Enclosure to
AECM-83/0689

GRAND GULF NUCLEAR STATION

UNIT 1

REPORT ON THE

DIVISION I, II and III

DIESEL GENERATORS

October, 1983

NUCLEAR PLANT ENGINEERING

OPERATIONAL ANALYSIS SECTION

DIVISION I, II, AND III DIESEL GENERATOR

OPERABILITY REPORT

REPORT NO.: 83-024

DATE: October 22, 1983

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1.0 ABSTRACT

This report summarizes the performance of the standby diesel generators installed at the Grand Gulf Nuclear Station (GGNS). Unit 1 has three (3) diesel generators; two (2) were manufactured by Transamerica DeLaval, Inc. (TDI) and the third was manufactured by the Electro-Motive Division (EMD) of General Motors.

The TDI diesels are dedicated to providing power to loads required to operate during post-accident conditions. The TDI diesel engines and associated Portec generators were supplied under the Bechtel scope of supply. The EMD diesel and associated Portec generator is dedicated to powering the High Pressure Core Spray (HPCS) System and was supplied under the General Electric (GE) scope of supply.

The report contains a description of the design criteria and operational history of the diesel generators. The information presented in this report highlights problems that have occurred with diesel generators, both at GGNS and within the industry, and indicates how these problems have been addressed at Grand Gulf.

Also described are measures which are being taken to enhance the reliability of the diesel generators. The measures incorporate recommendations made by NRC, INPO, and vendor documents, the GGNS Operational Analysis Section (OAS) of Nuclear Plant Engineering (NPE), the GGNS Safety Review Committee and available industry sources.

A comparison of the performance of the diesel generators with the industry is also summarized. Included in this comparison is a summary of the Shoreham diesel generator crankshaft failure and its applicability to the GGNS diesels. Overall, the performance of the GGNS diesel generators appears to be comparable to industry performance in most categories.

2.0 INTRODUCTION

MP&L's Grand Gulf Nuclear Station is a 2-unit BWR/6 plant with a Mark III containment. Each unit has a rated capacity of 3833 MWt or 1306 MWe. Unit 1 is complete and was loaded with its initial core in June, 1982. Power ascension and low power testing began on Unit 1 on September 25, 1983.

The Engineering Safety Features (ESF) electric loads for each Grand Gulf unit are divided into three (3) divisions (Division I, II, and III). Correspondingly, there are three (3) independent sources of onsite emergency power. Three diesel generator sets serve each Grand Gulf unit. Two of them supply power to ESF Division I and II, and are manufactured by Transamerica DeLaval, Inc., (TDI). The third diesel generator is manufactured by the Electro-Motive Division (EMD) of General Motors, and is a dedicated onsite emergency power supply for the reactor vessel High Pressure Core Spray (HPCS) system (ESF Division III).

The generators for all three diesels are manufactured by the Electric Products Division of Portec, Inc. They are designed with a 10%, two-hour overload capacity. The DeLaval diesels are model DSRV-16-4. This is a V-type 16 cylinder machine rated at 9770 HP and 7000 Kw at 450 RPM. The EMD diesels (HPCS dedicated) are model 12-645E4. Two diesels are tied to one generator. These two V-type 12 cylinder machines have a combined rating of 4610 HP and a generator rated at 3474 Kw at 900 RPM.

The main design parameters of the DeLaval and EMD diesel/generators are listed in Attachment 1.

3.0 DESIGN CRITERIA

The onsite diesel generators (D/Gs) and their associated support systems and components have been designed to provide a reliable backup source of power to equipment required to operate should the preferred offsite power supply fail or degrade to unacceptable levels. To provide some level of assurance that the diesel generators can perform this function, they have been designed to meet or exceed the requirements of various NRC regulations and industry standards.

As described in FSAR Section 8.3, the diesel generators meet the requirements of General Design Criteria (GDC) 17, 18, and 21 of 10 CFR Part 50, Appendix A, Regulatory Guides (RGs) 1.6, 1.9, 1.29, 1.32. and 1.108, and IEEE Standards 308-1971 and 323-1971 or 1974, as appropriate. These requirements ensure that the diesel generators have sufficient independence, redundancy, and capacity, permit periodic inspection and testing of all essential areas and features, can survive earthquakes, tornadoes, and pipe breaks, and can take a single failure.

FSAR subsections 9.5.4, 9.5.5, 9.5.6, 9.5.7 and 9.5.8 provide additional details of the design bases for the diesel generator fuel oil system, cooling water system, starting system, lubrication system and combustion air intake and exhaust system, respectively. The diesel generators have been designed to seismic Category I requirements, can take a single active or passive failure, and have been protected from or qualified to the environment created by a pipe break. These system design bases are summarized in FSAR Table 3.2-1.

In addition to the requirements described above, the design of the diesel generators also meets the criteria of IEEE Standard 387-1977, the ASME Code (1974 edition), ANSI Standards, ASTM Standard Specifications, DEMA Standard Practices, as well as other applicable codes, standards, and regulations.

The information provided in the above referenced FSAR sections has been supplemented in various responses to NRC Power Systems Branch (PSB) concerns in the Safety Evaluation Report (SER). Responses to concerns with the engine-mounted piping, fuel oil drip return system, cooling water system, starting air system, lubricating oil system, and combustion air intake and exhaust system, have been provided in AECM-82/262, dated June 10, 1982, AECM-82/459, dated August 9, 1982, and AECM-81/324, dated August 26, 1981. Based on these responses the NRC has found that the diesel generators and their associated support systems and components meet the requirements of the appropriate GDCs, Regulatory Guides, and Standard Review Plan (SRP) sections, perform their design function, and meet the recommendations of NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," and appropriate industry codes and standards, except for the following.

3.0 (Continued)

The NRC has requested in Supplement 4 to the SER (SSER 4) that prior to startup following the first refueling outage, 1) the EMD diesel generator be provided with a heavy duty turbocharger gear drive assembly, 2) confirmation that the HPCS diesel skid-mounted and standby diesel auxiliary systems piping has been hydraulically tested to at least 125% of design pressure be provided, and 3) upgrade of the standby diesel combustion air intake and exhaust system to augmented Quality Group D requirements be performed. These requirements are reflected in License Conditions 2.C.(33)(a)(1), (2), and (3), respectively.

A discussion of License Condition 2.C.(33)(a)(2) is provided in Attachment 2. This discussion clarifies the requirements used for leak testing the fuel oil, cooling water, air start, and lube oil piping.

Additional information regarding the design standards for the standby diesel generator engine-mounted components is provided in Attachment 3. This information is intended to clarify statements made in SSER 4 and to reiterate the results of an audit of Transamerica DeLaval, Inc. (TDI) performed to verify the adequacy of the engineering controls imposed on the design and fabrication of engine-mounted components. In addition to this audit, many checks of the quality of the standby diesels were made during procurement and manufacture.

4.0 PREOPERATIONAL HISTORY

The purpose of this section is to summarize the history of the GGNS Unit 1 diesel generators (Divisions I, II, and III) from the time of purchase to when the GGNS Operating Licensing (OL) was issued (June 16, 1982).

4.1 Division I and II Diesel Generators

The Division I and II D/Gs were purchased under Specification 9645-M-018.0. Operational and functional prototype testing for these D/Gs was performed on the Division I D/G. The prototype diesel was tested for start and load reliability by conducting 300 successive starts and run to reach normal operating oil and water temperatures. Testing was successfully completed by TDI in late 1976. Operability testing included the starting air system, sequential loading, load shedding, margin, endurance and load capability testing.

TDI coordinated the seismic qualification of the D/Gs. SSER 4, reflects the complete seismic qualification of these units.

Delivery of the Division I and II D/Gs and the associated auxiliary systems commenced on March 24, 1977 and continued through August 1977. Upon receipt, the equipment was transported to appropriate storage facilities and laid up in accordance with manufacturer's recommendations.

Following installation of the D/Gs and prior to issuance of the OL, several events occurred which could have had an impact on the reliability of these D/Gs. A summary of these early events is provided below.

4.1.1 Link Rod Assembly

A TDI letter, dated September 22, 1980, notified the NRC of a 10 CFR 21 potentially reportable condition in which the dowel counterbore in the link rod may be too shallow. Such a defect could lead to link rod bolt failure, thereby rendering the D/G unavailable. TDI similarly notified MP&L of the possible deficiency and outlined procedures for inspection of the link rod assemblies and criteria for determining acceptability. Subsequent inspection revealed that critical dimensions were within specified tolerances.

4.1.2 Piston Separation

The Division I and II D/Gs are provided with two piece pistons. These pieces, the crown and skirt, are bolted together with four studs each.

4.1.2 (Continued)

During preoperational testing of the Division I D/G, in November, 1981, the crown and skirt of one piston separated causing a discernable change in engine sound. The D/G was manually shut down and inspected. Examination of the piston revealed a failure of the hold down studs adjacent to the spherical washers used under the bottom stud nuts. TDI was contacted for information regarding similar failures.

TDI transmitted Service Information Memo (SIM) 324, dated November 10, 1980, outlining corrective action to preclude the subject event. SIM-324 attributed the failure cause to the use of spherical washers and specified as replacement Belleville washers. All pistons in the Division I and II D/Gs were returned to TDI for rework. The reworked pistons were installed at GGNS per manufacturer recommendations.

4.1.3 Lubrication of the Turbocharger Thrust Bearing

The lubrication oil system does not supply lube oil to the turbocharger thrust bearing until the lube oil pump initiates upon engine startup. This condition, which causes accelerated bearing wear and could lead to premature failure, was reported to the NRC under the provisions of 10 CFR 21 via TDI letter dated December 16, 1980. Redesign of the lube oil system to preclude this condition was provided by the vendor and implemented by MP&L. This redesign added a continuous drip lube oil subsystem.

4.1.4 Air Start Valve Capscrews

Each air start valve assembly (16 per engine) is mounted to the cylinder head with 2 3/4-10 X 3 inch steel bolts. A TDI letter, dated June 11, 1982, notified MP&L that the mounting capscrews may be bottoming out in the cylinder head tapped holes. This could result in insufficient or unequal forces being applied to, and possibly eventual failure of, the air start valves, and hence, the engine itself. In accordance with TDI recommendations, the existing bolts were reworked and reinstalled for all air start valves on Divisions I and II.

This condition was determined to be reportable under the provisions of 10 CFR 21 and 10 CFR 50.55(e). AECM-82/605, dated December 15, 1982, notified the NRC of this problem.

4.1.5 Flexible Drive Coupling

Each of the diesel engines is provided with a flexible drive element to couple the engine and governor. The drive element is made of an Isoprene material and is housed inside the governor drive coupling. TDI informed MP&L, via PMI-82/5825 of a potential problem concerning the capability of Isoprene to withstand the hot, oily environment encountered in the engine gearcase.

4.1.5 (Continued)

Isoprene is known to deteriorate rapidly in this environment and would eventually fail. Although the coupling is fail safe and would mechanically lock up if the drive element failed, sufficient frequency instability may be induced to trip the D/G off-line. A Neoprene material was recommended as the replacement material. A corrective action tracking document was generated and the vendor's recommendations for change out of the drive element and female portion of the coupling were implemented.

