Attachment 2
AECM-84/0103

GRAND GULF NUCLEAR STATION

COMPREHENSIVE REPORT ON STANDBY DIESEL GENERATORS - SIGNIFICANT ACTIVITIES TO ENHANCE AND VERIFY RELIABILITY

February, 1984

TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS
(CONTINUED)

FIGURES

ABSTRACT

This report contains a detailed description of the program of preventive maintenance, replacement of components with improved quality products, engine testing, and engineering evaluations which have been undertaken by MP&L, GGNS Unit 1, to enhance reliability and to assure with a reasonable level of confidence that the Transamerica Delaval, Inc. (TDI) diesel engines at Grand Gulf Nuclear Station (GGNS) will perform their required safety function.

The report also addresses implementation of vendor recommendations, NRC directives, problems encountered on TDI engines at other locations, in particular, the LILCO plant at Shoreham, potentially significant items identified at a TDI Owners Group meeting and other sources of operating experience information.

1.0 INTRODUCTION

Grand Gulf Nuclear Station, Unit 1 is equipped with three diesel generators, two of which are supplied by Transamerica Delaval, Inc. (TDI). These two diesel generators are sources of emergency power to the GGNS Division I and Division II ESF buses. The third D/G set, dedicated to the HPCS system, is supplied by the Electro-motive Division (EMD) of General Motors.

This report provides a detailed description of a program undertaken by MP&L to enhance the reliability and performance of the two TDI diesel generators at GGNS Unit 1. The report contains a description of activities of preventive maintenance, replacement of various components with improved quality products, and testing of the two TDI diesel generators.

The improvement program includes specific actions which have been or are being taken to correct the problems experienced with TDI diesel generators during the start-up testing phase of GGNS Unit 1. Potential problems identified to MP&L as a result of the experience with TDI diesel generators at other nuclear installations, in particular the LILCO plant at Shoreham, are also addressed.

The main emphasis of this report is to provide the results of an engineering evaluation of the two TDI diesel generators at GGNS Unit 1 for their reliability and performance. This evaluation is intended to provide reasonable assurance to the NRC that the TDI diesel generators will perform their required safety function. This report supplements earlier reports on the Division I and II diesel generators (Reference 12, 13, 14, 19).

Sections 2 thru 9 of the report contain descriptions of repairs or modifications which have been performed. Section 10 concerns TDI's product improvement program. Section 11 focuses on the testing programs, both the testing done in the past and the testing performed after completion of the piston skirt changeout. A summary of the overall engineering evaluation is provided in Section 12. The conclusions reached from these evaluations are provided in Section 13.

Attachment 1 provides details of concerns raised at a meeting of the TDI diesel generator owner's group with the NRC on January 26, 1984, their applicability to Grand Gulf and their resolution.

Attachment 2 provides a summary of various piston skirt designs that have been or are in use in the GGNS TDI diesels.

Table 1-1 provides a list of the principal design specifications for GGNS Unit 1 TDI diesel generators.

Table 1-2 shows the total operating hours, starts, valid tests and valid failures for the GGNS TDI D/Gs. Table 1-2 also shows that the ratio of valid failures (1) to valid starts (128) results in an excellent start reliability in excess of 99 percent.

1.0 (Continued)

Table 1-3 shows the Division I and II approximate run hours under load since the originally furnished piston skirts were modified in November, 1981.

Table 1-4 shows the procurement specification estimated electrical loads and the present electrical loadings for the Division I and II diesel generator.

The significant work activities completed on the Division I and II engines are:

- All piston skirts have been replaced with skirts of improved design,
- All 32 cylinder heads inspected and eight cylinder heads with rejectable indications have been replaced,
- All Division I and Division II connector push rods have been replaced with components of improved design,
- All connecting rod bearings have been replaced,
- Inspection of both crankshafts has been completed, and
- Rework of turbocharger piping and components using ASME welding, procedures and materials has been completed.

These work activities are intended to enhance engine performance and reliability. They have insignificant impact on engine specifications, design criteria, subsystems or performance characteristics.

None of the work activities affect the design considerations listed in Table 1 of IEEE 387-1977. As such, these work activities are considered minor design changes as defined by IEEE 387-1977. Therefore, the post maintenance qualification and availability testing of these diesels was planned according to the guidelines established in IEEE 387-1977 for minor changes. Additional testing was also performed.

TABLE 1-1

DELAVAL ENGINE SPECIFICATIONS

Model	DSRV-16-4
Quantity	2
Engine Serial Number	74033-2624 & 74034-2625
Service	Stationary generator for nuclear service
Fuel Mode	Diesel
Configuration	45° "V" type
No. of Cylinders	16
Bore (in.)	17
Stroke (in.)	21
Cycle Model	4 stroke
Total Displacement (cu. in.)	76,266
Crankshaft Rotation	CW (from Flywheel end)
Firing Order	1L-8R-4L-5R-7L-2R-3L 6R-8L-1R-5L-4R-2L-7R 6L-3R
Continuous Rating (kw)	7000
Overload Rating (kw)	7700
Crankshaft Diameter (in.)	13
Crank Pin Diameter (in.)	13

TABLE 1-2

GGNS D/G OPERATING DATA

	Division I	Division II
Shop and Pre-Op Run Time (Hrs)	535	252
Since Date of OL Run Time (Hrs)	736	560
Total Run Time (Hrs) (3)	1271	812
TOTAL NO. OF STARTS (3)		
Delaval Shop Runs (1)	310 (2)	5
Pre-Operational Runs	60	60
Since Date of OL Runs	154	105
Total Starts (4)	524	170

NOTES:

1. Source of Information - Delaval Technical Manuals.
2. Division I engine had 300 prototype runs for reliability testing.
3. Data as of February 1, 1984
4. Valid Starts: Div I - 76

   Div II - 52

   128

   Valid failures: 1 (Div I Control System Electrical Component)

   Start Reliability: 99.2%

   Valid starts and failures are as defined in Regulatory Guide 1.108.

TABLE 1-3

DIVISION I AND II APPROXIMATE RUN HOURS UNDER LOAD SINCE ORIGINALLY FURNISHED PISTON SKIRTS WERE MODIFIED IN NOVEMBER, 1981 TO FEBRUARY 1, 1984

Load, ± 5%	Division I Hours	Division II Hours
< 50	14	12
50 - 60	450	316
60 - 99	7	7
100	272	197
110	14	10

TABLE 1-4

D/G LOADINGS

	Division I	Division II
Procurement Specification	5730 KW	6100 KW
Design DG Rating	7000 KW	7000 KW
Loss of Offsite Power Loads	3627 KW (51.8%)	4745 KW (67.8%)
Post LOCA Loads	4711 KW (67.3%)	3914 KW (55.9%)
Total Connected ESF Bus Load	5963 KW (85.2%)	6397 KW (91.4%)

2.0 PISTONS

2.1 DESCRIPTION

MP&L received information from TDI that during a recent reassembly of the three TDI diesels at the Shoreham station, an inspection of the piston skirts revealed linear indications exceeding 1/16 inch in length in 23 of 24 modified "AF" piston skirts.

As a result of this finding, TDI generated a 10CFR21 report recommending that GGNS and San Onofre inspect 25% of the modified "AF" piston skirts in each engine for linear indications. MP&L subsequently found rejectable indications in three of four modified "AF" piston skirts during the 25% inspection on the GGNS Division II engine. All piston skirts on the Division II D/G were then inspected. The results of these inspections are shown in Table 2-1 and 2-2. The inspection criteria used for the inspection is described in Step 2.3 of this section.

2.2 ENGINEERING EVALUATION

Failure Analysis Associates (FaAA) performed an inspection and analysis of the modified type "AF" piston skirts which were removed from the Shoreham diesels. After comparing the GGNS Division II piston skirt inspection results with the Shoreham evaluation results (Reference 1), FaAA concluded that the GGNS Division I piston skirts could contain fatigue cracks of the same approximate depth as the Shoreham engines.

As a result of these early evaluations MP&L replaced all piston skirts in the two Unit 1 TDI engines with the improved "AE" style skirt provided by TDI. (See Attachment 2 for Details of Piston Designs). MP&L worked with TDI in the final phases of production and inspection of these piston skirts to assure that they are free of rejectable indications (as evidenced by fluorescent magnetic particle examination).

Preliminary results of an evaluation reported by FaAA indicates that the "AE" type piston will exhibit substantially lower stresses than the replaced modified "AF" type under similar loadings. FaAA has also indicated that some related information has been compiled on existing TDI engines using the "AE" pistons. The "AE" pistons in the TDI supplied Kodiak engine (more than 6000 hours of run time) and the TDI R-5 test engine (approximately 680 hours of run time at elevated cylinder firing pressures) exhibit no signs of piston skirt cracking.

At a meeting of the TDI D/G Owners Group on February 8, 1984, LILCO indicated that a Shoreham TDI engine is about to undergo a 100 hour full power test. LILCO has agreed to provide MP&L with piston skirt inspection results upon completion of the test.

TDI also has undertaken a program to further verify the adequacy of the "AE" piston design. Static loadings of fully instrumented "AE" pistons in the cold condition are being performed by TDI. Results of the testing will become available to MP&L when completed.

2.3 PISTON INSPECTIONS

(1) Division II modified "AF" piston skirts were nondestructively examined with liquid fluorescent dye penetrant and/or wet fluorescent magnetic particle processes. The specific area of concern was the filleted transition area between the skirt/crown stud hole bore and the skirt wall. All critical filleted areas of each modified "AF" piston skirts were initially inspected with the liquid fluorescent dye penetrant process. The results of this initial inspection are summarized in Table 2-1. The following criteria was used in recording possible indications:

1. all indications were to be evaluated, and

2. a linear indication is defined as an indication in which its length is greater than three times its width.

Numerous indications were found, ranging from 1/32 to 9/16 inches in length. The following additional inspections were performed to determine if the linear indications were superficial in nature. Each linear indication was ground and/or sanded to a depth of approximately 0.062 inches. These indications were then re-inspected using the liquid fluorescent dye penetrant or wet fluorescent magnetic particle process. Linear indications were found ranging from 1/32 to 1/2 inch in length. The results of these additional inspections are summarized in Table 2-2.

To characterize these indications, a confirmatory metallurgical analysis will be performed. The analysis will attempt to determine the mode of cracking, characterize the crack propagation rate, and estimate the depth.

(2) All replacement "AE" piston skirts were nondestructively examined by TDI using the wet fluorescent magnetic particle process prior to installation in the engines. All TDI nondestructive examination procedures were reviewed and approved by MP&L. The following criteria were established as levels of unacceptability:

1. any linear indication greater than 3/16 inch long,

2. rounded indications with dimensions greater than 3/16 of an inch,

3. four or more rounded indications in a line separated by 1/16 of an inch or less, edge to edge, and

4. cracks and hot tears.

These acceptance criteria were derived from ASTM Standard E 125-63, reapproved 1980.

2.3 (Continued)

All piston skirt castings were accepted to the above criteria. It should be noted that all acceptable indications that were found were documented by appropriate records.

2.4 MANUFACTURING DETAILS

The manufacturing details for the "AF", modified"AF" and "AE" piston designs have been provided to MP&L by TDI. The evolution of TDI's piston design is relevant to this report. As such, the details of manufacture for each of these piston designs is presented in Attachment 2.

It is important to note that the "AE" design utilizes a reinforced (lower stressed) casting and a half-stack Belleville washer arrangement. Also, "AE" skirts are heat treated to produce stress relieved nominal 100,000 psi tensile strength nodular iron. The "AE" style skirt is interchangeable with existing R-4 piston crown and requires only minor hardware changes.

2.5 CONCLUSIONS

As a result of the Division II modified "AF" piston skirt inspection, the piston skirts in the Division I and II D/Gs have been replaced with the type "AE" piston skirts.

Based on preliminary results of analytical work being performed by FaAA and the operating experience and subsequent inspection of the piston skirts on the TDI Kodiak and R-5 test engines, MP&L has concluded that the "AE" design is capable of performing the required function at all running loads. MP&L will continue to monitor piston skirt validation evaluations by the vendor, consultants and the TDI D/G owners group.

TABLE 2-1

RESULTS OF INITIAL INSPECTIONS OF GCNS MODIFIED AF PISTONS IN THE DIVISION II D/G

Piston Identification	Indication Length (Inches) (1) Stud Hole Bore Area (2) #1	#2	#3	#4
#1RB	None	1/8	3/32	1/4,1/32,1/16
#1LB	None	1/32	None	1/16
#2RB	None	1/32	None	1/4,1/16
#2LB	5/64,1/16	None	3/16	1/8,1/32
#3RB	1/4	1/32,3/16	None	1/2
#3LB	1/32	1/32	None	3/16
#4RB	None	None	1/4	None
#4LB	1/16,1/8	None	3/32,1/8	1/16
#5RB	1/32	1/32	1/4	1/4
#5LB	3/32,3/32	1/8	9/16	3/8
#6RB	1/4	3/16	None	1/4
#6LB	1/32	None	1/16	1/32
#7RB	None	None	None	3/32
#7LB	None	None	None	1/32
#8RB	3/32	None	None	None
#8LB	1/16,1/8	None	1/16	1/4

General Notes:

(1) All inspection performed using Liquid Flucrescent Penetrant Process.

(2) See Figure 2-1 for location of the stud bore area within piston skirt.

TABLE 2-2

RESULTS OF ADDITIONAL INSPECTION OF GGNS MODIFIED AF PISTONS IN THE DIVISION II D/G

Piston Identification	Indication Length (Inches) (1) Stud Hole Bore Area (2) #1	#2	#3	#4
#1RB	—	1/8 (MT)	NAD (MT)	NAD (MT)
#1LB	—	NAD (MT)	—	NAD (MT)
#2RB	—	NAD (PT)	—	NAD (PT)
#2LB	NAD (PT)	—	NAD (PT)	NAD (PT)
#3RB	1/4 (MT)	3/16 (MT)	—	NAD (MT)
#3LB	1/8 (MT)	1/8 (MT)	—	3/16 (MT)
#4RB	—	—	1/4 (MT)	—
#4LB	1/8 (MT)	—	1/8 (MT)	1/16 (MT)
#5RB	NAD (MT)	NAD (MT)	1/4 (MT)	NAD (MT)
#5LB	NAD (MT)	NAD (MT)	1/2 (MT)	1/4 (MT)
#6RB	NAD (MT)	NAD (MT)	—	1/4 (MT)
#6LB	NAD (MT)	—	NAD (MT)	NAD (MT)
#7RB	—	—	—	1/32 (MT)
#7LB	—	—	—	NAD (MT)
#8RB	NAD (MT)	—	—	—
#8LB	1/8 (MT)	—	NAD (MT)	1/4 (MT)

General Notes:

(1) PT indicates Liquid Fluorescent Dye Penetrant Inspection.
(2) MT indicates Fluorescent Magnetic Particle Inspection.
(3) See Figure 2-1 for location of the stud bore area within piston skirt.
(4) — Not performed. No discontinuities present during initial inspection.
(5) NAD No apparent defect.

FIGURE 2-1: LOCATION OF STUD BORE AREAS WITHIN PISTON

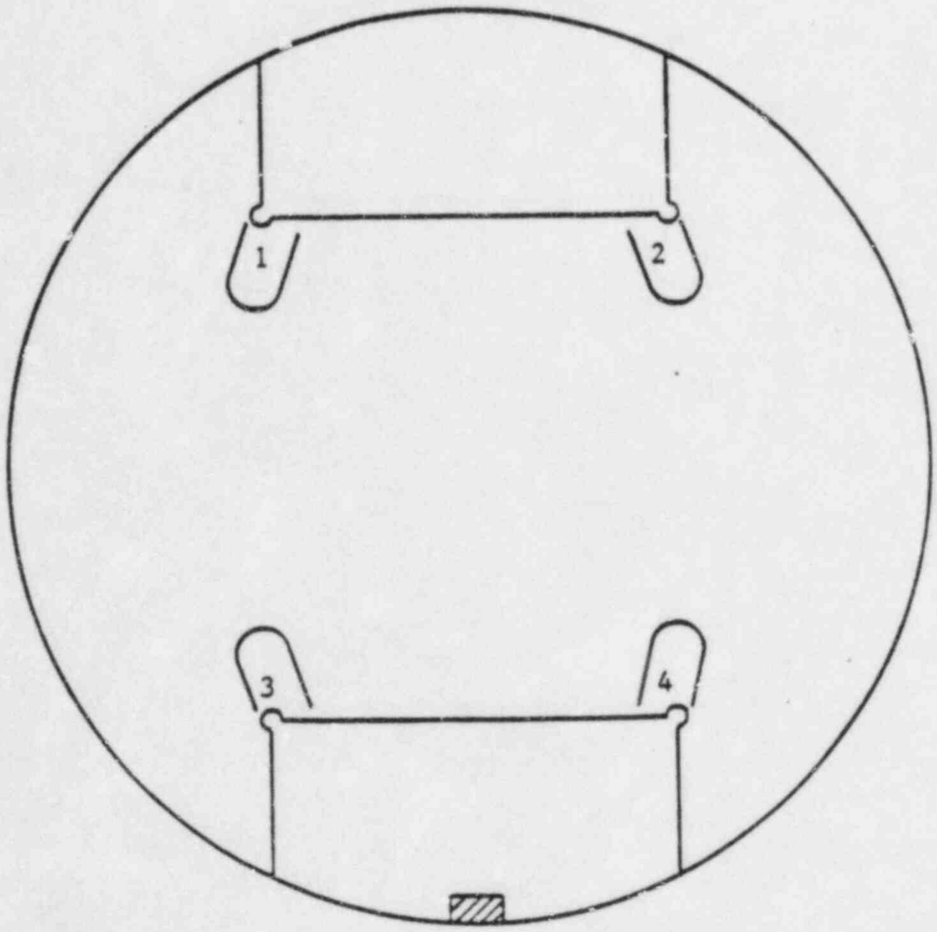


FIG. 2-1

3.0 CYLINDER HEADS

3.1 DESCRIPTION

During disassembly of the Division II engine for piston inspections, red rust was reported in the area of the exhaust valve seats on the #5 right bank head. Subsequent color contrast dye penetrant inspections showed cracks in the stellite exhaust valve seat overlays. Because of the rusting, it is postulated that one of the cracks may extend into the water jacket.

3.2 INSPECTION AND ENGINEERING EVALUATION

As a result of these cracks, an investigation has been initiated to determine the extent of the cracking and required corrective action. The investigation has been divided into two parts; short and long term. The short term investigation was initiated to determine if the extent of cracking is generic to all heads at GGNS. All cylinder heads on both Division I & II D/Gs were removed and were nondestructively examined in the area of the stellite seats with a color contrast solvent removable dye penetrant process. The following criteria were established as levels of unacceptability:

1. Any cracks or linear indications

2. Four or more rounded indications in a line separated by 1/16 inch or less, edge to edge

3. Any rounded indication with dimensions greater than 1/16 inch

4. Linear indications are those indications in which the length is more than three times the width

Two of the 16 heads on the Division II D/G and six of the 16 heads on the Division I D/G were determined to have rejectable indications. Of these, only the Division II D/G #5 right bank cylinder head had an apparent through wall crack. No other visual evidence of cracking was found in the cylinder heads. A description of the indications found during these inspections are detailed for Division I in Table 3-1 and Division II in Table 3-2.

To address the long term concern, a failure investigation has been initiated. A metallurgical evaluation will be performed to determine the cause of crack initiation, and the crack propagation mode.

3.3 CORRECTIVE ACTION

Based on the short term investigations, MP&L has replaced the two heads on the Division II D/G and the six heads on the Division I D/G with heads that were examined and determined to have no rejectable valve seat indications. No further action is planned, pending the results of the long term investigation.

3.4 CONCLUSIONS

Two heads on Division II and six heads on Division I were determined to have rejectable indications. However, as demonstrated by the operability of the D/Gs prior to the replacement of these heads, the ability of the Unit 1 D/Gs to perform their safety function was not impaired. The replacement of these eight heads with heads free of rejectable valve seat indications provides additional assurance that the potential for head cracking from this source is minimized.

To provide further assurance that any significant cracks in the heads will be detected, additional surveillance will be performed following D/G operation to detect the presence of water in the cylinders. These surveillances will be in addition to the current surveillances which are designed to check for the presence of water prior to manually initiated D/G starts.

