

**Battelle**

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March 30, 1984

Mr. Carl Berlinger  
Division of Licensing  
Office of Nuclear Reactor Regulation  
U. S. Nuclear Regulatory Commission  
Washington, D. C. 20555

Dear Mr. Berlinger:

SUBJECT: GRAND GULF NUCLEAR STATION STANDBY DIESEL GENERATORS: RELIABILITY  
REPORT SUBMITTED TO NRC BY MISSISSIPPI POWER AND LIGHT COMPANY  
LETTER DATED FEBRUARY 20, 1984

29 In response to your request of Friday, March 23, PNL reviewed the subject report and discussed it with you by telephone on Thursday, March 26. Those who participated in the review are identified in the enclosed summary of our comments and conclusions. Four of the reviewers participated in the telephone conversation: D. A. Dingee, A. G. Henriksen (consultant), B. J. Kirkwood (consultant), and myself.

You asked during the above-mentioned telephone conversation for our comments on the issues of engine start and engine operability. Our comments are as follows:

- Engine start - On the basis of tests at Grand Gulf (summarized in Table 1-2 of the subject report) and at the Shoreham Nuclear Power Station, the Transamerica Delaval, Inc. (TDI) diesel engines start with a high degree of reliability. We have seen no evidence to suggest that there is any problem peculiar to TDI engines in starting them within required time constraints.
- Engine operability - The information available for our review is not sufficient to provide a basis for predicting engine operability. In particular, unresolved issues that pertain to key components (e.g., connecting rods and cylinder heads) need to be addressed before engine operability can be predicted with reasonable certainty. Additional comments on this issue are included in Section II of the enclosed summary.

Mr. Carl Berlinger  
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Please don't hesitate to call me if you have any questions on the comments contained in this letter or in the enclosure.

Sincerely,

A handwritten signature in cursive script that reads "Walt Laity".

Walter W. Laity  
PNL Project Manager

WWL:fo

Enclosure

cc: M. Plahuta, DOE-RL

ATTACHMENT

Review of Mississippi Power & Light

Submittal Providing the NRC with

TDI Engine Status Report

Dated February 20, 1984

I. Basis of Review

This review incorporates the comments and discussions of the following staff after approximately a one-day reading and a one-day working session:

PNL Core Team(\*)

Ricardo Engineering (J. V. Webber, et. al.)(\*\*)

S. H. Bush, consultant(\*\*)

B. J. Kirkwood, consultant

A. Henriksen, consultant

This review focussed on an evaluation of the current reliability and operability of the MP&L TDI engines to meet the requirements to serve as backup power at the Grand Gulf nuclear plant operating at full power. This review dealt with the information provided in the MP&L letter to Mr. Harold Denton, dated February 20, 1984.

The review addressed the 16 generic issues identified by the TDI Owners' Group that were addressed in the MP&L submittal. Additional considerations are also noted.

The presentation generally follows the order of issues addressed in the MP&L submittal; the review of items where MP&L has effected repairs or modifications is provided first. A summary position follows as section II. This is followed by a review of the MP&L response to concerns for other issues raised at the January 26, 1984 Owners' Group meeting at Shoreham. Finally a review of the MP&L Testing and Maintenance Program is provided.

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(\*)W. W. Laity, D. A. Dingee, S. D. Dahlgren, M. Clement, J. R. Nesbitt, J. Alzheimer

(\*\*)Ricardo Engineering provided comments by telephone on the basis of a review done at their facilities in the U.K. No Ricardo representatives were available to participate in the meeting at PNL on March 28, or to review the comments and conclusions documented in the report. Likewise, S. H. Bush was not available for review and comment on the conclusions.

## II. Summary of Conclusions and Observations

The information available for our review is not sufficient to provide a basis for determining whether or not TDI engines at Grand Gulf can meet requirements for emergency service. Major unresolved issues (addressed later in this review) include:

- o connecting rods
- o wrist pin bushings
- o cylinder heads
- o turbocharger
- o connecting rod bearings
- o testing/maintenance plans

The reviewers note that action taken during implementation of the Owners' Group Program Plan may reveal issues that have not been addressed in the MP&L report of February 20, 1984. These issues may bear on the operability and reliability of the TDI engines at Grand Gulf. Accordingly, the issues addressed in the MP&L report are not necessarily the only issues that will need to be addressed for these engines.