TDI determined this condition to be reportable under 10 CFR 21 and notified the NRC via a TDI letter dated August 18, 1982.

4.1.6 Latching Relay (PRD-82/15)

During preoperational testing of the Division I D/G, an engine start was initiated by a simulated LOCA signal. The engine reached rated speed, but failed to reach rated voltage. The latching relay, which transfers voltage control from the manual voltage regulator to the automatic voltage regulator had failed and was inoperative. MP&L determined this condition to be reportable under the provisions of 10 CFR 50.55(e) and 10 CFR 21 and informed the NRC via AECM-82/340, dated August 9, 1982.

The failed relay was replaced with a J14 series ITE Gould control relay which was supplied and qualified with a similar Division III D/G panel. Subsequent preoperational testing continued to completion without further incident.

4.1.7 Air Start Pressure Sensing Line (PRD-82/04)

The air receiver tank has a 3/8 inch diameter sensing line attached directly to the sensing tank via a manual valve. The sensing line feeds directly back to the D/G starting air compressor. The starting air receiver tank is seismic Category I. However, the sensing line and air compressor are not seismically supported.

During a "Seismic Event", the following condition could occur. A break anywhere in the sensing line, or pressure sensing device could cause the air receiver pressure to decrease below the minimum allowable (160 psig) in approximately six (6) minutes. If the pressure is bled off, the air receiver tank would not be capable of performing the design safety function of providing starting air for the D/G. Since the same condition existed in the redundant system the same type of break could occur in the redundant system during a seismic event.

4.1.7 (Continued)

(NOTE: Credit cannot be taken for operator action to close the manual valve located in the sensing line near the air receiver tank.) To preclude this event, the air start sensing line was relocated from the loadless start device to just upstream of the air receiver tank inlet check valve. Thus, integrity of the starting air sensing line cannot be violated by a seismic event.

MP&L determined this condition to be reportable under the provisions of 10 CFR 50.55(e) and 10 CFR 21 and notified the NRC via AECM-82/85, dated March 8, 1982.

4.1.8 GE Type HFA Relays

The concern for the HFA relays was initiated by IE Notice No. 82-13, "Failures of General Electric Type HFA Relays." This IE Notice deals with coil spools made of Lexan or nylon material which were furnished in certain HFA relays. A total of 4 HFA relays, GE model number 12HFA53K91 are furnished with the Grand Gulf diesel generator control panels. Two relays are installed in each panel of Division I and II. As recommended by IEN 82-13 the correct replacement for these relays would have been the "century" series relays. For the 12HFA53K91, the "century" series replacement model is 12HFA153K2H. However, the 12HFA153K2H relay is not available from GE prequalified to Class 1E nuclear requirements. An inspection of the original relays did not reveal any defective coil spools. However, the relays were replaced as a precautionary measure. GE model number 12HFA151AZF, which is prequalified for Class 1E nuclear service, was used for replacement.

4.1.9 Governor Lube Oil Cooler (PRD-82/01)

The elevation of the governor lube oil cooler on the D/Gs was above the oil level of the governor. This presents the possibility of air being trapped in the governor lube oil system when the oil level in the governor is low. If air is trapped, engine starting may be affected. To preclude this condition, the governor lube oil cooler was relocated to below the governor sump to maintain oil in the governor and prevent air entry.

MP&L determined this condition to be reportable under the provisions of 10 CFR 50.55(e) and 10 CFR 21. The NRC was notified via AECM-82/48, dated January 29, 1982.

4.1.10 Pneumatic Logic Problem (PRD-81/53)

The D/G pneumatic logic was such that the diesels may inadvertently shut down under certain conditions. The D/G pneumatic logic is to be designed such that the engines will automatically shut down on either low lube oil pressure with a 2-out-of-3 logic or high crankcase pressure with a 2-out-of-3 logic. However, due to the two logic lines being tied into a common line, it was possible that the engines could be shut down on a 2-out-of-6 logic.

It has been determined that this condition has no adverse affects to the safety of the power plant. For this condition to occur, 2 sensing devices would have to fail (1 low lube oil pressure and 1 high crankcase pressure). Therefore, this condition is not applicable to the single active failure criteria.

Although the condition could affect reliability, the overall affect on the generator required operability is insignificant and does not create a safety concern. The condition did not violate either design specification requirements or NRC regulations.

Corrective action was not required. However, as a matter of good engineering practice, the design was revised and implemented such that the two logics are no longer tied together in a common line. The new design yields two 2-out-of-3 logics, thereby reducing the potential for inadvertent faults and enhancing reliability of the D/G.

MP&L determined that this condition was not reportable under the provisions of 10 CFR 50.55(e) or 10 CFR 21 and notified the NRC via AECM-82/104, dated March 23, 1982.

4.1.11 Nuclear Service Class 1E Qualified Auxiliary Motors (PRD-81/23)

Division I and II are supplied with auxiliary jacket cooling water and auxiliary lube oil subsystems. The pumps used in each of these subsystems utilize a motor driver qualified for Class 1E Nuclear Service.

TDI furnished stock commercial grade AC motors as opposed to the Nuclear Grade Class 1E motors required by our Architect/Engineer's contract with DeLaval. DeLaval retracted the original data utilized in establishing that the Grand Gulf motors are "equivalent" to Class 1E motors. This "equivalency" was to be used to qualify the motors supplied for the Grand Gulf Project. Due to the withdrawal of the "equivalency" claim, the motors could no longer be considered qualified. To assure that qualified motors are used, replacement motors were purchased and installed prior to operation.

4.1.11 (Continued)

MP&L determined that this condition was reportable under the provisions of 10 CFR 50.55(e) and notified the NRC via AECM-81/156, dated April 29, 1981.

4.2 Division III (HPCS) Diesel Generator

The Division III D/G was purchased under MP&L Contract 9645-M-001.0 to General Electric. The diesel engine was manufactured by General Motors-EMD and the generator by Electric Products. The Division III D/G assembly was supplied by Morris-Knudsen.

Operability and functional testing were undertaken by GE. This testing included start time tests, HPCS operation from the normal power source, operation from the D/G power source, and start and load reliability tests. Results of the prototype testing indicate that the Division III D/G satisfied design requirements and provided a 0.99 factor of reliability. A test report summary was provided to the NRC via AECM-82/152, dated April 14, 1982.

This report indicates that the prototype diesel was tested for start and load reliability by conducting 69 successive start and load tests. Sixty-three of these tests were started with the engine in a warm standby condition. Six were started with the engine at hot equilibrium. There were no failures during these tests, which demonstrated the reliability of the diesel. These tests also demonstrated that the Technical Specification time requirements to reach rated speed, voltage and frequency were met.

On June 2, 1982, MP&L and associated organizations met with the NRC in Bethesda, Maryland to present qualification documents and rationale to demonstrate seismic qualification of the Division III D/G. Based on the results of that meeting, the NRC concluded that the criteria were satisfied and the seismic qualification of equipment in this system is acceptable. NRC acceptance was documented in the Grand Gulf SSER 2, Section 3.10.

5.0 OPERATIONAL HISTORY

When the OL was issued, the GGNS Technical Specifications (TSs) became effective and testing of the diesel generator as required by the TSs began. Since the date of the OL, the TS requirements for the D/G monthly test have been changed. The requirements at the time of the receipt of the OL were that the D/G should reach a specified RPM in 10 seconds and a specific voltage and frequency in less than 13 seconds and then be run at 50% load for longer than one hour. The present TSs are more restrictive. They now require the D/Gs to reach a specified RPM, voltage and frequency in 10 seconds and be loaded to 100% capacity for longer than 1 hour. Eighteen month functional testing of the D/Gs was recently completed satisfactorily. This testing checked the automatic starts of the D/Gs, D/G interlocks, starting air recovery capacity, D/G protective trips and included a 24 hour run of which 2 hours was at 110% load and 22 hours at 100% load.

Diesel generator start times were obtained from completed surveillance test data sheets or chart recordings and are tabulated in Attachment 4. The data from the earlier surveillances indicates some inconsistency in the obtaining and recording of start times, but the times were determined to be within TS limits. The surveillance procedures were later revised as a result of an extensive review of all surveillance procedures. As can be seen in Attachment 4 the revisions resulted in a marked improvement in the obtaining and recording of times. Procedure 06-OP-1P75-V-0011, "Diesel Generator Start Log" was also written and issued to ensure that the data required by Regulatory Guide 1.108 is obtained and documented properly.

A tabulation of the tests run to date indicates that 233 attempts were made to start the diesels, 103 valid tests have been run, and there have been 3 valid failures; two on the Division III D/G and one on the Division I D/G.

Because of the three valid failure criteria in Regulatory Guide 1.108, tests are currently being conducted every 7 days. Since the receipt of the operating license the Division I D/G has been run for 558 hours, Division II for 108 hours and Division III for 75 hours. Start attempts and total run times are included in Attachment 5.

During the testing performed since the OL was issued, failures of D/G components have occurred. A summary of the significant failures and actions taken to correct them is provided below.

5.1 Division II D/G Failed Capscrews (LER 82-080, PRD-82/14)

During the performance of a 24 hour run test on March 15, 1982, the Division II D/G tripped on a "Generator Differential" which was accompanied by an observed electrical arcing flash inside the generator. In a subsequent inspection of the generator it was found that the stator insulation had been damaged and that a 15/16 inch bolt head from a 5/8 UNC X 1-3/4 inch long bolt was imbedded in the stator. The degraded stator insulation resulted in a phase-to-phase short in the stator that damaged the generator. It was determined that the bolt head was from a bolt on the diesel's rear crankcase cover that had sheared off and entered the generator through the air gap on the end of the generator.

5.1 (Continued)

The generator was replaced with a generator from Unit 2 and all rear crankcase cover bolts on the Unit 1, Division I and II diesels, were replaced with new replacement bolts. An independent lab performed an analysis of the 42 bolts removed from the Unit 1, Division I and II diesel generators (Reference 4).

A review of the analysis produced the conclusion that the failure mode was due to a low-stress fatigue front expanding from an initial small crack. The initial crack appeared to have been initiated by overtorquing or undertorquing the capscrews. It was also noted that the failed capscrews had a decarburized skin which may have contributed to the failure.

A maintenance work order (MWO) was initiated on October 4, 1982 to check the rear crankcase cover capscrews for the correct tightness (60 ft-lbs). Three of the capscrews on the Division II diesel generator were found to be less than 60 ft-lbs (20, 23, and 35 ft-lbs). The work order instructed that any capscrew not within ± 2 ft-lbs of the 60 ft-lbs be torqued to within the acceptable range. When the capscrew that was found at 20 ft-lbs was tightened, it sheared off approximately one inch from the bottom side of the head before reaching 60 ft-lbs. The capscrews on the Division II D/G were removed and replaced with new replacement capscrews and torqued to 60 ft-lbs. A check of the torque on the Division I D/G capscrews revealed no problems.

