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

April 18, 1984

NUCLEAR PRODUCTION DEPARTMENT

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

Attention: Mr. Harold R. Denton, Director

Dear Mr. Denton:

SUBJECT: Grand Gulf Nuclear Station
Units 1 and 2
Docket Nos. 50-416 and 50-417
License No. NPF-13
File: 0260/L-860.0/M-018.0
TDI Diesel Generator, Supplemental Information
AECM-84/0230

By letter dated April 11, 1984, (E. G. Adensam - NRC to J. P. McGaughy) your staff informed Mississippi Power & Light Company (MP&L) of several unresolved issues pertaining to the Transamerica Delaval, Inc. (TDI) diesel generators (D/G) installed at the Grand Gulf Nuclear Station (GGNS). The purpose of this letter is to formally respond to your staff's request of April 11, 1984.

If you have any questions please contact this office.

Yours truly,

L. F. Dale
Manager of Nuclear Services

REW/JGC:rg
Attachment

cc: See next page



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1/1

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

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# RESPONSES TO NRC UNRESOLVED ISSUES

(Reference NRC Letter, E. Adensam to J. McGaughy, April 11, 1983)

## ABSTRACT

This report provides responses to NRC questions about major unresolved issues pertaining to the TDI diesel engines at Grand Gulf Nuclear Station. In addition, a summary matrix of the enchanced maintenance and inspection testing program being adopted by MP&L is included as Attachment I. The list of questions was transmitted to MP&L on April 11, 1984 and discussed in detail with the NRC Staff in a meeting held on April 14, 1984.

NRC UNRESOLVED ISSUES

1. CYLINDER HEADS

The heads which were rejected on the GGNS Unit 1 TDI engines were rejected for minor indications which were revealed during a liquid penetrant examination of the valve seat areas. The cause of the rejectable indications is postulated to be nonuniformity of heat input from the old hand stick weld method of application of stellite valve seats. It is not known if any of these indications would have propagated, but the decision was made to install only clean heads with no indications. There was one head which had a crack that propagated from the valve seat area into the jacket water shroud of the head and leaked for some amount of time. This cylinder showed no significant differences in cylinder pressure or temperature readings during engine operation. There are no known head failures due to valve seat induced cracks. TDI has indicated by letter to MP&L that:

- There have been no cases of crack propagation in operation leading to engine and/or turbocharger damage for approximately five thousand 4-valve type cylinder heads placed on engines or supplied as spares by TDI.

- Since none of the engines produced by TDI with the 4-valve head has experienced a failure resulting from crack propagation it seems a failure rate analysis is academic.

- The R-5 engine head is similar to the R-4 cylinder head but is not interchangeable. None of the twelve cylinder heads tested on the R-5 research engine developed rejectable indications during 5400 operating hours.

Resolution measures for this issue are provided in Attachment I.

2. ENGINE BLOCK

TDI has indicated by letter to MP&L that linear indications found in the upper entablatures of all TDI engines so far inspected have been inconsequential. They have not compromised performance, nor have they caused concern from a "failure" standpoint. Resolution measures for this issue are provided in Attachment I.

3. WRIST PIN BUSHINGS

As part of the DR/QR program, LILCO recently discovered linear indications, using liquid penetrant testing methods, on the surface of the wrist pin bushings. These bushings are cast of bronze and are press fit into the connecting rod. The wrist pin attaches the piston skirt to the connecting rod with a .004 to .006 inch tolerance between the outside of the wrist pin and the inside mating surface of the wrist pin bushing.

From a historical perspective there are no known reports of any failures of wrist pin bushings on TDI engines. The indications discovered by LILCO by liquid penetrant techniques have been diagnosed to be casting defects caused by shrinkage and hot shortness (due to lead in the casting material).

FaAA examined representative samples of the bushings found with linear indications on both used and as received bushings. These examinations, utilizing liquid penetrant and scanning electron microscopy, on both used and as received bushings, revealed no differences in either crack surface morphology or liquid penetrant indications. These findings demonstrate that the indications found by liquid penetrant technique do not propagate as cracks. Furthermore, when the bushings were cut for sample removal, the sample piece sprung apart indicating a residual compressive stress on the inside surface of the bushing. This residual compressive stress together with the operational stresses (i.e., firing loads) would put the bushing in a state of triaxial compression. FaAA also observed that the used bushing, which had shown a linear indication in the highly stressed zone, did not show any evidence of permanent deformation. The most highly loaded area of the bushing during operation is an arc of 15° on either side of the bottom of the bushing relative to the firing plane (the axial loading plane on Figure 1).

