NRC FORM 366 U.S. NUCLEAR REGULATORY COMMISSION

APPROVED OMD NO. 3150-0104
EXPIRES: 5/31/95
ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
McGuire Nuclear Station, Unit 1	0 5 0 0 0 3 6 9	1 OF 7

TITLE (4)
Failure Of The Turbochargers Associated With The Emergency Diesel Generators Due To An NRC Cause Code Of Design Oversight.

EVENT DATE (5)			LER NUMBER (6)					REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR		SEQUENTIAL NUMBER		REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER(S)
											Unit 2	0 5 0 0 0 3 7 0
06	27	95	95	-	03	-	1	08	31	95		0 5 0 0 0

OPERATING MODE (9)	1	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR (Check one or more of the following) (11)									
POWER LEVEL (10)	100%		20.402(b)		20.405(c)		50.73(a)(2)(iv)		73.71(b)		
			20.405(a)(1)(i)		50.36(c)(1)	X	50.73(a)(2)(v)		73.71(c)		
			20.405(a)(1)(ii)		50.36(c)(2)		50.73(a)(2)(vii)	X	OTHER (Specify in Abstract below and in Text, NRC Form 366A)		
			20.405(a)(1)(iii)	X	50.73(a)(2)(i)		50.73(a)(2)(viii)(A)				
			20.405(a)(1)(iv)		50.73(a)(2)(ii)		50.73(a)(2)(viii)(B)				
			20.405(a)(1)(v)		50.73(a)(2)(iii)		50.73(a)(2)(x)				

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER	
	AREA CODE	
Rickey J. Deese, Manager, McGuire Safety Review Group	(704)	875-4065

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	
B6a	EEB	ENGINE	N152	YES							

SUPPLEMENTAL REPORT EXPECTED (14)			EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE)	X	NO				

ABSTRACT (Limit to 1400 spaces, i.e. approximately fifteen single-space typewritten lines) (16)

- This report also satisfies the reporting requirements of 10CFR 21 and Technical Specification 3.8.1.1.
- Unit Status: Units 1 and 2 were in Mode 1 (Power Operations) at 100 percent power.
- Event Description: On June 12, 1995, the turbocharger (turbo) on the Emergency Diesel Generator (EDG) 2A failed due to the loss of a blade on the compressor impeller during operability testing. Repairs were made and the EDG was returned to service. On June 27, 1995, prior to confirmation of the results of the root cause analysis for the first failure, the turbo on the EDG 2B failed. Evaluation of the failed turbo (ABB Turbo Systems Model VTR-500) components indicated the two failures were identical. Turbos on the Unit 1 and 2 EDGs had been replaced as commercial grade components during each unit's previous refueling outage (1 and 2 EOC9). The EDG 2A and both Unit 1 EDGs were declared inoperable on June 28, 1995, at 1345, and a shutdown of both units was initiated. Following approval of a Notification Of Enforcement Discretion, shutdown of Unit 2 was halted at reduced power.
- Event Cause: This event is assigned an NRC cause code of Design Oversight. The significance of a design change to the turbo wall insert was misjudged during the Acceptable Substitute evaluation of the new turbos. The design change produced an unanticipated resonance induced vibration at surveillance test operating speeds, resulting in fatigue failure of a compressor impeller blade.
- Corrective Actions: The remaining compressor impellers (on EDGs 2B, 2A, 1A, and 1B) were evaluated and/or replaced. The wall inserts on EDGs 2B, 2A, 1A, and 1B were replaced, eliminating the potential for resonance induced vibration.

EVALUATION:

Background

- Emergency Diesel Generators [EIIS: DG] (EDG) 1A, 1B, 2A, and 2B were originally (as purchased from Nordberg) equipped with ABB Turbo Systems Model VTR-500 turbochargers (turbo), which had a continuous slot machined in the compressor wall insert to admit air to the compressor for rapid response. The jet assist feature is not used at McGuire Nuclear Station (MNS).
- Engineering personnel were informed that parts for the Model VTR-500 turbo would not be available after 1996 due to ABB Turbo Systems policy.
- The decision was made to purchase and install 4 new Model VTR-500 turbos and return the old turbos to ABB Turbo Systems for refurbishment.
- These new turbos utilize a jet assist feature using 17 inlet nozzles in the compressor wall insert in lieu of the previous slotted design.
- Due to the inability to procure parts per the 10CFR 50, Appendix B program, these turbos were procured through the commercial grade program from ABB Turbo Systems.
- Engineering personnel requested a commercial grade evaluation on the new turbos.
- Component and Procurement Engineering personnel discussed and agreed upon the critical characteristics of the new turbos (per EPRI document "EPRI CGI Joint Utility Task Group Commercial Grade Item Evaluation for Turbocharger") and whether a functional test should be a requirement of the commercial grade evaluation.
- ABB Turbo Systems concluded that, based on past experience with the Model VTR-500 and VTR-304, the wall insert change was insignificant and no additional vendor proof testing was required.
- Component Engineering personnel determined that the 1 hour operability run of the EDGs following installation would provide an adequate in-situ performance test of the new turbos.
- Component Engineering and ABB Turbo Systems personnel agreed that testing the turbo in situ was preferable to a vendor test because it would eliminate the effect of slight differences in the design of other components, therefore resulting in a test using the exact configuration of the new turbos.
- Engineering personnel completed Acceptable Substitute documentation for the new turbos.
- One hour operability runs were performed on all 4 EDGs after installation of the new turbos.
- In addition, 24 hour runs were performed on EDGs 1A and 1B.

Description of Event

June 12, 1995

- EDG 2A turbo failed during monthly surveillance testing per procedure PT/2/A/4350/02A, Diesel Generator 2A Operability Test.
- Damage included a single failed compressor impeller blade section (approximately 2 square inches), a damaged bearing, and a damaged diffuser ring.
- Investigation of the failure mode was initiated and a preliminary root cause determined the cause to be infant mortality (a manufacturing defect in the compressor wheel or exhaust bearing that fails early in life).

June 13, 1995

- Damaged components on EDG 2A were replaced.

June 14, 1995

- The Plant Operations Review Committee (PORC) reviewed the initial failure analysis (including the potential for common mode failure, service history of the turbos, and the present operability evaluation for EDGs 1A, 1B, and 2B)related to the EDG 2A turbo failure.
- EDG 2A was returned to an operable status following a 1 hour operability run per procedure PT/2/A/4350/02A.

June 27, 1995

- Prior to confirmation of the results of the cause analysis for the EDG 2A turbo failure, EDG 2B turbocharger failed during monthly surveillance testing per procedure PT/2/A/4350/02B, Diesel Generator 2B Operability Test, at approximately 1030.
- The failure was identical to the earlier failure of the EDG 2A turbocharger.

June 28, 1995

- Due to the potential for a common mode failure, the EDG 2A and both Unit 1 EDGs were declared inoperable at 1345.
- Shutdown of Unit 1 was initiated at 1346.
- A Notification Of Unusual Event (NOUE) was declared for Units 1 and 2 at 1350.
- Shutdown of Unit 2 was initiated at 1415.
- The PORC reviewed a Notification Of Discretionary Enforcement (NOED) request for Unit 2, to change the required time to be in Mode 3 (Hot Standby) to 36 hours for Tech Spec 3.7.1.2b and 34 hours for Tech Spec 3.8.1.1f, to maintain an onsite power source while repair of the Unit 2 EDGs were completed.
- Approval of the NOED was requested from the NRC.
- Upon approval of the NOED at 1747, shutdown of Unit 2 was halted at approximately 28 percent.
- Unit 1 entered Mode 3 At 1841.

June 29, 1995

- Unit 1 entered Mode 4, Hot Shutdown, at 0127.
- EDG 2B repair/testing was completed, EDG 2B was restored to operable status, and Unit 2 was secured from the NOUE at 0727.
- Unit 1 entered Mode 5, Cold Shutdown, at 1830.
- An Independent Review Team consisting of personnel from McGuire Nuclear Station, the General Office, Catawba Nuclear Station, River Bend Nuclear Station, Surry Nuclear Station, and Brunswick Nuclear Station was formed to conduct an evaluation of the turbo failures.

June 30, 1995

- EDG 2A repair/testing was completed and EDG 2A was restored to operable status at 0331.

July 1, 1995

- EDG 1A repair/testing was completed and EDG 1A was restored to operable status at 0302.
- The Unit 1 NOUE was terminated at 0415.

July 2, 1995

- EDG 1B repair/testing was completed and EDG 1B was restored to operable status at 0936.
- The PORC reviewed the Operability Evaluation associated with returning the Unit 1 EDGs to service.