The Division II D/G was instrumented by Nutech and data was obtained during an operational test run. The test run was performed with the original capscrews installed. New capscrews of a higher strength material (SA-540, B24 SY=150,000) and lock tab washers were installed. The test data indicated that the highest vibration amplitude occurred during the startup and shutdown of the diesel (450 RPM) with capscrew stresses at 6000 PSI. The vibration amplitude was much less during steady state operation at 450 RPM with the capscrew stresses at 3000 PSI. However, the test results were inconclusive as to the root causes of the vibration source. As further corrective action, protective screens were installed to prevent entry of foreign objects in the generator air gap.

The present information indicates that the capscrews failed by a combination of metallurgical and transient vibration factors and that the failures are unique to the Division II D/G. The protective measures taken on both Division I and II, i.e., increased bolt strength, installation of capscrew lock tab washers, protective screens and increased surveillance, should prevent similar generator failures.

5.2 Load Shed & Sequence Panels (MNCR 658-83)

During performance of the 18 month surveillance testing of the diesel generators, it was discovered that the Division I and II Load Shed and Sequence System (LSSS) Panels, 1H22-P331 and P332, manufactured by VITRO Laboratories, did not always respond as designed to a LOCA signal while the panels were in the Auto Test Mode.

The LSSS Auto Test Mode, which is on-line for normal system operation, inputs high frequency signals and decodes output signals to determine if the panel logic is capable of functioning. The deficiency involves a situation where the high frequency auto test signal does not get blocked upon receipt of the LOCA signal, and the LSSS panel responds to the accident at a speed determined by the high frequency clock. Thus the shed and sequence output relays do not have time to energize and the Division I and II ECCS pumps would not auto start as designed and other loads would not shed or sequence at the right time. This incorrect operation only occurs when the LOCA signal is input to the system coincident and synchronous with the test pulse and does not occur on the receipt of a loss of power signal or when the Auto Test Mode is off.

A design modification (DCP-83/0348) was provided and installed by VITRO as a field change to the Unit 1 LSSS panels. Retests of the panels were satisfactory.

MP&L determined this condition to be reportable under the provisions of 10 CFR 21 and notified the NRC via AECM-83/0609, dated September 21, 1983.

5.3 Auto Voltage Regulator Failure (LER 83-140)

As part of a 18 month LOCA/LOP Division I Diesel Generator test on September 2, 1983, a loss of power to the Division I ESF bus was manually initiated. The D/G auto-started and loaded onto the bus, but did not regulate the bus voltage during the load-shedding sequence. The voltage dipped below 70% at least twice, resulting in three auto-starts of the LPCS pump and two auto-starts of the RHR "A" pump. The D/G was loaded to 3000 kw (43% load) and run for 3 hours. A successful 24 hour test run had been completed just prior to the LOCA/LOP test.

The initial investigation found a SCR burned out in the auto-voltage regulator circuit. The spare SCR bank in the D/G control panel was used to replace the failed SCR bank. The D/G was loaded to 3500 kw (50% load) for 8 hours and 20 minutes. The D/G was manually shutdown when a fuel oil fire started during the troubleshooting.

5.3 (Continued)

Subsequent to the fire, the regulator was removed and subjected to a thorough testing and troubleshooting procedure. A SCR, two integrated circuit chips, a potentiometer, and a remote gate firing module were found to have failed. The regulator was cleaned and the defective parts were replaced.

The LOCA/LOP test was reperformed successfully on September 21, 1983. No similar problems with the voltage regulator have occurred to date. The component which failed first and its failure mechanism is unknown.

5.4 Automatic Voltage Regulator Failure (MNCR 670-83)

The non-conformance described in MNCR 670-83 involves the paralleling transformer (T4) in a replacement automatic voltage regulator. When the automatic voltage regulator was installed and tested it was discovered that the transformer was apparently wound backwards. This caused a trip of the Division I D/G when an attempt was made to parallel the D/G to ESF bus 15AA. The transformer only affects paralleling operations and would not have prevented operation of the diesel as designed during a LOCA or loss of power.

The transformer leads P1 and P2 on the automatic voltage regulator were reversed and relabeled. The D/G was then retested satisfactorily.

5.5 High Pressure Fuel Injection Line Failure (LER 83-114)

A potential deficiency identified by TDI involves a possible draw seam on the inside of high pressure fuel injection lines supplied on the Division I and II D/Gs. Two tubing failures at Shoreham occurred and were attributed to the draw seam which acted as a stress riser and failed when subjected to approximately 1,000,000 operating cycles.

On August 2, 1983, a high pressure fuel injection line on the GGNS, Unit 1 Division I D/G similarly failed. An analysis of the failed tubing attributed the failure to a tubing manufacturing flaw (Reference 3).

A Transamerica DeLaval letter dated July 20, 1983 indicated that the failures occur at approximately 1,000,000 operating cycles and that fuel lines that have in excess of 10,000,000 operating cycles without failure are satisfactory. All the original lines on the Division I and II diesels were considered free of internal flaws of this type. One line on the Division I diesel and one line on the Division II diesel were not original lines and were considered suspect. Replacement lines were ordered and installed in place of the two suspect lines.

5.6 Broken Fuel Oil Line and Failure of Deluge Valve (LER 83-126)

On September 4, 1983, at 0610 hours, the Division I D/G was started for maintenance operation. The engine was manually stopped at 1436 hours and the outside fresh air fans were secured when a fire was reported at the engine. Approximately 8 personnel were inside the room when the fire occurred. The room was evacuated and the fire brigade was assembled. The fire brigade responded to the scene with water hoses and other necessary equipment. It was noted that the automatic fire water deluge valve had not opened. The manual release was pulled to no avail. A mechanic was able to open the valve by removing the actuator enclosure box cover and striking the top of the weight. The fire was reported to be extinguished at 1501 hours. An unusual event was declared and remained in effect from 1447 hours until 1559 hours.

5.6.1 Low Pressure Fuel Oil Line Failed

The cause of the fire was ignited fuel oil in the vicinity of the left bank turbocharger. An investigation revealed that the main fuel supply tubing which delivers fuel oil from the engine driven Fuel Oil Booster Pump to the left and right bank fuel headers had separated at a swagelock fitting at a tee connection. The part is DeLaval number CE-010-055. The failure would have rendered the engine inoperable due to a loss of fuel pressure even if the fire had not occurred. MP&L has received a metallurgical failure analysis report (Reference 1) on the fuel tube which concluded that the crack initiation, propagation and ultimate failure were due to high cycle (fretting) fatigue. This was postulated to be caused from excessive turbocharger vibration. MP&L is evaluating and coordinating with DeLaval on the installation of a tubing support which will limit the chances for reoccurrence of this type of failure.

Representatives from Middle South Services and Plant Staff performed a thorough examination of the area affected by the fire to delineate the fire affected areas. The examination revealed the three fire affected areas were:

1) Under the left bank turbocharger,

2) The top of the lube oil tank under the left bank turbocharger,

3) Under the lube oil cooler, approximately in the middle of the cooler.

5.6.1 (Continued)

The metal parts of the engine and pressure vessels exposed to the highest heat were visually examined. No areas of discolored metal, indicating excessive heat, were found. Based on this finding, it was determined that the pressure vessels and engine parts exposed to the highest heat were acceptable for further service. The engine and skid-mounted equipment located in the fire areas received varying amounts of damage, depending on the amount of exposure to heat, smoke, and water. The wiring, instruments and tubing located on the front of the engine also experienced heat, smoke and water damage, in varying amounts.

Components which were located in the fire area were replaced, since the ability to carry out their design function was in question. Other components which may have been subjected to heat or water damage were inspected and either replaced or reworked, depending on the "as found" condition. Any item whose condition could not be accurately evaluated was replaced. The following is a partial list of equipment replaced due to fire damage: Intercooler, tubrochargers, conduit, wiring, instrument tubing, supports and instruments on the front of the engine, governor, lighting, high pressure fuel lines, fuel injector pumps, starting air intake manifold elbow, and numerous miscellaneous small components.

When rework or replacement of the affected items was completed, the diesel generator was subjected to a maintenance run to verify all components were functioning normally. This type of engine operation allowed monitoring of engine operating parameters at different power levels, and uncovered items which warranted further attention. During the maintenance run, the engine was instrumented for vibratory analysis. The preliminary results of the vibratory analysis revealed that the engine exhibited vibrations which were well within the acceptable limits for this type of machinery. No additional vibration related failures are anticipated.

After the successful completion of the maintenance run, the unit was turned over to Operations for operational retesting. Following the operational retesting, the unit successfully completed a seven day reliability run. It may be concluded from the testing performed, subsequent to the engine rework, that the unit has been returned to a satisfactory operating condition.

5.6.2 Fire Water Deluge Valve Failure

The failed fire water deluge valve was a 6 inch Model C, serial number S10774, manufactured by Automatic Sprinkler Corporation of America. Although a trip signal was received from the local control panel, the valve failed to open. The valve and the release mechanism were tested and components were removed and examined. No significant abnormal conditions were noted. Some excessive friction was noted between the weight and weight guide rod, however, the valve operated properly.

The examination revealed the following:

1) Buckling was discovered in the weight guide rod, maximum deflection was 0.005 inches.
2) Evidence of scoring was found on the rod surface in two distinct locations.
3) The weight's upper guide collar had an inside diameter of 0.637 inches rather than the 0.640 inch minimum recommended by the manufacturer.
4) Scoring was noted on the enclosure box along the path the weight guide bushing traces during actuation.

Corrective actions taken were:

1) The guide rod was trued and sanded.
2) The weight's upper collar guide was reworked to an inside diameter of 0.640 inches + .005 inches.
3) The rod, latch hinge pin, and clapper hinge pins were lubricated.
   The enclosure box along the path of the weight guide bushings was also lubricated.

Although no conclusive cause for the failure of the deluge valve to operate was reached, it is believed that the weight dropped fully until it came into contact with the latch arm. For further corrective action, the surveillance procedure has been revised to visually verify that the clapper has lifted and locked open following the test under normal system pressure. An increase in testing frequency is under consideration.

5.7 Cracked Connecting Push Rod Weld (MNCR 742-83)

During performance of a MWO to check the air start valves on August 11, 1983, the connecting push rod on the #8 left bank cylinder of the Division I D/G was found to have separated into two pieces. The push rod is designed as a piece of 1¼ inch thick wall tubing with a hardened steel ball bearing welded onto each end. One end of the rod had broken at the tube/weld interface. This failure was discovered when the mechanic pulled the rod in order to reach the air start valve.

5.7 (Continued)

A metallurgical evaluation (Reference 2) determined that the basic cause of the failure was poor material selection. However, a review of the failure has shown that the D/G would have run satisfactorily with the rod broken. In fact, the fracture surfaces showed indications that the D/G had been run for some period of time while the push rod was broken. This could occur because a spring compression load on the push rod keeps it in place even when it is broken.

MP&L is working with DeLaval to determine the best way to correct the weld failure problem.

