UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
611 RYAN PLAZA DRIVE, SUITE 400
ARLINGTON, TEXAS 76011-4005

August 28, 2006

William R. Brian, Acting Vice
President, Operations
Grand Gulf Nuclear Station
Entergy Operations, Inc.
P.O. Box 756
Port Gibson, MS 39150

SUBJECT: GRAND GULF NUCLEAR STATION - NRC SPECIAL INSPECTION REPORT 05000416/2006010

Dear Mr. Brian:

On August 7, 2006, the U.S. Nuclear Regulatory Commission (NRC) completed a special inspection at your Grand Gulf Nuclear Station facility. The enclosed inspection report documents the inspection findings, which were discussed on August 7, 2006, with Mr. M. Krupa, Director, Nuclear Safety Assurance, and other members of your staff.

The inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your license. Specifically, the inspectors reviewed the circumstances surrounding the failure of the Division 1 standby diesel generator on May 11, 2006.

This report documents one NRC identified finding of very low safety significance (Green). This finding was determined to involve a violation of NRC requirements; however, because of its very low safety significance and because it was entered into your corrective action program, the NRC is treating this finding as a noncited violation (NCV) consistent with Section VI.A of the NRC Enforcement Policy. If you contest this NCV, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington DC 20555-0001; with copies to the Regional Administrator, U.S. Nuclear Regulatory Commission Region IV, 611 Ryan Plaza Drive, Suite 400, Arlington, Texas 76011-4005; the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, Washington DC 20555-0001; and the NRC Resident Inspector at the Grand Gulf Nuclear Station facility.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be made available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component

of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

/RA/

Kriss M. Kennedy, Chief
Project Branch C
Division of Reactor Projects

Docket: 50-416
License: NPF-29

Enclosure:
Inspection Report 05000416/2006010
w/Attachment: Supplemental Information
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SUNSI Review Completed: __gew_ ADAMS: : Yes ☐ No Initials: __gew____
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U.S. NUCLEAR REGULATORY COMMISSION

REGION IV

Docket:	50-416
Licenses:	NPF-29
Report No.:	05000416/2006010
Licensee:	Entergy Operations, Inc.
Facility:	Grand Gulf Nuclear Station
Location:	Waterloo Road Port Gibson, Mississippi 39150
Dates:	May 17 through August 7, 2006
Inspectors:	G. Werner, Senior Project Engineer W. Sifre, Senior Reactor Inspector G. Miller, Senior Resident Inspector A. Barrett, Resident Inspector J. Drake, Operations Engineer J. Groom, Reactor Inspector
Approved By:	Kriss M. Kennedy, Chief Project Branch C Division of Reactor Projects

SUMMARY OF FINDINGS

IR 05000416/2006010; 05/17/06 - 08/07/06; Grand Gulf Nuclear Station -- Other Activities.

The report documents special inspection activities conducted by a senior project engineer, senior reactor inspector, and an operations engineer. The inspection identified one Green finding which was also a noncited violation. The significance of most findings is indicated by their color (Green, White, Yellow, or Red) using Inspection Manual Chapter 0609, "Significance Determination Process." Findings for which the significance determination process does not apply may be Green or be assigned a severity level after NRC management's review. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 3, dated July 2000.

A. NRC-Identified and Self-Revealing Findings

Cornerstone: Mitigating Systems

Green. A self-revealing noncited violation of 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Actions," was identified for the failure of licensee personnel to preclude repetition of a significant condition adverse to quality. Specifically, the licensee failed to take actions to prevent subsequent standby diesel generator engine head failures attributed to corrosion fatigue in 1992, 1996, and 2006. This issue was entered into the licensee's corrective action program as Condition Report CR-GGN-2006-1955.

The finding was more than minor since it affected the Mitigation System Cornerstone attribute of availability and reliability of mitigating equipment, specifically the standby diesel generators. Using Manual Chapter 0609, "Significance Determination Process," Phase 1 Worksheets, the finding is of very low safety significance since it only involved the loss of one train of diesel generators for less than the Technical Specification allowed outage time (Section 4.b).