TABLE 3-1

INSPECTION RESULTS OF DIVISION I CYLINDER HEADS

Head Identification Number	Inspection Results
1LB	No Apparent Defects
1RB	No Apparent Defects
2LB	Linear Indications on Fusion Zone Between Casting and Stellite Valve Seat
2RB	No Apparent Defects
3LB	No Apparent Defects
3RB	No Apparent Defects
4LB	No Apparent Defects
4RB	Linear Indication in Stellite Valve Seat
5LB	Linear Indications in Stellite Valve Seat
5RB	No Apparent Defects
6LB	Linear Indication in Stellite Valve Seat
6RB	Linear Indications in Stellite Valve Seat
7LB	No Apparent Defects
7RB	No Apparent Defects
8LB	No Apparent Defects
8RB	Linear Indication in Stellite Valve Seat

TABLE 3-2

INSPECTION RESULTS OF DIVISION II CYLINDER HEADS

Head Identification Number	Inspection Results
1LB	Incomplete fusion 5/16 inch long on intake valve seat
1RB	No Apparent Defects
2LB	No Apparent Defects
2RB	No Apparent Defects
3LB	No Apparent Defects
3RB	No Apparent Defects
4LB	No Apparent Defects
4RB	No Apparent Defects
5LB	No Apparent Defects
5RB	Twelve linear indications ranging from 3/16 to 3/4 inch. All indications transverse to stellite overlay on two exhaust valve seats. All cracks are contained within the valve seat except for one, which extends from stellite into cast head material.
6LB	No Apparent Defects
6RB	No Apparent Defects
7LB	No Apparent Defects
7RB	No Apparent Defects
8LB	No Apparent Defects
8RB	No Apparent Defects

4.0 CONNECTING ROD BEARINGS

4.1 DESCRIPTION

Shoreham has experienced cracks in connecting rod bearings. These cracks were discovered (See Reference 2), when LILCO disassembled the three diesel engines at Shoreham (TDI Model DSR-48) to investigate a crankshaft failure (See Section 6.0). A complete inspection found that four of the forty-eight connecting rod bearing shells contained cracks. Even though the Grand Gulf D/G design is significantly different (i.e., GGNS has articulated connecting rod design and reduced connecting rod bearing loads) an inspection and evaluation was performed to determine if this concern exists at Grand Gulf.

4.2 ENGINEERING EVALUATION, SHOREHAM BEARINGS

A schematic of a cracked Shoreham bearing is shown in Figure 4-1. FaAA performed an analysis (Reference 18) on one of the cracked Shoreham bearings. The cracked bearing was checked for its chemical and physical properties. A scanning electron microscopy (SEM) analysis of the fracture was also performed and dimensional checks were made for wear. The chemical and physical properties met the current design specifications except for elongation. The elongation was found to be below specification, however, the test specimen was not standard, and led to results that were inconclusive. Reference chemical properties for B850.0-T5 are shown in Table 4-1. A Shoreham SEM examination of the fracture face indicated that voids in the bearing shell may have been crack initiation locations. In compression, voids in the "overhang" area would not pose a problem. However, the bearing/rod arrangement on the Shoreham diesels did not support the end part of the bearings (Figure 4-2). This unsupported end combined with the yawing of the crankshaft would put the internal diameter surface into tension. The surface porosity acting as a stress intensifier may have contributed to crack initiation in the unsupported end ("overhang" area). Also, the subsequent shell thickness measurements showed the bearing to be within the manufacturing tolerances, i.e., no appreciable wear.

4.3 GGNS D/G INSPECTION

The inspections delineated below were performed on Division II D/G components. New bearings were installed in both divisions to expedite the return to service of the diesel and to extend the replacement period of the bearings. The integrity of these replacement bearings was based on an exact part number exchange, visual inspection of the bearings before installation, and favorable results from the inspection/evaluation performed on the original bearings.

4.3 (Continued)

1. All of the connecting rod bearings were dimensionally checked for wear and signs of unusual or abnormal wear patterns.

2. Two (25% of total) of the connecting rod bearings were inspected by liquid penetrant (PT) and radiography. The radiography technique utilized an x-ray tube radiation source and obtained a 2-2T film sensitivity yielding at least of 0.015 to 0.020 inches resolution. The PT inspections used a liquid fluorescent dye penetrant process and met the requirements of ASTM Standard E165. No rejectable indications were found.

   Tests to check the chemical and physical properties of two (25% of total) original connecting rod bearings are planned. These tests will be performed in accordance with applicable ASTM Standards. These tests are considered confirmatory in nature.

3. The "overhang arrangement" of two bearings/connecting rod assemblies was dimensionally checked for unsupported bearing material. The chamfers on the connecting rods and rod bearings were dimensionally checked to determine if the "overhang arrangement" exists and to verify that the connecting rod configuration was of the correct design.

4.4 INSPECTION RESULTS

The initial Division II D/G inspections indicated the following:

1. Review of the radiographic film showed that any bearing porosity was less than 0.030 inches, however, some linear type indications were present. All linear type indications were directly traceable to minor gouges and marring located on the bearing surfaces which occurred during disassembly. As indicated in preliminary information by FaAA, porosity of less than 0.030 inches is predicted to be of little consequence to the satisfactory operation of the bearings.

2. The results of the dimensional inspections confirmed that the bearings were within manufacturing tolerances. No signs of unusual or abnormal wear patterns were noted. This indicates that there was no misalignment between the connecting rod assemblies and the crankshaft.

3. The results of the chamfer measurements indicate that there is no "overhang" arrangement on the #7 connecting rod/bearing assembly and that the #2 connecting rod/bearing assembly has an "overhang" of approximately 0.016 inch (i.e., 0.016 inch of unsupported bearing material). This amount of "overhang" is insignificant compared to the 0.25 inch "overhang" that existed on the Shoreham bearings at the time of bearing cracking.

4.4 (Continued)

4. The results of the Liquid Fluorescent dye penetrant examination indicated that no cracks were present.

4.5 CONCLUSIONS

The differences in design between Grand Gulf and Shoreham (i.e., articulated connecting rod design and reduced connecting rod bearing loads at Grand Gulf) preclude the types of problems that Shoreham has experienced. However, inspections were performed to verify the adequacy of the bearings.

Inspections of the original Division II D/G connecting rod bearings showed that no appreciable wear or unusual wear patterns were present. This confirms proper alignment of the connecting rod assemblies to the crankshaft.

Radiographic inspection of two original Division II D/G connecting rod bearings found no porosity of a size greater than 0.030 inches, which is judged to be insignificant. No rejectable indications were found on any of the bearings inspected by liquid dye penetrant methods.

Added assurance regarding integrity of the replacement bearings is being provided by confirmatory analyses. These analyses include destructive and non-destructive testing as well as analytical work being performed by FaAA.

TABLE 4-1

CHEMICAL SPECIFICATION LIMITS
FOR ALCOA B850.0-T5 ALUMINUM

Element	Composition %
Si	0.4 Max
Fe	0.7 Max
Cu	1.7 - 2.3
Mn	0.10 Max
Mg	0.6 - 0.9
Ni	0.9 - 1.5
Sn	5.5 - 7.0
Ti	0.20
Other Elements	0.30 Max
Al	Remainder

FIGURE 4-1: SHOREHAM CONNECTING ROD BEARING DESIGN AND NOMENCLATURE (SCHEMATIC)

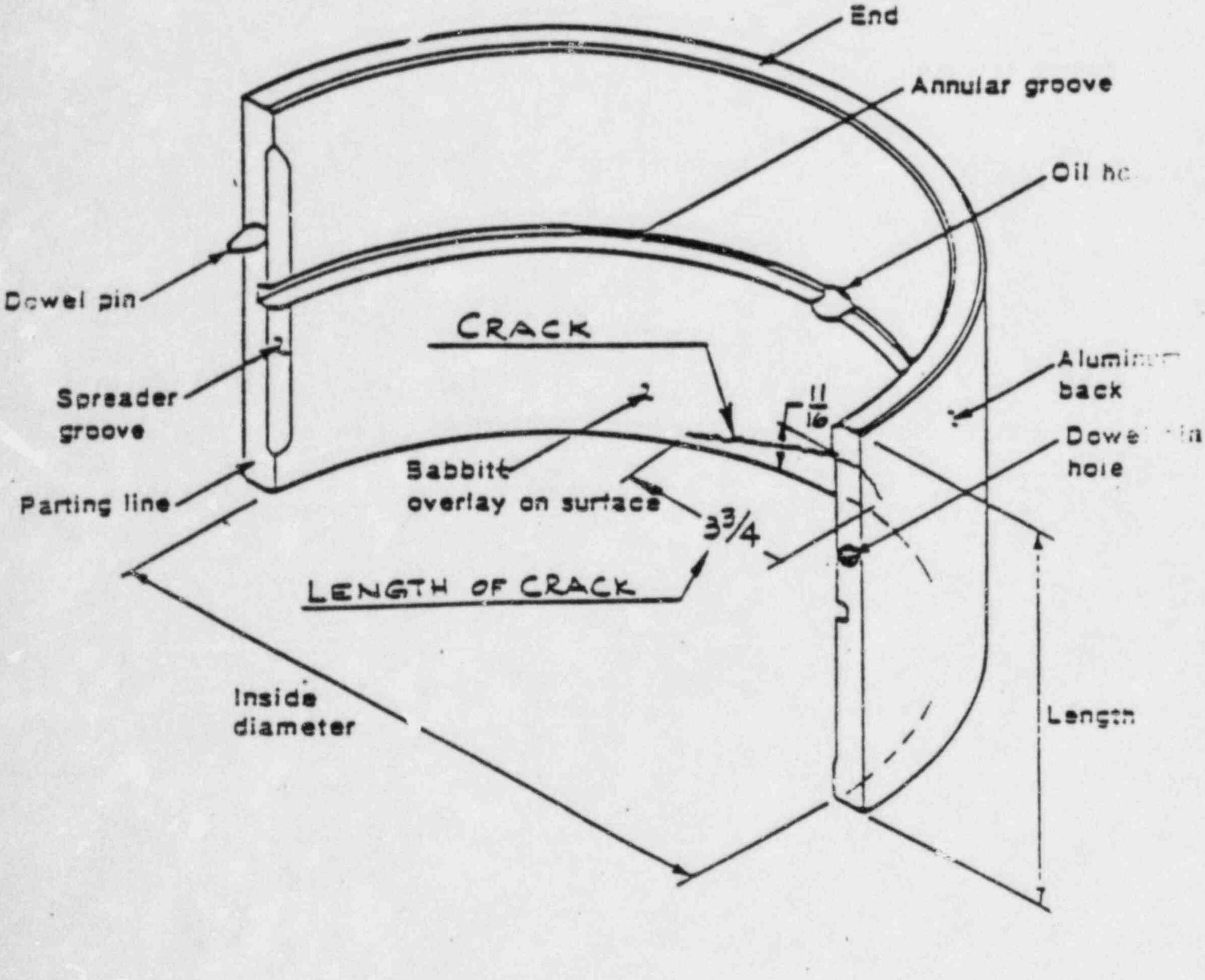
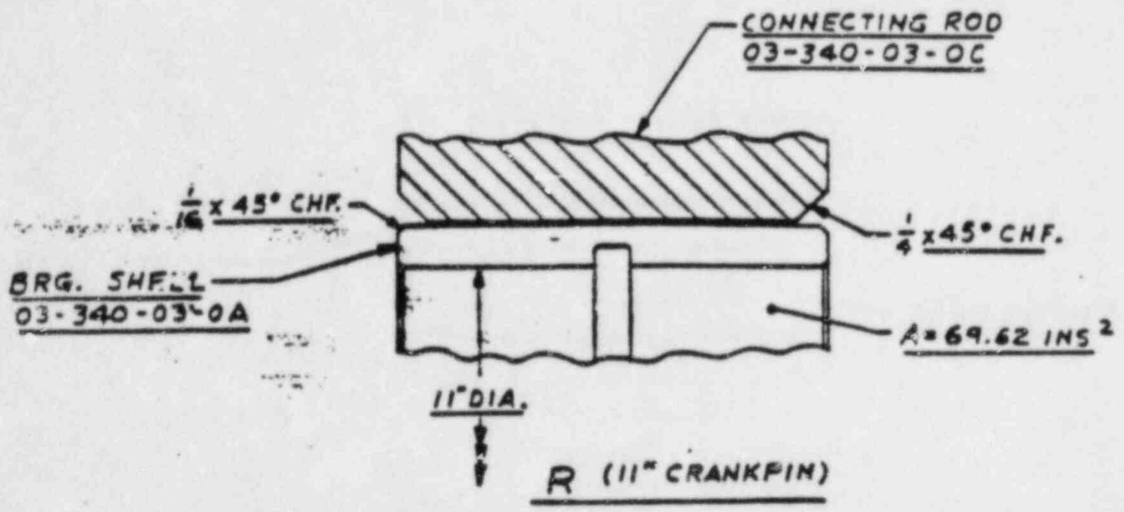
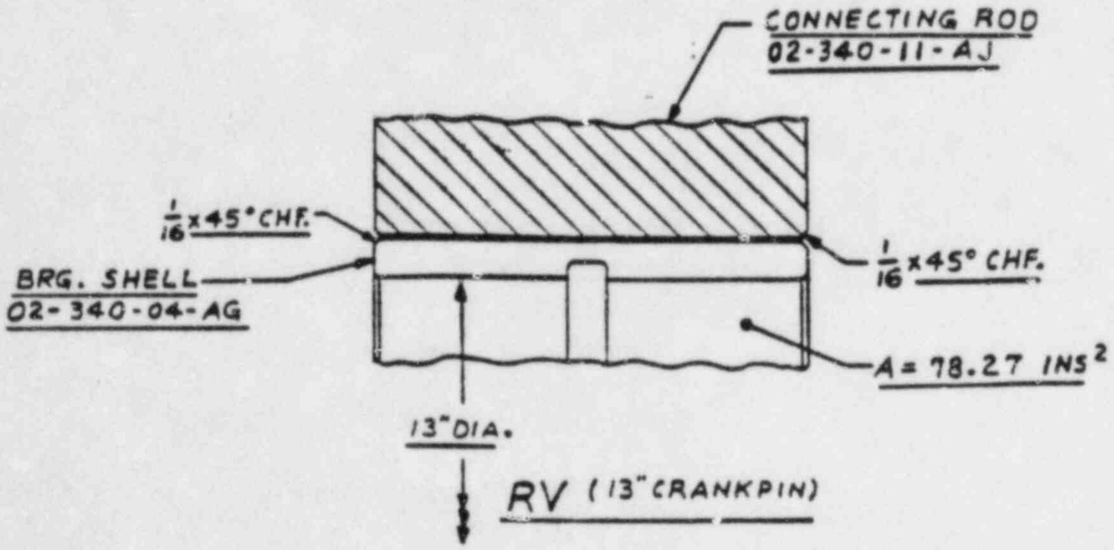


FIG. 4-1

FIGURE 4-2: COMPARISON OF CONNECTING ROD/BEARING CHAMFER ARRANGEMENTS



SCHEMATIC OF SHOREHAM "OVERHANG ARRANGEMENT" INDICATING UNSUPPORTED BEARING MATERIAL



SCHEMATIC OF GGNS BEARING ARRANGEMENT WITH BEARING MATERIAL SUPPORTED

FIG. 4-2

5.0 PUSH RODS

5.1 DESCRIPTION

On August 11, 1983, during the performance of unrelated maintenance, a rocker arm connector push rod was found to have a cracked weld. The push rod ball disengaged from the shaft as the push rod was removed from the Division I engine. The defective connector push rod was replaced and the Division I engine was tested and returned to service with additional connector push rod inspection criteria specified. During a subsequent inspection of the Division I engine, 14 of 16 connector push rods were discovered with cracked or separated welds. This inspection revealed one of the connector push rod balls was cracked in addition to the weld cracks previously observed. During the inspection of the Division II engine in December, 1983, 13 of 16 connector push rods were also found to have cracked tube-to-ball welds.

5.2 ENGINEERING EVALUATION AND CORRECTIVE ACTION

There were two types of push rod designs used at GGNS. The main push rods had a tubular steel shaft fitted with hardened steel end pieces which were attached to the tube with four plug welds near the ends of the tube. According to TDI, an estimated 2 percent of this design developed cracks in or adjacent to the plug welds on the rods.

The connector push rod consisted of a tubular steel body fillet-welded to carbon steel ball bearings. This design is the type which exhibited defects at Grand Gulf and is shown in Figure 5-1. A 1 1/2-inch high carbon steel ball bearing is fitted to 1 1/4-inch OD tubing with a 1/4-inch wall. The inside edge of the tubing has a 45° chamfer which results in a 7/8-inch circular seating ring for the ball at the end of the tube. The ball is attached to the tube with a continuous 360° fillet weld. The materials of construction are as follows:

Ball Material: AISI 52100

Tube Material: ASTM A519

Weld Material: UNIALOY 850

The first connector push rod found defective was subjected to metallurgical evaluation (Reference 3). The initial weld defect resulted from lack of penetration of the fillet weld with the tubing. Destructive examination of the ball and weld on the opposite end of the defective connector push rod revealed additional cracks in the heat-affected-zone (HAZ) of the ball bearing. The welds exhibited lack of penetration and slag inclusions in the crevice area behind the weld. The metallurgical evaluation concluded that the ball material is difficult to weld. The possibility of finding underbead cracks all around the ball in the HAZ is very high.

5.2 (Continued)

Previous operational experience did not indicate that the cracks would propagate out of the HAZ since the connector push rods are loaded in compression. Furthermore, none of the MP&L defects or other reported defects were associated with underbead cracking. Rather, all previous defects of this design were associated with insufficient weld penetration. Consequently, MP&L concluded that a push rod exhibiting these defects would not result in engine failure.

MP&L proceeded with an interim inspection program, until replacement connector push rods free of defects could be obtained. The discovery of a cracked connector push rod ball in the Division I diesel, however, demonstrated that the underbead cracks could, in fact, propagate through the ball material.

A new replacement connector push rod design (Figure 5-2) had been developed by TDI. This new design consists of a tubular steel shaft which is friction welded to cylinders of alloy steel on each end. These ends are then machine finished and hardened. The tube material is ASTM A-106 Grade B steel; the ends are AISI 8740/50 steel. During December, 1983, MP&L engineers reviewed all aspects of the connector push rod fabrication and observed procedural qualification runs at Delaval's push rod fabricator in Los Angeles. Samples of the qualification run were analyzed by MP&L and determined to be acceptable.

5.3 CONCLUSIONS

The connector push rod problems described have been corrected with the new push rod design that is installed in the Division I and II D/Gs. MP&L plans no further action on push rods, however copies of metallurgical evaluations of the old and new push rods are being provided to the TDI D/G owners group. In addition, a connector push rod with at least 100 hours at 100% load operation will be provided to the TDI D/G owners group for laboratory fatigue-proof testing to 10^7 cycles to verify a satisfactory endurance limit.