5.8 Cracked Jacket Water Welds (MNCR 709-83) and Turbocharger Mounting Bolt Failures (MNCR 713-83)

These two MNCRs documented the first problems that occurred, that indicated that the Division I D/G turbocharger was causing high vibration related problems. Other problems also occurred during this time period; broken stay-rods in the intercooler, cracked base metal on the intercooler, cracked welds on the turbocharger jacket water piping, and cracked metal on an air header flange. These problems were repaired as they occurred. The D/G is equipped with vibration sensors which are designed to trip the diesel if vibration exceeds preselected values. No trips or alarms had been reported however.

While no quantitative data (vibration measurements) were taken during this time period, several engineers and mechanics involved with the work on the D/G have stated that there is a discernable improvement in the vibration levels since the turbocharger was replaced. Vibration measurements were taken at several locations on the diesel and generator after a new turbocharger was installed. These measurements show reasonable vibration levels for a D/G of this size. A 7 day run of the D/G was also successfully completed following installation of the new turbocharger. A final report is in preparation by TEC on the vibration measurements taken.

To determine the cause of the turbocharger problems, it is being returned to the manufacturer for evaluation. This problem is considered closed pending the results of this evaluation.

5.9 Overspeed Trip on the Division III Diesel Generator (LER 82-033)

On August 14, 1982, at 1300 hours, the HPCS system initiated on a low water level signal while troubleshooting was underway on a reactor pressure vessel water level transmitter. The Division III diesel automatically initiated (as designed) with no complications. The diesel was then shutdown at 1310 hours on August 14.

5.9 (Continued)

On August 14, 1982 at 2030 hours the Division III D/G again started on a low reactor pressure vessel water level and tripped on overspeed. Division I, II, and III diesels were placed in the maintenance mode at 2120 hours to prevent inadvertent starts while level transmitters were revented and reference legs filled (during investigation of the incident). A maintenance work order was initiated to investigate the cause of the diesel start and failure.

On August 15, 1982, while troubleshooting, it was noticed that the governor oil appeared to be dirty. The oil was drained and refilled. On August 16, 1982, the Division III D/G was again started for troubleshooting and tripped again on overspeed. Upon investigation, the governor hydraulic oil system level was found to be low. Apparently during the fill on the previous day the system was not fully vented. Also on August 16, 1982, it was noticed that the D/G was intermittently giving false indications. The tachometer relay (P81-SY-K001) in panel 1H22-R118 was found faulty and replaced. The relay is a Dynalco Corporation Part No. RT 2450A. The governor oil system was properly vented on August 17, 1982. On August 18, 1982, at 0245 hours, surveillance test 06-OP-1P81-M-0002 was conducted and successfully completed.

5.10 <u>Air Start Valve Failures Division I (LER 83-082)</u>

On July 17, 1983, while performing a Division I D/G 24 hour test run, the starting air valve for the #8 right bank cylinder failed. The valve leaked, allowing exhaust air to enter the air start header, overheating the header. The diesel was secured and the air start valve was replaced. At the time, Division II and Division III diesels were operable.

On July 24, 1983, a similar event occurred, this time on the Division I #1 left bank cylinder starting air valve. The valve began leaking approximately six (6) hours into the test. The load on the diesel generator was reduced to approximately 5.7 megawatts. At this point the load could no longer be reduced due to loss of governor control. The generator output breaker was tripped which caused the diesel to trip on overspeed.

Although the exact root cause could not be determined, an inspection revealed the following:

1) The atmospheric vent lines on the starting air header were completely blocked by carbon particles. This would cause abnormal pressure to the valves.

2) The starting air distributors were contaminated with carbon particles.

3) The right bank starting air distributor was found to have some internal assemblies malfunctioning or broken. The left bank starting air distributor was contaminated but still functional.

5.10 (Continued)

4) The #1 right bank starting air valve was found corroded and frozen such that it would not open. It was discovered that the starting air supply line was blocked, which caused the valve to remain closed.

5) The #7 left bank starting air valve had begun to burn.

6) The filters which are just upstream from the starting air distributors, were found to have a significant buildup of carbon particles.

7) The #8 right bank starting air valve face and seating surfaces showed signs of pitting.

8) The #1 left bank starting air valve was observed to be slightly open and could not be seated. No signs of pitting were evident other than the actual burned area.

Corrective actions taken were:

1) The left bank vent line was cleaned and the right bank vent line was replaced.

2) Air start valves #1 left bank, #1 right bank, #3 left bank, #6 left bank, #7 left bank and #8 right bank were replaced.

3) The right bank starting air distributor was replaced.

4) All air distributor lines were cleaned and filters replaced.

5) A Preventive Maintenance program has been established to periodically check/replace the starting air distributor filters.

6.0 RELIABILITY ENHANCEMENTS

Extensive engineering studies have been performed in an effort to increase the reliability of the D/Gs. A comprehensive D/G reliability report was prepared by the Operational Analysis Section of Nuclear Plant Engineering which highlighted several problem areas and provided recommendations to enhance the operability of the D/Gs (References 8 & 9). These studies included a review of Grand Gulf System Operating Instructions and Maintenance Instructions, vendor recommendations, regulatory requirements, and Grand Gulf operating experience. A summary of diesel generator concerns raised by NRC I&E Bulletins, Circulars and Information Notices and INPO reports and the Grand Gulf resolution of these concerns is also provided in Attachment 6. This review resulted in two basic findings:

1) The Grand Gulf D/Gs are being operated and maintained in accordance with current industry practices and as close to the vendor recommendations as possible.

2) The reliability of the D/Gs can be improved.

Efforts to improve the reliability of the D/Gs, in addition to the current operation and maintenance programs, include both temporary and long-term augmented activities (References 5 and 6) such as:

1) Increasing surveillance testing run time from one (1) hour to four (4) hours. This increase in fully loaded run time will allow the engine and generator to reach a steady-state temperature condition.

2) A blowdown of the starting air systems on each D/G once per week. This will insure that all support components for the air-start systems are functioning properly.

3) Improved housekeeping requirements for the D/G rooms and equipment. This will lessen the accumulation of particulates in the air system since the air supply for the diesel air intake and starting air systems is taken from inside the room.

Also under consideration is the establishment of an inspection team, consisting of a maintenance engineer, an operator, and a mechanic, to perform a detailed inspection of the D/Gs at specified intervals. These inspections would spot potential trouble that could lead to future D/G failures, as well as existing damage to the engine or its components.

As part of the overall surveillance procedure review effort, the surveillance procedures for the D/Gs have been reviewed to ensure that regulatory requirements and commitments have been incorporated. In addition, reviews of various offsite and onsite documents for applicability to Grand Gulf are performed on a continuing basis.

6.0 (Continued)

Additionally, at the request of the Chairman of the Safety Review Committee (SRC), the Special Subcommittee for Review of Plant Operational Readiness has investigated diesel generator reliability. The Special Subcommittee made the following recommendations to the SRC Chairman on methods to improve long term D/G reliability (Reference 7).

1) Perform 7 day functional testing on the Division II D/G. This test has been successfully completed on the Division I D/G.

2) Develop a short- and long-term vibration monitoring program for the Division I and II D/G to identify any existing problems and to improve detection of component or primary equipment degradation before failures occur.

3) Establish a preventive maintenance program based on a comprehensive review of root causes of previous failures at GGNS and throughout the industry. In particular, the problems with DeLaval D/Gs at the Shoreham Nuclear Station should be reviewed and measures taken as necessary to assure that these problems are not present or are corrected at GGNS. In view of the cracking of crankshafts of the Shoreham diesel engines, a careful review of design differences and fabrication and operational histories of the Shoreham and GGNS engines should be made to determine whether similar flaws might be present in the GGNS engines. (A summary of this review has been provided in Section 7.0 of this report). For long-term assurance of the integrity of the GGNS crankshafts, consideration should be given to performing dye penetrant, ultrasonic, or other nondestructive inspections of the crankshafts at some time before the start of the second fuel cycle.

4) Develop a closer working relationship with DeLaval and consult with them with respect to modifications to prevent recurrence of equipment problems experienced at GGNS and throughout the industry. One of the areas that should receive special attention is a long term program for upgrading DeLaval supplied, engine-associated piping, tubing, fittings, and welding to a higher level of quality, in view of the safety importance of the D/Gs.

5) To reduce the possibility of personnel error, increased emphasis on pre-action planning sessions for the persons involved are recommended for planned operational and maintenance activities. The trend of personnel error should be closely monitored and additional training be provided as indicated by the trend and analysis of events.

Recently there have been several meetings and conversations between DeLaval and MP&L personnel to improve communication between the two organizations and resolve design and manufacturing related problems.

6.0 (Continued)

In the area of training, both DeLaval and EMD personnel have been on-site in the past to conduct training on maintenance and operation of the D/Gs. The Training Department is presently planning to conduct further classes early next year on operation and maintenance of the D/G and is negotiating with DeLaval and EMD as to scheduling of such classes.

The performance of the D/Gs has been closely monitored since receipt of the OL. Two comprehensive reports have been published by the Operational Analysis Section of Nuclear Plant Engineering (References 8 & 9). These reports summarize data on D/G failures to start, time-to-start, and significant system failure/malfunction events and provide recommendations to management staff for improving D/G reliability. Several of these recommendations have been or are in the process of being implemented.

7.0 INDUSTRY COMPARISON

A comparison of Grand Gulf diesel generator related Licensee Event Reports (LERs) to similar LERs generated by industry has been performed. Grand Gulf has generated 39 LERs related to diesel generator problems. These were compared to 1300 industry LERs generated from 1969 thru 1981. Information for comparison was extracted from a draft report prepared by MPR Associates for the Nuclear Safety Analysis Center (NSAC). This comparison categorized the LERs by the root cause of failure. These categories were 1) mechanical, 2) electrical, instrumentation and control, 3) people-related, and 4) miscellaneous failures.

Attachment 7 compares the percentage of failures in each category at Grand Gulf to the industry percentages. This comparison shows that the failure percentage in each category at Grand Gulf is similar to the industry percentages of failure.

A further breakdown of the people-related category has also been performed. The people-related failures were broken into four subcategories. These subcategories were 1) design deficient, 2) manufacturing/fabrication/ installation error, 3) procedure deficient, and 4) failure to follow procedures. Attachment 8 compares the percentage of failures in each subcategory at Grand Gulf to the industry percentages. Significant differences between Grand Gulf and industry were noted in the design deficient and manufacturing/fabrication/installation subcategories. An explanation for these differences cannot be made at this time. It should be noted that the LERs for Grand Gulf were generated prior to power ascension testing, while most of the industry data was from commercially operating plants. However, if the two subcategories are combined, the Grand Gulf percentage (45%) compares favorably to the industry percentage (42%).

A significant failure which has been evaluated for its impact on Grand Gulf is the Shoreham crankshaft failure. A summary of this evaluation was transmitted to the NRC via AECM-83/0653, dated October 14, 1983 (Attachment 9). The evaluation concluded that, pending the results of the analysis underway at Shoreham to determine the root cause of the crankshaft failure, there is reasonable assurance, due to design differences, that the Grand Gulf Division I and II D/G crankshafts will not fail in a mode similar to Shoreham.