B. Licensee-Identified Violations

None

REPORT DETAILS

4. OTHER ACTIVITIES

4OA5 Other Activities

Division 1 Standby Diesel Generator (SDG) Exhaust Valve Failure

1. Description of SDGs and a Historical Perspective

SDG 11 is a Transamerica Delaval, Incorporated (TDI) engine initially rated at 7000 kw and subsequently derated to 5740 kw because of concerns associated with the load capacity of the crankshaft and piston skirts. The engine is a 16-cylinder, 4-stroke, turbocharged, 45° V-type, DSRV-4 series designed to operate at 450 revolutions per minute.

The diesel generators manufactured for nuclear plants by TDI experienced numerous deficiencies, starting in the 1980's, associated with problems in design, manufacturing, and quality assurance. Based on these problems, the industry formed an owners' group to address operational issues and regulatory issues associated with the diesel generators. The NRC staff concluded in NUREG-1216, "Safety Evaluation Report Related to the Operability and Reliability of Emergency Diesel Generators Manufactured by Transamerica Delaval, Inc.," August 1986, that the actions recommended by the owners plus additional actions described in NUREG-1216 would ensure that the diesel generators would meet regulatory requirements. These requirements were incorporated into the Grand Gulf Nuclear Station facility operating license as a license condition in 1986 and were subsequently removed in 1995 by an approved license amendment.

Among the problems associated with these diesel generators, NUREG-1216 acknowledged that the Groups I and II cylinder heads manufactured before October 1980 were prone to manufacturing defects and susceptible to cracking from pre-existing flaws. Group III heads manufactured after September 1980 were determined to be much less susceptible to manufacturing defects and, therefore, pre-existing flaws. However, it was determined that all heads were adequate for service at nuclear power plants, even though Groups I and II heads had the potential for pre-existing flaws. As a result of the susceptibility of Groups I and II cylinder heads to cracking, the licensee was required to perform prestart and poststart air rolls with the cylinder stopcocks open to check for the presence of water. Currently, SDG 11 has 9 Group I heads and 7 Group III heads, while SDG 12 has 4 Group I heads and 12 Group III heads.

Although the NRC recognized and accepted (in NUREG 1216 and license conditions) that Group I heads were more likely to crack, the NRC attributed this to potential manufacturing defects. The NRC determined that, if a cracked head leaked water into the engine cylinder, immediate corrective action to replace the head had to be taken to ensure the emergency start capability of the engine.

2. Sequence of Events

a. Inspection Scope

The inspectors developed a sequence of events related to the May 11, 2006, Division I SDG mechanical failure and compared it to the licensee's sequence of events to determine if the event had been adequately reviewed.

b. Timeline

0358 hours, May 10, 2006: Began a planned maintenance outage on the SDG 11 that was scheduled for 44 hours.

1630 hours, May 11, 2006: Routine maintenance and modification work was successfully completed.

1647 hours, May 11, 2006: Commenced SDG 11 retest. Twenty minutes into a loaded maintenance retest, SDG 11 tripped (Condition Report CR-GGN-2006-1948) and a "Hi Vibration" alarm was received. Engineering, operations, and maintenance personnel met to discuss the potential causes of the trip and actions necessary to determine the actual cause. The first portion of the troubleshooting plan was to check the vibration switches to determine if any had tripped. Investigation revealed that the left bank turbocharger vibration switch was in a tripped state. Since no abnormal noises/indications were observed locally by operators, maintenance personnel, or engineers during the event, it was assumed that the vibration switch was faulty.

1800 hours, May 11, 2006: The licensee initiated Work Order 87726 to replace the vibration switch. During the retest run, vibration readings were taken manually, and no abnormal vibration readings were observed; however, the governor was observed to be "hunting" and abnormal cylinder exhaust temperature readings were observed. The expected range for cylinder exhaust temperatures is 760 to 960°F. The abnormal readings were: Cylinder 8L approximately 320°F, Cylinder 1L approximately 1190°F, and Cylinder 3R approximately 1015°F (Condition Report CR-GGN-2006-2165).

0000 hours, May 12, 2006: The diesel generator was started and was run for approximately 36 minutes to vent the oil side of the governor. Only a slight improvement in eliminating the hunting on the governor was noted.

0216 hours, May 12, 2006: Since there was only a slight improvement, a nonexcited run was performed to vent the governor. The additional venting resulted in no further improvement in governor performance. The licensee ran SDG 11 for approximately 35 minutes.

0313 hours, May 12, 2006: An emergency start was performed to allow completion of the postmodification testing. The engine was run unloaded for approximately 9 minutes.