FIGURE 5-1: WELDED BALL CONNECTOR

03-390-04-AB

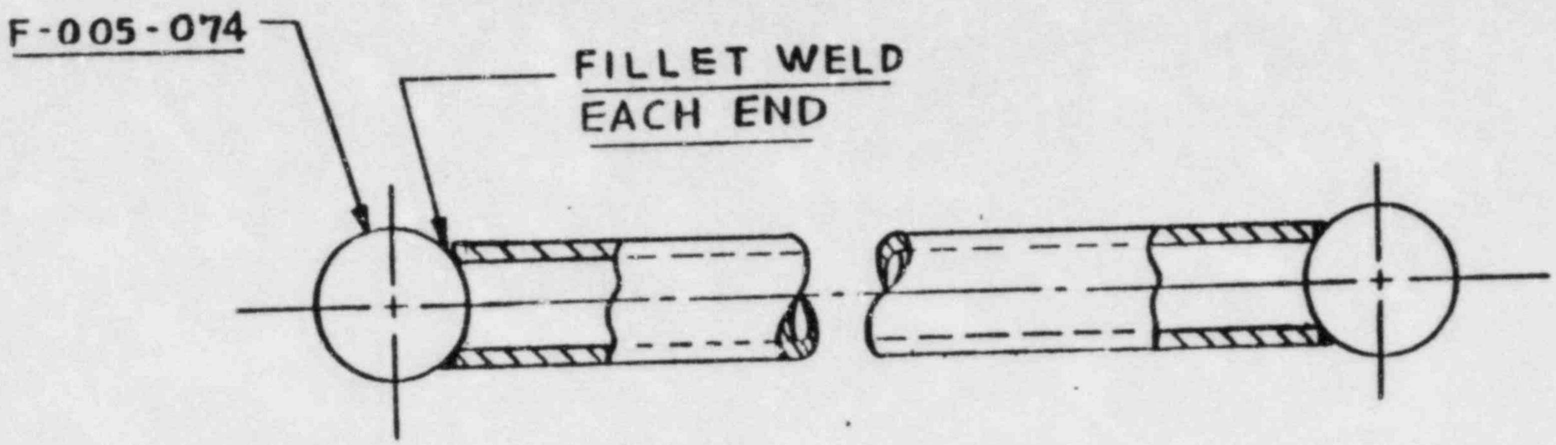


FIG. 5-1

FIGURE 5-2: FRICTION WELDED PUSH ROD

02-390-07-AH

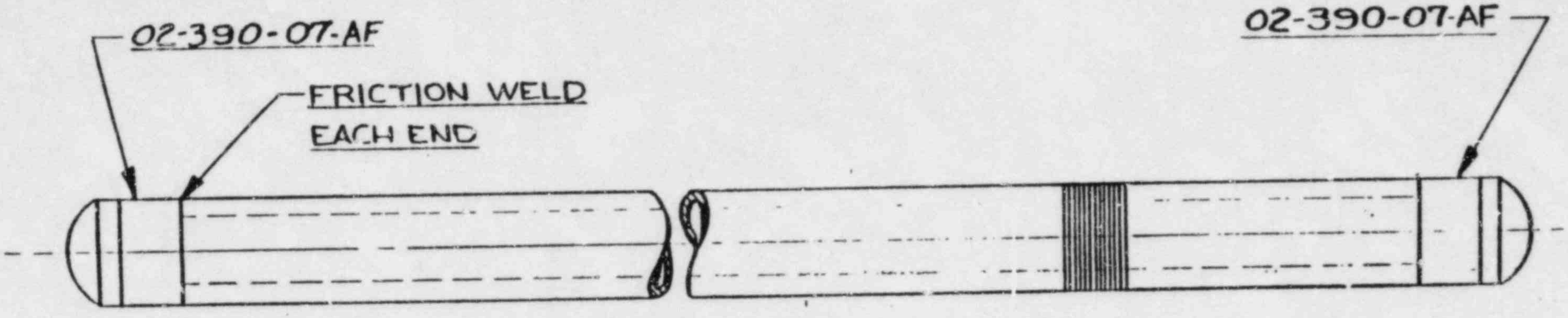


FIG. 5-2

6.0 CRANKSHAFT

6.1 DESCRIPTION

The concern over the design adequacy of the crankshaft was prompted by a crankshaft failure that occurred at Shoreham with their TDI supplied standby diesel generators. Investigation by FaAA revealed that the cause of the crankshaft failure was high cycle fatigue. This led the NRC to issue IE Information Notice No. 83-58 which identified Grand Gulf as having TDI supplied standby diesel generators with possible crankshaft design deficiencies.

6.2 ENGINEERING EVALUATION

Investigations were immediately conducted by MP&L on the applicability of the failures at Shoreham to the Grand Gulf TDI diesel generators. A physical comparison (Reference 19) of the DSR-48 (in-line eight cylinder) series engine crankshaft that failed, with that employed in the DSRV-16-4 (Vee-16 cylinder) series at Grand Gulf revealed some important differences. Among the significant design improvements on the Grand Gulf engine are the larger web size and shape, larger crankpin diameter, larger pin fillet radius and the use of counter-weights. In addition, it was learned that TDI may have used potentially non-conservative (1st generation) design harmonic coefficients in 1974 when the Shoreham stress analysis was performed.

The original GGNS design stress calculations utilized later 1975 (3rd generation) harmonic coefficient values. At the request of MP&L, TDI clarified the use of the GGNS 1975 Vs 1983 post-Shoreham 4th generation coefficients and recalculated the GGNS D/G shaft torsional stresses using the latest coefficients (Reference 4).

The changes made in the newest harmonic coefficients were an analysis refinement that resulted from analytically generated results being compared to actual test results. The changes were minor and did not substantially affect the analysis. The TDI results indicated that the GGNS crankshaft stresses are significantly less than the maximum allowable Diesel Engine Manufacturers Association (DEMA) standard and are also only ≈ 60% of the stresses in the failed crankshaft at Shoreham. This confirmed that a substantial design margin existed in the GGNS crankshafts.

To verify the adequacy and results of the TDI crankshaft design analysis, MP&L requested Bechtel to evaluate TDI's analytical methods. Bechtel concluded that the analytical methods used to predict crankshaft stresses by TDI are in accordance with industry standard practice and appear to be properly applied (Reference 5).

The results of the Bechtel analyses are summarized below:

- The shaft configuration lends itself to a simple dynamic model which adds assurance to the accuracy of the calculation. The calculated first mode natural frequency has been confirmed by results of the torsiograph test, while the predicted single mode shaft stresses are within the DEMA allowables.

6.2 (Continued)

- The harmonic coefficients, cylinder firing sequence, and engine configuration are such that the response of the major orders of critical speed are minimized. The harmonic coefficients have not been verified but it appears that a significantly detailed effort has been undertaken by TDI to provide accurate values.

- The TDI analysis did not combine the response from the various harmonics of a given mode and of other modes to calculate total stress. However, because of the expected random phasing, the reduced effects of higher modes, the first mode stress margins compared to DEMA, and the torsiograph results, the total stress remains acceptable.

- A comparison of the Grand Gulf and Shoreham crankshafts has been provided in Table 6-1. The improvement in the web area, fillet radius, properly applied counterweights, and shot-peened fillet radius surface finish provide for a significant reduction in stress concentrations.

- The torsiograph results provide verification of front end angle of twist and an indication of shaft stress even though it is not a direct stress measurement. One important piece of information suggested by the torsiograph tests is that the first mode dominates the response of the crankshaft. This would tend to confirm TDI's use of first mode response to predict crankshaft stresses.

- To address the total stress in the circular portion of the shaft, Bechtel performed an independent dynamic analysis using the normal mode method and applying modal superposition (Reference 16). Five sets of harmonic coefficients were considered in the analysis with the most important being the actual measured gas pressure values obtained from an engine of the same configuration and BMEP. The harmonic coefficients used by TDI are in good agreement with those derived from the measured gas pressure values. The results of the single order and total stress calculations are tabulated in Table 6-2 along with other crankshaft stress results for comparison.

- It should be noted that TDI's analytical crankshaft stress determination is based on individual harmonics within a given mode. TDI did not determine the stress for a specific harmonic due to the response of all modes, or sum the effects of all harmonics and stresses from experimental shaft deflection measurements to which a theoretical deflection/stress relationship was applied. The theoretical deflection/stress relationship is based solely on the characteristics of the first mode, whereas, the measured deflection includes the response of all modes.

6.2 (Continued)

- The value of overall stress reported by FaAA for the Shoreham crankshaft represents the average stress taken over the peak stress excursion. To provide a meaningful comparison a similar average stress was computed by Bechtel for the GGNS crankshaft. An average stress is a useful value for comparison with DEMA standards since the measure of stress reversal is directly related to fatigue life. The peak stress calculated by Bechtel for GGNS crankshaft is 6034 psi. Both the peak stress and the averaged reversed stress for the GGNS crankshaft are within the limits for allowable stress published by DEMA. More importantly it should be noted that the total GGNS crankshaft stress is lower than the FaAA calculated stress for the new Shoreham crankshaft, even though the rated output of the GGNS diesel is twice that of the Shoreham diesel.

As a further verification of crankshaft adequacy, during December, 1983, and January, 1984, when the Division I and II engines were disassembled for maintenance and replacement of existing piston skirts with improved piston skirts, the Division I and II crankshafts were inspected using accepted NDE methods. No rejectable indications were discovered.

All the rod bearing journals were examined using a liquid fluorescent dye penetrant process. The entire journal surface was inspected with particular attention to the journal fillets. All linear indications were evaluated with respect to integrity. The results of the examination are shown in Table 6-3.

6.3 CONCLUSIONS

The method of analysis used by TDI has been reviewed and is in accordance with industry standard practices. Additionally the total stress values not addressed in TDI analysis have been calculated based upon measured gas pressure input and are shown to be within the DEMA limits. Liquid penetrant examination has shown no defects to exist on the journal fillets.

The total stress analysis results are lower than DEMA recommendations and when combined with acceptable liquid penetrant examinations alleviates the concerns over the design adequacy of the GGNS crankshafts.

TABLE 6-1

SHOREHAM AND GGNS CRANKSHAFT DATA

	Shoreham R Series	Grand Gulf RV Series
Web Width	21 in.	25 in.
Web Thickness	4 1/2 in.	5 1/8 in.
Web Shape	Flat Sided	Round
Crank Pin Dia.	11 in.	13 in.
Fillet Radius	1/2 in.	3/4 in.
Fillet Finish	Not Shot Peened	Shot Peened

TABLE 6-2

CRANKSHAFT STRESSES AS REPORTED BY VARIOUS ANALYSES

	Single Order Stress (psi)			Total Average Stress (psi)		
Crankshaft	Bechtel	FaAA	TDI	Bechtel	FaAA	TDI
Shoreham (11" pin)	-	5790 (15)	4570 (2)	-	8910 (15)	5314 (2)
Shoreham (12" pin)	-	3300 (17)	2990 (17)	-	5640 (17)	4208 (2)
GGNS (13" pin)	2389 (16)	-	1967 (4)	5084 (16)	-	3507 (2,4)

General Comments:

(A) DEMA limit for single order stress is 5000 psi and 7000 psi for the total stress.

(B) References to the source of information are identified in parentheses.

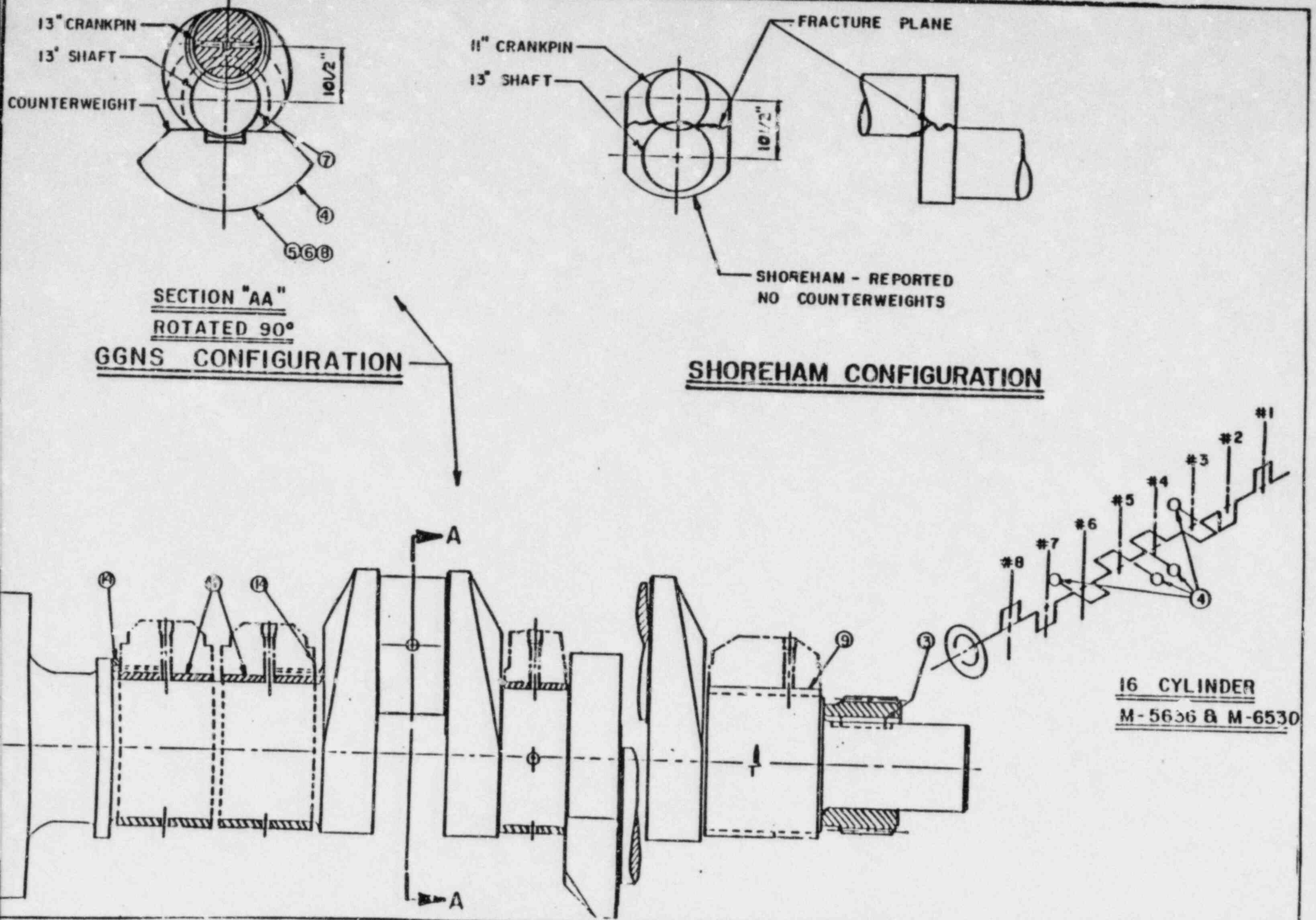
(C) The differences between the TDI and Bechtel calculations are primarily due to Bechtel's summation of stresses from all modes (modal superpositions) and TDI's method of including only harmonics within a single mode. For additional information see discussion in Section 6.2.

TABLE 6-3

CRANKSHAFT LIQUID PENETRANT INSPECTION RESULTS

Rod Bearing Journal Number	Inspection Results
Div I	
All Journals	Indications were present - evaluated as wear surface marks and marring caused by micrometer measurements. No apparent defects.
Div II	
#1, #2, #3 #4, #5, #6 and #8	Indications were present - evaluated as wear surface marks and marring caused by micrometer measurements. No apparent defects.
Div II	
#7	No indications present - No apparent defects

FIGURE 6-1: Crankshaft Comparisons



7.0 L.P. FUEL LINE FAILURE

7.1 DESCRIPTION

On September 4, 1983,the Division I D/G was sta[illegible]tenance operation. The engine was manually stopped and [illegible] fresh air fans secured when a fire was reported at the eng[illegible]ire was caused by a break in a 1-inch fuel oil supply head[illegible]break sprayed fuel oil onto the exhaust gas piping to the left b[illegible]k turbocharger. Closer examination revealed that the tubing cracked circumferentially along a line between the two ferrules of the Swagelok connector which connects the 1-inch tubing to the cross connect pipe between the the right and left bank fuel oil supply lines. The fire required extensive rework and replacement of various components.

7.2 ENGINEERING EVALUATION

Three possible causes of the tubing failure identified in the analysis by Middle South Services (Reference 6) are as follows: (1) an improper tubing material, (2) improper fitup and assembly of the tubing connector, and (3) vibration loading.

(1) The strength of a Swagelok type connection depends on controlled deformation of the tubing between the body of the connector and the front and back ferrules. Consequently, the tubing must be ductile enough to deform significantly without cracking. Swagelok recommends an ASTM A179 material. Metallurgical analysis revealed that the tubing composition, hardness and ductility were all within the specified ranges for ASTM A179 material and that the tubing was acceptable for the application. The 0.049-inch tube wall was the minimum recommended by Swagelok, but more than adequate for the operating pressures. The tubing was replaced with Delaval standard spares.

(2) A Swagelok representative from the Oakland Valve and Fitting Company, inspected the failed tubing and the associated Swagelok connector which had been sectioned for analysis. The Swagelok representative stated that the tubing had been properly deformed and that fitup or assembly problems would have been very unlikely. The Swagelok fitting was replaced with Delaval standard spare material.

(3) Vibration and fatigue were the most likely causes of the failure. The assembly of the Swagelok fitting forms a small ledge which acts as a stress concentrator. There were no supports on this section of tubing, although Delaval drawing 02-450-13 shows a clamp or support as item number 7.

(3) (Continued)

Analysis revealed no evidence of cracking at the other end of the tubing at the fuel oil filter Swagelok connection. The crack in the failed section of tubing initiated at the root of the ledge. The crack was initiated and propagated by high cycle fatigue mechanisms. This particular section of tubing had been subjected to unusual vibration loading by a defective left bank turbocharger.

The root cause of the failure was determined to be the unusual vibration loads imposed by the defective turbocharger combined with the absence of any supports to isolate the Swagelok connector from vibration loading. The defective, out-of-balance turbocharger (combined with a period of operation after the turbocharger mounting bolts were discovered to be loose) is suspected as the initiating source of vibration. The fuel oil header, to which the failed tubing section connects, is mounted to the turbocharger mounting pedestal. This turbocharger, however, was replaced prior to the ultimate failure of the tubing which resulted in the fire.

7.3 CORRECTIVE ACTIONS

MP&L designed and installed a tubing support for this section of tubing on both standby diesels. In addition, following completion of all rework related to the fire, the engine was subjected to a maintenance run to verify that all components were functioning properly. During the maintenance run, the engine was instrumented for vibration analysis. The results of the vibratory analysis revealed that the engine exhibited vibration levels which were well within the limits which could be expected from this type of machinery. These actions were described to the NRC in Reference 12.

7.4 CONCLUSIONS

The root cause of the low pressure fuel line failure was attributed to unusual vibration loading and the absence of any supports to isolate the Swagelok connector from this loading. The corrective actions taken alleviates the loads imposed on these lines. Therefore, further failures of these lines are not expected.

8.0 H.P. FUEL LINE FAILURE

8.1 DESCRIPTION

Shoreham experienced a failure of a fuel injection line during pre-operational testing. TDI filed a 10CFR21 notification on July 20, 1983 to alert the NRC to a deficiency involving a possible draw seam on the ID of the high pressure fuel injection lines supplied on TDI diesel generators. The tubing failures at Shoreham were attributed to the draw seam which acted as a stress riser and failed when subjected to repeated operating cycles (about one million cycles).

At approximately the same time of the notification, a high pressure fuel injection line on the GGNS, Unit 1, Division I diesel generator failed. An analysis of the failed tubing attributed the failure to the tubing manufacturing flaw.

8.2 ENGINEERING EVALUATION AND CORRECTIVE ACTION

All of the GGNS D/G fuel lines were original equipment, except one on each division, and had been subjected to more than ten million operating cycles. Therefore, they were considered free of defects of this type. The two lines that were not original equipment had been replaced during startup testing because of leakage around the fittings. One of these two replacement lines subsequently failed, as stated above, at approximately one million cycles.

Based on the results of an analysis performed by Middle South Services, (Reference 7), the failed tubing exhibited a crack which initiated from a manufacturing flaw on the inside surface of the tube. The flaw, which ran the entire length of the failed tubing section, was formed by a defective mandrel during the initial extrusion phase of the forming process. Additional rolling operations lapped over the flaw, which was about 6-8 mils deep. The fuel injection line operating pressure, which cycles between atmospheric pressure and about 5000 psi, provided the fatigue loading which produced cracks along the stress riser provided by the manufacturing defect. The preexisting flaw acting with the fatigue stresses generated by the cyclic operating pressures produced the failure. These evaluations and actions were described to the NRC in Reference 12.

8.3 CONCLUSIONS

The TDI 10CFR21 notification indicates that the failures occur at approximately one million operating cycles and that fuel lines that have in excess of ten million operating cycles without failure are satisfactory. All of the original lines on the Division I and II diesels were, therefore, considered free of internal flaws of this type because they have in excess of ten million operating cycles and have not failed. One line on the Division I diesel, the one that failed and was replaced, 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 these two lines.

8.3 (Continued)

This problem is, therefore, considered resolved for the GGNS, Unit 1, TDI diesels.

9.0 CRANKCASE CAPSCREWS

9.1 DESCRIPTION

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 capscrew head from a 5/8 UNC X 1-3/4 inch long capscrew had imbedded in the stator and damaged the generator. It was determined that the capscrew head was from a capscrew 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. The generator was replaced with a generator from Unit 2 and all rear crankcase cover capscrews on the Unit 1, Division I and II diesels, were replaced with new replacement capscrews.

An independent lab performed an analysis (Reference 9) of the 42 capscrews removed from the Unit 1, Division I and II diesel generators. 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. It was also noted that the failed capscrews had a decarburized skin which may have contributed to the failure.