Since the indications have been diagnosed to be typical casting defects, it is reasonable to assume that a fraction of wrist pin bushings in service in TDI engines may show such indications. However, based on the experimental evidence and the state of stresses experienced by the bushing, it is very unlikely that these indications could propagate as cracks and fail under the expected service environment. In addition, there is no reported history of failure of these components in either nuclear or non-nuclear service.

Resolution measures are provided in Attachment I.

4. CONNECTING RODS

TDI initiated an evaluation of the problem based on the operating history of the engines with 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 time 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 the incidence of cracking.

A decrease in cracking frequency was noted. However, connecting rods using both 1-1/2 and 1-7/8 inch bolts continued to exhibit cracks. 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 increased 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.

To date, all engines using 1-7/8 inch connecting rod bolts exhibiting cracking have been suspected of being under-torqued. 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.

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).

Based on low probable propagation rate of incipient cracks, relatively low run hours on Division I and II engines and the expected low future run times (estimated 100 hours/year), deleterious cracking of the GGNS connecting rods is not expected.

Resolution measures are provided in Attachment I.

5. CONNECTING ROD BEARINGS

During the piston skirt changeout on the GGNS Unit 1 D/Gs, the connecting rod bearings were inspected for unusual or abnormal wear patterns. No signs of unusual or abnormal wear patterns were noted. Two of the Division II D/G connecting rod bearings were inspected by 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. Review of radiographic film showed that bearing porosity was less than 0.030 inches which is well below the acceptance criteria of 0.050 established by the Owner's Group.

Prior to installation of the bearing journals, MP&L Plant Quality personnel performed a measurement of each bearing shell. The measurements were taken with the use of a calibrated ball micrometer at six different locations on each shell. All readings were within TDI's tolerance. In addition, 100% of the machined surface edges of four bearing shells were nondestructively examined by dye penetrant fluorescent solvent method. The nondestructive examination was performed in accordance with MP&L PT procedure QAP 3.23.A.2 and no defects were identified.

The evidence collected by FaAA shows that the cracked bearings in the LILCO engines continued to perform their intended function even though they had been cracked for possibly as much as 100 hours.

6. TURBOCHARGER

Original problems with supports and components adjacent to the Division I D/G left bank turbocharger have been attributed to a turbocharger that had exhibited signs of unusual vibration. This turbocharger was replaced with a spare turbocharger in August of 1983. Both Division I D/G turbochargers were replaced following the D/G fire in September of 1983 because they were located in the fire area and their ability to carry out their design function was in question. Recurring problems with alignment on the left bank turbocharger were experienced following the replacement in August of 1983. This was corrected in February of 1984 when an extensive maintenance effort was undertaken to correct the alignment problem. Following this effort the Division I D/G completed an 100 run (32 hours @ 100%, 68 hours @ 75%) with no further problems.

6. TURBOCHARGER - (CONTINUED)

The alignment problems with the turbochargers are partially a function of the custom fit arrangement of the turbocharger with the flanged connections on the mating piping and apparatus. Each engine supplied by TDI has slightly different piping due to the fact that it is hand built. The specific problems encountered with the left bank turbocharger on the Division I D/G was the misalignment of the turbocharger and intercooler mating flanges. These flanges were misaligned such that if the flanged connection was tightened down, the turbocharger would cock on the mounting pedestal approximately 30 mils (Figure 2). This problem was attacked several times before a satisfactory conclusion was achieved. Finally, TDI recommended that (1) the intercooler flange be cut, (2) the turbocharger bolted down, (3) the intercooler flange be bolted to the turbocharger, (4) the intercooler flange tack welded to the intercooler, (5) the turbocharger removed, (6) the intercooler flange rewelded, (7) the turbocharger remounted, (8) the turbocharger bolted down, (9) the intercooler flange bolted up, (10) the turbocharger mounting bolts removed, (11) the mounting plate checked for clearances, (12) the turbocharger remounted, (13) a maintenance run performed, (14) the turbocharger mounting bolts removed, (15) the mounting plate rechecked for clearances, (16) the mounting bolts and reinstalled.