0800 hours, May 12, 2006: A Kepner Tregoe team was formed to identify potential causes for SDG 11 load swings and abnormal cylinder temperatures. The licensee

determined that the most likely causes were blockage of combustion air flow into Cylinder 8L, a stuck fuel injector in Cylinder 8L, or some other mechanical problem.

The combustion air path for Cylinder 8L was inspected and no blockage was found. The fuel injector was removed and a boroscopic inspection of the cylinder revealed that one of the two exhaust valves (the left valve or Valve "A") was broken, with approximately a quarter of the valve face missing. Condition Report CR-GGN-2006-1955 was initiated to document the finding.

May 13, 2006: Cylinder head 8L assembly was removed from the engine. Visual inspection of the head assembly revealed not only the broken exhaust valve (Valve A), but that the other exhaust valve (Valve B) also had cracks in similar locations. Near the exhaust Valve B port, there was visual evidence of a jacket water leak into the cylinder. No evidence of cracking was visible on either of the intake valves. There was no visual evidence of abnormal seating conditions (e.g., excessive seating forces or asymmetrical seating patterns) to indicate problems (e.g., previous improper installation) related to valve guides, lifters, or valves. The missing portion of the exhaust valve face was found lodged in the stationary vanes of the turbocharger. The engine tripped as a result of high vibration caused by the impact of the exhaust valve face on the turbocharger.

May 19, 2006: The licensee replaced the Cylinder 8L liner, piston rings, head, and valves and performed other inspections to check for other damage to the engine. The retest and surveillance run of SDG 11 was completed and the diesel was declared operable early on May 20. The 4-hour and 24-hour poststart air rolls were completed with no indication of water. The air rolls were conducted using "Kolor Kut" water detecting paste applied to indicator plates installed adjacent to the cylinder petcocks.

May 23, 2006: After the return of SDG 11 to service, a boroscope inspection of all cylinders on SDG 12 was conducted to determine the potential extent of condition. No visual evidence was found of any jacket water leaks in any cylinder, or of any visible cracking in any exhaust valves. Air rolls of SDG 12 were performed using the "Kolor Kut" water detecting paste described above with no indications of water noted.

c. Findings

No findings of significance were identified.

3. Operator Response

a. Inspection Scope

The inspectors evaluated the adequacy of the operator response to this event. The sequence of events log, annunciator report, and operator logs were reviewed. The inspectors also interviewed the system engineer, SDG 11 operators, and nuclear equipment operators that were on duty at the time of the event.

b. Findings

No findings of significance were identified.

4. SDG 11 Exhaust Valve Failure Analysis and Root Cause Determination

a. Inspection Scope

The inspectors reviewed root cause analysis Condition Report CR-GGN-2006-1955 in detail and interviewed members of the licensee staff, including members of the root cause team, the system engineer, maintenance personnel, and plant operators. In addition, one NRC special inspection team member observed portions of the destructive and nondestructive examinations performed on the valves and cylinder head at the off-site failure analysis lab.

The inspectors reviewed the licensee's sequence of events, operating experience, maintenance history, and metallurgical issues associated with this valve failure and previous diesel generator head failures. The inspectors examined the failed exhaust valve and failed cylinder head. The inspectors reviewed the results of previous lube oil and fuel oil analyses, the maintenance history of SDG 11, plant computer data, performance monitoring data, engine operating logs, a previous overhaul work order, and maintenance rule failure and trending data.

The inspectors also reviewed both internal and external operating experience to determine if there were any similar failures of engine valves or preventive maintenance requirements to prevent such failures.

b. Findings

Root Cause Assessment

Introduction: The inspectors identified a Green noncited violation (NCV) for failure to prevent recurrence of SDG cylinder head cracking.

Description: On May 13, 2006, the licensee identified a jacket water leak in SDG 11, Cylinder Head 8L. The inspector observed the metallurgical examination of Cylinder Head 8L and associated exhaust valves. The licensee performed a detailed examination of the fracture surfaces of the through-wall crack in Cylinder Head 8L. The examination revealed a fatigue crack morphology with identified copper and zinc deposits. The licensee concluded that the crack initiation site resulted from galvanic corrosion and the cracks propagated as a result of cyclic stresses (corrosion fatigue).