An appropriate surveillance and maintenance program might provide a basis for engine operation during the period when the Owners' Group Program Plan is being implemented. We cannot predict at this time whether or not the surveillance and maintenance program would be sufficient to ensure that the diesels could be expected to meet all of the emergency power requirements described in the Grand Gulf FSAR. This tentative conclusion is subject to the following:

- o Identification of the root causes of unresolved problems (e.g., rejectable indications in cylinder heads), and appropriate corrective action.
- o Verification through inspections currently underway at Grand Gulf that engine components are exhibiting only normal wear in the operating experience accumulated to date.

## III. Review Results - Grand Gulf Engine Repairs and Modifications (MP&L Report Sections 2 through 9)

### A. Pistons

#### 1. Considerations:

- o Because the peak pressure in the TDI engine at Kodiak is about 3/4 the peak pressure in the Grand Gulf engine at full power, the operating time at Kodiak is not of as much value as the

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higher operating time in the TDI R5 engine, which operates at a higher peak pressure. Further, the R-5 tests will only be relevant to the AE piston skirts used in the Grand Gulf engines if it can be demonstrated that the AE piston skirts used in the former are the same as those used in the latter.

- o Our tentative conclusion concerning the suitability of the AE piston skirts is contingent upon finding no rejectable indications in them following the recently completed 600 hour test at Grand Gulf.

## 2. Conclusion

- o Subject to the above considerations, the evidence available to the reviewers suggests that the AE piston skirts are suitable for Grand Gulf operation.

### B. Cylinder Heads

#### 1. Considerations

- o Crack propagation in a cylinder head during operation may lead to serious damage to the engine and/or turbocharger, possibly resulting in sudden engine shutdown.
- o The MP&L report of 25% of the heads with rejectable indications is very high. The cause of the rejectable indications has not been identified.
- o An analysis of failure rates of cylinder heads of this type operated at comparable loads may be instructive for establishing confidence in the suitability of these heads for engines in nuclear service.
- o It would be of interest to know whether the heads operating in the R-5 engine are of the same design and whether they are performing without development of rejectable indications.

#### 2. Conclusion

- o The cause of the rejectable indications has not been identified. Accordingly, there is insufficient evidence to say that the heads will perform reliably.

### C. Connecting Rod Bearings

#### 1. Considerations and Conclusion

The evidence available to the reviewers is insufficient to conclude whether the problems identified at Shoreham are applicable to Grand Gulf. Pertinent information for establishing bearing suitability includes the following:

- o Radiographic inspection of all bearings to acceptance criteria established by the Owners' Group in a recently issued bearing shell report.
- o Inspection and documentation of wear patterns of all bearings at Grand Gulf to verify absence of abnormal conditions, such as end loading.

### D. Push Rods

#### 1. Considerations

- o A push rod failure will ultimately lead to shutdown of a cylinder and will require early shutdown of the engines.
- o The MP&L submittal addresses corrective action for the connector push rods but does not address the 2% failure of the main rods.
- o There is no evidence that the new design has been proven to be reliable.

#### 2. Conclusion

- o Adequacy of the modifications should be verified through 100% inspection of the push rods to establish that no cracks developed during recent testing at Grand Gulf which included 600 hours at full power.

### E. Crankshaft

#### 1. Considerations

- o Results in the MP&L report of analyses performed independently by TDI and Bechtel suggest that the stresses in the crankshaft used in the TDI engines at Grand Gulf are acceptable.
- o Incipient problems would be indicated by wear patterns on the bearing. Likewise, hot\* and cold shaft deflection readings



reveal alignment problems that could lead to difficulties with shaft, bearings, bearing supports and base.

- o The reviewers feel that TDI statistics concerning shaft problems would be pertinent to establish confidence in the Grand Gulf designs.

## 2. Conclusion

- o The Grand Gulf crankshaft designs appear to be satisfactory. This is contingent upon MP&L determination that other crankshafts of this design in similar service have not failed due to design deficiencies, an examination of bearing wear patterns, and hot and cold crankshaft deflection readings.