At the end of this process the engine was tested for 100 hours and the mounting clearances rechecked. The final conclusion was that the problem has effectively been solved. The final clearances were 0,0,0,3 mils on each of the four corners of the mounting plate. This is considered acceptable and the successful completion of the 100 hour run demonstrated that the problem has been solved.

7. TESTING/MAINTENANCE PLANS

Requalification Testing

As indicated in Section 11.2 of MP&L letter, dated February 20, 1984 (AECM-84/0103), requalification testing of the Unit 1 TDI D/Gs following piston skirt replacement was performed in accordance with the requirements of IEEE Std. 387-1977, "IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations". IEEE Std. 387-1977 implements the requirements of Regulatory Guide 1.9 which implements the requirements of General Design Criterion 17 of Appendix A of 10CFR Part 50 and Criterion III of Appendix B of 10CFR Part 50.

The monthly surveillance test is a technical specification test that was performed to demonstrate operability of the D/Gs following maintenance as required by Tech Specs. The monthly surveillance was also utilized to meet the starting, load acceptance and design load tests of IEEE 387-1977. The 18 month testing was not required and was not performed, however, Test #3 of the 18 month test procedure was utilized to accomplish the load rejection test required by IEEE 387-1977. The September, 1977 "Errata" sheet for Regulatory Guide 1.108, Revision 1, "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants" corrects Regulatory Position C.2.a(9) to read "During the plant preoperational test program only, demonstrate the required reliability by means of any 69 consecutive valid tests". This requirement was met during the preoperational testing of the Unit 1 TDI D/Gs and was not required or performed following piston skirt changeout in the D/Gs.

The summary of testing presented in Table 11-1 of AECM-84/0103 indicates the IEEE 387-1977 required testing that was performed after piston skirt changeout and also additional testing that was performed to further demonstrate the reliability of the TDI D/Gs.

8. PISTONS

TDI has confirmed that the "AE" piston skirts in use at GGNS are the same as those used in the R-5 tests.

The FaAA report FaAA-84-2-14, FME-F-6/7396 investigation of types AF and AE piston skirt indicates that these AE skirts have now been operated for over 300 hours in one of the SNPS engines including 100 hours of full power operation. Other AE skirts have accumulated over 6000 hours in a stationary generating plant, and over 600 hours in an advanced development engine. Inspection of these skirts (one after 6000 hours, two after 600 hours, and four after 300 hours) with a high-resolution eddy current procedure disclosed no cracking.

The present run time on the type "AE" piston skirts in addition to the run times that could be acquired on the engines by the first refueling outage would establish solid baseline data that can be used for the piston skirt inspection. When MP&L performs the major disassembly and/or inspections recommended by the Owner's Group at the first refueling outage the skirts will be inspected at this time.

Resolution measures are provided in Attachment I.

9. PUSH RODS

All intake, exhaust and connector push rods on both Unit 1 engines are the new friction welded push rods. FaAA has performed a cyclic wear test to $10^7$ cycles on a sample friction welded push rod after which it was examined metallurgically. No signs of abnormal wear or deterioration of the welded joint were observed. It is MP&L's opinion that there will be no problems with these friction welded push rods. MP&L considers the issue resolved with no further action required. MP&L was extensively involved in the development and qualification of these push rods, including metallurgical evaluations, throughout the development and production process.

10. CRANKSHAFT

MP&L inspected the individual crank throw areas in December, 1983 and January, 1984 on both Unit 1 engines. No relevant indications were found using liquid penetrant examination methods. MP&L feels that the problems with crankshafts are not relevant to the GGNS TDI engines because of test and analytical results previously reported to you.

Resolution measures are provided in Attachment I.