The inspector also reviewed the licensee's examination of the crack surface on the failed valve. The licensee determined that valve failure was due to intergranular corrosion. This was deduced based on the fact that the crack was entirely along the grain boundaries and that the grain boundaries were high in carbides. The presence of carbides in the grain boundary region was indicative of sensitization due to high temperatures. The licensee concluded that the sulphur from the fuel combined with the moisture that leaked into the cylinder through the crack in the cylinder head, caused the formation of polythionic sulphurous acids which preferentially attacked the sensitized grain boundaries, resulting in crack growth on the exhaust valve.

Over the past 23 years, SDG 11 has experienced a total of four failed Group I cylinder heads (current issue, 1996, 1992, and 1984) where jacket water leaked into the cylinder. For SDG 11, a total of 15 cylinder heads have been replaced for various reasons, including 7 heads for either cracks or indicated flaws. For SDG 12, a total of 17 cylinder heads have been replaced for various reasons; however, only 1 head appears to have been replaced for a water leak. It is important to note that the documentation did not always specify the reason for the cylinder head replacement, so there were potentially more heads replaced due to cracks and flaws than recorded.

The cracked heads from 1984 and 1992 (the 1996 cracked head was not examined) were metallurgically examined and the licensee concluded that the cracks occurred due to corrosion fatigue. The galvanic corrosion was related to chemical additions to the jacket water system. Prior to 1986, nitrite was added to the jacket water to control corrosion. However, the nitrite caused high copper content in the water and set up the galvanic corrosion cells in the jacket water passages of the cylinder heads. These galvanic corrosion cells were the crack initiators. The jacket water chemistry was changed to a molybdate-based additive in 1986 as part of a corrective action following the 1984 head failure. Even though the jacket water chemistry program was changed, the subsequent head failure and jacket water leak in 1992 was determined to be caused by the same failure mechanism. The licensee did not destructively examine the cracked head in 1996, but attributed the failure to corrosion fatigue. With the exception of changing the jacket water chemistry in 1986, the licensee took no additional corrective actions to mitigate, predict, or prevent additional failures of cylinder heads due to this failure mechanism.

Analysis: The licensee failed to take corrective actions to prevent recurrence of cracked cylinder heads due to corrosion fatigue initiated by improper jacket water chemistry control, especially after the 1992 and 1996 cracked cylinder heads. In both instances, the licensee replaced the heads and took no additional corrective actions to prevent recurrence. This finding affected the Mitigating System Cornerstone since the SDGs are required to mitigate the consequences of an accident. The finding was more than minor since it affected the cornerstone attribute of availability and reliability of mitigating equipment. The finding was determined to be of very low safety significance based on Phase 1 of the Significance Determination Process screening, since it involved the loss of only one train of diesel generators for less than the Technical Specification allowed outage time. The licensee performed an evaluation and determined that the SDG could have continued to operate and supply electrical loads as designed for 30 days even with the broken exhaust valve. The inspectors reviewed and agreed with the evaluation.

Enforcement: 10 CFR Part 50, Appendix B, Criterion XVI, requires that measures shall be established to assure that conditions adverse to quality, such as failures and malfunctions, are promptly identified and corrected. In the case of significant conditions adverse to quality, measures shall be taken to assure that the cause of the condition is determined and corrective action taken to preclude repetition. Contrary to this requirement, Grand Gulf Nuclear Station failed to correct and preclude repetition of a significant condition adverse to quality. Specifically, the licensee failed to take actions to prevent subsequent head failures attributed to corrosion fatigue in 1992, 1996, and 2006. This violation, which was determined to have a very low safety significance and was entered into the licensee's corrective action program as Condition Report

CR-GGN-2006-1955, is being treated as an NCV, consistent with Section VI.A of the NRC Enforcement Policy: NCV 05000416/2006010-01, Inadequate Corrective Actions for SDG Cylinder Head Cracks.

Extent of Condition

Based on the root and contributing causes for this failure, the inspectors determined that SDGs 11 and 12 are susceptible to exhaust valve failures because the valve material is susceptible to intergranular corrosion cracking and the valves currently installed are of the same material. In addition, both SDGs have Group I heads that are known to have the potential for defects, as well as some Group I heads that were exposed to the original nitrite jacket water chemistry control program and associated high copper concentrations, which has been attributed to being the crack initiator on four previous SDG 11 cracked heads. The licensee has implemented actions to identify the presence of cracked cylinder heads and are evaluating additional corrective actions, as described below, to prevent another exhaust valve failure.