Conclusion

- This event is assigned an NRC cause code of Design Oversight, resulting in an unanticipated interaction of components. The significance of a design change to the turbo wall insert was misjudged during the Acceptable Substitute evaluation of the new turbos.
- Analysis of the failed EDG 2A and 2B turbo compressor impellers indicated the failures resulted from high cycle fatigue due to resonance induced vibration at an EDG load of 3700 to 4200 kW.
- This load range corresponds to a turbo speed of 12970 to 13410 RPM.
- Acoustic/vibration testing of the compressor blades revealed a natural frequency of approximately 3750 hertz.
- The natural frequency of the compressor blading, in conjunction with the 17 inlet nozzle wall insert (part number 77-SLHA11), resulted in a condition of resonance at or near the normal surveillance test operating speed (13500 RPM) of the turbos. This resulted in the fatigue failure of the compressor blading.
- Actual ESF EDG load (for a worst case loss of offsite power (LOOP)/ Large break Loss Of Coolant Accident (LOCA)) is 3508 kW as determined by calculation and supported by testing.
- For this load the maximum turbo speed would be 12600 RPM.
- Therefore, under ESF loads, the EDG turbos would not have been subject to the blade resonance fatigue failures.
- Dye penetrant inspection of the EDG 1A and 1B turbo compressor blades did not reveal any cracking.
- Since there were no cracks and no mechanism for crack initiation at ESF loads, the Unit 1 EDGs were past operable and capable of carrying the ESF loads.
- Even though both Unit 1 EDGs were declared inoperable (and Unit 1 was shutdown) on June 28, 1995, both EDGs remained available at all times except for the time period when each EDG was removed from service to implement corrective action to remove the 17 inlet nozzle wall inserts.
- Therefore, there was no adverse impact to safety for Unit 1.
- Crack growth calculations by Failure Analysis Associates indicated that a crack would propagate from initiation to blade failure in 4 to 8 minutes.
- Since the surveillance test time in the load range where turbo failure could occur was greater than 8 minutes for EDGs 2A (40 minutes) and 2B (15 minutes), it is concluded that the turbo blade crack initiated and grew to failure during the surveillance test runs.
- Therefore, the Unit 2 EDGs were past operable for the entire period with the 17 inlet nozzle air assist design installed except for:

EDG 2A:

- Inoperable on June 12, 1995, at 1520 (EDG start time of 2A failure run).
- Operable on June 14, 1995, at 1543 (Completion of 1 hour operability run, after repairs).
- Inoperable on June 29, 1995, at 0743 (Start time of wall insert replacement)
- Operable on June 30, 1995, at 0100 (following wall insert replacement and completion of a 1 hour operability run).

EDG 2B

- Inoperable on June 27,1995, at 0948 (EDG start time of 2B failure run).
- Operable on June 29, 1995, at 0605 (Completion of 1 hour operability run, after repairs).

- Since the Unit 2 EDGs would have performed satisfactorily under ESF loads and were only out of service one at a time for less than the 72 hours allowed by Technical Specifications, there was no adverse safety impact on Unit 2 due to turbo failures.
- This was the first Valid Failure in the last 20 Valid Tests and the second Valid Failure in the last 100 Valid Tests of EDG 2B. On a Unit basis, this was the fourth Valid Failure in the last 100 Valid Tests of EDGs 2A and 2B.
- Surveillance testing remains monthly per the requirements of Technical Specification 4.8-1 (Diesel Generator Test Schedule).
- A review of the Problem Investigation Process (PIP) data base for the past 24 months revealed three previous events which resulted from design oversight. Those events were documented in LERs 369/93-10, 369/94-01, and 369/94-02. None of these events involved the same equipment, systems, or vendors. Corrective actions for those events were specific to those events and would not have prevented this event. This event is not considered to be recurring.
- This event is Nuclear Plant Reliability Data System (NPRDS) reportable.
- This event did not result in any uncontrolled releases of radioactive material, personnel injuries, or radiation overexposures.
- The Independent Review Team identified several issues, some of which are included in the corrective actions. The team also identified the following strengths:

  - Management exercised appropriate conservative decision making following the EDG 2B turbo failure in declaring all EDGs inoperable. The decision to pursue discretionary enforcement to allow continued operation of Unit 2 was conservative from a nuclear safety perspective.
  - The overall response from all site groups following the EDG 2B turbo failure was timely, effective, and well coordinated in identifying and addressing the common mode failure. The challenging situation of a unit shutdown and cooldown in combination with a power reduction on the other unit while conducting analysis and repair work on the turbos was handled exceptionally well.

