



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20655

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION  
RELATED TO EMERGENCY DIESEL GENERATOR NO. 3 OPERABILITY  
CAROLINA POWER & LIGHT COMPANY  
BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2  
DOCKET NOS. 50-325 AND 50-324

1.0 INTRODUCTION

Carolina Power & Light Company (CP&L or the licensee) reported to the Nuclear Regulatory Commission (NRC) on October 16, 1991, that the Nordberg Emergency Diesel Generator No. 3 (EDG-3) at the Brunswick Steam Electric Plant (BSEP), had been inadvertently operated at higher than allowable temperatures. The EDG's at BSEP are four V-16 cylinder Nordberg Series 13 diesel engines. During a recent 14-day allowed outage time, maintenance actions of a preventative and corrective nature were performed on EDG-3 to satisfy its Technical Specification requirements. Included in these maintenance actions was the adjustment of the intake and exhaust valves which has been identified as the cause of turbocharger surging and high cylinder exhaust temperatures reported to the staff on October 16, 1991. Fourteen of the 16 intake valves were reported to have been improperly adjusted.

The NRC staff raised a number of concerns with the licensee regarding the high engine exhaust temperature. During meetings on October 31, and November 1, 1991, CP&L addressed the staff concern of possible damage to valves and components caused by high temperatures. The licensee reported no damage to the valves, exhaust components, such as piping or the turbocharger. However, a visual inspection of the internal components (e.g., valves, valve seats, and heads) had not been conducted. Individual cylinder exhaust temperatures were not recorded, but the turbocharger inlet temperature was reported to be 1200°F. The licensee evaluated the EDG-3 operability, based on input from the vendor and its engineering personnel, and concluded that EDG-3 was fully operational and capable of performing its intended design function.

At the meetings on October 31, 1991, and November 1, 1991, the NRC staff requested that the licensee (1) furnish documentation authorizing operation of the EDG at individual cylinder exhaust temperatures in excess of the 775°F maximum limit specified in the Technical Manual, and (2) provide further analyses of the EDG-3 pull cards to explain step anomalies during the power stroke that were identified by the staff during the review of the pull cards. A summary of these meetings was issued on December 11, 1991.

## 2.0 EVALUATION

As reported during the November 1, 1991, meeting, EDG-3 was taken out of service on October 1, 1991, to allow for scheduled maintenance as part of the BSEP, Unit 2, refueling outage. The licensee then started and operated EDG-3 on October 2, 1991, to obtain crankshaft deflection readings which required operation for a minimum of six hours to ensure that equilibrium of the EDG was reached. Approximately four hours into the run, sparking was noted on the engine number 2 inner ring exciter brush rigging, and the run was terminated. The corrective maintenance action for the brush rigging involved grinding of the slip ring which was accomplished by operating the diesel for approximately 48 hours. During the slip ring grinding effort, malfunctions occurred that required extensive troubleshooting and subsequent replacement of diesel components which included:

- replacement of the engine driven governor,
- calibration and reinstallation of the original governor,
- replacement of the link shaft actuator diaphragm.

In addition to the corrective maintenance actions taken, the intake and exhaust valves were adjusted as a preventative maintenance measure. Operational runs were conducted to verify corrective actions taken, and it was reported during one of these operational runs that the EDG-3 was operated inadvertently at higher than allowable exhaust temperatures which was attributed to improper valve settings. CP&L reported the overtemperature event and submitted a copy of the BSEP Technical Support Memorandum (TSM 91-0856) dated October 16, 1991, in response to staff questions.

Subsequently on October 20, 1991, the licensee performed an operability surveillance run on EDG-3 and declared it operational. Based on a review of the data taken during this operability surveillance run, the staff concurred that EDG-3 is currently operational.

Overtemperature occurrences are a primary concern of the NRC staff due to the effect on the components and materials subjected to the overtemperature. Manufacturers of diesel engines place operational limits on their products to ensure reliability and dependability. The staff reviewed the information provided by the licensee (1) in the TSM 91-0856, (2) in meetings on October 31, and November 1, 1991, and (3) in the licensee's November 27, 1991, response. Based on this review, the staff finds that the above information does not eliminate the staff concern regarding the possibility that the engine may have been damaged. Pull card comparison data, which appears to be the basis for CP&L's conclusion, is not considered to be adequate proof that valves, valve seats, or the heads have not been damaged. Pull cards

demonstrate a level of performance of individual cylinders with emphasis on compression pressure and firing pressure values and do not provide indications of metal fatigue or cracking. Pull cards were reviewed for EDG-3, and the NRC staff found anomalous steps in the power stroke excursion. The normal appearance of this excursion is a smooth transition line gradually descending to the atmospheric line of the pull card. Combustion patterns were viewed by CP&L staff while employing diagnostic equipment, and the step excursions were not present in the power stroke. CP&L subsequently submitted tracings of the combustion patterns for review by the staff which confirm the absence of the step excursions.