5. Corrective Actions Implemented Following the May 2006 Event

Cylinder Head 8L was removed from the engine and both intake and exhaust valves were removed and sent to an offsite laboratory for metallurgical examination. In addition, the licensee sent similar valves from the warehouse and valves from another site for comparison. The licensee also pressure tested the jacket water passages for leaks. No leaks were discovered.

The licensee disassembled and inspected the left bank turbocharger for damage and found only cosmetic damage, which was caused by the impact of the broken section of the exhaust valve on the stationary turbocharger vanes. Cylinder Liner 8L was replaced due to corrosion found under the glazing (unrelated to valve failure). The piston was removed, inspected, cleaned, and reinstalled. In addition, the piston rings, cylinder head, and all four valves were replaced. The remaining 15 cylinders were inspected using a boroscope and no other visible valve cracking or jacket water leaks were identified.

In addition to the immediate corrective actions to repair the diesel, the licensee instituted two interim corrective actions to identify any future jacket water leaks into the cylinders:

- Boroscopic inspections are planned for each of the Group I cylinders to look for water leaks or valve cracking through January 2007. The quarterly inspection schedule was determined based on the licensee's estimated crack growth time of approximately 14 weeks. The licensee estimated this period of time based on corrosion indications on the cylinder liner and best guess estimates of corrosion rates. The inspectors concluded that the licensee's method for calculating corrosion rates was at best a crude method, but seemed reasonable, since no other test or historical data were available to either support or refute the licensee's estimated valve crack growth rate.

- Monitor for small amounts of water in the cylinder by using a water sensitive paste applied to aluminum plates installed in front of each engine cylinder petcock.

The inspectors found that these actions appeared to be technically acceptable and appropriate. Though the inspectors were unable to predict with certainty the effectiveness of the current interim measures, the inspectors verified that they were being performed and/or have been incorporated into licensee procedures.

6. Additional Long-Term Corrective Actions Planned (by end of 2006)

The inspectors also noted that the licensee planned to implement the following long-term corrective actions related to the SDG 11 exhaust valve failure:

- Identify and evaluate a method to detect small quantities of jacket water in the lube oil.
- Establish new valve material specification and install new valves.
- Establish a long-range reliability plan for the heads, including the strategy for replacing all Group I heads with Group III heads.
- Identify and evaluate changes in jacket water chemistry controls that might reduce head crack growth rate.

The inspectors determined that the licensee had planned appropriate long-term corrective actions to prevent a similar valve failure from recurring.

7. SDG Monitoring and Maintenance

a. Inspection Scope

The inspectors reviewed the maintenance history, nondestructive examination records, SDG preventive maintenance program, maintenance packages for the last overhaul of both SDGs, and licensee testing to identify cylinder leakage for the Divisions I and II SDGs. The inspectors reviewed data of numerous maintenance and surveillance engine tests for both SDGs. In addition, the inspectors reviewed cylinder pressure and exhaust temperature data, fuel oil receipt analysis, and fuel oil tank inspections to verify that acceptance criteria were met. Additional documents reviewed by the inspectors are listed in the attachment.

The inspectors concluded that the maintenance and testing activities performed by the licensee were adequate and none of the information reviewed indicated the potential of the exhaust valve failure.

b. Findings

No findings of significance were identified.

8. Testing Program to Confirm Operability of SDG 11 Following Repair Activities

a. Inspection Scope

The inspectors reviewed the postmaintenance test activities following the repair of the SDG 11. The inspectors: (1) reviewed the applicable licensing and design basis documents to determine the safety functions; (2) evaluated the safety functions that may have been affected by the repair activities; and (3) reviewed the test procedure to ensure it adequately tested the safety functions that may have been affected. The inspectors witnessed portions of the retest of the SDG, including test runs and inspections of the diesel at various loads used to seat the new piston rings, an unloaded run of the diesel, and a monthly surveillance run of the diesel per Technical Specification Surveillance Requirement 3.8.1.3. In addition, the inspectors reviewed test data to verify that acceptance criteria were met, plant impacts were evaluated, test equipment was calibrated, procedures were followed, test data results were complete and accurate, test equipment was removed, the system was properly re-aligned, and deficiencies during testing were documented. The inspectors also reviewed the Updated Final Safety Analysis Report to determine if the licensee identified and corrected problems related to the postmaintenance testing. Additional documents reviewed by the inspectors are listed in the attachment.