11. L.P. FUEL LINE

MP&L contracted Technology for Energy Corporation (TEC) to perform vibration testing on both Unit 1 engines following the September, 1983 fire rebuild effort. During the course of this testing all piping systems in the area of the turbochargers were inspected along with most other major engine components. No areas of abnormal or suspect vibrations were reported. In conclusion, TEC stated that both engines had normal vibration levels and that no further problems should be anticipated in the operation of these engines. MP&L has committed to implement a vibration monitoring program to routinely inspect both Unit 1 engines.

12. H.P. FUEL LINE

TDI has inspected the fuel line material used for the new MP&L lines using a sampling technique where a 1-1/2 inch long portion is cut from each end of each 17-20 ft. long stock tube. These short sections are split axially by saw cut and the bore surfaces checked for draw deficiencies. If there are no imperfections in the end pieces, then the stock tube is acceptable.

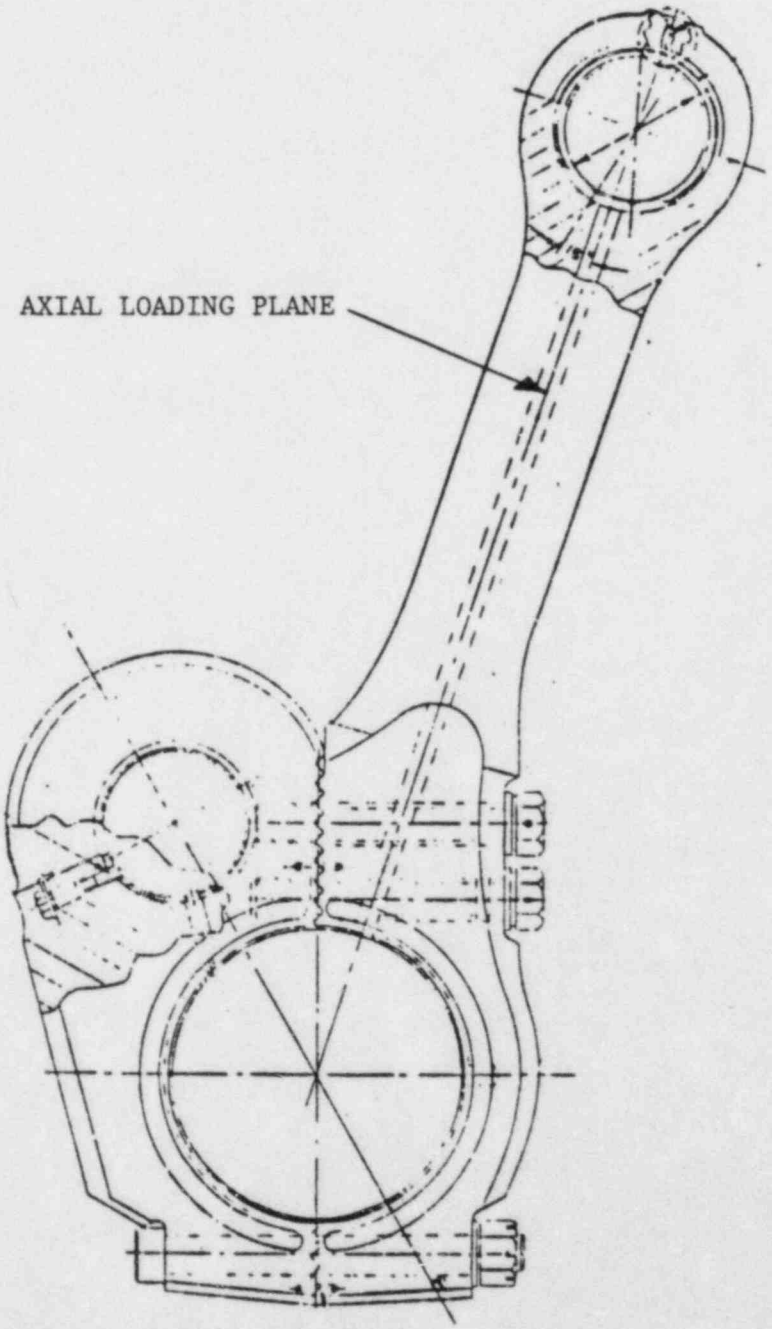
13. ENGINE BASE

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

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. If through bolts, main bearing cap bolts and other fasteners are kept tightened correctly, i.e., maintained at TDI recommended torques, no base problems will occur.