On October 4, 1982, the rear crankcase cover capscrews were checked 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). Any capscrew not within ± 2 ft-lbs of the 60 ft-lbs was to 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.

9.2 INSPECTION AND TESTING

The Division II D/G was instrumented by Nutech in January of 1983 and data was obtained during an operational test run. The test data indicated that the highest vibration amplitude occurred during the startup and shutdown of the diesel, 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. 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.

9.3 CORRECTIVE ACTIONS

The main thrust of the corrective action taken was the design and installation of protective screens for the generator air gaps. The failure of the rear crankcase cover capscrew, by itself, would not

9.3 (Continued)

prevent the diesel from performing its safety function. On the other hand, the entry of foreign material into the generator could cause failure, therefore, the screens were installed to protect against a similar mode of failure. At the same time fatigue resistant, high strength capscrews and tab washers were installed to extend the life of these capscrews. One of these capscrews was pulled from each division and subjected to destructive analysis.

While there was no sign of crack initiation there were signs of fretting on the threads of the capscrew removed from the Division II D/G. The expected life of these capscrews has not been confirmed. After the metallurgical report is evaluated, the schedule for removing another bolt from the Division II D/G for analysis will be determined.

9.4 CONCLUSIONS

Although MP&L is continuing to inspect the crankcase cover capscrews and isolate the source of cyclic loading, the possibility of failure of one of these capscrews no longer poses a threat to diesel generator operability due to the installation of protective screens on the generator air gaps.

10.0 TDI PRODUCT IMPROVEMENTS

TDI has a product improvement program which addresses both changes that are required to ensure diesel generator operability/reliability and changes that are developed to extend component life, allow easier maintenance operations, or use improved manufacturing techniques. The TDI program classifies changes as follows: (1) changes required to correct 10CFR21 deficiencies, (2) changes developed to improve diesel generator performance or reliability (not as a result of a potential defect) and issued to customers under TDI's Service Information Memo (SIM) program, and (3) changes developed by TDI that are determined by TDI to be relatively insignificant to diesel generator operation and therefore do not necessitate immediate customer notification.

The TDI program of product improvement has included applicability reviews for the diesel generators installed at Grand Gulf and the applicable changes have been identified to MP&L (Reference 2). The TDI Nuclear Check List for SIMS identifies those that are applicable to TDI diesels at nuclear stations. The thirty-three SIMs identified by the list were reviewed by MP&L to determine which SIMs could be considered product improvements. Four categories; product improvement, instructions, information and guidelines were utilized for the review. Eight of the thirty-three SIMs reviewed were considered to be product improvements, nine SIMs as recommended instructions, ten SIMs as informational and six SIMs as guidelines. A listing of the eight SIMs considered product improvements is provided in Table 10-1. Review of the vendor manual for the TDI diesels and other documents indicates that the eight product improvement SIMs have been incorporated on the Unit 1, Division I and II diesel generators.

A continuing review will be performed for TDI SIMs as they are received to determine their applicability to the GGNS TDI diesels and appropriate actions taken, as deemed necessary.

TABLE 10-1

TDI PRODUCT IMPROVEMENT SIMS

SIM NO.	SUBJECT
64	1. Increase link rod torque - 735 to 1050 ft/lbs 2. Increase rod bolt torque - 1 1/2 in bolt 1200 to 1700 ft/lbs 1 7/8 in bolt 1800 to 2600 ft/lbs 3. Product improvement designed to increase reliability 4. Deletes SIM 270 5. Use in conjunction with SIM 332 6. Incorporated during "AF" piston skirt modification in November, 1981
307	1. Change in ring end gaps on new piston rings in 4 valve R & RV engines 2. Incorporated
313	1. Information on removing intake manifold supports on 4 valve RV engines to reduce oil leakage at the camshaft covers 2. Incorporated
324	1. Modification of type "AF" piston skirt 2. Incorporated on Unit 1, Unit 2 "AF" piston skirts have not been modified 3. The modified "AF" piston skirts have been replaced with the "AE" style piston skirts on the Unit 1, Division I and II D/Gs
324A	1. Information for reuse of piston crown studs 2. Incorporated
332	1. Newer harder washers on connecting rod bolts RV engines 2. Incorporated
360	1. Information on possible problem of air start valve capscrews being too long 2. Incorporated on Unit 1, Div I and II, tracking document issued for Unit 2
361	1. Information on potential problem with commercial grade cable in certain engines and panels 2. Incorporated on Unit 1, Division I and II engines - Cable replaced with Class 1E qualified cable, tracking document issued for Unit 2

11.0 QUALIFICATION/RELIABILITY DEMONSTRATION TESTING

11.1 HISTORY

All the GGNS Unit 1 diesel generators have been tested and qualified in accordance with the requirements of Regulatory Guides 1.9 and 1.108 and IEEE Std. 387-1977. The Division I and Division II engines were shop tested by TDI, including a 300 prototype test run on the Division I engine as required by IEEE 387-1977. On-site testing was done by Bechtel and MP&L before fuel loading in June, 1982. Since then the engines have been tested in accordance with the plant surveillance test procedures, as described in the plant technical specifications.

Augmented testing such as a 7-day performance run was performed on both of the TDI engines under a directive of MP&L management (Reference 10) before the present maintenance and parts replacement work was started in December, 1983.

To verify the operability and reliability of the Division I D/G following the D/G rework after the fire, the 18 month functional test was repeated for the Division I D/G. This additional 18 month functional test included the following:

1. Starting air receiver capacity test
2. Testing of D/G trips and response to ECCS actuation signals
3. 100% load rejection
4. Simulated loss of offsite power followed by the loss of and restart of the D/G
5. Simulated loss of offsite power in conjunction with ECCS actuation signals
6. 24 hour load test
7. LOP/LOCA test

This additional 18 month functional test was completed satisfactorily.

The following sections outline the recent tests that were performed on the Division I and II diesels following completion of maintenance work, before each of the two engines was returned to service.

11.2 REQUALIFICATION TESTING REQUIREMENTS

Testing requirements for modifications to a previously qualified diesel generator unit are set-forth in IEEE Std. 387-1977. The recent maintenance and parts replacement work on the two TDI diesels had no significant impact on engine specifications and design criteria, related subsystems, or engine performance characteristics. Nor, did these work activities involve changes in plant load characteristics

11.2 (Continued)

for the two TDI engines. No modification of the generator or related electric or instrumentation circuitry was performed. Therefore, none of the design considerations listed in Table-1 of IEEE Std. 387-1977 were modified or altered. As such, the various tasks performed during the current maintenance activities were considered minor design changes as defined by IEEE 387-1977 criteria. Appropriate testing was conducted to verify satisfactory operability of the engines.

11.3 REQUALIFICATION/DEMONSTRATION TESTING FOLLOWING PISTON SKIRT REPLACEMENT

The requalification testing is described in the following section.

11.3.1 To perform TDI's recommended breakin run, following the installation of the "AE" piston skirts, the engines were started and run at 300 rpm and no load for about 15 minutes. During this run the D/Gs were inspected to ensure that the rocker arms, valves, push rods, fuel injection pumps, nozzle holders, high pressure fuel injection lines and drip return headers were secure, functioning properly and that there were no fuel leaks. The engines were then stopped, the crankcase side door covers removed and various internal components checked for indication of excessive heat. The covers were replaced and the engines run at 20% load for about one hour. After this run the engines were inspected as above. The engines were then run at levels varying between 25% to 100% load for approximately 8 hours. After this run hot crankshaft web deflection checks were performed. The engines were then allowed to cool and another inspection as above was performed.

11.3.2 The load rejection tests were accomplished by performing Test #3 of Surveillance Procedure Nos. 06-OP-1P75-R-0003 and 06-OP-1P75-R-0004 "Standby Diesel Generator (SDG) 11 (12) 18 Month Functional Test". These tests demonstrated the capability to reject a full load (7000 kw) without exceeding speeds or voltages which could cause tripping, mechanical damage, or harmful overstresses.

11.3.3 In addition to the required testing, 24 hour run tests were performed; 2 hours at 110% load followed by 22 hours at 100% load. These tests demonstrated the capability of the D/G to carry the rated load for an extended period.

11.3.4 The starting, load acceptance and design load tests were accomplished by performing Surveillance Procedure Nos. 06-OP-1P75-M-0001 and 06-OP-1P75-M-0002, "Standby Diesel Generator (SDG) 11 (12) Functional Test". These tests demonstrated the ability of the D/G to start and reach rated frequency and voltage within 10 seconds after the start signal, the capability to be loaded to at least 100% load within 60 seconds and to operate for at least one hour at full load.

11.4 TESTING NOT REQUIRED FOR REQUALIFICATION

The main consideration in developing the requalification test program described in Section 11.3 above was that any engine component or subsystem that was replaced, modified or reworked would be adequately tested, followed by an integrated testing of the total diesel generator system. Accordingly, an engine component or subsystem that was not affected by the maintenance activities and was previously qualified, was not tested individually or in conjunction with engine testing.

11.5 D/G RELIABILITY ENHANCEMENT TESTING

MP&L has developed comprehensive maintenance programs and established operating practices to assure a high level of diesel generator reliability. This program was developed using vendor recommendations as well as good engineering practice and operating experience. This program covers the diesel generator as well as its supportive equipment.

Critical diesel generator parameters such as jacket water temperature, lube oil temperature, jacket water standpipe level, generator bearing oil level, turbocharger lube oil flow, starting air pressure, heater operation, and alarm checks are performed once per 8 hours; while other various supportive equipment is checked once per day by the Operations Department. These checks will assure that the diesel generators are in a satisfactory state, and that potential problems are identified.

During the monthly surveillance test, operating parameters are checked to verify that the diesel generator is operating as required. The generator operating parameters monitored are voltage, amperes, frequency, VARS, DC volts-field, DC Amps-field, RPM and watts. The engine operating parameters monitored are lube oil temperature and pressure, jacket water temperature and pressure, turbocharger lube oil pressure, lube oil filter differential pressure, fuel oil pressure, fuel oil filter differential pressure, combustion air pressure, crankcase vacuum, RPM cylinder temperatures, and exhaust stack temperatures. The monitoring of these parameters aids in detecting any problems which would affect engine operation and reliability.

11.6 ADDITIONAL DEMONSTRATION TESTS

Since the discovery of the failed crankshafts at Shoreham, additional testing/monitoring of the D/Gs at Grand Gulf has been implemented (Table 11-1). This includes the completion of a 7-day equivalent test run on both D/G units, 24 hour run tests (22 hours @ 100 percent and 2 hours @ 110 percent power), additional planned 100 percent power tests, monitoring of vibration levels by Technology for Energy Corporation (Reference 8), increased emphasis on pre-action planning sessions for persons involved in planned operational and maintenance activities and an improvement in the working relationship with TDI (Reference 10 and 11).

TABLE 11-1

SUMMARY OF QUALIFICATION AND VALIDATION TESTING

	REQ	ADDITIONAL DEMONSTRATION SURVEILLANCES
TESTING PRIOR TO INSTALLATION OF "AE" PISTON SKIRTS		
Qualification Testing (1)	X	
Preop Testing (2)	X	
Tech Spec Testing (3)	X	
18 Month Functional Test, Division I D/G		X
7-Day Equivalent Test		X
Vibration Test Runs		X
"AE" PISTON SKIRT INSTALLATION		
Piston Inspection		X
Crankshaft Inspection		X
Rod Bearing Inspection		X
Cylinder Head Inspection		X
TESTING FOLLOWING INSTALLATION OF "AE" PISTON SKIRTS		
Break-In Run	X	
Load Rejection	X	
24-Hour Run - 2 Hr @ 110%, 22 Hr @ 100%		X
Additional 100% Power Runs (Div I 101 Hrs, Div II 79 Hrs)		X
Monthly Surveillance	X	

(1) Qualification Testing includes 300 Start Prototype Tests Performed by TDI.

(2) Includes Starting, Load Acceptance, Overload, Design Load, Rejection, Reliability, Electrical and Subsystem Tests.

(3) Includes Monthly Surveillance and 18 Month Functional Tests.

12.0 SUMMARY

Specific actions have been taken to correct problems identified during testing of the Division I and II TDI diesel generators and to also evaluate and resolve problems identified to MP&L as a result of experience with TDI diesel generators at other nuclear installations. Significant actions that have been completed, or are planned, are as follows.

- The suspect modified type "AF" piston skirts in the Division I and II D/G have been replaced with new type "AE" pistons. The new type "AE" piston skirts were inspected prior to installation to assure they were free of the type of rejectable indications found on the type "AF" piston skirts and to establish documented baseline data for the new skirt. These actions serve to enhance the reliability of the GGNS Unit 1 TDI diesel generators.

- During removal of cylinder heads on the Division II D/G the stellite overlays on the exhaust valve seats on the #5 right bank cylinder were discovered to have cracks. There was also incomplete fusion on the intake valve seat of the #1 left bank head. Inspection of the Division I heads found six with rejectable indications. The eight heads with rejectable indications were replaced with heads that had no rejectable indications. To address a long term concern, a failure investigation has been initiated to determine the cause of the crack initiation and the crack propagation mode.

- As a result of the connecting rod bearing failure identified at Shoreham, MP&L initiated an inspection of the connecting rod bearings and connecting rods during the scheduled piston replacement on the Division II D/G.

  The inspection results indicate that the integrity of the bearings is good and not affected by previous service. A final analysis for chemical and physical properties is planned.

- Numerous weld failures between the D/G connector push rod ball and tube have been discovered. MP&L concluded that it was not likely that a failed push rod would result in engine failure. However, during a recent inspection one of the push rod balls was cracked in addition to the weld cracks. At this point a new replacement design was pursued. The new design has been determined to be acceptable by MP&L and replacements have been installed in the Division I and II diesels.

- Due to the crankshaft failure at Shoreham an engineering evaluation of differences in design between the Shoreham and GGNS TDI diesel crankshafts was performed. This evaluation shows that the potential for the type of failure experienced at Shoreham does not exist at GGNS. During the piston skirt replacement the Division I and II crankshafts were inspected. These inspections did not indicate defects of the type found at Shoreham.

12.0 (Continued)

- A fire in the Division I D/G room on September 4, 1983 was determined to be caused by the break of a low pressure fuel oil line. Analysis indicated that the line break was caused by a combination of unusual vibration loads imposed by a turbocharger that had been replaced several weeks before the fire, and the absence of any supports to isolate the Swagelok connector from vibration loads. Tubing supports were designed by MP&L and installed on the Division I and II diesel-generators.

- A 10CFR21 notification to the NRC by TDI dated July 20, 1983 identified a possible draw seam on the ID of high pressure fuel oil lines supplied on the Division I and II D/Gs. A high pressure fuel oil line on the Division I D/G also similarily failed. An analysis of the failed tubing attributed the failure to a manufacturing flaw (draw seam) in the tubing. The TDI letter of July 20, 1983 indicated that the failure occurred at approximately one million operating cycles and that fuel lines that have in excess of ten million operating cycles without failure are acceptable. Using this rationale, all of the original lines on the Division I and II D/Gs were considered to be free of flaws of this type, however, the replacement for the failed line 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.

- The generator on the Division II D/G was damaged and replaced in mid-year of 1982 when a head from a capscrew on the rear crankcase cover sheared off and entered the generator via the generator air gap. Protective screens have been installed on the Division I and II generator air gaps to prevent recurrence of damage to the generator from an incident of this type. Subsequent testing indicated that the problem of the capscrew shearing was unique to the Division II D/G and that the failure was due to low stress high cycle fatigue, however, test results were inconclusive as to the root causes of the vibration sources. High strength capscrews and tab washers were installed to extend the life of the capscrews. Periodically a capscrew will be removed from the crankcase covers and subjected to destructive analysis in an attempt to obtain further information for identifying the root cause.

- Following piston skirt replacement, qualification/reliability testing in accordance with IEEE Std. 387-1977 was performed on the Division I and II diesel generators. Testing of the D/Gs prior to this maintenance included the satisfactory completion of a 7-day equivalent test run on both D/Gs. Post maintenance testing included breakin runs, twenty-four hour runs, load rejection tests and surveillance tests. Additional post maintenance demonstration testing has resulted in approximately 125 hours at 100% load on the Division I diesel generator and 103 hours at 100% load on the Division II diesel generator.

13.0 CONCLUSION

In conclusion, the specific corrective actions, engineering evaluations and testing that have been completed, enhance the reliability of the D/Gs and provide assurance, with a reasonable level of confidence, that the GGNS TDI engines will adequately perform their required safety function.

14.0 REFERENCES

1. FaAA Preliminary Report on GGNS Modified AF Piston Skirts.

2. TDI Letter Dated 12-15-83 "Nuclear Power Plant Standby Diesel Generator User's Group Minutes of November 30, 1983, Meeting".

3. Metallurgical Evaluation of Diesel Engine Push Rod Weld From Grand Gulf Nuclear Station-Unit 1 Emergency Diesel Generator (Division I), prepared by Middle South Services.

4. TDI Response to MP&L for NRC Request of Additional Information on TDI D/Gs, Dated November 2, 1984.

5. Preliminary Standby Diesel Generator Crankshaft Design Analysis Review Grand Gulf Nuclear Station, prepared by Bechtel Power Corporation.

6. Metallurgical Evaluation of Diesel Engine Fuel Oil Line Failure from Emergency Diesel Generator - Division 1, Grand Gulf Nuclear Station - Unit 1, prepared by Middle South Services.

7. Metallurgical Evaluation of Diesel Engine Fuel Injection Tube from Grand Gulf Nuclear Station - Unit 1 Emergency Diesel Generator Prepared by Middle South Services.

8. Test Evaluation Report on the Grand Gulf Nuclear Station Division I and Division II Diesel Generators (TEC Report No. R-83-033), prepared by Technology for Energy Corporation.

9. Engineering Investigation of the Failure of Rear Crankcase Cover Capscrews for the Delaval Standby Diesel Generators at MP&L, GGNS, LETCO Job No. G-8847, Dated August 17, 1982, by Law Engineering Testing Company.

10. PMI 83/12569, J. P. McGaughy to J. B. Richard Letter on D/G Enhancement.

11. PMI 84/0210, J. E. Cross to J. F. Pinto Letter on Plant Staff Response to NRC D/G Questions.

12. AECM-83/0689 - GGNS Diesel Generator Reliability Report, October 26, 1983.

13. AECM-83/0724, GGNS Diesel Generator - NRC Request for Additional Information, November 15, 1983.

14. AECM-84/0030, GGNS Diesel Generator - NRC Request for Additional Information, January 18, 1984.

15. FaAA-83-10-2 PA07396 - Emergency D/G Crankshaft Total Stress Analysis Summary, February 2, 1984.

IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6″

IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6"

14.0 (Continued)

16. Bechtel Standby Diesel Generator Crankshaft Total Stress Analysis Summary, February 2, 1984.

17. FaAA-83-10-02 PA07396, Analysis of the Replacement Crankshafts for Emergency Diesel Generators, Shoreham Nuclear Power Station, October 31, 1983.

18. FaAA-83-10-16, PA07396, Emergency Diesel Generator Connecting Rod Bearing Failure Investigation Shoreham Nuclear Power Station, October 31, 1983.

19. AECM-83/0653, Applicability of Shoreham Diesel Generator Crankshaft Failure to GGNS, October 14, 1983.

ATTACHMENT 1 TO THE
FINAL REPORT ON GGNS
DIVISION I AND II TDI
DIESEL GENERATORS

RESPONSES TO SIXTEEN POTENTIALLY SIGNIFICANT PROBLEMS
IDENTIFIED IN TDI OWNERS GROUP
MEETING WITH THE NRC ON
JANUARY 26, 1984

FEBRUARY, 1984

1.0 INTRODUCTION

A meeting of the Transamerica Delaval, Inc. (TDI) diesel generator (D/G) owners group with the NRC Staff was held on January 26, 1984. During the meeting the owners group presented a slide summarizing significant potential problems with TDI diesels. These potential problem areas are detailed below:

- Crankshaft
- Connecting Rod Bearings
- Pistons
- Cylinder Heads
- Cylinder Liners
- Cylinder Block
- Engine Base
- Head Studs
- Push Rods
- Rocker Arm Capscrews
- Connecting Rods
- Electrical Cable
- Fuel Injection Lines
- Turbocharger
- Jacket Water Pumps
- Air Start Valve Capscrews

Further details of these concerns, their applicability to Grand Gulf, and their resolution are described in the following sections.