### F. L.P. Fuel Line Failure

#### 1. Considerations and Conclusion

- o The problem appears to be an isolated one, not generic.
- o The problem definition and solution are deemed to be acceptable. MP&L should determine that no new vibration response problems have been introduced by their solution.

### G. H.P. Fuel Line Failure

#### 1. Considerations

- o The problem appears to be related to manufacturing rather than design.
- o MP&L did not indicate how (or whether) the new lines were inspected to verify absence of the drawseam.
- o The line pressure cycles are severe; ranging from near atmospheric to about 5,000 psi and cycling at the rate of 1/2 the engine speed (i.e., 225 rpm).

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\*Hot deflection readings should be completed within 15 minutes of engine shutdown to be valid.

## 2. Conclusion

- o The problem appears to be adequately understood and the solution is acceptable. MP&L should verify through inspection that the new lines are not defective.

### H. Crankcase Capscrew

#### 1. Considerations and Conclusion

- o Failure of crankcase door capscrews is relatively common due to difficulty in obtaining even loading at the capscrew panel interface. The reported consequence, namely a piece of the bolt entering the generators, is unusual. The solution (protecting the generator) is acceptable.

## IV. Review Results - Grand Gulf Responses to Other Owners' Group Generic Problems (MP&L Report Attachment 1)

### A. Cylinder Liners

#### 1. Considerations and Conclusion

- o The method of examination of the damaged liner was not stated. The reviewers agree with the probable cause of the grooving observed in that liner.
- o The corrective action (replacing the damaged liner) is judged to be acceptable.

### B. Cylinder Block

#### 1. Considerations and Conclusion

- o The MP&L report does not address whether cylinder block cracks of the type noted at another nuclear installation are present in the Grand Gulf engines. If such cracks are present, the issue needs to be addressed. We have no basis at this time to comment on the Grand Gulf cylinder blocks.

### C. Engine Base

#### 1. Considerations and Conclusion

- o The information presented suggests that the problem stems from a failure in maintenance to apply proper bolt torque. The corrective action (verification of correct preload values in main bearing studs) appears adequate, subject to verification by



MP&L with TDI of historical data to confirm that the problem does not involve other than maintenance considerations in installations similar to Grand Gulf.

#### D. Head Studs

##### 1. Considerations and Conclusion

- o There is no basis in the MP&L report to comment on this problem.

#### E. Rocker Arm Capscrews

##### 1. Considerations and Conclusion

- o A recent report issued by the Owners' Group on this topic addresses: (1) design, (2) materials, and (3) retorquing.
- o MP&L should implement the Owners' Group recommendations.

#### F. Turbocharger

##### 1. Considerations

- o The MP&L statements on misalignment as the cause does not provide a convincing argument.
- o It is considered unlikely that vibration generated internal to the turbocharger could be the cause. Such imbalance would rapidly lead to destruction of the bearings and rotor.
- o It is considered more likely that vibration is caused by engine vibration transmitted inappropriately through turbocharger supports and/or piping.
- o MP&L should verify that appropriate consideration has been given to exhaust pipe residual loads on the turbocharger. These loads contribute to the loads on turbocharger mounting bolts, and may contribute to excitation of turbocharge mounting vibration.

##### 2. Conclusion

- o There is insufficient evidence to accept the MP&L problem resolution.

##### 3. Observation

- o With regard to the turbocharger thrust bearing failure that has been experienced at Shoreham, we concur that the Grand Gulf

diesel engines appear to be adequately protected with an electrically-operated prelube system for normal startup. In the event of a "black start" (i.e., no electrical power), however, there appears to be no protection.

#### G. Connecting Rods

##### 1. Considerations

- o Consequences of connecting rod failure include immediate shutdown of the engine, possibly catastrophic damage, and a potentially severe hazard to operating personnel in the vicinity of the engine.
- o The reference to marine experience is not necessarily applicable because of differences in engine loading.
- o Evidence presented suggests that a reduction in frequency of failures may have been achieved but not necessarily a solution to the problem.
- o The  $10^4$  hour figure is given as the average hours of operation between occurrences. It is not accompanied by a time distribution of failures which may be an important consideration.

