1.108, Sections B and C.2.e(2), this event is considered to be a valid failure.

This event was caused by the failure of the air starting motor pinion gear retainers of both air starting motors A2 and B1 of DG 1-1. Based on the results of the investigation conducted to date, two potential root causes for failure of the pinion gear retainers have been identified: (1) excessive starting air header pressure, and (2) improper assembly of the pinion gear, retainer, and bolting. Further system inspection and evaluation is required for identification of any additional actions. Based on the comprehensive evaluation planned, submittal of a revision to this report is expected within approximately three months.

Additional information is provided in the enclosure.

In accordance with RG 1.108, section C.3.b, the following information is included:

(1) Diesel Generator involved: DG 1-1

(2) Number of failures in last 100 DG 1-1 valid tests: 3

(3) Cause of failure: Failure of air starting motor pinion gear retainer

(4) Corrective measures taken: See Enclosure

(5) Time diesel was unavailable: DG 1-1 was declared inoperable on February 1, 1989 at 1305 PST and was declared operable on February 3, 1989 at 0600 PST for a total of 40 hours and 55 minutes of unavailability.

(6) Current surveillance test interval: 31 days

(7) Check RG 1.108, section C.2.d to confirm proper test interval: The total number of valid failures in the last 100 valid tests for DG 1-1 is 3 and the total number of valid failures in the last 20 valid tests for DG 1-1 is 1, therefore the 31 day test interval is in compliance with the schedule of Technical Specification Table 4.8-1 and an accelerated testing schedule is not required.

These conditions have in no way affected the public's health and safety.

Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it in the enclosed addressed envelope.

Sincerely,

W. S. Kaefer for

J. D. Shiffer

cc: J. B. Martin
M. M. Mendonca
P. P. Narbut
B. Norton
H. Rood
B. H. Vogler
CPUC
Diablo Distribution
INPO

Enclosure

2558S/0067K/ALN/2245

ENCLOSURE

DIESEL GENERATOR 1-1 FAILURE TO START
DUE TO AIR MOTOR PINION RETAINER FAILURE
SPECIAL REPORT 89-01

I. PLANT CONDITIONS

Unit 1 was in Mode 1 (Power Operation at 100 percent power).

II. DESCRIPTION OF EVENT

A. Event:

On February 1, 1989 during performance of Surveillance Test Procedure (STP) M-9A, "Diesel Engine Generator Routine Surveillance Test," Diesel Generator (DG) 1-1 failed a manual start attempt. At 1305 PST Operations declared DG 1-1 inoperable and entered Technical Specification (TS) 3.8.1.1 action statements b. and d. This start attempt was made using the normal DC power source with the backup DC power source disabled. A second start attempt with the same power source alignment was unsuccessful at 1325 PST. A third start attempt at 1600 PST with both the normal and backup DC power sources available was successful. A fourth start attempt at 1645 PST with the backup DC power source disabled was unsuccessful.

The DG starting configuration has four air motors: A1, A2, B1, and B2. A1 and A2 share a common air supply, and B1 and B2 share a separate and independent common air supply. Air motors A1 and B2 share a common DC power supply for their controlling solenoid valves while A2 and B1 share an independent common DC power supply. The normal lineup for the DGs has starting air available to both the A and B starting air trains and both the normal and backup DC power available. During normal operation, if a start signal is received, all four air starting motors would engage to start the DG. It was suspected that the DG 1-1 failure to start with normal power available was due to the failure of one of the air starting motors having a solenoid valve powered by normal DC power.

Additional start attempts were made to determine which of the air starting motors was deficient. A fifth start attempt at 1745 PST with the A train starting air supply isolated and backup DC disabled was unsuccessful. A sixth and seventh start attempt at 1750 PST and 1800 PST with the B train starting air supply isolated and backup DC disabled were unsuccessful. The last in this series of start attempts was made at 1810 PST with normal DC power source disabled and the backup DC power source available. This start attempt was successful. Results of these start attempts indicated that both A2 and B1 air starting motors or their associated solenoid valves were deficient.

Electrical troubleshooting was performed to verify voltage and connections to the A2 and B1 air start motor solenoid valves. On

February 2, 1988 at 0335 PST following troubleshooting, a start attempt was unsuccessful with the backup DC power source disabled.

Further troubleshooting by Operations, Mechanical Maintenance and I&C verified that these solenoid valves were functioning properly (i.e., opening fully to permit full air flow), and indicated that the problem was with air starting motors A2 and B1. Inspection of these air motors showed that both of them had broken pinion retainers, broken and bent retainer bolting, and cracked rotor shafts. Air starting motor A2 also had a chipped and cracked cylinder end plate on the bendix side of the rotor assembly. The air motors were reassembled using replacement parts in accordance with vendor recommendations.