With regard to the staff concern on engine exhaust temperature limit, the Nordberg Series 13 Technical Manual (Revision A and Revision C) General Data Section, specifies the maximum individual exhaust temperature limit at 775°F. However, during the meetings on October 31, and November 1, 1991, CP&L interpreted and applied the pre-turbine exhaust temperature of 940°F as the maximum individual exhaust temperature limit based on previous EDG operating records. The NRC staff requested CP&L to provide the latest revision and/or documentation authorizing operation above the 775°F limit specified in the Technical Manual. Documentation (provided with the November 27, 1991, CP&L letter) does not support the EDG operation at higher temperatures. The explanation provided in the November 27, 1991, letter cites and provides pre-delivery test data exhibiting operation of three of the four EDG's with individual cylinder exhaust temperatures in excess of the maximum limit of 775°F with 100% load applied. The temperature ranges for the four EDG's are:

- EDG-1 temperatures ranged from 750°F - 775°F with one cylinder at 780°F.
- EDG-2 temperatures ranged from 790°F - 825°F,
- EDG-3 temperatures ranged from 810°F - 845°F,
- EDG-4 temperatures ranged from 760°F - 800°F,

Review of this data clearly indicates that the limit of 775°F is achievable at the rated 100% load based on the EDG-1 data. A further licensee review of historical data to determine long-term engine degradation based on previous maintenance-related actions that had caused overtemperature should be considered.

In its November 27, 1991, response, the licensee makes a statement that, "values in the manual are vendor recommended values and are not to be taken as absolute values." The staff disagrees with this statement and believes that vendor-recommended values exhibit minimum and maximum limits on operating temperature and, therefore, should be strictly adhered to by the licensee. Flexibility or approximations should not be arbitrarily applied. Further, selective application of limits from EDGs at other utilities, such as McGuire, is not appropriate. The McGuire EDG's, for example, are rated at higher power which dictates a higher individual cylinder exhaust temperature and is not compatible with the BSEP operation.

Revisions A and C of the Nordberg Technical Manual establish the maximum exhaust (pre-turbine) temperature of 1020°F. The staff reviewed the data recorded in TSM 91-0856 and data presented during the November 1, 1991, meeting. This review shows pre-turbine temperatures at 1100°F during the operational runs on October 1, 1991, and October 16, 1991. The TSM states the pre-turbine temperature was observed to be 1200°F at the time the overtemperature event occurred. Reference is also made to the maximum pre-turbine temperature limit being 1238°F. The explanation offered in paragraph 3 of the licensee's November 27, 1991, response addresses the cylinder exhaust temperature and cites the 1983 Revision 19 of OP 39 as being the authority for the 940°F individual exhaust temperature. The 1238°F maximum pre-turbine temperature identified in paragraph 3 of the licensee's November 27, 1991, response is not supported by any documentation; and the determination that 940°F is a reasonable limit for cylinder exhaust temperature is unfounded.

During the review of information provided by the licensee, additional secondary areas of concern were revealed, such as (1) operating exhaust temperatures and firing pressures of individual cylinders recorded during the October 1, 1991, and October 16, 1991, operational runs are not indicative of a load-balanced engine; (2) compression pressures below the minimum requirements of 830-880 psi, (3) crankcase vacuum readings were recorded as 3.2 and 2.9 inches of water when limits specified are 0.2 to 1.0 inches of water; and (4) inconsistencies in recording pull card data at 2900 KW and 3500 KW when it is directed in the Technical Manual to take the readings at rated speed and load. It was also apparent that the Technical Manual limits and BSEP record data sheet direction were not adhered to by the licensee.

Based on the above review, the staff finds that the licensee has not provided adequate documentation to justify operating temperatures in excess of the 775°F for EDG-3; and, if no other justifiable documentation is available, the staff recommends that the licensee implement the following actions or propose alternatives to ensure that no damage has occurred to EDG-3 and to ensure long-term operability for the three remaining EDGs:

1. Calibrate all EDG pyrometers.
2. Review operating logs on all DG's installed at BSEP and identify all cylinders with readings in excess of 775°F.
3. Select the cylinder that was subjected to the highest temperature exceeding the 775°F limit in each EDG and conduct an inspection on this cylinder using a baroscope or, preferably, a video probe to detect the possibility of valve damage. Access should be through the injector opening if possible; however, in the event a clear view is not attainable, it is recommended that the exhaust header be removed to inspect the valves through the exhaust port. These inspections should be completed on EDG-3 and the three remaining EDGs at the earliest opportunity, but no later than the next refueling outage. Any unusual findings should be reported to NRC.

4. Balance all engines to meet as closely as feasible, temperature and firing pressure limits established in the Technical Manual at 100% load. Test data, including the cylinder exhaust temperatures, taken during the operability surveillance test after balancing of engines should be submitted to NRC for review.

### 3.0 CONCLUSION

Based on a review of the information provided by the licensee, the staff concludes that the EDG 3 is currently operational. However to ensure continued operational readiness of all of the BSEP EDG's, the licensee should implement the staff's recommended inspection measures discussed above, and comply with the specifications and operational limits of the EDG vendor's technical manual, or propose alternative measures that are acceptable to the staff.

Principal Contributor: J. Rajan

Date: April 21, 1992