8.0 Summary

The GGNS, Unit 1 diesel generators have experienced various problems during their preoperational and operational history. Several of these problems were described in Sections 4.0 and 5.0 of this report. These problems involved failures of capscrews, mounting bolts, welds, air start valves, automatic voltage regulators, fuel lines and a piston. In addition to these failures, various deficiencies were described. These reported deficiencies detailed potential problems with the link rod assemblies, turbocharger thrust bearing lubrication, air start valve capscrews, air start sensing lines, engine/generator drive couplings, relays, lube oil coolers, auxiliary motors, pneumatic logic and load shed and sequence panels.

Corrective action taken to resolve these failures and deficiencies is also provided in Sections 4.0 and 5.0. These actions demonstrated that MP&L has responsibly and appropriately corrected these problems.

In addition to correcting the above problems and deficiencies, MP&L has performed several studies in an effort to identify diesel generator problems occurring at other units that could affect Grand Gulf, to trend problems occurring at Grand Gulf, and to evaluate various operating and surveillance procedures, vendor recommendations and industry practices.

These studies are part of an effort to enhance plant reliability by evaluating potential problems and instituting corrective action to prevent them at Grand Gulf. Other measures being considered/implemented include increased surveillances on diesel generator components, institution of a vibration monitoring program, development of closer working ties with the diesel manufacturers, and increased emphasis on preplanning of operation and maintenance activities.

9.0 CONCLUSION

The Grand Gulf Division I, II, and III diesel generators have been designed in accordance with applicable regulations and industry standards. The manufacturing process was monitored to assure that the diesels were manufactured as designed. Extensive prototype testing was performed on the DeLaval and EMD diesel generators prior to the issuance of the Operating License. Problems and failures encountered with the diesel generators during the preoperational and operational phases of the plant have been identified and their resolution addressed. Surveillance testing and regular maintenance helps to ensure that the diesel generators are operable as needed. Continuous review of Grand Gulf and industry problems with diesel generators assures that potential problems are evaluated and possible trends are noted.

Therefore, adequate measures have been and will continue to be taken to ensure that the onsite diesel generators provide a reliable backup source of power to equipment required to operate following a loss or degradation of offsite power.

10.0 REFERENCES

The following references were used in the preparation of this report.

1) J. S. Brihmadesam, Nuclear Engineering Department, Middle South Services, Inc., New Orleans, LA, "Metallurgical Evaluation of Diesel Engine Fuel Oil Line Failure from Emergency Diesel Generator - Division I Grand Gulf Nuclear Station - Unit 1," October, 1983.

2) J. S. Brihmadesam, Nuclear Engineering Department, Middle South Services, Inc., New Orleans, LA, "Metallurgical Evaluation of Diesel Engine Push Rod Weld from Grand Gulf Nuclear Station - Unit 1, Emergency Diesel Generator (Division I)".

3) J. S. Brihmadesam, Nuclear Engineering Department, Middle South Services, Inc., New Orleans, LA, "Metallurgical Evaluation of Diesel Engine Fuel Injection Tube from Grand Gulf Nuclear Station - Unit 1, Emergency Diesel Generator".

4) Law Engineering Testing Co., LETCO Job Number G-8847, "Engineering Investigation of the Failure of Rear Crankcase Cover Capscrews for the DeLaval Standby Diesel Generators, Mississippi Power and Light Company".

5) IPC-83/6295, Memo from C.R. Hutchinson to A.S. McCurdy and F.H. Walsh, "Diesel Generator Reliability".

6) IPC-83/6562, Memo from F.H. Walsh to C.R. Hutchinson, "Status Report on Diesel Generator Reliability."

7) PMI-83/11532, "Special Subcommittee Report on GGNS Diesel Generator Reliability," September 15, 1983.

8) NPE-OAS Report No. 83-017, "GGNS D/G Systems Reliability," July 15, 1983.

9) NPE-OAS Report No. 82-017-1, "GGNS D/G Systems Reliability, Supplement No. 1," August 24, 1983.

Attachment 1

D/G DESIGN PARAMETERS[1]

DIESEL	DELAVAL	EMD
Model	DSRV-16-4	12-645E4
Horsepower	9770	4610 (Total for 2 diesels)
Bore	17"	9-1/16"
Stroke	21"	10"
Crankshaft Length	20'-7"	9'-6"
Crankshaft Diameter	13"	7.5"
Crankpin Diameter	13"	6.5"
No. of Cylinders	V-16	V-12
Compression Ratio	11.6:1	14.5:1
RPM	450	900
Number of Bearings	10 Main (Last 2 in one journal)	7
GENERATOR		
KVA	8750	4343
KW	7000	3474

NOTE 1: Source of Information - DeLaval and EMD Technical Manuals

Clarification of Requirements to Hydrostatically Test HPCS Diesel Generator Skid-Mounted and Standby Diesel Generator Auxiliary System [Fuel Oil,Cooling Water, Air Start, Lube Oil] Piping

A review of Supplement 4 to the Grand Gulf Nuclear Station Safety Evaluation Report (SSER4), dated May, 1983, by MP&L has indicated the need to clarify statements regarding hydrostatic testing of HPCS diesel generator skid-mounted and standby diesel generator auxiliary system piping. Section 9.6.3 of SSER4 states, in part, that:

> "ASME requires a hydrostatic test to 125% of the design pressure. The licensee stated the piping and components would be hydrostatically tested to the requirements of ANSI B31.1, which requires that piping be leak tested at operating pressure during engine operation. The staff finds this partially acceptable. In addition, the staff requires that all HPCS diesel engine skid and standby diesel engine auxiliary system piping be hydrostatically tested to a minimum of 125% of design pressure..."

ANSI B31.1 (1973) requires that, for hydrostatic tests, the minimum test pressure be 1.5 times the design pressure, provided the test pressure does not exceed the maximum test pressure of any component such as vessels, pumps, or valves in the system. Section 9.6.3 incorrectly states that ANSI B31.1 requires hydrostatic testing at operating pressures. ANSI B31.1 permits substitution of pneumatic tests for hydrostatic tests when piping systems are so designed and/or supported that they cannot be safely filled with water or when the piping systems, which are not readily dried, are to be used in services where traces of the testing medium cannot be tolerated. Such pneumatic tests are conducted at 1.25 times the design pressure.

In summary, piping designated as ASME Section III, Class 3 was either pneumatically tested or hydrostatically tested in accordance with the applicable codes. All Quality Group D piping that is required for the safe operation of the diesel generators has been hydrostatically tested, as previously committed by MP&L, and is in compliance with ANSI B31.1

Clarification of Design Standards for Engine - Mounted Components (Division I and II Diesel Generators)

A review of Supplement 4 to the Grand Gulf Nuclear Station Safety Evaluation Report (SSER4), dated May, 1983, by MP&L has indicated the need to clarify statements regarding the design standards applied to engine-mounted components on the Division I and II diesel generators. Section 9.6.3 of SSER4 states, in part, that:

> "...engine-mounted auxiliary systems and the fuel oil drip system piping and associated components...are designed, manufactured, and inspected in accordance with the guidelines and requirements of American National Standards Institute (ANSI) Standard B31.1...The design of the engine-mounted auxiliary system and fuel oil drip system piping and components to the cited design philosophy and standards is considered equivalent to a system designed to ASME Section III, Class 3, requirements with regard to system functional operability and inservice reliability."

MP&L agrees with the above stated SSER4 conclusion that the standards used in the design of engine-mounted, manufacturer supplied components, will assure overall system functional operability and inservice reliability commensurate with that which is inherent to ASME Section III, Class 3, requirements. Our conclusion is based on an assessment of the engine manufacturer's actual design practices, which were summarized in our letter of August 9, 1982 (AECM-82/459); however, these design practices do not specifically require the implementation of ANSI B31.1 in the design and fabrication of engine-mounted components.

The following summarizes our prior statements regarding standby diesel engine-mounted components. In our letter of August 26, 1981 (AECM-81/324), MP&L stated that on-engine hardware was designed to the diesel manufacturer's in-house standards, not necessarily national standards. Our letter of June 10, 1983 (AECM-82/262) clarified our response in AECM-81/324 and indicated that engine-mounted components conform to the guidelines of the Diesel Engine Manufacturer's Association (DEMA) standards, the requirements of IEEE 387-1977, "Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Station," and the guidelines of Regulatory Guide 1.9, "Selection, Design, and Qualification of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Plants."

To further define the criteria which were imposed on the design and fabrication of engine-mounted components and to verify the adequacy of these engineering controls, MP&L and Bechtel performed an informal audit of the standby diesel generator manufacturer, Transamerica DeLaval, Inc. The results of this audit were provided to the NRC in our letter of August 9, 1982 (AECM-82/459) and are reiterated below:

a. On-engine components were designed to manufacturer's standard procedures.

b. ASTM materials, which are acceptable by ANSI B31.1 guidelines, were used.

c. Welding was performed in accordance with ASME Section IX.

d. Engine-mounted components were conservatively designed in consideration of service pressure, temperature, flow, stress levels, etc.

e. The jacket cooling water manifold was hydrostatically tested at 1.5 times the design pressure, and remaining components, as appropriate, were tested at operating temperatures and pressures.

f. A QA program was imposed in accordance with Appendix B of 10 CFR 50.

g. The diesel generator, including engine-mounted components, was designed for and excited/analyzed at frequencies greater then 35 Hz.

In summary, based on the above audit results, MP&L has concluded that the design and fabrication of engine-mounted components provide reasonable assurance that these components will reliably perform their design safety function. MP&L will revise FSAR Table 3.2-1 to document the design criteria applicable to engine-mounted components.