The inspectors concluded that the testing activities performed by the licensee were adequate to confirm the operability of SDG 11 following the repair activities.

b. Findings

No findings of significance were identified.

9. Industry Operating Experience

a. Inspection Scope

The inspectors reviewed various NRC generic communications and operating experience from other licensees relevant to TDI diesel generators. Specifically, the inspectors reviewed NUREG-1216, “Safety Evaluation Report Related to the Operability and Reliability of Emergency Diesel Generators Manufactured by Transamerica Delaval, Inc.,” August 1986, and other generic documents listed in the appendix. The inspectors also performed internet searches for similar types of valve failures on non-nuclear industrial diesel generators. No relevant valve failures of this type were identified in either nuclear or industrial diesel generators. However, several reports discussed concerns with exhaust valves. One report dealing with marine diesel engines did note that exhaust valves have the highest failure rates for the propulsion system, but no discussion of failure mechanisms were included. Another report indicated that the center area of an exhaust valve experiences the hottest temperatures and is most susceptible to corrosion (no analytical data provided, only qualitative).

The inspectors did note that Group I head failures were expected to occur and that proper testing was put in place to identify gross cylinder water leakage before diesel generator operability would be compromised. However, the testing was not designed to

identify very small jacket water leaks that would be required to form the conditions necessary for the sulfurous acid to cause the intergranular corrosion cracking mechanism to occur. This particular environment necessary for the sulfurous acid corrosion mechanism was not recognized or known to occur.

b. Findings

No findings of significance were identified.

10. Potential Common Failure Mode and Generic Safety Issues

The potential exists for exhaust valves to crack in both SDGs 11 and 12. Both engines were manufactured by Transamerica Delaval and the engines have the same valve material and same Group I heads that were found broken and cracked. In addition to the through-wall cracks, the licensee also identified numerous nonthrough-wall cracks in the other exhaust port on the failed 1984, 1992, and 2006 heads due to the same failure mechanism. The cracks were similar in length to the through-wall cracks, but had not become through-wall because the wall thickness of these ports was at or above the minimum wall thickness specification of 0.500 inches. The through-wall cracks occurred in the SDG 11 exhaust port areas with the following thicknesses: Cylinder Head 7L (1984 failure) 0.250 inches, Cylinder Head 2R (1992 failure) 0.325 inches, and Cylinder Head 8L (2006 failure) 0.350 inches. None of the identified cracks were initiated as a result of manufacturing defects as was the original concern in NUREG-1216; therefore, based on this information, the inspectors determined that any head exposed to the high copper concentration is susceptible to a similar failure mechanism.

There are 20 TDI diesel generators currently in use in the nuclear industry. The inspectors concluded that other TDI engines are susceptable to failure of exhaust valves if similar conditions exist. However, Grand Gulf Nuclear Station has taken corrective actions to identify the adverse conditions prior to valve failure. The licensee informed other nuclear utilities of the exhaust valve failure through the utility's operating experience network and indicated that they are planning to submit a voluntary licensee event report.

4OA6 Meetings, Including Exit

On August 7, 2006, the results of this inspection were presented to Mr. M. Krupa and other members of his staff who acknowledged the findings. The inspector confirmed that the supporting details in this report contained no proprietary information.

ATTACHMENTS: SUPPLEMENTAL INFORMATION AND SPECIAL INSPECTION CHARTER

SUPPLEMENTAL INFORMATION

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NRC personnel

A. Barrett, Resident Inspector, Reactor Project Branch C
R. Bywater, Senior Reactor Analyst
J. Groom, Reactor Inspector, Engineering Branch 1
G. Miller, Senior Resident Inspector, Reactor Project Branch C

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

None

Opened and Closed

05000416/2006010-01	NCV	Inadequate Corrective Actions for SDG Cylinder Head Cracks (Section 4.b.)