Retesting was successful and Operations declared DG 1-1 operable at 0600 PST on February 3, 1989 and exited the TS 3.8.1.1 action statements.

B. Inoperable Structures, Components, or Systems that Contributed to the Event:

DG 1-1 Starting Air Motors A2 and B1.

C. Dates and Approximate Times for Major Occurrences:

February 1, 1989 - 1305	Event/Discovery Date - DG 1-1 failed to start during STP M-9A, Operations declares inoperable. TS 3.8.1.1 action statements entered.
February 1, 1989 - 1335	DG 1-1 troubleshooting begins.
February 2, 1989 - 0335	Troubleshooting identifies internal problems with air starting motors A2 and B1. Repairs to motors A2 and B1 commence.
February 3, 1989 - 0600	STP M-9A performed satisfactorily for DG 1-1. Operations declares DG 1-1 operable and TS 3.8.1.1 action statements exited.

D. Other Systems or Secondary Functions Affected:

None.

E. Method of Discovery:

Personnel performing STP M-9A observed that DG 1-1 failed to start and reported this information to the Control Room.

F. Operator Actions:

DG 1-1 was declared inoperable. TS 3.8.1.1 action statements b. and d. were entered.

Testing of DGs 1-2, 1-3, 2-1 and 2-2 was performed. The air solenoid valves and air starting motors of these DGs were observed to function correctly.

G. Safety system responses:

None.

III. CAUSE OF THE EVENT

A. Immediate Cause:

DG 1-1 failed to start during STP M-9A. Inspection revealed broken pinion retainer bolting and broken pinion retainers on air starting motors A2 and B1. Failure analysis indicated overload failures of the pinion retainers, pinion retainer bolting, and rotor shafts on air starting motors A2 and B1.

B. Root Cause:

Based on the investigation discussed below, two potential root causes have been identified: (1) excessive starting air pressure, and (2) improper assembly of the pinion retainer and bolting. The investigation has identified the following potential failure mechanisms.

Communication with the vendor following this event indicates that 160 psig or greater could result in damage to the air starter components. The data sheets from January 10, 1989 and the February 1, 1989 tests indicate that the A train air supply header pressure was 190 psig. This excessive air pressure could cause overloading and subsequent failure of air starter A2, and is the most probable failure mechanism for air starting motor A2.

Air starting motor B1 could experience an increased shock loading when the failure of air starting motor A2 occurred. Also, after the failure of one air starting motor, all additional start attempts with a two starting motor lineup would subject the functional air starting motor to twice its normal starting load. (It should be noted that air starting motors A2 and B1 failed on or before the February 1 initial DG 1-1 start attempt, since if either motor had been operable DG 1-1 would have started. Subsequent troubleshooting caused no additional component failures.) If the pinion gear/shaft interface (ground taper fit) was not adequate, the entire torque from the air starting motor would be transferred from the shaft to the pinion via the pinion retainer. This would cause an increase in the load seen by the pinion retainer and could possibly cause its failure.

1. A Technical Review Group (TRG) was convened to ensure that a multidisciplinary review of this event was conducted. The TRG investigation actions and results are as follows.

   a. Technical and Environmental Services (TES) performed a failure analysis of the broken pinion retainers, retainer bolting and cracked rotor shafts. An additional analysis by Ingersoll Rand (vendor) is in progress. No evidence of fatigue or corrosion failure was identified by TES.

   b. The vendor and manufacturer were contacted to determine whether any other similar failures have occurred, and to discuss any known potential causes. There have been no similar failures. However, the manufacturer did provide recommendations for improved pinion retainer bolting installation.

   c. The original vendor installation recommendations were reviewed. Although no torque value for the pinion retainer bolting was documented, communication with the vendor established that the correct value was 15 to 18 ftlbs of torque.

   d. Previous STP results have been examined for start time trending to determine if there was a gradual degradation of DG 1-1 starting time. No significant increase in the DG 1-1 starting time was found. The B train air header pressure for DG 1-1 and the air header pressures for the other diesels were verified to be approximately 150 psig.

   e. All DG air starting motor maintenance records were reviewed. No similar failures were identified.

   f. The Nuclear Plant Reliability Data System was reviewed to investigate for failure information. No similar failures were identified.

   g. INPO and NRC operating experience information was reviewed. No similar failures were found.

   h. The air starting motor failure information was entered into Nuclear Network system to describe the problem experienced at DCPP and to inquire if any other utilities have experienced similar failures. No similar failures were identified.

