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November 4, 1996

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

Subject: Catawba Nuclear Station, Unit 1
Docket No. 50-413
Special Report
Valid Failure of Diesel Generator 1B

Pursuant to Technical Specification 4.8.1.1.3 and 6.9.2, attached is a Special Report concerning the Unit 1 Diesel Generator (DG 1B) valid failure which occurred on October 1, 1996.

Sincerely,

W. R. McCollum, Jr.

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Attachment

xc: SD Ebneter, Regional Administrator

RJ Freudenberger, SRI

PS Tam, ONRR

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CATAWBA NUCLEAR STATION
DOCKET NO. 50-413
DIESEL GENERATOR 1B VALID FAILURE
DUE TO A MECHANICAL BIND IN THE
FUEL CONTROL ROD LINKAGE ASSEMBLY
PIP 1-C96-2697

A **valid failure** of the Unit 1B Diesel Generator (DG 1B) occurred at 1535 10/04/96. This failure occurred when the generator was being paralleled to the grid. The DG became unstable during a load increase to a point where the generator breaker tripped on overcurrent. DG 1B was being run for its required monthly operability test when this failure occurred (Start #1134). This is the first valid failure in the last 20 and 100 valid starts. The DG 1B remains on a 31 day test frequency. DG 1B was successfully started, run, and declared operable on 10/06/96 (Start #1137). DG 1B was unavailable for 48 hours due to this failure.

Background Information

The design basis of the DG is to provide emergency AC power in the event of a loss of cooling accident (LOCA) and/or loss of offset power (LOOP). The generator is designed with an overcurrent trip to ensure equipment damage does not occur when an overcurrent condition arises during testing of the DG. The trip is bypassed on emergency starts and only functions when the DG is paralleled to the essential bus. When the trip is actuated, the generator output breaker opens and the engine returns to an unloaded operating condition. The protective relaying functioned as designed during the failure which occurred on the 1B DG. Although generator breaker trip on overcurrent is a non-emergency trip, the failure is classified as valid because the DG was in an unstable condition due to a load swing which prevented the periodic operability test from being completed.

The 1B diesel generator breaker (1ETB-18) tripped as load was increased as the DG was paralleled to the grid. During this activity, the load on the generator began to swing to a point where the overcurrent trip setpoint was reached.

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Evaluation

The following failure modes were evaluated as potential root causes for the 1B DG valid failure:

1. Motor Operated Pot failure
2. Electronic Governor failure (EGA)
3. Mechanical Governor failure (EGB)
4. Failure of the Governor Droop (UPR) Relay
5. Mechanical binding of the fuel rack control linkage

1. The Motor Operated Pot is part of the DG electric governor system. The purpose of the pot is to provide a speed reference signal. The pot is used to raise and lower speed during unparalleled operation and load during paralleled operation. In the failure mode, if there is a 'dead' spot on the potentiometer, a speed signal would be sent to the governor but would not be recognized. This could cause the load swings that were observed prior to the generator output breaker tripping on overcurrent.

   Extensive testing was performed on the motor operated pot which included exercising the pot through full range of motion while monitoring output voltage with a chart recorder. This device did not show any indication of failure. The vendor was contacted, and agreed that the testing was satisfactory and indicated the pot was operating as designed. Conservative decision making was utilized and the pot was replaced to eliminate this as a potential root cause. The vendor also stated that it was highly unlikely that a failure of the motor operated pot would be sporadic.

2. The Electronic Governor (EGA) was replaced on 08/11/96 (Work Request 96032980) as a result of a similar load swing that occurred during performance of the maintenance break-in runs prior to returning the 1B DG to operable status. The data from this load swing indicated that the EGA was not controlling load as designed. The electronic governor was successfully retested following replacement. The failure which occurred on 10/04/96, was preceded by the same load swing as evidenced prior to replacement of the new EGA

governor. The EGA is not believed to be a root cause of this problem since load swings continued with the new governor. The vendor agreed that the load swing which is being observed on the 1B DG is not due to the EGA controller.

3. The Mechanical Governor (EGB) is designed to control load if the Electric Governor fails. The EGB begins to control load when engine speed reaches 61.3 HZ and the EGA controls load up to that speed. The failure mode that possibly exists is that the EGB is taking control of the engine during parallel operation when the frequency is locked at the grid frequency of 60 Hz. The vendor which was contacted stated this is not possible. The vendor also stated that if the EGB were to fail it would occur at all loads. The load swings that have occurred on the 1B DG have always been at 3000 - 4000 kW. The first time the load swings occurred, the EGA was controlling and not the EGB mechanical governor. This indicated that the mechanical governor was not part of the load swing problems.

   The EGB governor is a hydraulic piece of equipment which requires oil to be changed every refueling outage. Following the oil change, the governor is vented by maintenance personnel. The vendor was asked if trapped air in the mechanical governor could cause the load to swing. The vendor explained that the EGB component is self-venting and that a load swing due to an non-vented governor had never been observed. Another piece of data which was used to rule out this item as a potential root cause, was that when the generator breaker tripped on overcurrent and engine speed exceeded the setpoint for the EGB governor, the engine was returned to stable frequency when the EGB governor took control.