Closed

None

Discussed

None

LIST OF DOCUMENTS REVIEWED

Procedures

04-1-03-P75-1, “Division 1 Diesel Generator Unexcited Run,” Revision 5

04-1-01-P75-1, “Standby Diesel Generator System,” Revision 70

04-1-02-1HH22-P400, Alarm Response Instruction Panel 1H22-P400 Safety Related.” Revision 108

06-OP-1P75M-0001, “Standby Diesel Generator Functional Test,” Revision 127

EN-OP-104, “Operability Determinations,” Revision 1

GGNS-MS-37, “Grand Gulf Nuclear Station Mechanical Standard for the Division I and II Standby Diesel Generator Maintenance,” Revisions 3 and 5

Condition Reports

CR-GGN-1986-00715	CR-GGN-1987-00449	CR-GGN-1996-00231
CR-GGN-1996-00630	CR-GGN-1996-00661	CR-GGN-1999-01410
CR-GGN-2001-01429	CR-GGN-2002-02616	CR-GGN-2003-00251
CR-GGN-2003-03152	CR-GGN-2004-02575	CR-GGN-2005-01599
CR-GGN-2006-01577	CR-GGN-2006-01948	CR-GGN-2006-01955
CR-GGN-2006-01959	CR-GGN-2006-01982	CR-GGN-2006-01984
CR-GGN-2006-01985		

Industry Information/Operational Experience

NUREG-1216, “Safety Evaluation Report Related to the Operability and Reliability of Emergency Diesel Generators Manufactured by Transamerica Delaval, Inc.,” August 1986

LER 3871990033, “Diesel Generator ‘D’ Piston Pin Bushing Failure,” Susquehanna 1 and 2

LER 4131985022, “Diesel Generator 1B Inoperable,” Catawba 1

LER 4131987011, “Unit Shutdown Due to Diesel Generator Inoperability Because of Manufacturing Deficiency,” Catawba 1

LER 4131988019, “Inoperability of Diesel Generators Due to a Manufacturer’s Design Deficiency,” Catawba 1 and 2

LER 4141986031, “Nuclear Service Water Inoperable Due to Diesel Generator Equipment Failure,” Catawba 2

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00068478, “06OP1P75-0001-02 Div I STBY Diesel Generator Functional Test”

00082944, “Diesel Fuel Oil Receipt Analyses”

00082946, “Diesel Fuel Oil Receipt Analyses”

00087726, “Vibration Switch Found Tripped During Surveillance Run”

00087732, “Inspect Left Bank #8 Intake Air EL”

00087773, “1P75C015A [RF To Online] Partial Disassembly and Cleaning of Turbocharger”.

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LIST OF ACRONYMS

CFR	*Code of Federal Regulations*
NCV	noncited violation
NRC	U.S. Nuclear Regulatory Commission
SDG	standby diesel generator
TDI	Transamerica Delaval Incorporated

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
611 RYAN PLAZA DRIVE, SUITE 400
ARLINGTON, TEXAS 76011-4005

May 18, 2006

MEMORANDUM TO: Greg E. Werner, Senior Project Engineer, Project Branch D

FROM: Arthur T. Howell III, Director, Division of Reactor Projects ***/RA/***

SUBJECT: CHARTER FOR NRC SPECIAL INSPECTION TEAM AT GRAND GULF NUCLEAR STATION -- REVIEW OF LICENSEE ACTIONS RELATED TO THE FAILURE OF DIVISION 1 EMERGENCY DIESEL GENERATOR

On May 11, 2006, the Division 1 emergency diesel generator experienced a significant mechanical failure during postmaintenance testing that resulted in a broken exhaust valve and a crack in another exhaust valve. Based on the results of an evaluation conducted in accordance with Management Directive 8.3, "NRC Incident Investigation Program," a Special Inspection will be performed to inspect the circumstances surrounding the failure and the licensee's actions in response to the failure. You are hereby designated as the team leader for the Special Inspection.

A. Basis

On May 11, 2006, during a postmaintenance surveillance test of the Division 1 emergency diesel generator, the diesel automatically tripped due to high vibration in the left bank turbocharger. The licensee initially diagnosed the cause of the trip to be a faulty vibration switch. They replaced the switch and performed another diesel run. During the subsequent run, the licensee measured high cylinder head temperatures in Left Bank Cylinder 1 and Right Bank Cylinder 3 (both greater than 1000EF). The Left Bank Cylinder 8 temperature was approximately 350EF, or colder than normal. Normal cylinder head temperature is approximately 800EF. The engine was tagged out for repairs and inspections. The licensee discovered that the Cylinder 8 exhaust valves were damaged, with one exhaust valve cracked and the other broken. Pitting was also found on the cylinder liner and a small crack was found in the cylinder head. Further robotic borescope inspections in the exhaust header discovered the missing valve head piece lodged in the turbocharger stationary inlet vanes. The licensee believes that this piece accounts for the broken part of the valve head (i.e., no other pieces are believed to be in the system). The exhaust valves have been sent to a metallurgical lab in Baton Rouge, Louisiana.