2.0 CRANKSHAFT

A summary of the concern and its resolution on Grand Gulf is provided in Section 6.0 of the Final Report.

3.0 CONNECTING ROD BEARINGS

A summary of the concern and its resolution on Grand Gulf is provided in Section 4.0 of the Final Report.

4.0 PISTONS

A summary of the concern and its resolution on Grand Gulf is provided in Section 2.0 of the Final Report.

5.0 CYLINDER HEADS

A summary of the concern and its resolution on Grand Gulf is provided in Section 3.0 of the Final Report.

6.0 CYLINDER LINERS

6.1 DESCRIPTION

A concern has been raised regarding cylinder liner damage in TDI D/Gs. One incident was listed for GGNS, AECM-82/157, dated April 15, 1982, which transmitted the final report on PRD-81/45 dealing with the separation of piston crown from the piston skirt during testing of the Division II D/G. An additional deficiency noted in this report was damage to a cylinder liner on the Division I D/G. The damaged cylinder liner was discovered during disassembly of the Division I D/G for corrective action for the piston skirt/crown separation.

The damaged Division I cylinder liner was found to be grooved in three places. These grooves were approximately 10 inches long and 1/16 inch deep. As indicated in the PRD final report, the grooving was probably caused by debris that entered the cylinder during assembly or initial startup.

6.2 ENGINEERING EVALUATION AND CORRECTIVE ACTION

The grooved cylinder liner was replaced with a new liner. The Division I lube oil was flushed and replaced and the lube oil sump was cleaned.

At a meeting between MP&L, LILCO and TDI on February 2, 1984, TDI indicated that the only case of a cylinder liner failure occurring without some other initiating event causing it, occurred on the ship

6.2 (Continued)

Columbia. This damage was attributed to the high vanadium content of the light-heavy fuel oil and the high ash content of the lube oil (heavy oil). Despite the cracking of the liner which resulted from the use of these oils, the engine continued to perform its function. The GGNS TDI diesels use light fuel oil with a lower vanadium content and utilize light lube oil.

During the recent piston skirt changeout on the GGNS Unit 1 TDI engines, the cylinder liners were subjected to a close visual inspection before and after honing the liners to receive the new rings. No obvious damage was discovered during these inspections.

6.3 CONCLUSIONS

Based on lube oil cleanup efforts, recurrences of the subject problem is considered to be resolved. To date, no known cylinder liner failure has been the root cause of a TDI engine failure.

Neither liner material, manufacturing process nor design are considered to be the root cause of the damage on the Division I GGNS engine.

Inspections of the Division-I and II D/G cylinder liners during the recent piston skirt changeout in December, 1983 did not reveal any indication of liner damage.

Based on the above conclusions and root cause, cylinder liner failure is not expected to occur at GGNS.

7.0 CYLINDER BLOCK

7.1 DESCRIPTION

The non-nuclear industry has reported cracks occurring in the area around the cylinder liner landing. Cracks may also propagate from the head stud/stud bore to the jacket cooling water passage. MP&L has also been recently advised of the discovery of cracks in the area of engine head studs on a cylinder block used in a nuclear application.

7.2 ENGINEERING EVALUATION

If this cracking were to occur and propagate into the jacket water passage it would be possible for an extremely low flow of jacket cooling water to come into contact with the head studs and cylinder head. This flow would be prevented from entering the cylinder by two spiral wound head gaskets. It is unlikely that jacket cooling water would enter the firing chamber (cylinder) and only a very slow loss of jacket cooling water to the outside of the engine would be evident.

To prevent this cracking, TDI has indicated that proper torque must be placed on the cylinder head studs.

7.3 CORRECTIVE ACTION AND CONCLUSION

MP&L considers that no corrective action is required for these conditions, since the postulated condition would not interfere with the operation of the engine and because the proper torque of 3600 foot-pounds, as recommended by TDI, has been applied to the head studs of the GGNS Unit 1 TDI D/Gs. Even if cracks were to occur they would be expected to propagate very slowly because of the large mass of metal in the cylinder block. However, MP&L will continue to closely follow the investigation findings of the TDI D/G owners group.

8.0 ENGINE BASE

8.1 DESCRIPTION

Linear indications have been found on the bearing base journal of several marine diesel engines. These indications were apparently caused by improper torquing of the bearing holddown studs during assembly of the engine.

8.2 CORRECTIVE ACTION

TDI issued SIM #286 to correct this problem. This fix resulted in an increased preload being placed on the holddown studs.

8.3 CONCLUSIONS

Grand Gulf's TDI D/Gs were assembled after SIM #286 was issued. GGNS installation of main bearing bolt nuts, as witnessed by GGNS Plant Quality, indicate that correct preload values were verified during recent engine disassembly at the site on all main bearing studs. This problem, therefore, is not expected to occur at Grand Gulf since no defects have been reported to have occurred in engines using the proper torque.

9.0 HEAD STUDS

This concern is related to the cylinder block concern described in Section 7.0 of this Attachment. Refer to this section for further details.

10.0 PUSH RODS

A summary of the concern and its resolution on Grand Gulf is provided in Section 5.0 of the Final Report.

11.0 ROCKER ARM CAPSCREWS

11.1 DESCRIPTION

Shoreham has experienced problems recently with fatigue failure of a rocker arm capscrew.

11.2 ENGINEERING EVALUATION AND CORRECTIVE ACTION

The failure at Shoreham was apparently caused by undertorqued poor quality capscrews. New capscrews made of ASTM A-193 material were installed and torqued to specified torque values to correct the problem at Shoreham.

11.3 CONCLUSIONS

GGNS rocker arm capscrews have not experienced this type of failure after greater than 10^7 cycles of operation. Since these capscrews are original components of the diesels, and have been properly torqued to 365 ft-lbs, no failures of this type are expected to occur at GGNS.

12.0 CONNECTING RODS

12.1 DESCRIPTION

TDI has informed MP&L of several incidences of connecting rod failure. At a meeting between MP&L, LILCO and TDI, on February 2, 1984, TDI defined the historical problem with connecting rods. Cracking of the connecting rod link assembly in a master rod-longitudinal plane through the bottom of upper bolt holes (See Figure A12-1) has occurred on several non-nuclear applied diesel engines built by TDI.

12.2 ENGINEERING EVALUATION AND CORRECTIVE ACTION

TDI Vee-type engines of a comparable size to GGNS Division I and II utilize either 1 1/2 or 1 7/8 inch connecting rod bolts. The original design of the GGNS engines (TDI's earlier design) uses the larger of the two bolt sizes. TDI originally specified that these bolts should be torqued to 1800 foot-pounds.

TDI initiated an evaluation of the problem based on the operating history of the engines with failed or cracked connecting rods. For example, several instances of connecting rod cracking were reported to have occurred in a marine diesel on the ship Columbia. The average hours of operation between occurrence was approximately 10,000 hours. Evidence of fretting in the "rack-teeth" almost always accompanied connecting rod failure or cracking.

The first design change to remedy the situation was a decrease in the connecting rod bolt diameter to 1 1/2 inches. Decreasing the connecting rod bolt diameter effectively increased the amount of base metal where cracking was occurring. Since the cause of the cracking was thought to be relative motion between the rod parts and flexure of connecting rod parts, an increase in the base metal adjacent to the crack initiation site should increase stiffness and hence decrease incidence of cracking or failure.

A decrease in cracking frequency was noted. However, connecting rods using both 1 1/2 and 1 7/8 inch bolts were still reported exhibiting cracking. It was then thought that fretting of the "rack-teeth" was due to lack of clamping force between the connecting rod link and the master rod and box assembly. TDI issued Service Information Memo (SIM) 64 to rectify the suspected clamping force problem. SIM 64 effectively increases the required torque on 1 1/2 and 1 7/8 inch connecting rod bolts from 1200 to 1700 foot-pounds and from 1800 to 2600 foot-pounds, respectively. This design change greatly reduced the reported cases of connecting rod cracking.

12.2 (Continued)

The GGNS Division I and II engines were originally assembled at the vendor's shop using the pre-SIM 64 torque values. Therefore, the GGNS engines have been run part of the present total sum times with the connecting rods torqued to pre-SIM 64 torque values and the balance at post SIM 64 torque values. The table below indicates the approximate run times on the Division I and II engines before and after SIM 64 was implemented:

	Division I	Division II
At Assembly	0	0
Before SIM 64	332	44
After SIM 64	939	768
Present Run Times	1271	812

At a recent TDI D/G owners group component selection committee meeting, the owners group diesel generator specialists agreed that the type of cracks reported by TDI would propagate very slowly. The cracking of connecting rod parts on non-nuclear diesel engines were reported to have occurred at relatively large run times (greater than 10,000 hours).

12.3 CONCLUSIONS

To date, all engines using the 1 7/8 inch connecting rod bolts exhibiting failures or cracking have been suspected of being undertorqued. Further, no known failures have occurred on connecting rods using 1 7/8 inch bolts that were properly torqued. All torques used on the subject bolts at GGNS have been verified to be in accordance with SIM 64.

Based on low probable propagation rate of incipient cracks, relatively low run hours on Division I and II at pre-SIM 64 torques, and the expected low future run times, (estimated 200 hours/year) deleterious cracking of the GGNS connecting rods is not expected.

FIGURE A12-1: Articulated Connecting Rod Assembly

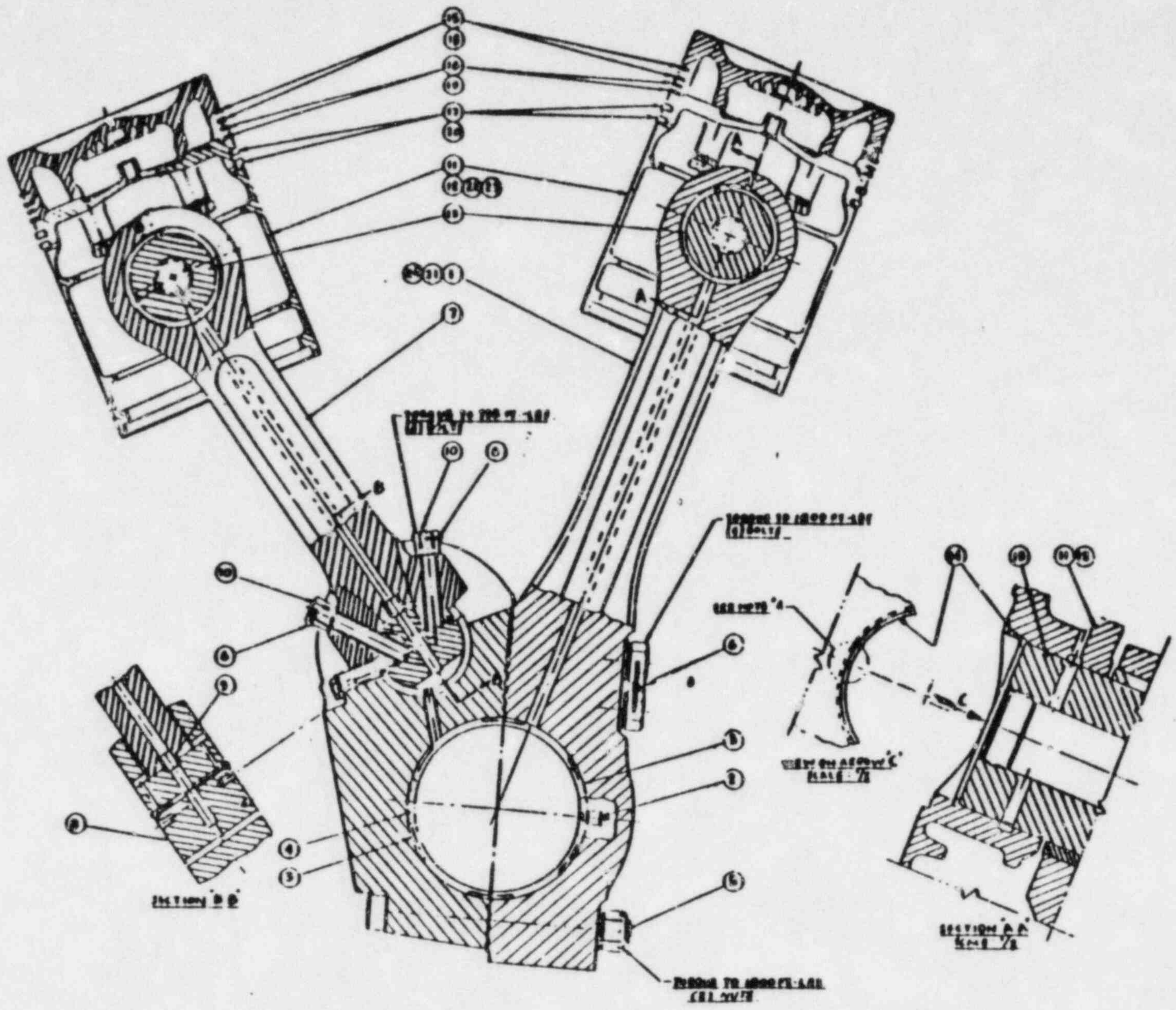


Fig. A12-1

13.0 ELECTRICAL CABLE

13.1 DESCRIPTION

Memo (SIM) No. 361 concerning certain Class 1E cable which failed the IEEE 383-1974 insulation flame test was issued by TDI. The content of this SIM is detailed in Table 10-1. This SIM identified the affected cable as being the shielded cable from the terminal block to the Airpax tachometer relay in the engine control panel, the shielded cable from the Airpax magnetic pickups to the junction boxes on the side of the engine and the multiconductor cable from the engine side mounted junction box to the Woodward governor actuator.

Another notification from Delaval received by MP&L on October 20, 1983 (API-83/0974), idicated that the manufacturer's temperature rating for the cable insulation may be exceeded during operation of the diesel generator. Delaval recommended that these cables be replaced with 90° rated cable.

13.2 ENGINEERING EVALUATION AND CORRECTIVE ACTION

It was determined by Nuclear Plant Engineering that this potential deficiency could create a substantial safety hazard. A Design Change Package (DCP-82/3196) was implemented for Unit 1 in which the installed commercial grade shielded cable on the Division I and II D/Gs was replaced with Class 1E IEEE 383-1974 qualified cable.

Further investigations into the problem subsequently revealed that Bechtel Design Specification M-018.0, Section 6.8.2.6, calls for compliance with Design Specification Appendix N which requires compliance with IPCEA Publication No. S-19-81, Section 6.

In responding to API-83/0974 it was determined that the affected cable had previously been replaced on the Unit 1, Division I and II D/Gs. Therefore, no further action was initiated for Unit 1. Bechtel has issued NCR 6762 to track this concern for the Unit 2 D/Gs.

13.3 CONCLUSIONS

This issue is considered closed for the Unit 1 D/Gs. The replacement electrical cable meets the appropriate requirements of IEEE 383-1974 and TDI's recommended temperature rating.

14.0 FUEL INJECTION LINES

A summary of the concern and its resolution on Grand Gulf is provided in Section 8.0 of the Final Report.

15.0 TURBOCHARGER

15.1 DESCRIPTION

Turbocharger vibration has been identified as the cause of several problems with D/G engine mounted components.

Turbocharger abnormalities resulted in broken mounting bolts. When the turbocharger is not anchored correctly, the intercooler and the jacket water pir~~ are forced to partially support the turbocharger and thereby absor~ a larger amount of fatigue stress. This stress would normally be absorbed by the turbocharger mount. Since neither of these two auxiliaries was designed to support the turbocharger, they both developed cracks and broken welds.

Table 15-1 presents a summary of past problems, causes, and corrective action taken. Further details are provided below:

15.1.1 CRACKED WELDS AND BASE METAL ON INTERCOOLERS

Cracks developed in the base metal on the top of the intercooler along an extruded seam. This seam has since been redesigned by Delaval and a piece of flat bar stock welded over the top of the extruded vee shape to stiffen it. The stay rods extend from one side of the intercooler to the other through a heavier block of steel on the outside. The rod is then welded to this heavier block, this is the weld which broke on the right bank intercooler. Several other stay rods were observed to have deficient welds and were also cut out and rewelded.

15.1.2 CRACKED WELDS ON JACKET WATER PIPING

There were several cracked welds which developed on flanges and fittings where the jacket water system ties into the turbochargers. Since more than one repair was necessary the header was refabricated using standard pipe, fittings, and ASME Section III Welding & NDE Criteria in order to work with codes with which MP&L maintenance and engineering personnel were acquainted.

15.1.3 LOW PRESSURE FUEL OIL HEADER FAILURE

On September 4, 1983, the main fuel oil line feeding the Division I engine headers failed due to fatigue. The oil sprayed onto the turbocharger exhaust gas header transformation piece and ignited. All affected components were repaired or replaced. The failed tube and Swagelok fitting were subjected to a metallurgical evaluation, and the cause of the failure was identified as high cycle fatigue compounded by the absence of tubing supports. Further discussion is provided in Section 7.0 of this final report.

15.1.4 TURBOCHARGER MOUNTING BOLT FAILURES

There have been several instances of turbocharger mounting bolt failures on the GGNS Division I D/G left bank turbocharger.

15.1.5 INDUSTRY EXPERIENCE

Turbocharger problems at other nuclear plants have also been experienced. Recently, Shoreham has experienced a failure of turbocharger thrust bearing in two of their engines.

15.2 ENGINEERING EVALUATION AND CORRECTIVE ACTION

The Division I D/G left bank turbocharger has exhibited signs of unusual vibration and misalignment in the past. Improper turbocharger alignment and running of the engine with broken/missing turbocharger mounting bolts, has produced conditions conducive to fatigue crack initiation and propagation in adjacent supports and components.

During the rework of the Division I engine after the fire, the turbochargers were removed and re-seated twice before proper fitup was attained. The result was an engine that had no noticeable areas of high vibrations, as attested-to by Technology for Energy Corporation when they instrumented the Division I and Division II engines after the fire rework was completed.

Thrust bearing failures similar to those at Shoreham have not been identified at GGNS and are not expected because of the differences in design of the lubrication systems. The failures of the turbocharger thrust bearings at Shoreham have been attributed to probable lack of lubrication during manual engine starting.

Shoreham's TDI D/Gs lube oil systems utilize two pumps, one an engine driven pump and the other an electric driven heater pump (See Figure 15-1). The GGNS D/Gs lube oil system utilizes three pumps, one an engine driven pump, one an electric driven heater pump and the other an electric driven auxiliary pump (See Figure 15-2).

Presently, on a manual start Shoreham does not have the means of supplying oil to the turbocharger thrust bearing other than through a turbocharger lube oil drip system. The turbocharger lube oil drip system is also used at GGNS and is essentially the same as Shorehams. However, prior to a manual start of the D/Gs at GGNS the engine is prelubed for two minutes or less with the auxiliary lube oil pump which pressurizes the turbocharger thrust bearing with lube oil. This precludes the type of failures reported at Shoreham.

There have been several occasions when the Division I D/G left bank turbocharger mounting bolts have failed. The main reason for these failures has been misalignment of the turbocharger with its associated piping and components. The recent failures can also be attributed to misalignment. An engineering evaluation of the turbocharger mounting arrangement is being performed and procedures designed to preclude misalignment have been implemented.

15.3 CONCLUSIONS

The susceptible areas in the piping and components around the turbochargers have been identified by past failures. The integrity of these areas has been enhanced by the use of approved ASME code welding, procedures, and materials during rework. Since these enhancements, the weld and component failures have not reoccurred.

With implementation of the alignment procedures, future failures of the mounting bolts are not expected. Upon completion of the engineering evaluation of the turbocharger mounting arrangement any required design changes will be implemented and reported to the TDI D/G owners group for generic consideration.

TABLE 15-1

ENGINE MOUNTED COMPONENTS PROBLEMS

CAUSED BY TURBOCHARGER VIBRATION

ITEM	DESCRIPTION OF PROBLEM	CAUSE	CORRECTIVE ACTION
1	Cracked welds and base metal cracks on intercoolers.	Fatigue compounded by high vibration from turbocharger.	Repaired welds and base metal cracks. Reseated turbocharger to eliminate undue stresses caused by misalignment.
2	Cracked welds on jacket water flanges and piping headers.	Fatigue compounded by high vibration from turbocharger.	Repaired welds. Refabricated header to ASME III Class 3 reseated turbocharger.
3	Low pressure fuel oil header failure resulting in Div I fire.	Fatigue compounded by high vibration from turbocharger.	Replaced fuel line and fittings reseated turbocharger.