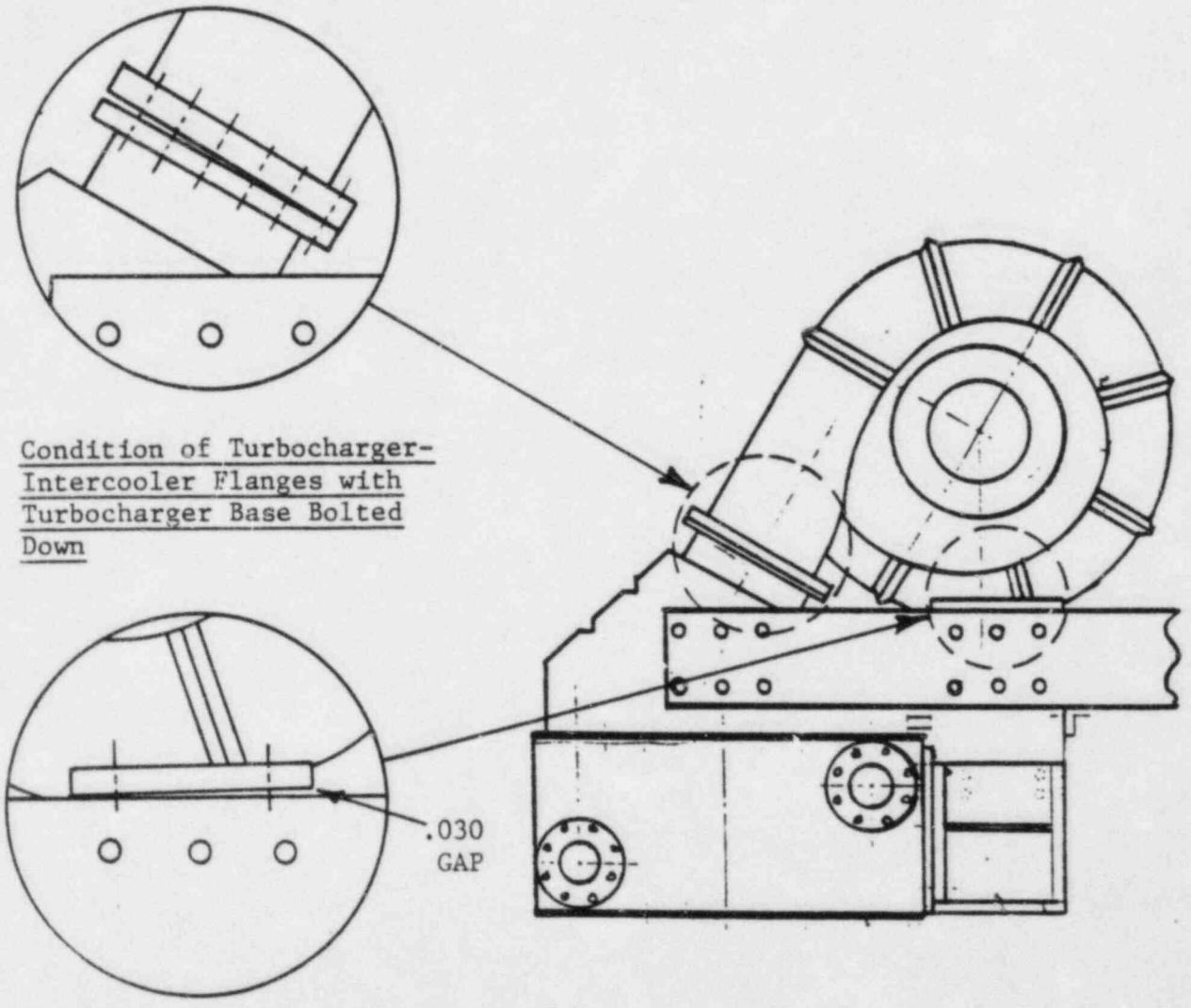
14. ROCKER ARM CAPSCREWS

The Emergency Diesel Generator Rocker Arm Capscrew Stress Analysis report dated March, 1984 concluded that both the original and modified rocker arm capscrews are adequately designed for the given service conditions. The GGNS rocker arm capscrews are original components of the diesels and have been properly torqued to 365 ft-lbs. MP&L considers this issue resolved with no further action required.