Attachment 4

DIESEL GENERATOR START TIMES

SDG 11 (DeLaval - Division I)

Spec: Achieve 441 RPM in 10 seconds
Achieve 4160 ± 416 Volts and 60 ± 1.2 Hz in 13 seconds

Start Date	Time to RPM/RPM	Time to Ready to Load	Time to Volts/Hz
7-19-82	10 sec/460	Not Required	6 sec
8-8-82	10 sec/455	Not Required	10 sec
9-16-82	10 sec/450	Not Required	9.07 sec
10-2-82	10 sec/452	Not Required	9.0 sec
11-18-82	6.5 sec/452	12 sec	Not Required
1-9-83	5.4 sec/441	4.5 sec	Not Required
2-15-83	7.0 sec/460	5.7 sec	Not Required
3-9-83	7.1 sec/460	6.0 sec	Not Required
5-7-83	5.36 sec/450	6.26 sec	Not Required
6-7-83	6.1 sec/461	6.0 sec	Not Required

Amendment 7 to Technical Specifications

Spec: Achieve 441 RPM in 10 seconds
Achieve 4160 ± 416 Volts and 60 ± 1.2 Hz in 10 seconds

7-8-83	7.0 sec/450	6.0 sec	Not Required
9-16-83	9.07 sec/441	Not Required	9.07
9-22-83	5.56 sec/441	Not Required	5.3/5.8
9-23-83	5.4 sec/441	Not Required	4.6/5.5
10-4-83	5.95 sec/441	Not Required	5.0/8.0

SDG 12 (DeLaval - Division II)

Spec: Achieve 441 RPM in 10 seconds
Achieve 4160 ± 416 Volts and 60 ± 1.2 Hz in 13 seconds

Start Date	Time to RPM/RPM	Time to Ready to Load	Time to Volts/Hz
6-22-82	10 sec/451	Not Required	6.0 sec
7-23-82	10 sec/460	Not Required	3.9 sec
8-24-82	10 sec/450	Not Required	6.0 sec
8-28-82	6.5 sec/448	3.0 sec	Not Required
10-10-82	6.0 sec/450	6.0 sec	Not Required
12-4-82	6.7 sec/450	5.5 sec	Not Required
12-28-82	8.0 sec/*	5.7 sec	Not Required
1-30-82	5.7 sec/450	5.8 sec	Not Required
3-27-83	5.4 sec/450	3.3 sec	Not Required
5-4-83	7.1 sec/450**	7.4 sec	Not Required
5-31-83	7.6 sec/445	7.8 sec	Not Required

Amendment 7 to Technical Specifications

Spec: Achieve 441 RPM in 10 seconds
Achieve 4160 ± 416 Volts and 60 ± 1.2 Hz in 10 seconds

7-3-83	7.23 sec/441	7.28 sec	Not Required
8-5-83	6.0 sec/441	Not Required	5.5/5.5
8-11-83	6.0 sec/441	Not Required	5.8/6/7
8-18-83	6.6 sec/441	Not Required	5.8.5.6
8-25-83	6.8 sec/441	Not Required	5.6/6.1
9-9-83	6.8 sec/441	Not Required	5.5/5.75
9-23-83	5.9 sec/441	Not Required	5.4/8.6
10-3-83	6.2 sec/441	Not Required	5.5/8.7

* RPM was not logged, however time to reach required RPM was derived from strip chart and logged on data sheet at the time of the test.

** This data was obtained from chart recording of the test.

SDG 13 (EMD - Division III)

Spec: Achieve 882 RPM in 10 seconds
Achieve 4160 ± 416 Volts and 60 ± 1.2 Hz in 13 seconds

Start Date	Time to RPM/RPM	Time to Volts/Hz
6-10-82	9.0 sec/890	9.0 sec
8-18-82	10 sec/882	9.6 sec
9-16-82	13.5 sec/900*	10 sec
10-19-82	8.4 sec/900	10 sec Volts, 8.6 sec Hz
12-24-82	9.0 sec/882	12.5 sec
12-23-82	10.0 sec/890**	12.5 sec
2-27-83	7.6 sec/882	9.7 sec
3-27-83	7.8 sec/882	7.8 sec
3-21-83	8.0 sec/882	10.4 sec***
6-18-83	7.6 sec/882	9.7 sec
6-20-83	8.2 sec/882	8.1/8.2

Amendment 7 to Technical Specifications

Spec: Achieve 882 RPM in 10 seconds
Achieve 4160 ± 416 Volts and 60 ± 1.2 Hz in 10 seconds

7-18-83	8.0 sec/882	9.0/8.5
7-27-83	9.5 sec/882	8.7/7.0
7-30-83	7.7 sec/882	8.2/7.7
8-2-83	7.8 sec/882	8.2/7.8
8-11-83	9.0 sec/882	9.0/9.0
8-26-83	7.3 sec/882	7.6/7.3
9-9-83	7.5 sec/882	8.0/7.5

SDG 13 (EMD - Division III) (Continued)

Spec: Achieve 882 RPM in 10 seconds
Achieve 4160 ± 416 Volts and 60 ± 1.2 Hz in 10 seconds

Start Date	Time to RPM/RPM	Time to Volts/Hz
9-23-83	8.5 sec/882	8.5/8.2
10-4-83	8.0 sec/882	8.0/7.6
10-10-83	8.0 sec/882	8.1/7.8

* Time of 13.5 seconds to reach RPM was due to a sticky tachometer. Time of 10 seconds to reach required frequency verifies that requirement for RPM was met.

** RPM of 890 was obtained at 10 seconds thus verifying that required RPM was obtained in 10 seconds.

*** The recorded time of 10.4 seconds meets the previous TS limit of 13 seconds. However, it would not have met the present TS limit of 10 seconds (Amendment 7 to TS).

GGNS D/G OPERATING DATA[1] (As of 10/11/83)

	Division I	Division II	Division III
Shop and Pre-Oper. Run Time (Hrs)	535	252	298
Since Date of OL Run Time (Hrs)	558	108	75
Total Run Time (Hrs)	1093	360	373
Total No. of Starts			
DeLaval/EMD Shop Runs	310[2]	5	30
Pre-Operational Runs	60	60	80
Since Date of OL Runs	112	60	61
Total Starts	482	125	171

NOTES:

1. Source of Information - DeLaval and EMD Technical Manuals
2. Division I engine had 300 prototype runs for reliability testing.
3. Per R. G. 1.108 (As of 10/17/83):

   No. of valid tests: 103

   No. of valid failures: 3

Implementation of NRC I&E Bulletins, Circulars and Information Notices and INPO Reports Related to Diesel Generator Problems

IEB 74-16, "Improper Machining of Pistons in Colt Industries (Fairbanks - Morse) Diesel Generators"

Action

Determined not applicable, however TDI was requested to take precautions to prevent similar problems.

IEB 79-23, "Potential Failure of Emergency Diesel Generator Field Exciter Transformers"

Concern

Design error in wiring a transformer primary neutral on EMD D/G. Corrective action was to allow transformer primary neutral to float.

Action

Investigation revealed that the HPCS D/G was designed and supplied with a floating primary neutral, therefore, this problem is not considered applicable to Grand Gulf.

IEB 83-03, "Check Valve Failures in Raw Water Cooling Systems of Diesel Generators"

Concern

Numerous check valve failures in D/G raw water cooling systems.

Action

GGNS D/G cooling water systems were reviewed. IEB 83-03 was determined to be applicable to three SSW check valves. These valves were included in the ISI program for inspection at the first refueling outage and every five years thereafter. A report is to be made to NRC after the first inspection.

IEC 77-15, "Degradation of Fuel Oil Flow to the Emergency Diesel Generators"

Concern

Fuel oil flow from the storage tank to the day tank could be less than the flow needed to support full load fuel consumption by the D/G.

Action

Procedure 09-S-09-5 provides for chemical addition (Biocide) to the fuel oil storage tanks. The Technical Specifications require sampling every three months, water drained from the day tanks every 31 days or when the D/G is run greater than 1 hour, and that the storage tanks be cleaned every 10 years.

IEC 77-16, "Emergency Diesel Generator Electrical Trip Lockout Features"

Concern

A field voltage trip interlock with the D/G output breaker was not bypassed during an emergency start of the D/G due to a design error.

Action

A review of preoperational and 18 month surveillance tests determined that all trip functions designed to be bypassed during emergency starts are in fact bypassed.

IEC 79-12, "Potential Diesel Generator Turbocharger Problem"

Concern

On fast repeat starts of EMD diesels, the engine may reach actual operating speed before required oil pressure is established at the turbocharger thrust bearing. This may cause some smearing of the bearing metal so that the cumulative damage from several similar starts would result in a turbocharger failure.

Action

IEC 79-12 was determined to be applicable to the Division III D/G. The recommendations of the vendor and IEC 79-12 were incorporated into the Division III D/G operating procedures. In addition, the existing turbocharger will be replaced by a heavy duty turbocharger prior to startup after the first refueling outage.

IEC 80-05, "Emergency Diesel Generator Lubricating Oil Addition and Onsite Supply"

Concern

IEC 80-05 concerns an incident in which lube oil was pumped into the D/G air box through a mismarked drain connection. An additional concern was the minimum amount of lube oil to be kept on site.

Action

Lube oil addition points were identified for all three D/Gs. Oil consumption of the D/Gs was calculated and a 7 day supply is onsite for the HPCS D/G. The Division I and II D/Gs have sufficient reserve capacity for 7 days.

IEC 80-11, "Emergency Diesel Generator Lube Oil Cooler Failure"

Concern

Lube oil cooler failures caused by severe corrosion of solder that sealed tubes to tube sheets. These failures were attributed to incompatible corrosion inhibitor in the coolant.

Action

IEC 80-11 was evaluated and determined to be applicable to the Division III EMD D/G. The soldered tube ends in the lube oil coolers were inspected and found acceptable. The sampling procedure was revised to provide for monthly sampling of the D/G coolant and corrosion inhibitors were added per the manufacturer's recommendations.

IEC 80-23, "Potential Defects in Beloit Power Systems Emergency Generators"

Concern

Loss of field due to frayed insulation on leads between collector rings and field coils.

Action

IEC 80-23 was evaluated and determined to be not applicable to GGNS. The deficiency was only applicable to generators built by Beloit Power Systems. GGNS uses Protec Inc. generators.

IEN 83-17, "Emergency D/G Control Logic"

Concern

D/G did not respond to Auto Start Signal upon testing its shutdown relay.

Action

Evaluation in progress.

IEN 83-51, "Diesel Generator Events"

Concern

Cracked cylinder heads have been observed at the Shoreham Nuclear Station, as well as other facilities which use diesel generators manufactured by Transamerica DeLaval, Inc.

Action

This problem has not been observed at Grand Gulf. A chemical analysis sampling program is in effect for the jacket water (weekly) and lube oil system which would indicate cracks if they should occur.

IEN 83-58, "Transamerica DeLaval Diesel Generator Crankshaft Failure"

Concern

Crankshaft failures in DSR-48 D/G at Shoreham.

Action

An evaluation is in progress, however, it has been preliminarily determined to be unique to Shoreham due to crankpin size and differences in crankshaft design.

SOER 80-1, "Loss of Redundant Emergency Diesel Generator Starting Air System"

Concern

Using an approved surveillance procedure, a failure of one starting air system could go undetected until both systems failed to start the diesel.

Action

Review of SOER 80-1 determined that the HPCS air start system was similar to that described. The monthly surveillance for the HPCS D/G was revised to test the air start systems independently and simultaneously on an alternating basis as per the recommendations in SOER 80-1.

SOER 83-6, "Unavailability of Emergency Power Caused by Diesel and Breaker Control Circuitry Design"

Concern

Design oversight in diesel generator starting circuitry and in breaker control circuitry preventing D/G restart and restoration of de-energized bus.

Action

SOER 83-6 and the control circuitry for the D/G start circuit and breaker control circuits were reviewed. It was determined that the concerns described in SOER 83-6 do not exist at GGNS.

SER 13-80, "Diesel Generator Failure to Accept Full Load"

Concern

A D/G failed to accept full load during a test due to undersized exciter leads to the exciter field.

Action

Inspection and calculations by MP&L determined that exciter leads on the three Unit 1 D/Gs are adequately sized for full load.