##### 2. Conclusion

- o The evidence presented does not provide a sufficient basis for conclusions regarding the adequacy of the connecting rods for the intended service. Because of the potentially serious consequences of connecting rod failure, a conservative approach to establishing connecting rod adequacy is called for. This approach should take into consideration such factors as the root cause of connecting rod cracking, appropriate tests to verify corrective action, probable minimum time between failure under worst-case conditions that may be imposed on Grand Gulf engines, and appropriate ongoing surveillance to ensure that the connecting rods remain sound in service.

#### H. Jacket Water Pumps

##### 1. Considerations and Conclusion

- o The problem appears to be adequately understood and the solution is acceptable.

## 2. Observation

- o It is common practice in non-nuclear installations to have an electrically driven standby jacket water pump.

### I. Air Start Valve Capscrews

#### 1. Considerations and Conclusion

- o The problem appears to be adequately understood and the solution is acceptable.

## V. Wrist Pin Bushing (a new problem area not addressed by the TDI Owners' Group at this time)

#### 1. Considerations and Conclusion

- o Failure of wrist pin bushings may have serious consequences, comparable or worse than failure of the connecting rod bearings.
- o Unit loadings on wrist pin bushings are larger than on connecting rod bearings.
- o All eight wrist pin bushings removed from the 101 engine at Shoreham during the week of March 19 were dye checked and found to be cracked. No pattern of cracking was evident. It was also reported, but not verified, that new bushings received at Shoreham from TDI but not installed, are also cracked. This suggests that the cracking is a manufacturing problem, and if so, it may be present in the wrist pin bushings in the TDI engines at Grand Gulf. Accordingly, we believe that all wrist pin bushings should be dye checked and those found to have cracks should be replaced with bushings that are not cracked.
- o This problem needs to be addressed immediately because of the seriousness of the consequences.

## VI. Comments on the MP&L Qualification/Reliability Demonstration Testing (MP&L Report Section 11.0)

- o The test program to demonstrate the adequacy of the TDI engines should be related to the demands that may be placed on the engines under emergency conditions as described in the Grand Gulf FSAR.
- o The test program followed after replacement of the piston skirts as described in section 11.3 of the MP&L report appears to meet standard industry practice. However, the summary of testing presented in Table 11-1 suggests that the AE piston skirts were not

installed in the Grand Gulf engines during "Tech Spec Testing." This issue should be addressed in the overall test program for the TDI engines.

- o The brief description (provided in the MP&L submittal) of the maintenance program and reliability enhancement testing is not convincing to the reviewers that there will be adequate surveillance of physical conditions and monitoring of operating parameters to assure continuous availability and operability of the engines.

#### VII. Consultant Concurrence

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B. J. Kirkwood  
Covenant Engineering

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Adam Henriksen



Pacific Northwest Laboratories  
Richland, Washington 99352  
Telephone 875-2780  
Telex 15-2674

April 16, 1984

Mr. Carl Berlinger  
Division of Licensing  
Office of Nuclear Regulatory Commission  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555

Dear Mr. Berlinger:

In response to your request of Monday, April 16, PNL has reviewed the questions you raised on the subject of diesel generators. These questions were discussed by Dave Dingee and Walt Laity with the following diesel engine consultants who, as subcontractors to PNL, participated in a meeting on this subject at NRC on April 13: Adam Hendriksen, B.J. Kirkwood, and Arthur Sarsten. Summarized in the enclosure to this letter are the assumed operating requirements for the diesel engines, followed by our comments on each of the questions.

Please do not hesitate to call if you have any questions on the enclosure.

Sincerely,

*Walt Laity*  
Walter W. Laity  
PNL Plant Manager

WWL:rf  
Enclosure  
cc: M. Plahuta, DOE-RL

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GRAND GULF NUCLEAR POWER STATION STANDBY DIESEL GENERATORS - PNL RESPONSES  
TO NRC QUESTIONS OF APRIL 16, 1984.

1. Must MP&L conduct an engine tear-down and inspection? If so, must this be both engines?

The consultants had a range of opinions about the necessity for complete engine tear-down of both engines. All agreed that at least one engine must be completely torn down. Action on the second engine would be contingent on findings. If no problem is noted with the first engine, then the second engine can be accepted without tear-down if MP&L can demonstrate through a review of the manufacturers' QA program that these two engines are essentially identical. If the QA program review does not give this assurance the opinion of the consultants varied, depending on the level of assurance. Action thought to be appropriate ranged from a "sampling" inspection of readily accessible items to a tear-down to inspect the critical components (e.g., wrist pin bushings, conrod bearings, and conrods).