FIGURE 15-1: Illustration of Shoreham TDI Diesel Generator Lube Oil System

(Reference Telecon Shoreham)

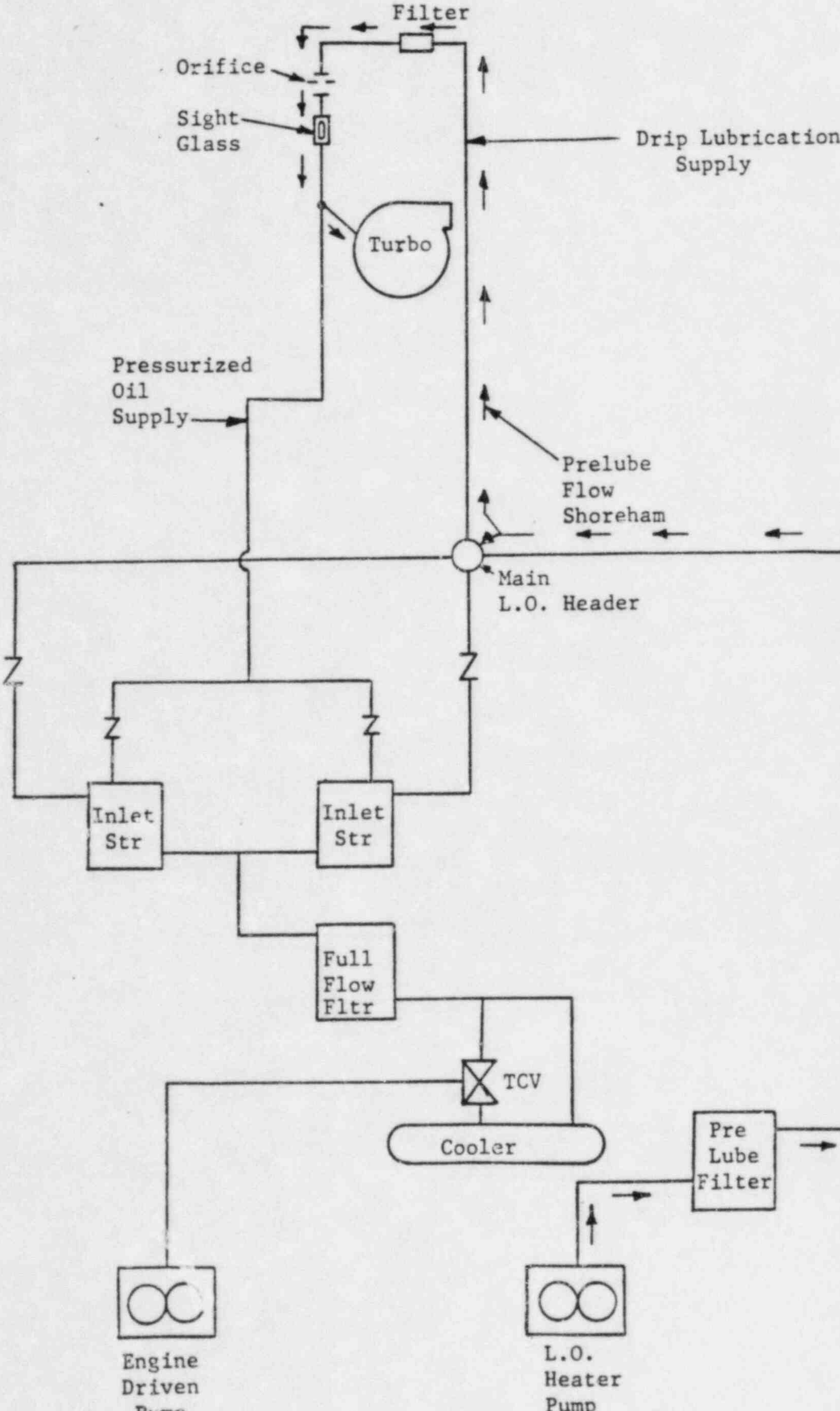


Fig. 15-1

FIGURE 15-2: Illustration of GGNS TDI Diesel Generator Lube Oil System

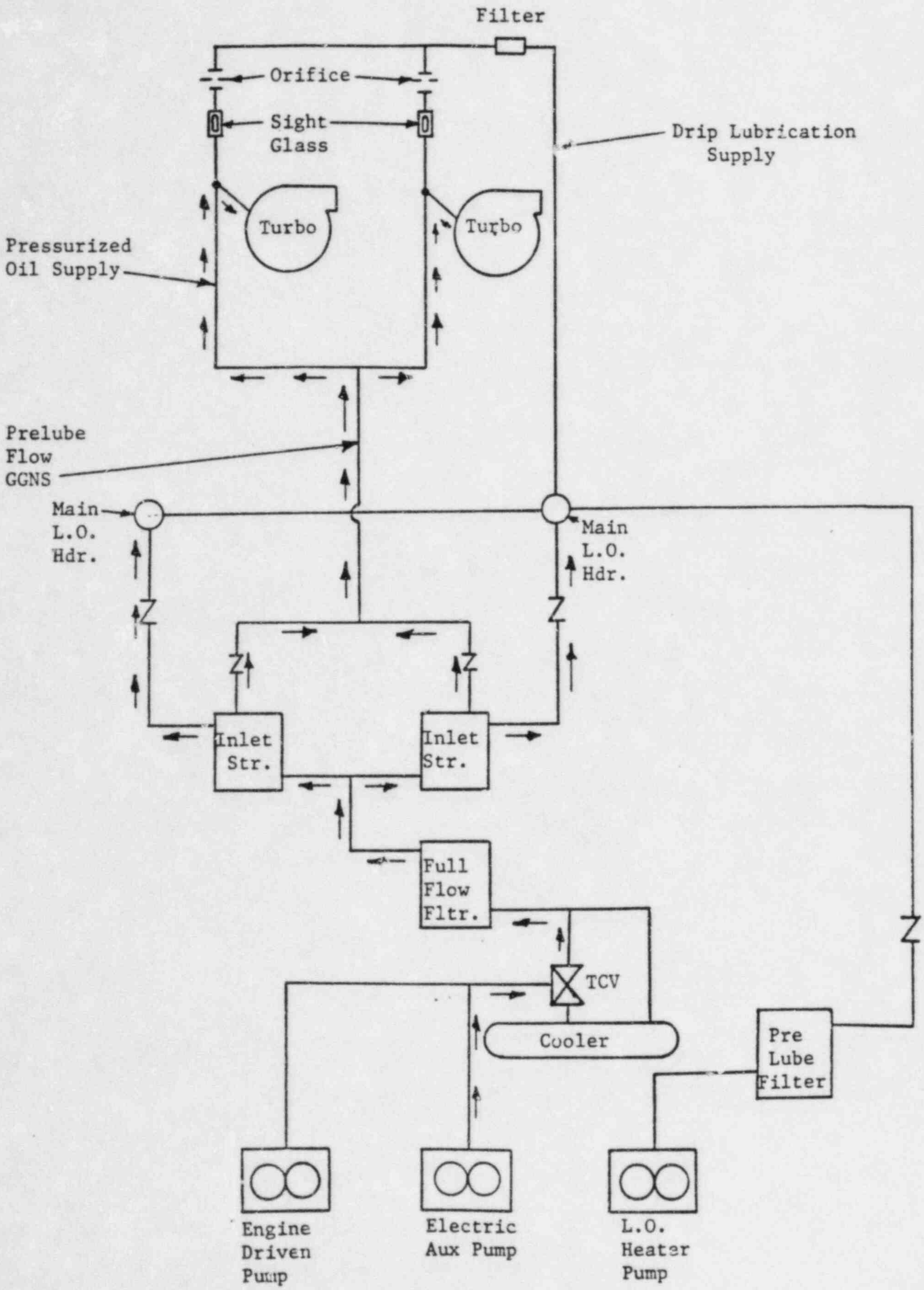


Fig. 15-2

16.0 JACKET WATER PUMPS

16.1 DESCRIPTION

Shoreham has experienced a jacket water pump shaft failure.

16.2 ENGINEERING EVALUATION

This problem apparently affects only the in-line engines. No jacket water pump shaft failures have been reported on Vee-type engines to date.

16.3 CONCLUSIONS

As of this time, MP&L has been unable to obtain evidence of generic jacket water pump shaft failures on DSRV-16-4 engines.

Since this problem appears to be unique to in-line engines, it has not and is not expected to occur on the GGNS diesel engines.

17.0 AIR START VALVE CAPSCREWS

17.1 DESCRIPTION

On May 13, 1982, TDI reported a potential defect concerning the capscrews that are used to retain the air start valves in the cylinders heads to the NRC under the provisions of 10CFR21. The 3/4-10x3 inch long capscrews were suspected of bottoming out in the tapped holes in the cylinder heads. This could result in insufficient or unequal clamping forces being applied to the air start valve.

17.2 ENGINEERING EVALUATION AND CORRECTIVE ACTIONS

TDI recommends replacement with 2 3/4 inch long capscrews or machining 1/4 inch off the existing 3 inch capscrews. A design change was issued by MP&L to implement corrective actions. The air start valve capscrews on the Unit 1, Division I and II D/Gs were modified by machining 1/4 inch off the length.

17.3 CONCLUSIONS

Corrective action is considered complete in regards to the air start valve capscrew problem on the Unit 1 D/Gs.

ATTACHMENT 2 TO THE
FINAL REPORT ON GGNS
DIVISION I AND II TDI
DIESEL GENERATORS

PISTON MANUFACTURING DETAILS

FEBRUARY, 1984

ATTACHMENT 2 TO THE
FINAL REPORT ON GGNS
DIVISION I AND II TDI
DIESEL GENEPATORS

PISTON MANUFACTURING DETAILS

FEBRUARY, 1984

ATTACHMENT 2

PISTON MANUFACTURING DETAILS

1.0 GENERAL

As reported by TDI (Reference 2), all 450 RPM rated "Enterprise" R-4 series engines have been furnished with two-piece pistons which incorporate a cast steel piston crown attached to a cast modular iron piston skirt by means of four studs. This piston design has evolved since its inception in 1969 to incorporate design improvements for high reliability and less costly manufacture. As horsepower ratings of engines increased in the mid-1960's, Transamerica Delaval and other medium speed diesel engine manufacturers abandoned the older style single piece piston design. The two piece piston is inherently better equipped to deal with the higher thermal inputs of high Brake Mean Effective Pressure (BMEP) engines, because it allows thermal growth of the crown without causing excessive bending stresses in the skirt. The two piece piston design is also better equipped to handle the higher pressure and inertia loadings of the increased horsepower engines. The modular iron skirt has passed through several design changes. Five different designs have been used and are identified by TDI terminology as "AF", modified "AF", "AN Old Style", "AN New Style", and "AE".

2.0 GGNS BACKGROUND

Only the "AF", modified "AF" and "AE" piston skirts have been used at GGNS. The "AF" piston skirts were originally supplied by TDI on the Division I and II GGNS engines. When problems were encountered with material quality of the washers (piston crown/skirt bolt) and GGNS experienced a piston crown/skirt separation, MP&L responded by upgrading hardware in accordance with SIM 324 to the modified "AF" piston skirt design. The cracking discovered later on Shoreham modified "AF" piston skirts and rejectable indications found at inspection prompted MP&L to change out all piston skirts at GGNS to the latest "AE" design piston skirts.

3.0 PISTON TYPES

3.1 "AF" AND MODIFIED "AF" PISTON SKIRTS

"AF" piston skirts use spherical washers on the four studs which attach the crown to the skirt. These spherical washers provide fastener flexibility. These commercially supplied washers proved to have inconsistent quality and large variations in heat treatment and manufacturing tolerances. As a result, a small number of the washers failed in service, resulting in piston, skirt/crown separation. One such separation occurred on the Division II D/G during field testing. To solve the spherical washer problem, the design was modified to incorporate a "full stack" Belleville washer arrangement resulting in a modified "AF" piston skirt.

3.1 (Continued)

The "AF" style piston skirt casting received the following heat treatment:

- Heat to 1750 degrees F. (near the upper critical temperature) for 3 hours. Normalize (air cooled) in still air. This results in a pearlitic structure with 100,000 psi tensile strength.

- Re-heat to 1050 degrees (slightly below the lower critical temperature) for 3 hours and cool in still air. This tempering process produces the desired ductility in the nodular iron.

3.2 "AE" Pistons

The "AE" piston, the latest R-4 piston skirt design, just concluding research development testing, incorporates the field experience on the R-4 series engine and the R-5 series engine.

The "AE" design utilizes a "half stack" Belleville washer arrangement. All "AE" skirts are heat treated to produce stress relieved 100,000 psi tensile strength nodular iron. All piston skirts in the TDI units at GGNS Unit 1 have been replaced with this design. The "AE" style skirt is interchangeable with existing R-4 piston crowns and requires only minor hardware changes.

FIGURE A2-1: PISTON COMPARISONS

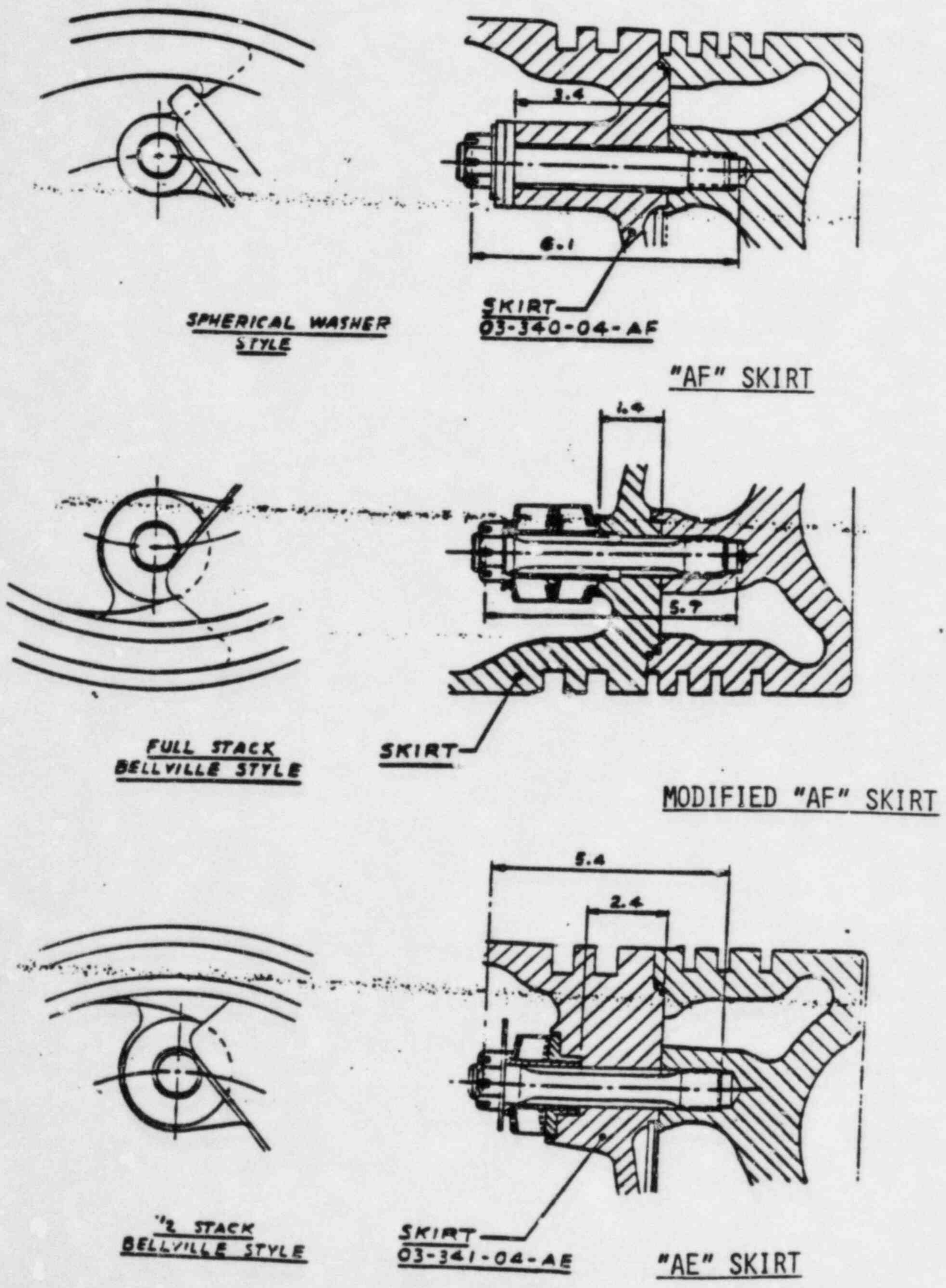


Fig. A2-1

REPEAT SUBMITTAL OF SELECTED MP&L RESPONSES

Based on discussions between MP&L and the NRC Staff in the meeting of January 27, 1984, and more recently in several telephone conversations, MP&L is providing in this attachment copies of selected responses to NRC questions. This information is being provided here as a matter of convenience, such that the majority of information necessary to support the NRC review is provided in one submittal. These responses were originally provided in MP&L letter AECM-83/0724, dated November 15, 1983, with the exception of the response to Question 430.17, which was provided in AECM-84/0030, dated January 18, 1984.

Previous MP&L responses containing subject matter not adequately covered by Attachment 3 to this submittal are included in this attachment. Any previous responses containing information no longer current were specifically excluded.

430.1 "Provide a copy of the procurement specifications to which the standby diesel generators (DG) were ordered."

RESPONSE

Copies of the original bid specification (Specification 9645-M-018.0, Rev. 1) and the original purchase specification (Specification 9645-M-018.0, Rev. 2) were provided as Attachments 2 and 3, respectively, to the MP&L letter, AECM-83/0724, dated November 15, 1983.

430.2 "Provide the performance specification and inspections performed upon receiving the DGs to show that the procurement specifications were met."

RESPONSE

The performance specification is the same as the procurement specification; the original procurement specification is provided as Attachment 2 to the response to Question 430.1. In the QA program, items upon receipt are examined for identification, quantity, damage, packaging, the presence of the appropriate documentation and surveillance inspection release by the Bechtel Supplier Quality Representative. With respect to the receipt of the diesel generators, the receiving inspection plan was as follows:

1. Performed preliminary visual inspection prior to unloading. Inspected for environmental damage, tie down failure, or rough handling.

2. Checked component physical markings for conformance to Specification 9645-M-018.0, i.e., fitted with permanent nameplates bearing its rating.

3. Verified packaging and shipping met ANSI N45.2.2, Level C requirements.

4. Visually inspected diesel generator for completeness and physical damage:

   a. Checked external and internal accessible areas for detrimental gouges, dents, scratches and burns.

   b. Checked for cracks in engine.

   c. Checked for crimps in tubing.

5. Reviewed documentation per Appendix B to Specification 9645-M-018.0 (G321C).

   a. Checked for supplier's signature in block 21 and Bechtel Supplier Quality Representative's signature in block 22 of the G321C, as evidence that the diesel generator was fabricated, tested, and inspected in accordance with the requirements of the specification, applicable codes, drawings, and purchase order.

   b. Checked to ensure that the documentation referenced by the vendor on G321C, Category No. 8 was received and legible.

Through the Bechtel Supplier Quality Representative, who performed surveillance during the manufacturing of the diesel generator, TDI's compliance to the procurement documents was also verified. The representative's activities, which primarily consisted of witness and hold points, were performed as follows:

Witness Points

1. Non-Destructive Examination (NDE) was witnessed on a first operation basis for each required examination. Magnetic particle examination was performed on the crankshaft.

2. Fit up and welding were witnessed on a first operation basis for each approved procedure on the fuel oil system.

3. Visual inspection for internal cleanliness was performed on the tube bundles for the lube oil and jacket water heat exchangers and on the air starting tanks.

4. At 30% completion, a review of the diesel generator assembly was performed.

5. A visual inspection, after operational testing, was performed for evidence of bearing wipage. This witness point was conducted in conjunction with the final inspection hold point.

6. Surface preparation prior to coating and final coating was witnessed on the diesel generators and various attachments to the diesel generators.

Hold Points

1. Pressure tests were witnessed on the engine blocks.

2. Operational and Functional tests were witnessed as follows: 300 start tests (at various starts); Sequential Load test; Load Rejection test; Margin test; Functional tests; Endurance tests; Load Capacity test; Accoustical test; Operational test (Field Currents); Starting Bottle Capacity test; Starting Air Compressor Capacity test; Torsiograph test.