CORRECTIVE ACTION:

Immediate:

1. EDG 2B was declared inoperable and an investigation was initiated to evaluate the potential of a common mode failure.

2. ABB Turbo Systems was contacted to assist in determining the root cause of the failures.

3. A third party consultant (Failure Analysis Associates), with expertise in rotating equipment failure analysis, was contracted to assist in determining the root cause of the failures.

Subsequent:

1. The EDG 2B turbo rotor, air inlet casing/wall insert assembly, bearings, and lube oil pumps were replaced.

2. The EDG 2A turbo (with only 2 hours operation since the June 14, 1995 repair) wall insert was replaced and the compressor impeller was dye penetrant tested and reinstalled. The bearings and lube oil pumps were also reused.

3. The EDG 1A turbo (with 40-50 hours operation since installation) wall insert and rotor were replaced. The bearings and lube oil pumps were reused.

4. The EDG 1B turbo wall insert, rotor and turbine side bearing were replaced. The compressor side bearing and oil pumps were reused.

5. A Nuclear Network Message was issued explaining the turbo failures experienced at MNS.

6. A metallurgical analysis, which included material composition and hardness testing, was performed and documented for the failed 2A & 2B compressor impeller, wall insert, and bearings.

7. An independent third party failure analysis/review of the turbo failures was performed by Failure Analysis Associates.

8. Acoustic/vibration testing was conducted and documented on compressor impeller blading.

9. An ABB Turbo Systems project team reviewed the acoustic test data and concurred that the 17 inlet nozzle wall insert design was the cause of the failures.

10. A Root Cause Fault Tree Analysis was completed.

11. A Minor Modification was completed deleting use of the 17 inlet nozzle wall insert.

12. The D. C. Cook and Brunswick Nuclear Stations were provided information regarding the failures.

Planned:

1. Component Engineering personnel will complete an Engineering Root Cause Analysis Report of the turbo failures by September 1, 1995. This report will incorporate the results of the final ABB Failure Analysis Report.

2. Engineering personnel will enhance the Acceptable Substitute and Modification Programs to address rotating equipment changes affecting natural frequency and critical speeds by December 1, 1995.

3. Engineering personnel will implement a more systematic equipment failure root cause analysis process by December 1, 1995 (McGuire Nuclear Station) and February 1, 1996 (Nuclear Generation Department).

4. Engineering personnel will evaluate a common mode failure review process for safety significant components to determine if additional guidance is needed by December 31, 1995 (McGuire Nuclear Station) and February 1, 1996 (Nuclear Generation Department).

5. Engineering personnel will perform a review of common mode failure potential for modifications to be implemented during the Unit 1 and 2 EOC10 outages. These reviews will be completed by December 1, 1995 (Unit 1) and March 1, 1996 (Unit 2).

SAFETY ANALYSIS:

The turbo is required for the EDG to operate at the necessary loading to support Engineered Safety Feature (ESF) loads. Loss of the turbo impacts the ability of the EDG to mitigate an accident. FSAR Chapter 15 contains the analysis of several accidents assuming the LOOP event. The primary event of interest is the LOOP event as an initiating event. The existing MNS PRA assumes the frequency of LOOP events to be 0.07 per year.

Based on industry data, LOOP to more than one unit occurs in only 17% of all LOOP events. At MNS, there is an additional margin of safety since there are two shared 4160V auxiliary transformers which can power the essential 4160V busses from either unit.

Assuming both EDGs fail following the occurrence of the LOOP and failures of power from the other unit, power run back, and recovery of offsite power, the unit could still be maintained in a safe shutdown condition with the use of the Standby Shutdown Facility (SSF), which can supply the reactor coolant pump seal injection and provide Steam Generator cooling by means of the turbine driven auxiliary feedwater pump. Thus a variety of means are available to mitigate a LOOP event even if the EDGs fail.

The Unit 1 EDGs were operable at all times except for the time period when each EDG was removed from service to implement corrective action to remove the 17 inlet nozzle wall inserts. For Unit 2, the EDGs were operable except for the time period when each EDG was inoperable due to the actual failure and associated repairs and the time period on EDG 2A during which corrective actions to replace the 17 inlet nozzle wall insert were being implemented. All repairs were completed within the 72 hour allowable outage time for each EDG. At no time were two EDGs inoperable at the same time.

Based on these time periods, the core damage probability as a result of the turbo failures is estimated to be approximately 2.3E -07.

During this period of reduced reliability of the McGuire emergency ac power system, no event requiring the use of the EDGs occurred at the McGuire site. Therefore, this event did not affect the health and safety of the public.