The root cause of the exhaust valve failure has not been determined.

The licensee has completed borescope inspections of the other 15 cylinders on the Division 1 emergency diesel generator and did not identify any additional damage (i.e., no indications of cracks in valves or cylinder heads and no pitting on cylinder liners).

The licensee is in the process of rebuilding Left Bank Cylinder 8 and the left bank turbocharger, which was disassembled for inspections and repair of the inlet vanes. The licensee entered the 14-day limiting condition for operation on May 10, 2006, and plans to complete diesel repairs and testing by Thursday, May 18th (Day 9 of the 14-day limiting condition for operation).

Based on the results of an evaluation conducted in accordance with Management Directive 8.3, "NRC Incident Investigation Program," a Special Inspection will be performed to inspect the circumstances surrounding the failure and the licensee's actions in response to the failure. The purpose of the special inspection is to understand the cause of the diesel failure, the extent of the condition, the potential generic implications, and the corrective actions proposed by the licensee.
A preliminary risk analysis performed by a Senior Reactor Analyst resulted in an estimated incremental conditional core damage probability in a range between 1.26 x 10^{-6} and 8.48 x 10^{-6}.

B. Scope

The team will perform data gathering and fact-finding in order to address the following:

1. Develop a chronology of the Division 1 emergency diesel generator failure.

2. Review the licensee's root/probable cause determination for completeness and accuracy.

c. Review the adequacy of the licensee's corrective actions to address the root and contributing causes and prevent recurrence of the failure mechanism.

d. Evaluate the licensee's extent of condition review, specifically as it relates to the Division 2 emergency diesel generator.

5. Review records associated with the maintenance history for the diesel generators at Grand Gulf Nuclear Station, including previous mechanical failures.

6. Review the licensee's program for periodic monitoring and maintenance of the emergency diesel generators, including inspection and assessment techniques and scope, periodicity, and the results of past inspections. Assess the adequacy of licensee testing (e.g., as it relates to identification of jacket water leakage into cylinders) and identify and evaluate any adverse trends in parameters. Identify and assess the impact of changes to the maintenance program and schedule that may have been implemented. Review the results of fuel oil receipt inspections and fuel oil tank sample results for adverse trends.

7. Review and assess the corrective actions for past similar failures, including vendor recommended actions to prevent such failures.

8. Review and assess the licensee's planned testing program to confirm the operability of Emergency Diesel Generator 1 following repair activities.

9. Review the circumstances associated with the diesel failure to identify potential common failure modes and generic safety concerns.

10. Review operating experience associated with Trans-America Delaval, Inc. emergency diesel generators, including applicable NRC Information Notices, Generic Letters, and NUREGs (NUREGs 1216 and 1416). Evaluate the adequacy of licensee actions in response to operating experience.

11. Working with a Senior Reactor Analyst, gather necessary information to evaluate the risk significance of any performance deficiencies identified during the inspection.

C. Team Members

Greg Werner - Team Leader
Jim Drake - Team Member
Wayne Sifre - provide support to team in the materials area
Russ Bywater - provide Senior Reactor Analyst Support

D. Guidance

This memorandum designates you as the special inspection team leader. Your duties will be as described in Inspection Procedure 93812, "Special Inspection." The team composition has been discussed with you directly. During performance of the special inspection activities assigned to them, designated team members are separated from their normal duties and report directly to you. The team is to emphasize fact-finding in its review of the circumstances surrounding the event, and it is not the responsibility of the team to examine the regulatory process. Safety concerns identified that are not directly related to the event should be reported to the Region IV office for appropriate action.

The team should begin inspection activities on May 17, 2006. You should conduct an entrance meeting with the licensee at the appropriate time at the site. A report documenting the results of the inspection, including findings and conclusions, should be issued within 45 days of the exit meeting conducted at the completion of the inspection. While the team is active, you will provide periodic status briefings to Region IV management.

This Charter may be modified should the team develop significant new information that warrants review. Should you have any questions concerning this Charter, contact Kriss Kennedy, Chief, Project Branch C, Division of Reactor Projects, at (817) 860-8144.