3. Hydrostatic tests were witnessed on various components, i.e., heat exchangers, air starting tanks, engine blocks.

4. Final inspection on the completed diesel generators was performed with the following characteristics verified: visual inspection of materials; field connection type; size and orientation; coupling alignment; grounding connection; accessibility; cleanliness; coating; marking; tagging; and preparation for shipment.

5. Documentation was reviewed for completeness and accuracy.

430.3 "Identify the materials used in the design of the DGs at your plant (specifically limiting components such as crankshafts, camshafts, rocker arms, bearing materials, cylinder blocks, cylinder heads, pumps, turbochargers, etc.). Discuss how you assured yourself that design materials used in the manufacture of your DGs were as stated and in accordance with materials described in the TDI proposal and your purchase specifications."

RESPONSE

The diesel generator purchase specification did not specifically identify materials of construction for the diesel generator. For certain items specific material requirements were identified by the various codes and standards referenced by the purchase specification. Diesel generator materials were specified by the manufacturer based on manufacturing experience and on the codes and standards referenced by the purchase specification. Assurance was provided by verifying the implementation of the Transamerica DeLaval, Inc. (TDI) Quality Assurance Program through audits. Prior to the start of and throughout the diesel generator fabrication cycle, Bechtel performed audits of the TDI Quality Assurance Program. Each of the audits performed during the fabrication cycle verified (through sampling) that TDI's system for the identification and control of material, parts, and components was being implemented.

Another source of assurance was provided by surveillance inspection. Bechtel reviewed (at the TDI facility) the material certification for ASME pressure retaining parts of the diesel generator system and certificates of complience for all other materials of the diesel generator system, in accordance with the procurement specification. These documents were found to be in compliance with the procurement specification.

The materials used in the design of the diesel engine components identified above (not including auxiliary components) are identified in Table 1.

Response to Question 430.3

TABLE 1
Diesel Generator Design Materials

ITEM	DESCRIPTION	MATERIAL SPECIFICATION	(1)	(2)	(3)	(4)	(5)
A	Crankshaft	Steel Forging ASTM A668E	X	X	X	X	X
B	Main & Con Rod Bearings	Aluminum Perm Mold Casting Alloy B 850-T5	X	X	X	X	X
C	Cylinder Block	Grey Iron Casting ASTM A 48 Class 40	X	X	X	X	X
D-1	Camshaft	C.F. Ground Shafting AISI C-1045 Steel	-	-	-	-	-
D-2	Cams	Steel Forging AISI B620	X	X	X	-	X
E	Cylinder Head	Steel Casting ASTM A216 Gr. WCB	X	X	X	X	X
F	Rocker Arms	Ductile Iron Casting ASTM A536 Gr. 65-45-12	X	X	X	X	X

(1) Heat/Series Number Material Specification

(2) Physical Requirements

(3) Chemical Requirements

(4) Test Coupon

(5) Certification

430.5 "If applicable, provide responses to all NRC open items on standby DGs at your plant."

RESPONSE

In Supplement 4 to the Grand Gulf Nuclear Station Safety Evaluation Report (SSER4), dated May 1983, the NRC concluded that License Condition 2.C.(33) of Operating License NPF-13 should be revised to reflect two open items. As stated in SSER4, the revisions to operating License NPF-13 should read as follows:

"(1) Paragraph (a)(2) should read: 2.C.(33)(a)(2) Provide confirmation acceptable to the NRC that HPCS diesel engine skid-mounted and standby diesel engine auxiliary systems piping has been satisfactorily tested at a minimum hydraulic pressure equal to 125% of design pressure.

(2) Add (3) to paragraph (a) to read: 2.C.(33)(a)(3) Upgrade the combustion air intake and exhaust system for the standby diesel engines to meet the augmented Quality Group D requirements."

The responses to items (1) and (2) above are provided in Attachments 1 and 2 to this response, respectively.

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) 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 the 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 skid-mounted piping that is required for the safe operation of the diesel generators has been hydrostatically tested, as previously committed by MP&L, and in compliance with ANSI B31.1.

Attachment 2 to Response to Question 430.5

Application of Augmented Quality Group D Requirements to Standby Diesel Engine Combustion Air Intake and Exhaust System

In a January 16, 1975 meeting between representatives of Mississippi Power & Light Company and the Nuclear Regulatory Commission staff and in subsequent communications, it was agreed that MP&L would provide the design criteria to be used in the purchase of the diesel generator auxiliaries (Division I and II) for the Grand Gulf Nuclear Station.

On February 14, 1975, MP&L provided the NRC (reference AECM-75/11), with information which stated that the following diesel generator auxiliary systems would be designed as seismic Category I and Quality Group D:

1. Starting Air;
2. Lube Oil;
3. Jacket Cooling Water.

Additionally, MP&L committed to augment the Quality Group D design requirements of these diesel generator auxiliary systems as follows:

1. The assembly of the diesel generator auxiliary systems will be performed by qualified welders under the provisions of the QA program covering the design and fabrication of the diesel generators;
2. Hydrostatic testing of system piping and valves will be in accordance with the requirements of ANSI B31.1;
3. Liquid penetrant examination of welds in piping 4" in diameter and larger will be performed.

During the course of these discussions related to diesel generator auxiliary systems, additional supplemental requirements for the combustion air intake and exhaust system were not imposed.

During this same period, Section 3.2.2 of the Standard Review Plan (SRP) (NUREG-75/087), "System Quality Group Classification," stated that diesel generator auxiliary systems were important to safety for BWRs. These "auxiliary systems" were not defined by the NRC. Additionally, Section 9.5.8 of the Standard Review Plan, "Emergency Diesel Engine Combustion Air Intake and Exhaust System," did not specify a Quality Group C classification. In July 1981, Standard Review Plan Sections 3.2.2 and 9.5.8 were revised. SRP Section 3.2.2 defined auxiliary systems and specifically called out combustion air intake and exhaust. SRP Section 9.5.8 required that piping associated with the combustion air intake and exhaust system be classified as Quality Group C.

On August 21, 1981, MP&L received NRC Question 260.2, which required the addition of the diesel engine combustion air intake and exhaust piping to the operational quality assurance program. FSAR Amendment 51, dated November 1981, stated that although this piping was non-safety related, it would be added to the operational quality assurance program. On August 26, 1981, (reference AECM-81/324), MP&L responded to draft NRC Safety Evaluation Report concerns. This response stated in part:

"...Unlike these other diesel generator auxiliary systems which benefit from higher quality requirements imposed on the pressure boundary, the combustion air intake and exhaust system would not benefit from higher quality due to the mild service conditions.

The existing Quality Group D and seismic Category I classification is commensurate with the service conditions imposed on the combustion air intake and exhaust system and adequately ensures the integrity of the system..."

As stated in AECM-82/459, dated August 9, 1982, the standby diesel generator combustion air intake and exhaust system incorporates significant design margin based upon actual service conditions, i.e., pressure and temperature. ANSI B31.1 minimum thickness calculations were performed for design and service conditions for the exhaust piping. Table 1 presents a comparison of design requirements versus actual service requirements for both intake and exhaust piping. The existing design margin has been translated to a percentage overdesign. The status of components in the intake and exhaust piping, such as the intake air filter, intake air silencer and exhaust air silencer was further investigated; these components are designed for low pressure, are non-safety related, and procured by the diesel manufacturer from sub-vendors. The sub-vendors were contacted to ascertain the pressure rating of these components. Based on their experience, American Air Filter indicated that the intake air silencer is capable of withstanding 2 psig. Maxim Silencer Products indicated that the exhaust silencer is capable of withstanding 5 - 10 psig. American Air Filter indicated that the intake air filters are designed for a maximum pressure drop of 3 inches of water; based on their experience, the highest pressure drop experienced in an installed diesel generator application was 20 inches of water; this high pressure drop occurred as a result of filters which were not cleaned for an extended period of time. American Air Filter further indicated that pressure in excess of a few psig would be unlikely, since this condition would correspond to the condition of combustion air starvation.

It is apparent that the licensing basis for the diesel generator auxiliary systems has been in a state of evolution. The scope of higher quality group systems (i.e., jacket water, lube oil and starting air) was previously agreed upon by MP&L and the NRC. The standby diesel engine combustion air intake and exhaust system was not included in the group of systems for which augmented Quality Group D requirements were imposed.

Based on the design margins for the pipe wall thickness, operational quality assurance program for the piping, maximum operating pressures of -0.5 to 1.0 psig, low pressure rating of the components, the standby diesel generator combustion air intake and exhaust system conforms to those commitments previously made by MP&L.

TABLE 1

BECHTEL SUPPLIED INTAKE AND EXHAUST
PIPING FOR THE STANDBY DIESEL GENERATOR

Pipe Description	Pipe Size (in.)	Design Temp. (°F)	Design Pres. (Psig)	Normal Operating Temp. (°F)	Normal Operating Press. (Psig)	Maximum Operating Temp. (°F)	Maximum Operating Press. (Psig)	Calculated Min. Wall (in.) Design*	Calculated Min. Wall (in.) Oper.**	Existing Pipe Wall (in.)	% Excess Pipe Wall Design*	% Excess Pipe Wall Oper.**
Air Intake from Filter to Silencer 24" JBD-407	24	150	125	120	-0.5	120	-0.5	0.180	0.081	0.375	108%	363%
Exhaust Pipe from Manifold to Silencer 24" JBD-408	24	800	125	720	0.5	760***	1	0.218	0.081	0.281	29%	247%
Exhaust Pipe-Stack from Silencer 42" JBD-409	42	800	125	720	0.5	760***	1	0.364	0.081	0.375	3%	363%

* Based upon design temperature and pressure.
** Based upon maximum operating temperature and pressure.
*** During the first hour of peak loading.

430.9 "Tabulate, compare and discuss differences in present actual DG loading to estimated loads included in the procurement specifications. Identify the magnitude of the increased load (if any) on the DGs and describe how the increased loading affects the DG capability with regard to reserve margin."

RESPONSE

The present actual loadings for the diesel generators are as follows:

Diesel	Proc Spec Estimated Load	Specified DG Rating	LOSP Loads	Post LOCA Loads	Total Connected ESF Bus Load
Div. I	5730 KW	7000 KW	3627 KW	4711 KW	5963
Div. II	6100 KW	7000 KW	4745 KW	3914 KW	6397

It can be seen that both the LOSP and post-LOCA loads are less than the estimated loads and much less than the specified 7000 KW diesel generator rating. The total connected ESF bus loads are provided to show that the diesel generators are capable of providing total ESF bus loads. Although the total connected ESF bus loads are greater than the estimated loads, the ESF bus loads remain below the 7000 KW diesel generator rating.

The LOSP and post-LOCA loads have remained below the estimated loads, therefore, margins have not been reduced. Furthermore, it has been shown that sufficient margin exists to carry the total connected ESF bus load.

430.10 "If DG loading has increased from that specified in the procurement specifications, has it been necessary to upgrade the standby DGs to meet the new load requirements. If DG upgrading has been performed, provide a detailed description of the upgrading accomplished on your DGs. What is the revised manufacturer's rating for each upgraded unit for normal continuous duty and short time overload conditions. Is the DG built-in design margin (after upgrading) still within the recommendations of IEEE Std. 387. What is the reserve load carrying capability (margin) of your upgraded DGs."

RESPONSE

It has not been necessary to upgrade the Grand Gulf Nuclear Station diesel generators to meet new load requirements. Since no upgrading has taken place, the remaining portions of Question 430.10 are not applicable.

430.13(1) "Your justification should include, but not be limited to the following: (1) quality assurance program conducted by you during procurement, manufacturing and receipt of your DGs."

RESPONSE

The Bechtel Quality Assurance Program provided for the identification of the applicable regulatory, design, and quality requirements to be imposed on the supplier. The quality requirements imposed included the applicable portions of 10 CFR 50, Appendix B and the ANSI N45.2 series standards, as well as the identification of documentation to be provided by the seller, submittal of a written description of the supplier's quality program for approval, and provided access to the supplier's facility records for inspection or audit.

Suppliers were evaluated prior to award to assure that their quality assurance program and facilities complied with the procurement document requirements. These evaluations were based on surveys, past performance, audits and the review and approval of the suppliers' documented quality programs.

The Quality Assurance Program controls exercised during manufacturing were accomplished through surveillance inspections, review of suppliers' documents, and quality program audits.

Surveillance inspections were performed at the supplier's facility to assure that materials, equipment, and verification documents conformed to the selected requirements of the procurement document. Surveillance inspections consisted of reviewing, observing, and/or inspecting (at random and at selected stages of manufacture), the supplier's personnel, material, equipment, processes, and test performed. Reports were prepared documenting inspections performed, tests witnessed, discrepancies observed, and corrective action taken.

Engineering and quality verification documents were reviewed for accuracy, completeness, and conformance to procurement documents.

Nonconformances to procurement documents dispositioned by the supplier as "repair" or "use-as-is" were submitted for Bechtel review and approval prior to shipment.

The Quality Assurance Program defined the responsibilities for the inspection of items and the associated quality verification documents received at the jobsite. Items were examined upon receipt for identification, quantity, damage, presence of appropriate documentation, and Bechtel's Supplier Quality Representative's release.

Items identified as nonconforming at receiving were not released for installation until authorized dispositions had been completed.

Inspection for identification and quantity consisted of checking markings and identification on the item, container, and tags attached to the item or container or records showing traceability of the items.

In the application of the Bechtel QA program with respect to the procurement of the diesel generators, during the pre-award stage TDI was evaluated based on their QA program meeting the 18 elements of 10CFR50, Appendix B, their past performances in manufacturing diesel generators, and their technical qualification in meeting the requirements of the procurement specification. After award, the identified procedures, drawings and documents required by the procurement specification were reviewed and approved prior to TDI implementation. These are detailed in Attachments 1 and 2 to the response to Question 430.13(1).

During the manufacturing of the diesel generators, Bechtel's control through surveillance inspection (as detailed in the response to Question 430.2) was exercised. A summary of surveillance inspection statistics is provided in Attachment 3 to the response to Question 430.13(1). In addition, audits of TDI's Quality Assurance program and the implementing procedures were performed prior to the start of manufacturing, and then annually through the manufacturing of the diesel generators. Noncompliances disclosed during manufacturing resulted in hold on shipment restrictions (Attachments 4 and 5 to the response to Question 430.13(1)). Corrective action was initiated by TDI and verification of this corrective action was performed.

As earlier stated, Bechtel's Quality Assurance program defined the receiving inspection. The characteristics checked at receiving inspection are detailed in our response to Question 430.2.

Attachment 1 to Response to Question 430.13(1)

Documentation Required From TDI
(Summary)

- Engineering Drawings, Diagrams and Data Sheets
- Manufacturing/QA/QC Procedures and Reports
- Welding/NDE Procedures and Reports
- Testing Procedures and Reports
- Installation Drawings and Instructions

Documentation Required From TDI
(Detailed)

Outline Dimensions-Foundations

Details-Drawings

Assembly Drawings

Wiring Diagrams

Control Logic Diagrams

Piping and Instrumentation Drawings

Spare Parts Lists - Parts Costs

Equipment Data Sheets

Erection/Installation Instructions

Operating Instructions

Maintenance Instructions

Site Storage and Handling Instructions

Eng. and Fabrication Schedules

Q.A. Manual Procedures

Seismic Data Report

Analysis and Design Report

Acoustic Data Report

Welding Procedure and Qualif Records

Weld Rod Control Proced. and Records

Weld Repair Procedure Reports

Cleaning and Coating Proced. and Records

Heat Treatment Proced. and Records

Material Test Reports

Material Certificate of Compliance

Code Data Reports

Mt/Mag. Part. Exam Proced. and Records

Pt/Liq. Pt. Exam Proced. and Records

Pressure Test Proced. and Records

Performance Test Proced. and Records

Mechanical Test Proced. and Records

Electrical Test Proced. and Records

Prototype Test Reports

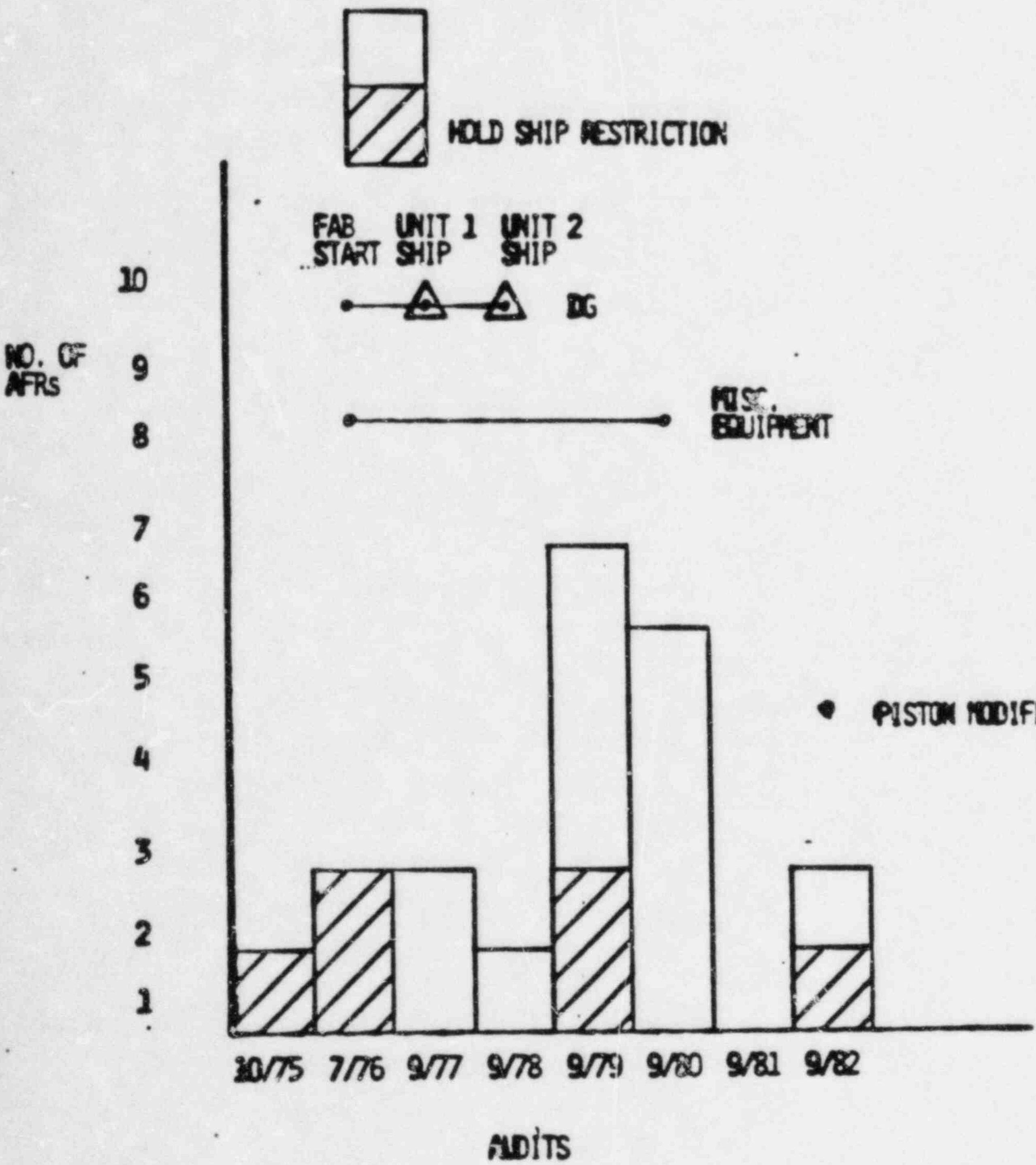
Shipping Preparation Proced. and Records