SER 45-80, "Potential Diesel Generator Overload Conditions"

Concern

Non-safeguard loads on ESF busses not included in degraded bus and/or accident load calculations may create overload conditions.

Action

Review of GGNS D/G systems determined that the concerns described in SER 45-80 are precluded by the GGNS D/G system design.

SER 2-81, "RHR/Diesel Generator Cooling Pump Room Flooding"

Concern

Leakage exceeded the capacity of the D/G cooling water pump room sump thus flooding the room.

Action

A review of the D/G cooling system design determined that the concern of SER 2-81 was not applicable to GGNS.

SER 16-81, "Failure of D/G Speed Control Coupling"

Concern

Defective coupling in EMD D/G due to exposure of elastomer spider to an oil vapor environment.

Action

Review of EMD D/G design at GGNS determined that SER 16-81 was not applicable to the HPCS D/G.

SER 36-81, "D/G Fire Hazard"

Concern

D/G oil fire due to oil carryover into the D/G exhaust caused by running the D/G at no-load conditions.

Action

A review of D/G procedures has determined that adequate precautions and instructions to preclude the concern described in SER 35-81 are in place. These procedures require loading of the diesels within a specified time period.

SER 55-81, "Fire in Diesel Generator Room"

Concern

A fire occurred in the D/G room when a lube oil pressure indicator failed and the lube oil ignited on contact with the turbocharger. The fire suppression system was out of service, however, the required fire watch and equipment was available and the fire was extinguished in eight minutes.

Action

Included SER 55-81 as required reading for operations and maintenance personnel to alert personnel to potential failure modes of peripheral equipment.

SER 67-82, "D/G Bearing Failure due to Inadequate Prelubrication"

Concern

Bearing failure on a Fairbanks-Morse D/G due to inadequate prelubrication.

Action

Review of the D/G systems determined that continuous prelube is used on Division I and II D/Gs. Specifications and instructions are in place for the Division III D/G to ensure adequate prelube for manual starts only. Prelubing is required once a week when the Division III D/G has not been run.

SER 70-82, "Diesel Generator Fire from Leaking Lube Oil"

Concern

Fire caused by lube oil spraying from the lube oil filter O-Ring on to the exhaust manifold.

Action

SER 70-82 was routed to operations, maintenance and training for information to alert personnel to potential failure modes of peripheral equipment.

SER 78-82, "Loss of All D/Gs"

Concern

One D/G was out of service when the other D/G started on a loss of power and subsequently tripped on loss of excitation. The D/G trip occurred due to an design error in a previous modification.

Action

SER 78-82 was routed to the appropriate design and maintenance organization for information to alert personnel to potential failure modes of peripheral equipment.

SER 21-83, "Inoperable D/G due to Inadvertent Fire Actuation Signal"

Concern

A fuel oil transfer pump tripped on an inadvertent fire signal causing a clean fuel oil tank to overflow. The fuel oil was secured to the diesel to stop the overflow thus rendering the D/G inoperable.

Action

Review of the GGNS D/G systems determined that SER 21-83 was not applicable to GGNS.

SER 25-83, "D/G Restart Malfunction"

Concern

Design review of a D/G control circuit disclosed that under certain conditions a restart of the D/G would fail.

Action

Evaluation in progress.

SER 48-83, "Emergency D/G Room Ventilation"

Concern

D/G heat load was greater than that originally specified by vendor and caused the ventilation system capacity to be exceeded.

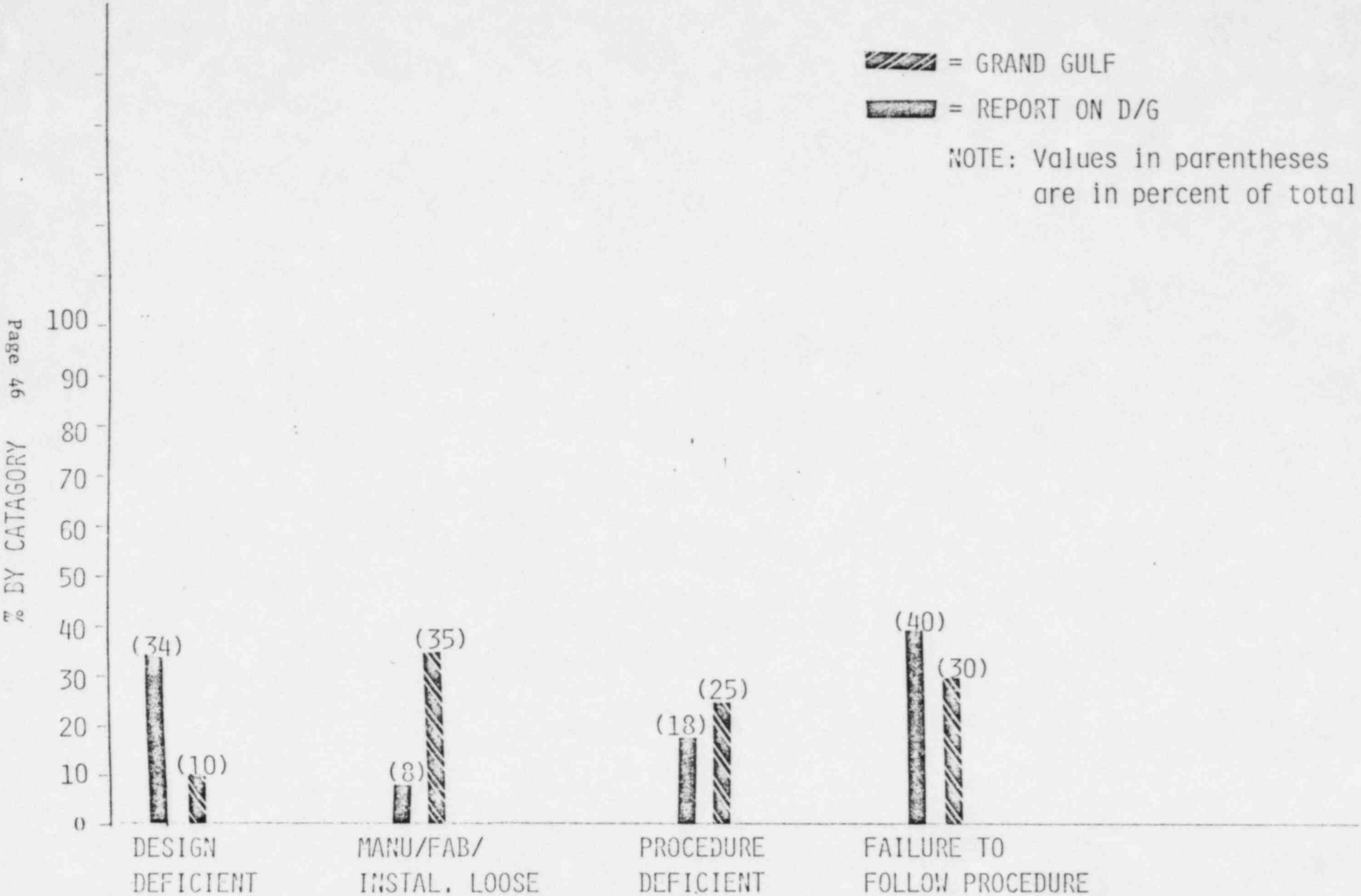
Action

Evaluation in progress.

A review of the documents listed below has determined that the concerns were either not applicable to GGNS or were addressed in one or more of the above documents.

IEN 79-23	SER 55-80
IEN 82-08	SER 57-80
SOER 80-4	SER 8-81
SOER 83-1	SER 80-81
SER 1-80	SER 102-81
SER 71-80	

DIESEL GENERATOR LERs SORTED INTO ROOT CAUSE CATAGORIES



DIESEL GENERATOR LERs IN THE PEOPLE RELATED CATAGORY

MISSISSIPPI POWER & LIGHT COMPANY
Helping Build Mississippi
P. O. BOX 1640, JACKSON, MISSISSIPPI 39205

Attachment 9

October 19, 1983

NUCLEAR PRODUCTION DEPARTMENT

U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D. C. 20555

Attention: Mr. Harold R. Denton, Director

Dear Mr. Denton:

SUBJECT: Grand Gulf Nuclear Station
Units 1 and 2
Docket Nos. 50-416 and 50-417
License No. NPF-13
File: 0260/L-860.0
Applicability of Shoreham Diesel/
Generator Crankshaft Failure to
GGNS
AECM-83/0653

IE Information Notice No. 83-58, "Transamerica Delaval Diesel Generator Crankshaft Failure," dated August 30, 1983, addressed the recent failure of a diesel engine crankshaft at Shoreham Nuclear Station. The attached report is provided by Mississippi Power & Light (MP&L), as informally requested by the NRC, to compare the Shoreham and Grand Gulf Nuclear Station (GGNS) designs, to discuss the applicability of that failure to GGNS, and to substantiate MP&L's conclusion that continued operation of the GGNS standby diesel generators is justified.

While the attached report identifies certain similarities between the Shoreham and GGNS crankshaft design and manufacture, there exists significant differences in some critical parameters. The GGNS design exhibits lower crankshaft torsional stresses, greater overlap between the crankpin and crankshaft cross-sections, a circular crankarm, and a counterweighted crankshaft. Overall, MP&L considers that these differences contribute to a smoother running engine with a more favorable level and distribution of crankshaft component stresses, in comparison to the Shoreham design.

The attached report and conclusions presented here are based on MP&L's evaluation of the GGNS diesel engine design, information provided by Transamerica Delaval, Inc., and discussions with Long Island Lighting Company. Overall, MP&L concludes that there exists reasonable assurance that a failure will not occur at GGNS similar to that which occurred at Shoreham Nuclear Station. MP&L will continue to closely monitor the evaluations of the Shoreham crankshaft failure and will apply that information to the justification presented here for continued operation of the GGNS diesel generators and to

Attachment 9 (Cont'd)

the development of an inspection program, as appropriate. MP&L will keep the NRC advised of any development that alters the position presented here.

Yours truly,

L. F. Dale
Manager of Nuclear Services

JHS/JGC:rg

Attachments

cc: Mr. J. B. Richard (w/a)
Mr. R. B. McGehee (w/o)
Mr. T. B. Conner (w/o)
Mr. G. B. Taylor (w/o)

Mr. Richard C. DeYoung, Director (w/a)
Office of Inspection & Enforcement
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Mr. J. P. O'Reilly, Regional Administrator (w/a)
U.S. Nuclear Regulatory Commission
Region II
101 Marietta St., N.W., Suite 2900
Atlanta, Georgia 30303

APPLICABILITY OF SHOREHAM DELAVAL
DIESEL/GENERATOR CRANKSHAFT FAILURE TO GGNS

IE Information Notice No. 83-58, "Transamerica Delaval Diesel Generator Crankshaft Failure" concerns the failure of a Transamerica Delaval Inc. DSR-48 diesel/generator (D/G) installed at the Shoreham Nuclear Station. The diesel failed during post modification testing when its crankshaft assembly fractured at the crankpin and crankarm on the generator side of the cylinder No. 7 crankthrow. The fracture occurred in a transverse plane across the crankarm as reported by Transamerica Delaval, Inc. (see attached figure). Subsequent to the failure, the crankshafts of the two other Shoreham diesel generators were examined. Cracks were also discovered in the crankshafts of these two diesels in the same general location.