2. Assuming the one-engine tear-down discloses defects, what must MP&L do immediately, and later?

The inspection of the torn-down engine might reveal information that would suggest a meeting between NRC and MP&L. However, even if the inspection reveals no new information,\* all defective parts should be replaced. Possibly the block and engine base could be excepted if cracking is not severe or in critical areas. However, if more recent history and analyses confirm the cracks to be serious, these parts also must be replaced. Again, action on the second engine would be contingent on findings. If the inspection of the first engine reveals serious defects, these need to be evaluated as a basis for establishing inspection requirements for the second engine.

In the long term, MP&L must be bound to implement an enhanced surveillance and maintenance program (see below) and implement the Owners' Group recommendations (currently being formulated) on both engines at the first refueling shutdown.

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\* Progress by the Owners' Group on generic issues can affect the status of understanding at the time of MP&L licensing.



3. Assuming Grand Gulf goes into operation, what maintenance and inspection requirements must be imposed?

There will be an inspection frequency in the Owners' Group plan calling for a complete tear-down. This should be implemented at Grand Gulf. Subject to that determination, special attention should be given to selected components as described below. If defects are noted, the parts should be replaced. The nature of the defect will determine if this is all that is required. The Owners' Group maintenance program recommendations or experience may be used to establish relaxed (or tightened) inspection frequencies.

Detailed inspection and maintenance requirements should be established in conjunction with the engine manufacturer. This should also include all maintenance/inspection identified by MP&L at the April 13 meeting.

Cylinder Heads: After engine shutdown the engine should be rolled over with air pressure once each hour for four hours (during cooldown) with the indicator cocks open. Engines not in operation should be rolled over once a day. Any heads found leaking must be replaced.

Engine Block and Base: Inspect once a month or after 24 hours operation for any cracks. No other special maintenance required if any defects found are "noncritical".

Connecting Rods: After each 25 starts or 50 hours of operation or 6-months, all bolts on conrods should be retorqued and the results recorded.

Lube Oil Checks: Weekly (or after each 24 hours operation) for water and monthly for particulates and chemical contaminants associated with wear of bushings and bearings. Also collect sample from bottom of sump and check for water. The filters should also be checked (no time interval given).

Capscrews: Monthly spot check (25%) of all capscrews in question.

Other: If per question 1 an engine is not torn down, each 6 months a 25% random check of piston crowns, liner walls, heads, upper block at studs, head bolts, areas around head bolts, and push rods (both main and connecting). Also on this engine, a 12 1/2% check of bearings and wrist pin bushings should be done.

Push Rods: After 24 hours operation, cams, tappets, push rods, etc., should be checked. This can be done one at a time with the engine shutdown but without affecting its availability for service.

4. Regarding the surveillance program, what data recording should be taken in engine standby and operating conditions?

To accommodate standby monitoring, the daily, weekly, and monthly actions should be accomplished as identified in the MP&L D/G Maintenance/Testing Program (received on 4/13/84) except that the oil pressure filter drop should be monitored daily instead of monthly. One additional standby monitoring requirement is a shaft deflection measurement every six months.

The engine operating surveillance program should include the following. If alarm levels are reached on any of these, this indicates the need to switch engines.

- o exhaust temperature monitor and alarm for each cylinder (continuous)
- o temperature recording before and after turbo-charger (continuous)
- o hourly readings on standard temperature and pressures for such items as lube oil, jacket water, intercooler, air pressure, etc.
- o accelerometer monitoring (continuous) on all main bearings and the turbo-charger
- o monitor daily the lube oil filter pressure drop

5. What preoperational testing would be required following assembly of the inspected engine(s)?

The manufacturers' standard preoperational testing should be done. In addition:

- o run 10 modified starts (defined as prelube and 3-minute loading to 40% load)
- o conduct two quick-starts to 70% load and hold for four hours duration
- o conduct one 24 hour run at 70% load (to look for excursions in temperature).