Certified Performance Data Record

Supplier Surveillance Statistics

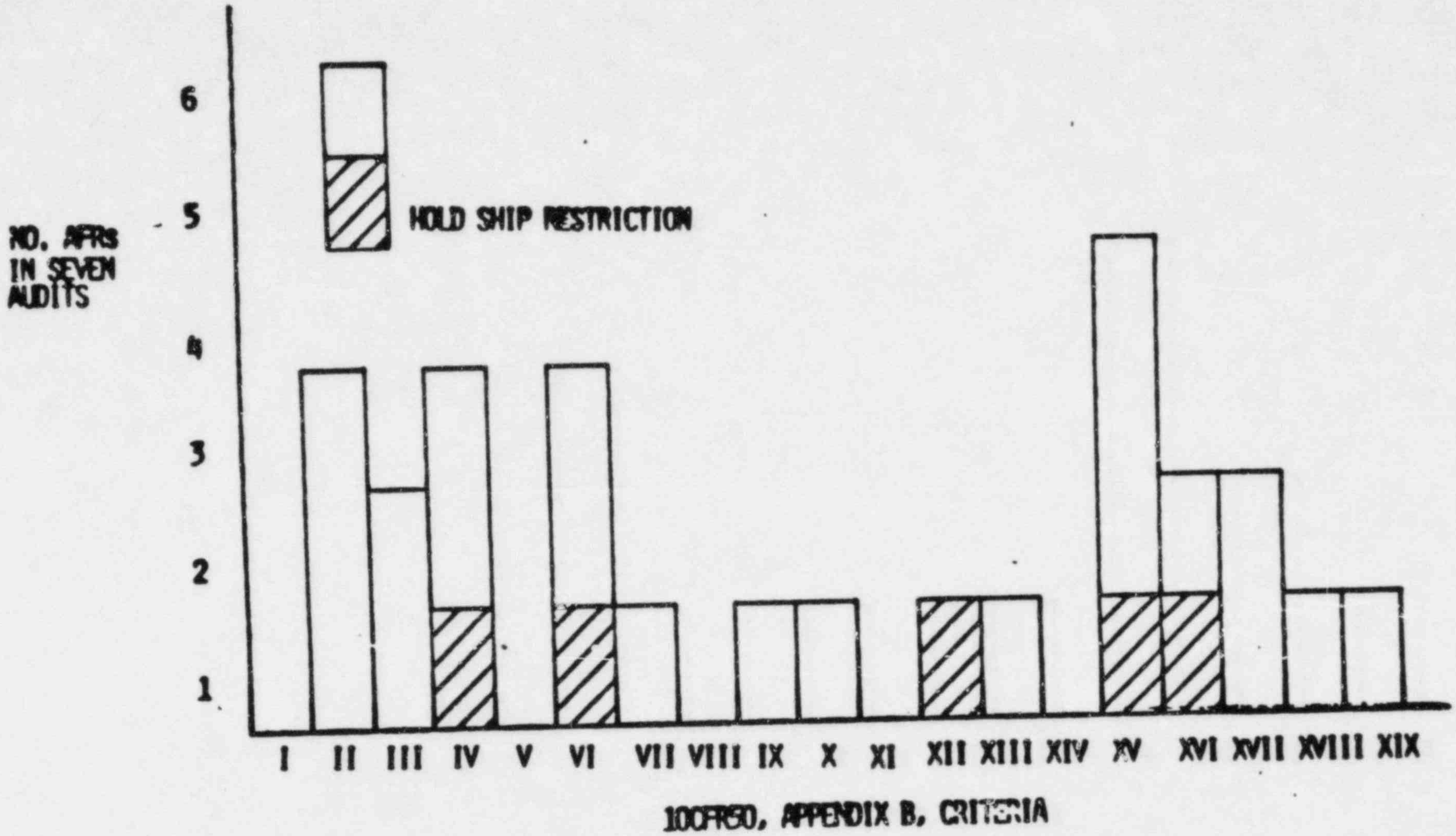
	TDI (Diesel	Portec (Generator)	RTE-Delta (Control Panels)	Total
Reports	112	8	24	144
Days in Shop	279	14	19	312
Shipments	47	3	2	52
Deficiencies	33	1	40	74
Witness and Hold Points	124	4	6	134
In-Process Inspections	53	4	3	60

Attachment 4 to Response to Question 430.13(1)



Attachment 5 to Response to Question 430.13(1)

DISTRIBUTION OF AFRs VS 10CFR50, APPENDIX B



430.13(2) "Your justification should include, but not be limited to the following: (2) your assessment of the TDI manufacturing process, inspection, and quality assurance program conducted during manufacture of your diesel generators."

RESPONSE

As detailed in Attachments 1 and 2 to the response to Question 430.13(1), TDI's engineering drawings, diagrams and data sheets, manufacturing/QA/QC procedures and reports, welding/NDE procedures and reports, testing procedures and reports and installation drawings and instructions were required to be submitted for review and approval by Bechtel prior to utilization.

In verifying the implementation of TDI's documents, as described above, various noncompliances were identified during surveillance inspection and audit activities (Reference Attachments 1, 2 and 3 to the response to Question 430.13(1)). These noncompliances were disclosed in quality program implementation (resulting in 8 hold on shipment restrictions), compliance to the Bechtel procurement specification, and compliance to TDI QC procedures. Some of these noncompliances were resolved through TDI's disposition to rework. Other noncompliances (those dispositioned repair or use-as-is by TDI) were submitted to Bechtel for approval.

430.13(3) "Your assessment of TDI responsiveness to problems that have occurred with your engines during installation and preliminary operation including assessment of TDI performance."

RESPONSE

Throughout the installation period of the diesel generators, a TDI representative participated in the supervision of installation activities and coordinated the resolution of installation related problems. TDI provided engineering support services, as required, in an effective and timely manner to support the installation activities. Our assessment of TDI's responsiveness to problems encountered during installation of the diesel generators is that TDI was cooperative in providing accurate and timely resolutions to installation problems.

A TDI representative also participated in the preliminary operation of the diesel generators, responded to problems that occurred with the engines, and coordinated the resolution of the problems. During the initial stages of preliminary operation of the diesels, TDI provided engineering support services in an effective and timely manner. TDI's onsite representative was responsive to our problems and needs at all times. However, after a major problem developed (i.e.; piston crown separation) TDI's engineering support service and the timeliness of TDI's responses, in our estimation, appeared to decrease. We attribute this, in part, to the generic nature of the problem and to TDI's limited manpower available to respond to affected D/G users, though other reasons not known to MP&L may also be offered by TDI. More recently, however, TDI has been responsive to MP&L's requests for assistance and significant efforts are being made to further improve these communications.

430.13(4) "Comparison of your diesel generators with all other TDI emergency diesel generator models now in use or to be used in other nuclear generating stations (and other non-nuclear facilities) to show that the conditions and/or failure modes present at Shoreham will not occur at your plant and at other nuclear plants; provide any supporting information that may be obtained from non-nuclear installations."

RESPONSE

San Onofre Unit 1, Grand Gulf Unit 1, Catawba, Commanche Peak and Shoreham are nuclear generating stations with operating time with TDI diesel generators. Table 1 lists operating times for plants with TDI Model DSRV-16-4 diesel generators.

While Grand Gulf has experienced various failures of TDI diesel generator equipment, it's operating history shows a relatively high valid test reliability (greater than 98%) for the TDI diesel generators (Reference: Reg. Guide 1.108).

In verbal conversations with various nuclear and non-nuclear facilities, we have found that, in general, the TDI diesel generators are reasonably reliable with problems in various areas similar to items as reported in the response to Question 430.8.

A summary of the evaluation of the Shoreham crankshaft failure on Grand Gulf was transmitted to the NRC via AECM-83/0653, dated October 14, 1983. This 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 diesel generator crankshafts will not fail in a mode similar to Shoreham.

A significant number of contacts have been made with TDI, and all effort is being made to cooperate in the exchange of information and resolution of problems with TDI and other utility owners of TDI diesel generators. In addition, a diesel generator Technical Information Exchange meeting was sponsored by MP&L in Atlanta, Georgia, on October 25, 1983. The purpose of the meeting was to provide a forum for the exchange of diesel generator operational experiences, reliability information and to find solutions to problems common to utility owners. Fifty-nine (59) utility, INPO and EPRI representatives were in attendance. A diesel generator User's Group Steering Committee was organized with the intent of forming a Nuclear Task Action Committee to address utility diesel generator reliability issues. The committee consists of representatives from twelve (12) utilities, of which ten (10) are TDI owners. MP&L's Operational Analysis Section Principal Engineer was selected as Chairman of the committee and will liason with upper management and other appropriate officials on diesel generator issues of importance to MP&L.

Response to Question 430.13(4)

Table 1
A List of Plants With Delaval DSRV-16-4

DIESEL GENERATORS[1]

UTILITY	PLANT	RUN HOURS	FUEL LOAD DATE
Texas Utilities	Comanche Peak Unit 1 (2 D/Gs)	100/each	Early, 1984
Duke Power	Catawba Unit 1 (2 D/Gs)	24/each	May, 1984
CP&L	Shearon Harris	0	June, 1985
Cleveland Elec.	Perry	0	December, 1984
WPSS	Unit 1 and 4	0	1986 or later
Georgia Power	Vogtle	0	1987
TVA	Hartsville/ Phipps Bend	0	Indefinite
MP&L	Grand Gulf Unit 1[2] Division I Division II	 1097 473	June 16, 1982

NOTES:
1. Data as of August, 1983, except Grand Gulf.
2. The data for Grand Gulf Unit 1 includes run hours for the test that were performed by DeLaval and Bechtel prior to the issuance of the Operating License, as of October 27, 1983.

(S)OAS Attachment(12)

430.13 (Last paragraph)

"In addition, provide a tabulation of the number of times (including date of occurrence) voltage was lost at the emergency bus(es) requiring operation of the diesel generators including a brief description of each incident. In the above tabulation, also identify the loss of emergency bus voltage due to loss of offsite power."

RESPONSE

A tabulation of identified incidents involving the loss of voltage to one or more of the three divisional Engineered Safety Features (ESF) busses at the Grand Gulf Nuclear Station is provided as the attachment to the response to Question 430.13 (Last paragraph). This tabulation is for the period of June 16, 1982 to October 27, 1983 and provides the date and time of the occurrence, the ESF bus involved, diesel generator status and starts, the offsite power sources remaining available and a brief description of the incident.

A total of thirteen incidents involving a loss of voltage to an ESF bus were identified. Of these thirteen, three were considered a result of the loss of one or more offsite power sources and one as the loss of a 500 kv supply from the switchyard to the plant. None of the incidents involved the total loss of all offsite power. One or more offsite power supplies remained available throughout all the incidents. All features of the offsite power supply are designed to provide maximum practical reliability and total redundancy in servicing the station load groups.

Attachment to Response to Question 430.13 (Last paragraph)

Engineered Safety Features 4.16 KV Busses Undervoltage Incidents
(June 16, 1982 to October 31, 1983)

1. Incident Report - IR 82-08-50 (LER 82-045)

Date - 8-26-82
Time - 1415 to 1418
ESF Bus - Division I, 15AA & Division II, 16AB
Offsite Source Lost - Franklin 500 KV & Baxter Wilson 500 KV
Offsite Source Available - Port Gibson 115 KV
D/G Start - Division I & Division II

Description

During line cleaning activities in Franklin County, Mississippi a worker accidently felled a tree across a 500 KV line. Protective relays tripped the Franklin line due to the electrical fault produced and attempted to transfer power to the 500 KV Baxter Wilson line, however, a blown fuse in the carrier relaying for the GGNS switchyard caused a signal to be sent to the Baxter Wilson switchyard indicating the fault was in the 500 KV Baxter Wilson line. This caused the secondary relaying at the Baxter Wilson switchyard to trip the 500 KV Baxter Wilson line. The Division I and II D/Gs automatically started and tied into their respective ESF busses. The 500 KV lines were restored within three minutes. The 115 KV Port Gibson line remained available throughout the incident. A self check system for the carrier relaying has since been installed to prevent this type of incident from recurring.

2. Incident Report - IR 82-08-55

Date - 8-29-82
Time - 1845
ESF Bus - Division I, 15AA
Offsite Source Lost - No
Offsite Source Available - All
D/G Start - Division I

Description

Feeder breaker 152-1501 from ESF transformer 21 to 4.16 KV ESF bus 15AA tripped for no apparent reason. The Division I D/G started and tied onto ESF bus 15AA. Offsite power sources were not lost and remained available throughout the incident. The cause of the breaker trip could not be determined and was considered to be spurious.

3. Incident Report - IR 82-09-31

Date - 9-23-82
Time - 0644
ESF Bus - Division I, 15AA & Division III, 17AC
Offsite Source Lost - 500 KV to Service Transformer 21
Offsite Source Available - All
D/G Start - Division I & Division III

Description

The 500 KV feeder breaker (J5204) to service transformer 21 tripped on low quench gas pressure. This resulted in a loss of service transformer 21, ESF transformer 21 and the Division I and III 4.16 KV busses. The Division I and III D/G's automatically started and tied onto their respective busses. Division I, 15AA, was subsequently transferred to ESF transformer 11 and 17AC to ESF transformer 12. The cause of the low quench gas pressure was determined to be a defective governor switch in 500 KV breaker J5204. The switch was replaced and the breaker returned to service. All offsite lines remained available to the switchyard throughout the incident.

4. Incident Report - IR 82-09-34

Date - 9-24-82
Time - 1136
ESF Bus - Division I, 15AA
Offsite Source Lost - No
Offsite Source Available - All
D/G Start - Division I

Description

Feeder breaker 152-1501 from ESF transformer 21 to the Division I, 4.16 KV ESF bus 15AA tripped causing an undervoltage condition on the bus. The Division I D/G started and tied onto the bus. The cause of the breaker trip could not be determined and was considered to be spurious. Offsite power source remained available throughout the incident.

5. Incident Report - IR 82-12-19

Date - 12-27-83
Time - 1232 - 1235
ESF Bus - Division II, 16AB
Offsite Source Lost - Port Gibson 115 KV
Offsite Source Available - 500 KV Lines
D/G start - None, Division II D/G in Maintenance Mode

Description

A five second interruption on the 115 KV Port Gibson line caused a loss of the Division II 4.16 KV bus 16AB. The Division II D/G was in the Maintenance Mode at the time and did not start. Approximately three minutes later ESF bus 16AB was reenergized from ESF transformer 21. The 500 KV offsite lines remained available throughout the incident. The interruption on the 115 KV line was attributed to a storm in the Port Gibson area at the time.

6. Incident Report - IR 83-2-14

Date - 2-5-83
Time - 1445 & 1500
ESF Bus - Division II, 16AB and Division I, 15AA
Offsite Source Lost - Port Gibson 115 KV and 500 KV feed to service Transformer 21
Offsite Source Available - All 500 KV lines to switchyard
D/G start - Division II and Division I

Description

A downed tree on the 115 KV line between Fayette and Natchez caused a loss of the Port Gibson 115 KV line. The Division II D/G automatically started and tied onto the Division II 4.16 KV ESF bus 16AB. Fifteen minutes later the 500 KV feeder breaker (J5024) to service transformer 21 tripped causing a loss of the Division I 4.16 KV ESF bus 15AA. The Division I D/G automatically started and tied onto ESF bus 15AA. All 500 KV lines to the switchyard remained available throughout the incident. BOP loads were transferred to the 34.5 KV bus 12R. ESF busses 15AA and 16AB were transferred to ESF transformer 11.

The cause of the 500 KV breaker J5024 trip was determined to be low quench gas pressure caused by a loss of service power to the switchyard. Service power was lost to the switchyard due to the preferred breaker lineup for the 4.16 KV ESF busses at the time. The preferred breaker lineup has been changed to ensure that at least two separate sources of power are available for switchyard service power to prevent a similar incident.

7. Incident Report - IR 82-02-43

Date 2-16-83
Time - 0027
ESF Bus - Division II, 16AB
Offsite Source Lost - No
Offsite Source Available - All
D/G start - None, Division II D/G in Maintenance Mode

Description

Feeder breaker 152-1614 from ESF transformer 21 to the Division II 4.16 KV bus 16AB tripped for no apparent reason. The Division II D/G was in the Maintenance Mode at the time and did not automatically start. ESF bus 16AB was immediately reenergized from ESF transformer 12. Offsite power remained available throughout the incident. The cause of the breaker trip could not be determined and was considered spurious.

8. Incident Report - IR 83-2-67

Date - 2-21-83
Time - 1740 to 1745
ESF Bus - Division II, 16AB
Offsite Source Lost - No
Offsite Source Available - All
D/G start - None, Division II D/G in Maintenance Mode

Description

A spike on the Port Gibson 115 KV line during a storm caused feeder breaker 152-1611 from ESF transformer 12 to the Division II 4.16 KV bus 16AB to trip. The Division II D/G was in the Maintenance Mode at the time and did not automatically start. Five minutes later ESF Bus 16AB was reenergized from ESF transformer 11. Offsite power remained available throughout the incident.

9. Incident Report - IR 83-3-127

Date - 3-29-83
Time - 0210
ESF Bus - Division II, 16AB
Offsite Source Lost - No
Offsite Source Available - All
D/G start - Division II

Description

Feeder breaker 152-1614 from ESF transformer 21 to the Division II 4.16 KV ESF bus 16AB tripped on an RHR pump start attempt. The Division II D/G automatically started and tied onto ESF bus 16AB. ESF Bus 16AB was later transferred to ESF transformer 12. An investigation attributed the breaker trip to a dirty overcurrent relay. Offsite power remained available throughout the incident.

10. Incident Report - IR 83-4-12

Date - 4-6-83
Time - 1005
ESF Bus - Division I, 15AA
Offsite Source Lost - No
Offsite Source Available - All
D/G start - Division I

Description

A spike on the Port Gibson 115 KV line during a storm caused the feeder breaker 152-1511 from ESF transformer 12 to the Division I 4.16 KV ESF bus 15AA to trip. The Division I D/G automatically started and tied onto ESF Bus 15AA. Offsite power remained available throughout the incident. After the required run time on the D/G the electrical lineups were restored.

Attachment to Response to Question 430.13 (Last paragraph)

11. Incident Report - IR 83-6-13 (LER 83-074)

Date - 6-6-83
Time - 0500
ESF Bus - Division I, 15AA
Offsite Source Lost - No
Offsite Source Available - All
D/G start - None, Division I D/G in Maintenance Mode

Description

Feeder breaker 152-1511 from ESF transformer 12 to the Division I 4.16 ESF bus 15AA tripped on an LPCS pump start attempt. The Division I D/G was in the Maintenance Mode and did not automatically start. Feeder breaker 152-1511 was immediately reclosed and ESF bus 15AA reenergized from ESF transformer 12. Offsite power remained available throughout the incident.

12. Incident Report - IR 83-8-45A

Date - 8-15-83
Time - 1415
ESF Bus - Division II, 16AB
Offsite Source Lost - No
Offsite Source Available - All
D/G start - Division II

Description

Cajun Power Association Plants 1, 2, and 3, simultaneously tripped off the grid causing the incoming 500 KV line voltage at GGNS to dip to approximately 445 KV. This resulted in the loss of the Division II 4.16 KV ESF bus 16AB on undervoltage. The Division II D/G automatically started and tied onto ESF bus 16AB. When the grid voltage stabilized at normal voltage the Division II ESF bus electrical lineup was returned to normal. Division II was the only ESF bus affected due to the breaker lineup in use at the time of the incident. Offsite power remained available to the switchyard throughout the incident.

13. Incident Report - IR 83-9-4

Date - 9-1-83
Time - 0850
ESF Bus - Division I, 15AA
Offsite Source Lost - No
Offsite Source Available - All
D/G start - None, Division I D/G in Maintenance Mode

Attachment to Response to Question 430.13 (Last paragraph)

Description

Power was lost to the Division I 4.16 KV ESF bus 15AA, when an operator passing the switchgear inadvertantly caught the breaker trip handle for feeder breaker 152-1511 from ESF transformer 12 to the Division I ESF bus 15AA with a radio and tripped the breaker. The Division I D/G was in the Maintenance mode and did no automatically start. ESF bus 15AA was immediately reenergized from ESF transformer 11. Offsite power remained available throughout the incident.

430.17 What surveillance practices in addition to those required by plant technical specifications have you instituted to assure optimum reliability of your diesel generators at your plant?

RESPONSE

MP&L's surveillance program was developed to identify and perform surveillances required by the plant technical specifications. No additional Surveillance Procedures have been developed at this time. MP&L contends that the current Surveillance Procedures are adequate and have been effective to assure availability and performance of the D/G's.

However, efforts are underway to improve the reliability of the D/Gs in addition to the current Surveillance Program. These practices include both temporary and long term augmented activities such as:

1) Increasing surveillance testing run time from one (1) hour to four (4) hours, if deemed necessary. 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 ensure 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.

In addition to the efforts described above, MP&L management determined that a 7-day equivalent test run would enhance the reliability of the D/Gs. This 7-day equivalent test run has been successfully completed for Division I and Division II D/Gs.