2. The TRG considered the following factors in order to identify a root cause. Per this investigation, the TRG identified two potential root causes as noted above. The root cause investigation is continuing.

   a. Material degradation - Inspection of the failed retainers showed no signs of fatigue, corrosion, or material defects

that could have lead to the failure. However, inspection indicated a brittle failure resulting from an apparent overload stress that exceeded retainer impact strength.

b. Design - The manufacturer considers the pinion retainer design to be acceptable, with no prior reports of a similar failure.

c. Installation - The air starting motors had been installed in accordance with vendor recommendations.

d. Manufacturing - There was no evidence of a manufacturing flaw in the pinion retainer or bolting which could have caused this failure.

e. Lack of maintenance - Maintenance on the air starting motors was performed during each refueling outage until 1988 when the interval was extended to every other refueling outage due to previous maintenance inspections which found no excessive wear or degradation.

f. Inappropriate equipment operation - Operation of the DGs and their air starting motors has been in accordance with DCPP approved procedures and vendor recommendations. The A train air header pressure was noted to be approximately 190 psig on January 10, 1989 and on February 1, 1989; the nominal value is 150 psig. Original vendor information specified no maximum value for air pressure in this header, and DCPP procedures likewise did not. Communication with the vendor following this event indicates that air pressure in excess of 160 psig is potentially damaging to the air starting motors.

g. End of component life - The manufacturer stated that for the diesel service conditions experienced at DCPP, the pinion retainers and bolting should last longer than the power plant.

IV. ANALYSIS OF THE EVENT

A. Safety Analysis:

Each vital bus can be supplied by either of two offsite power sources or any of the three DGs supporting that Unit. Each DG has four air starting motors, each capable of independently starting the DG. The most likely cause of failure identified was a higher than normal air pressure in the A train starting air header. Since each of the DGs have two independent starting air systems, it is unlikely that both air systems for a DG would have a higher than normal pressure at the same time. It was demonstrated during troubleshooting that DG 1-1 was

able to start satisfactorily on the unaffected air starting motors A1 and B2. Therefore, if an actual start signal had occurred, all DGs would have responded as intended. The possibility of a similar failure occurring on a different DG is unlikely based on the type of failure and the experience of DCPP and the rest of the Industry. Thus the health and safety of the public were not affected by this event.

V. CORRECTIVE ACTIONS

A. Immediate Corrective Actions:

1. All DG starting air headers were verified to have a pressure less than 160 psig.

2. Air starting motors A2 and B1 were disassembled and the damaged parts replaced with vendor recommended parts. The air starting motors were reassembled and installed on DG 1-1.

3. All other DG Unit 1 and 2 air start motors were visually verified to be functioning properly.

B. Additional Corrective Actions

The actions below are additional inspection and evaluation actions to be performed prior to completion of PG&E investigation and identification of further corrective actions, if needed.

1. All other Unit 1 and 2 DG air starting motors will be disassembled and inspected, including the tightness of the pinion retainer bolting.

2. The air pressure regulator for the A train of DG 1-1 will be disassembled and inspected. The valve model number will be verified to be appropriate for this service.

3. Upon completion of the investigative actions, the identified potential root causes will be reevaluated and final root cause(s) and corrective actions will be determined.

C. Corrective Actions To Prevent Recurrence:

1. An OTSC will be made to STP M-9A to require an acceptance criteria of greater than 140 psig and less than 160 psig.

2. An Operations Night Order has been issued and the Operator Rounds Sheet will be revised to include a check of the DG starting air header pressure to verify it to be within the acceptable pressure range and take appropriate actions if the pressure is not within the acceptable range.

3. A Field Change Transmittal (FCT) will be issued to incorporate the latest vendor pinion retainer bolting instructions into the PG&E vendor manual.

4. A new maintenance procedure will be issued to provide more detailed instructions for DG air starting motor maintenance including the torque required for the installation of pinion retainer bolting.

5. Engineering will evaluate the design of the DG air starting system and implement improvements as necessary.

VI. ADDITIONAL INFORMATION

A. Failed Components:

DG 1-1 air starting motors A2 and B1
Manufacturer: Ingersoll Rand
Model: B41RH 1

B. Troubleshooting Sequence:

Date/Time (PST)	Air Lineup	DC Lineup	Result
2/1/89 - 1305	A and B	backup disabled	unsuccessful
2/1/89 - 1325	A and B	backup disabled	unsuccessful
2/1/89 - 1600	A and B	both available	successful
2/1/89 - 1645	A and B	backup disabled	unsuccessful
2/1/89 - 1745	B only	backup disabled	unsuccessful
2/1/89 - 1750	A only	backup disabled	unsuccessful
2/1/89 - 1800	A only	backup disabled	unsuccessful
2/1/89 - 1810	A and B	normal disabled	successful
2/2/89 - 0335	A and B	backup disabled	unsuccessful
2/3/89 - 0315	A and B	backup disabled	successful