4. A vendor field service representative from Woodward Controls was also consulted about the load swing problems. The Woodward rep mentioned that another utility had had a recent problem when the governor droop relay for the governor failed causing the governor to switch from the droop mode of operation to the isochronous while paralleled. The Governor Droop Relay

(UPR) was checked in our DG control panel and no problems were identified with its operation.

5. The vendor felt that the load swing and resulting generator trip was a result of some type of mechanical binding in the fuel controlling linkage. Sticking in this linkage could cause the governor to be unable to maintain stable load at the point where the sticking was occurring. The vendor recommended that troubleshooting efforts include a thorough investigation of the fuel rod linkage which is controlled by the governor output. Upon investigation by Maintenance it was discovered that the connecting linkage from the fuel rack to the fuel pump on the 7R cylinder was installed in a condition that could cause binding to occur.

   The DG governor system is designed to maintain engine load by metering the amount of fuel oil provided to the engine. During normal operation when the engine is paralleled to the grid the electronic governor controls load by sending a signal to the output actuator which in turn controls fuel rod position. The motion of the fuel control rod determines the amount of fuel oil input to the cylinders by the fuel oil pumps. The fuel control rod is connected to the output of the governor actuator. Linkage assemblies are connected from the individual cylinder fuel pumps to the fuel control rod so that the fuel flow to the engine is controlled by the governor system. Each cylinder is tied together by the fuel control rod such that a problem with just one cylinder would effect the output load.

   The linkage assembly on the 7R cylinder was installed in such a manner that binding was occurring. The linkage assembly is connected such that the assembly is at right angles to the fuel control rod. On the cylinder in question, both of the spacers/counter weights were installed on the same side of the 'assembly to fuel pump' connection. For this particular cylinder, one counter weight/spacer should have been installed between the fuel pump and fuel linkage assembly in order to ensure the fuel linkage was at a right angle with the control rod. The fuel control rod was disconnected from the governor actuator and exercised by hand with

the linkage assembly connected in each manner as described above. A point of binding was observed with the assembly connected in the as found condition.

Per manufacturing drawing CNM-1301.00-0237, vol 2, sheet 02-371-04, note 5, "All linkage assemblies, regardless of the position shown, are to be set up with levers making a right angle with rod when they pass through the midposition of their ARC". The remaining cylinders on the 1B DG as well as the other DGs were inspected to ensure the levers were at or near 90° with the fuel control rod. The inspection indicated that the 7R cylinder on the 1B DG was the only one that had a fuel linkage installed such that the required 90° angle could not be maintained through its range of motion.

The probable cause for the load swing on the 1B DG which led to the overcurrent generator trip was due to mechanical binding in the fuel control linkage. As stated above, the fuel linkage assembly for the 7R cylinder was installed in such a manner that binding could occur. The problem with binding is that when the generator is at a specific load, the fuel control rod will be at a corresponding position. If the required fuel rod position for a load is the point where the binding is occurring, the governor will begin to hunt because the demanded position cannot be met.

The fuel rod linkage assembly on the 7R cylinder would freely move through a full range of motion on an engine start and as load was increased because the output force from the governor was sufficient to move the linkage assembly through the point where the binding was occurring. However, the governor output is determined by corresponding load (demand) on the DG. If the point where the binding is occurring is the corresponding position for the required load, the binding will prevent this position from being obtained. Since the governor output does not change for a set demand, there is no output force to move the 7R fuel linkage assembly through the binding position. This is why the first load swing stopped when the Operator changed load on the generator. At the binding point, the correct fuel linkage assembly position for the 7R cylinder could not

be obtained which resulted in the 1B DG becoming unstable as the remaining cylinders attempted to maintain the demanded load. This is why the load swing was not sporadic but was only occurring when the generator load was at the level which corresponded to the binding position of the fuel linkage assembly. The load swing would continue to occur until the load on the engine was changed which in turn changed the demand on the fuel.

The fuel rod linkage assembly was re-installed correctly to ensure binding did not occur. The 1B DG was started and load was slowly changed throughout the range where the instability occurred to try and recreate the load swings. The swings could not be recreated.

Conclusions

Based on the data obtained from inspections on the 1B DG coupled with information received from Woodward Controls, the probable root cause for the 1B DG valid failure was due to a mechanical bind in the fuel control rod linkage assembly on the 7R cylinder. The linkage assembly had been removed and replaced during the 1EOC9 inspections. The linkage assembly from the fuel control rod to the respective fuel pump was installed such that the required 90° angle was not maintained. This is a process failure in that the applicable procedures did not give clear guidance on the importance of the fuel linkage assembly position with the fuel shaft control rod.

Corrective Actions to be Taken

Applicable DG procedures which cover the removal and replacement of fuel rod linkage assemblies will be revised to include a note which states that the assemblies should be installed such that a 90° angle is maintained with the fuel shaft control rod as referenced in CNM-1301.00-0237, vol 2, sheet 02-371-04, note 5. This commitment has been assigned to MNT and will be tracked through completion in corrective action #3 of Problem Investigation Process (PIP) 1-C96-2697.