ARTICULATED CONNECTING ROD

FIGURE 1




LEFT BANK TURBOCHARGER MOUNTING ARRANGEMENT

FIGURE 2

GGNS ENHANCED MAINTENANCE PROGRAM

| NRC ITEM | DISCUSSION | RESOLUTION |
|---|---|---|
| 1. Cylinder Heads | a. GGNS performed dye penetrant tests on on all 32 heads in valve seat area presently installed. No cracks or linear indications found.<br><br>b. Cause of rejectable indications is currently postulated to be non-uniformity of heat input from the old hand stick weld method of application of stellite valve seats.<br><br>c. There are no known TDI engine failures due to valve seat-induced cracks in the cylinder heads.<br><br>d. Since R-4 and R-5 heads are not interchangeable the R-5 history is not applicable. | a. At Next Refueling Will:<br>(1) Perform dye penetrant test of total firing surface.<br><br>(2) Perform U.T. for firing surface to jacket water chamber thickness.<br><br>b. Oil analysis for water will be performed after every surveillance run.<br><br>c. Air roll prior to planned start.<br><br>d. Air roll 8 Hr. after each shutdown. |
| 2. Engine Block | a. Failure mode is believed to be due to thermal induced stresses which result from quick heatup and expansion of liners imposed on slower thermal growth of block. TDI Owner'sGroup still investigating for final recommendations.<br><br>b. If cracks develop, indications are water in cylinders or oil sump and/or loosening of head bolt torque. | a. D/Gs have experienced 270 and 170 hours of full load run, respectively, since last head bolt torque.<br><br>Head bolt torques will be checked after 50 hours ±10 hours or refueling, whichever comes first.<br><br>b. Oil analysis for water will be performed after every D/G surveillance run.<br><br>c. Will implement TDI Owner's Group recommendations next refueling outage. |

| NRC ITEM | | DISCUSSION | RESOLUTION |
|---|---|---|---|
| 3. Wrist Pin Bushings | a. | MP&L has determined through analysis by FaAA that it is very unlikely that a failure of a wrist pin bushing could occur. There is no industry history of problems with these components in either nuclear or non-nuclear service. | a. Dye Penetrant check next refueling outage for cracks.<br>b. Replacement of bushings found to be cracked.<br>c. Perform elemental oil analysis for metals after every engine surveillance run.<br>d. Batch traceability to lots compared to Shoreham, Comm. Peak, and Columbia are being investigated. |
| 4. Connecting Rods | a. | There have been no failures of V-16 Conn. Rods since torque increase to 2600 ft-lb. | a. Will perform oil elemental analysis after every D/G surveillance run.<br>b. Will recheck torques after 50 hours of operation or refueling, whichever is first.<br>c. Will implement TDI Owner's Group recommendations for inspections at first refueling outage. |
| 5. Connecting Rod Bearings | a. | Radiographed 1 pair of bearings of the original set installed. | a. Will perform oil elemental analysis after every D/G surveillance run sampling for bearing metals. |
| | b. | Micrometer readings and close visual inspection performed on old and new installed bearings by MP&L. FaAA inspected sample bearings, wear patterns were normal. | b. Will radiograph new set of bearings 100% and replace first refueling outage. |