The DSR-48 diesel utilized at Shoreham is an eight cylinder in-line engine with a bore of 17 inches and stroke of 21 inches. The engine is rated at 4889 horsepower and 3500 kw at 450 rpm. The crankshaft is an eight throw crankshaft approximately 20' long with a crankpin diameter of 11 inches and a main journal diameter of 13 inches. Present information indicates that the crankshaft was not counterweighted.

The DSRV-16-4 diesel utilized at Grand Gulf Nuclear Station is a 16 cylinder V-type engine with a bore of 17 inches and a stroke of 21 inches. The engine is rated at 9770 horsepower and 7000 kw at 450 rpm. The crankshaft is an eight throw crankshaft approximately 20'7" long with a crankpin diameter of 13 inches and main journal diameter of 13 inches. Four (4) counterweights are used on crankthrows 3, 4, 5 and 6.

DESIGN DIFFERENCES

Review of the present information for the DSR-48 diesel at Shoreham and the DSRV-16-4 diesel at GGNS indicates that several similarities and several major differences exist between the two types of diesel engines. These differences are as follows:

1. The DSR-48 is an eight cylinder in-line engine and the DSRV-16-4 is a sixteen cylinder V-engine. Each crankthrow on an eight cylinder engine has force from the power stroke applied to it every two revolutions of the crankshaft while a crankthrow on a sixteen cylinder has force from the power stroke applied every revolution of the crankshaft. This results in a more evenly applied force to the crankshaft and a potentially smoother running engine.

2. Crankshaft torsional stresses at synchronous speed (450 rpm) are 2500 PSI for the Shoreham DSR-48 and 1800 PSI for the GGNS DSRV-16-4. The torsional stresses are therefore approximately 28% less for the GGNS diesel engine crankshaft at operating speed as reported by Delaval, Inc.

3. The GGNS DSRV-16-4 has a 13 inch crankpin diameter versus a 11 inch diameter crankpin on the Shoreham DSR-48 crankshaft. In the Grand Gulf design the larger crankpin diameter provides a greater overlap between the crankpin and shaft cross-sections at the crankarm.

The shape of the GGNS crankarm is also circular, rather than elliptical, giving added crankarm cross-sectional area at the most probable fracture plane (see attached figure.)

4. The GGNS DSRV-16-4 utilizes four (4) counterweights on crankthrows 3, 4, 5 and 6 while the Shoreham DSR-48 uses none. Though specific vibrational data is not available for the Shoreham engine, this should result in less vibration in the DSRV-16-4 and a smoother running engine.

Due to the differences listed above, the manner of distribution and transmission of stresses on the DSRV-16-4 crankshaft is substantially different from the DSR-48. In addition, in a letter from Delaval to GGNS, Delaval has indicated that the Shoreham engine crankshafts were unique to those engines in that they were the only crankshafts having 11 inch diameter crankpins and 13 inch diameter journal supplied in DSR-48 in-line engines rated at 225 lb/in^2 BMEP (Brake Mean Effective Pressure).

DESIGN SIMILARITIES

As indicated in the earlier discussion, the GGNS and Shoreham diesel engine crankshafts are similar in several parameters, including the following:

1. Bore and stroke
2. Number of crankthrows
3. Main journal diameter

In addition, present information indicates the crankshaft material and manufacturing process are the same for the DSR-48 and DSRV-16-4 diesels. However, there is no substantive evidence available to MP&L at the present time that deficiencies in the materials or fabrication process existed in the Shoreham crankshaft.

The following manufacturing data was obtained via telecon with Transamerica Delaval Inc.:

DIESEL	MANUFACTURING CO.	MANUFACTURING DATE
GGNS		
Crank #1 (D/G 11)	Elwood City Forge, Penn.	6/26/75
Crank #2 (D/G 12)	National Forge Penn.	6/28/76
Crank #3 (D/G 21)	National Forge Penn.	7/1/77
Crank #4 (D/G 22)	Elwood City Forge, Penn.	6/27/77

Attachment 9 (Cont'd)

Shoreham

Crank #1 (Cracked)	Mitsubishi Japan	6/29/72
Crank #2 (Fractured)	Elwood City Forge, Penn.	2/27/75
Crank #3 (Cracked)	Elwood City Forge, Penn.	6/10/70

INSPECTION DATA

Although the crankshafts in both Division I and II GGNS Diesel Generators have not specifically been examined for the problem described in IEN 83-58, they have been visually examined on two separate occasions while performing required modifications and preventive maintenance. (It should be noted that examinations of the crankshaft discussed here were not formal code visual examinations). The first maintenance effort took place during the piston modification in November, 1981. At this time the engine run hours stood at approximately 331 hours for Division I and 44 hours for Division II. During this modification which required the removal of the connecting rods, the crankshaft was lightly polished prior to reassembly of the engine. No cracks or other obvious deficiencies were noted by either craft or supervisory personnel.

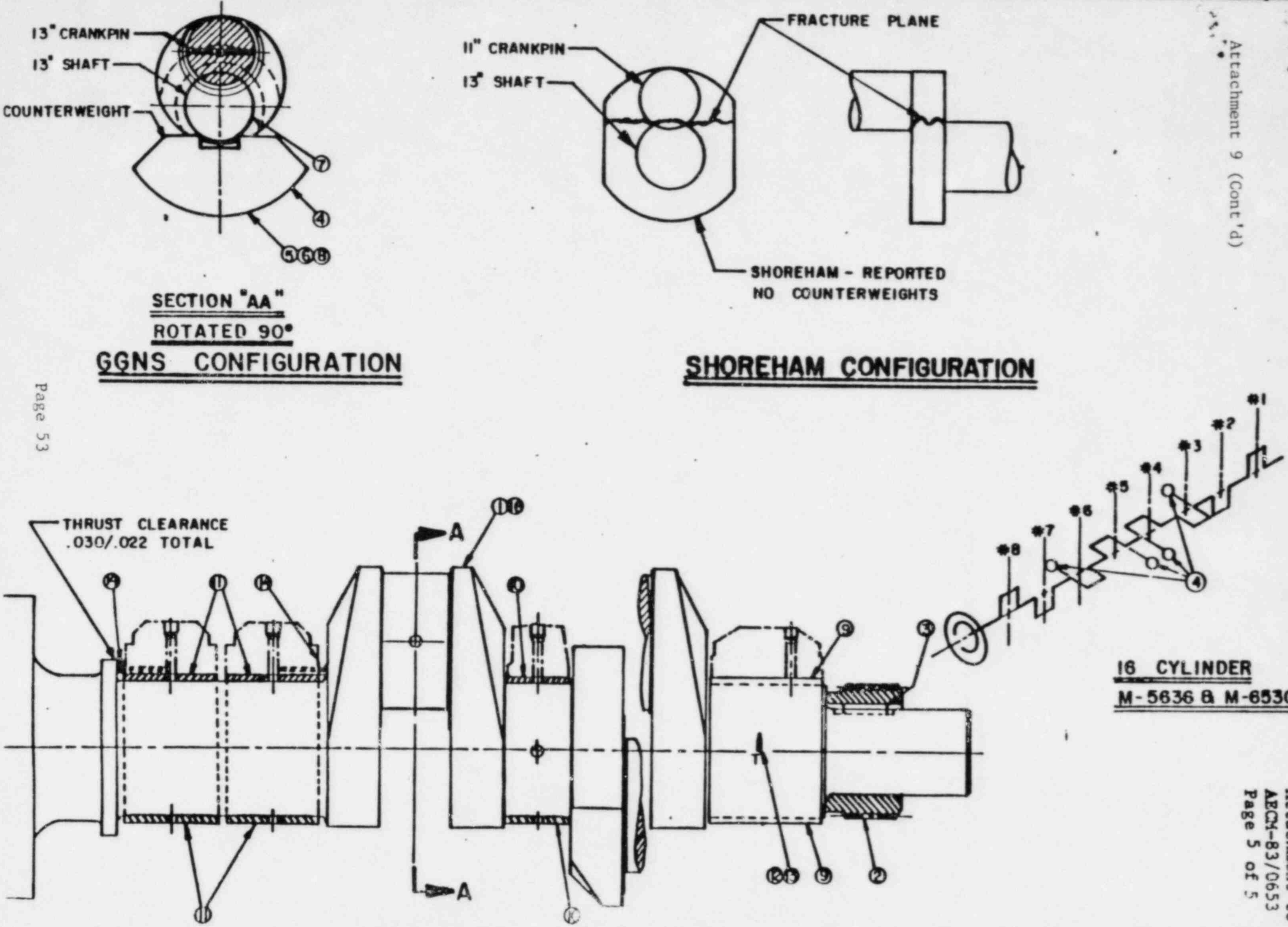
The second maintenance effort took place in January and March of 1983 during the Crankshaft Deflection and Thrust Clearance Checks being performed as part of an 18-month Preventive Maintenance program. The run time during this P.M. stood at approximately 600 hours for Division I and approximately 280 hours for Division II. During these checks the pistons and connecting rods remained in place; however, no obvious deficiencies were noted in the crankshaft by craft or supervisory personnel.

VIBRATION MEASUREMENTS

As of 10/6/83, the Division I D/G has approximately 1090 hours run time and the Division II 360 hours. The Division I and II D/G's recently underwent operating tests in which vibration measurements were made. One of the tests for the Division I D/G included a seven day test run at approximately 60% load. The engine performed satisfactorily during the test. A preliminary conclusion of the vibration measurements is that both GGNS D/G's exhibit vibrations which are typical of large internal combustion engines.

CONCLUSIONS

The failure analysis at Shoreham is incomplete at the time, so the root cause of the failures is not known; however, it is considered to be a problem unique to that facility for reasons discussed above. The Shoreham and Grand Gulf diesel engine crankshaft designs differ in several critical parameters, including the utilization of counterweights and larger crankpins in the GGNS design. In addition, crankshaft torsional stresses are lower in the Grand Gulf design. Therefore, there is reasonable assurance that the GGNS Division I and II Emergency Diesel Generator crankshafts will not fail in a mode similar to that experienced by Shoreham and that the engines will continue to operate as designed. The need and schedule for inspection of the GGNS D/G crankshafts will be evaluated when the results of the analysis of the Shoreham crankshaft failure is available.


13" CRANKPIN
13" SHAFT
COUNTERWEIGHT
7
4
5 6 8
SECTION "AA"
ROTATED 90°
GGNS CONFIGURATION
FRACTURE PLANE
11" CRANKPIN
13" SHAFT
SHOREHAM - REPORTED
NO COUNTERWEIGHTS
SHOREHAM CONFIGURATION
THRUST CLEARANCE
.030/.022 TOTAL
A
A
#1
#2
#3
#4
#5
#6
#7
#8
4
3
9
2
16 CYLINDER
M-5636 & M-6530