| NRC ITEM | DISCUSSION | RESOLUTION |
|---|---|---|
| 5. Connecting Rod Bearings (Continued) | c. FaAA performing analysis of acceptable discontinuity size at reduced load and 100 hours run time. | |
| 6. Turbocharger | | |
| a. Alignment | a. Was an external misalignment problem. | a. Clarification and update to Feb. 20 letter in response to NRC April 11 letter. |
| b. Intercooler | b. Degradation of intercooler on marine engine. | b. Was individual corrosion problem. GGNS uses demineralized water treated with corrosion inhibitors. This problem is not considered applicable to GGNS, thus no additional action is necessary. |
| 7. Testing/Maintenance | | |
| a. Test Program | a. Complies with FSAR criteria related to emergency conditions | a. GGNS tests per Reg. Guide 1.108 which is MP&L's FSAR commitment. |
| b. Post Test Inspections | b. Submit inspection and sampling plan after 1000 hours @ 70% power. | b. As previously discussed 100% inspection and/or sampling will be performed at first refueling outage which is conservatively estimated at 100 additional hours per D/G. In summary, this refueling inspection will be as follows or equivalent:<br>1. Cyl. Heads - Dye Pen, UT for thickness<br>2. Engine Block - Dye Pen., & other NDE<br>3. Wrist Pin Bushings - Dye Pen.<br>4. Conn. Rod Box - Appropriate NDE<br>5. Conn. Rod Brgs. - Radio.<br>6. Turbo - Standard P.M. inspection |

| NRC ITEM | DISCUSSION | RESOLUTION |
|---|---|---|
| 7. Testing/Maintenance (Continued) | | 7. Pistons - Fluorescent Mag, Sample Basis<br>8. Push Rods - Dye Pen Sample, Visual<br>9. Crankshaft - Hot and Cold Standard Deflection Readings<br>10. Fuel Lines - Evaluate Owner's Group Recommendations. |
| c. Maintenance Program Enhancements | c. The following concerns will be monitored:<br>1. Starting air, control air sys. cleanliness.<br>2. Turbo, engine in general<br>3. No common mode D/G failures<br>4. Head cracking, head bolt torque loosening due to block cracking<br>5. Same as 4 above<br>6. a. Excessive wrist pin bushing wear<br>b. Excessive Conn. Rod. Brg. wear<br>7. Engine block cracking<br>8. Rod box cracks causing loosening of rod bolts. | c. As addressed in each issue, the maintenance program will be enhanced to more closely monitor engine operation. A summary of these enhancements are as follows:<br>1. Blow down air receivers daily<br>2. Detailed vibration analysis every monthly surveillance<br>3. Staggered test runs<br>4. Air roll prior to every manual start checking for water and oil accumulation in cylinders<br>5. Air roll 8 hours after every run checking for water and oil accumulation in cylinders.<br>6. Elemental oil analysis for water and metals.<br>7. Head bolt torque check at 90% torque every 50 hours.<br>8. Rod box upper bolt torque check at 90% torque every 50 hours. |

| NRC ITEM | | DISCUSSION | | RESOLUTION |
|---|---|---|---|---|
| 8. Pistons | a. | GGNS has the new type AE pistons which have been shown free of wear induced defects on the Kodiak, TDI R-5 and LILCO engines. | a. | To be inspected first refueling outage. D/G's will have 400 and 300 hours, respectively, of 70 - 100% load operation. |
| 9. Push Rods | a. | MP&L was involved from inception of design in the development and qualification of these push rods. MP&L and FaAA have performed metallurgical examinations showing no defects in this design. | a. | Failure of pushrods was a manufacturing process defect. New rods are manufactured differently. |
| | | | b. | MP&L and FaAA have performed extensive testing to verify the adequacy of this design. |
| 10. Crankshaft | a. | Crankshaft thrust and deflection readings have been made. | a. | This is a standard 18 month surveillance procedure recently performed. |
| | b. | MP&L has verified through analysis and inspections that the GGNS crankshafts are sound and have no potential problems. | b. | In addition, it will be performed at first refueling outage. |
| 11. L.P. Fuel Line | a. | TEC concluded, after vibration testing both Unit 1 diesels, that no further problems should be expected with these components. | a. | Vibration monitoring program for each surveillance run. |

| NRC ITEM | | DISCUSSION | | RESOLUTION |
|---|---|---|---|---|
| 12. H.P. Fuel Line | a. | MP&L verified that all tubes were sampled and are clean of internal defects. | a. | All new tubing was individually sampled and had no draw seams. |
| 13. Engine Base | | | a. | Implement Owner's Group recommended tests and inspections. |
| 14. Rocker Arm Capscrew | a. | TDI D/G Owner's Group stress report concluded that with required torque verified there should be no recurring problems. | a. | MP&L considers this issue resolved. Will continue to have QC verify torque values when checked. |